CERIC

Central European
Research Infrastructure
Consortium

Report

2022

ERIC established by the European
Commision Implementing Decision
392/2014/EU

Open for Science

Table of Contents

Providing Open Access to Excellent Researchers

CERIC-ERIC is an integrated multidisciplinary research infrastructure for basic and applied research in all fields of materials, biomaterials and nanotechnology. Located in 8 countries in Europe (Austria, Croatia, Czech Republic, Hungary, Italy, Poland, Romania and Slovenia), it is open to researchers from all over the world. It offers a single access point to world class facilities and techniques based on the use of electrons, ions, neutrons and photons. Each Member Country contributes to CERIC a high-quality Partner Facility (PF), which is available to researchers on the basis of a positive review from the International Scientific and Technical Advisory Committee (ISTAC) of CERIC.

Jana Kolar
CERIC Executive Director

Dear stakeholders, colleagues, and friends,

As we look back at 2022, I am proud to present the CERIC Annual Report, highlighting our journey in the face of unprecedented challenges brought by the COVID-19 pandemic. Through resilience, dedication, and teamwork, CERIC has not only returned to its ordinary activities but has also continued to evolve and grow as a leading research infrastructure in Europe.

Our commitment to Excellent Science has never wavered. With an increase in proposals, expansion of our instruments, and continued support for remote access and sample mailing, we have successfully maintained our impact on the global scientific community. By evaluating and monitoring our performance, we ensure that we continue to contribute significantly to research and innovation.

Improving the Quality of Services has been a top priority for us. From expanding our Partner Facilities, investing in new instruments, and adopting FAIR principles in our data lifecycle, we have strived to enhance the experience and opportunities for our users. Our ongoing projects, including the development of a CERIC "mini-EOSC" and the exploration of a new Proposal Management System, further illustrate our commitment to continuous improvement.

We have made significant strides in various areas, continuing to invest in the growth and development of our staff and the wider scientific community through training and capacity-building opportunities. By enhancing our industrial collaborations and communication efforts, we've showcased the value of our infrastructure. We have also worked towards a more sustainable business model, updated our Statutes and Internal Regulations, and implemented a Gender Equality Plan, demonstrating our dedication to contributing to the UN Sustainable Development Goals and the European Research Area.

As we move forward, I would like to extend my heartfelt gratitude to our dedicated team, our collaborators, and our stakeholders for their unwavering support and commitment. Our achievements in 2022 would not have been possible without your collective efforts. As we embark on a new year, we will continue to strive for excellence, improve our services, and expand our impact on research and innovation across Europe and the world.

With warm regards,

Jana Kolar

Executive Summary

In 2022, CERIC started to get back to its ordinary activities as in the period before the outbreak of the COVID-19 pandemic. The number of proposals received further increased, the offer of instruments continued expanding, and participation in policy-related activities started increasing again, both online and again at physical events across Europe (Table 1).

Headline Indicators	2019	2020	2021	2022	% Change 2022-2021
Proposals received	279	270	298	343	15%
Number of papers	88	113	109	120	10%
Projects' funding (CERIC)	694,316.91	699,279.20	796.171,00	514,052.88	-35,5%
Share of papers among 10% top cited*		12,2%		8,2%	-33%

Table 1 Headline indicators for 2019-2022 and changes in the last reported year.

Excellent Science

In 2022, CERIC continued to provide access to its research infrastructure (RI) and contribute to the advancement of science. Its calls for open access attracted 343 proposals from 37 countries and five continents, requesting the use of 511 instruments.
Also in 2022, CERIC kept on accepting sample mailing, thus allowing the performance of experiments, also via remote access.
The number of publications has increased (+10%) since 2021, whereas the average Impact Factor (IF), at 6.52, has remained stable in comparison to the previous year, with a very slight decrease. However, IF is a poor proxy for scientific excellence. Therefore, also in 2022, CERIC collected the information about the impact of scientific publications. Such impact is expressed as the percentage of publications that are among the 10% top-cited. 8,2 percent of CERIC scientific articles published in 2019-2020-2021 are among the top 10% cited publications[1].
A core activity of CERIC is also to promote the integration of its Partner Facilities (PFs) through internal research projects, RI investments and funding of PhD students and post-doc researchers, bringing together at least two CERIC facilities. The activities also contribute to increasing the capabilities of CERIC, and to pooling resources across EU countries towards the same objectives.

Improving the Quality of Services

Monitoring the quality of CERIC's infrastructure and services continued in 2022, with a periodic evaluation of the Czech and Romanian PFs. Also, new Associated Facilities in Italy, France and Greece have joined the CERIC's calls for proposals widening its open access offer with new instruments and laboratories. In addition, and in line with the CERIC Science and RI development strategy, the purchase of new instruments at the Czech, Romanian and Slovenian PFs has started to further enhance CERIC's role as a leading infrastructure for energy research. In this domain, and with a focus on fuel cell research, the Science@CERIC workshop was organised, bringing together directors and scientists from different PFs to exchange on research results and ongoing activities in this field.
Adopting the FAIR (Findable, Accessible, Interoperable and Reusable) principles in the whole data lifecycle has become a priority at RIs. CERIC, via the H2020 PaNOSC project, has widely contributed to making more data FAIR for the community of users and for scientists from all domains, by taking part in the development of FAIR data policies, frameworks and services for enabling Open Science. Moreover, with the goal of setting up a CERIC "mini-EOSC", the IT team has been supporting all PFs in developing their own FAIR-enabled workflow. The work is ongoing and envisages to test, in 2023, a scientific data management pilot project, which aims to allow CERIC users perform and accelerate the data analysis process.
In the IT domain, and to improve the operation of experiments' administration, CERIC has started to explore the possibilities for developing its own Proposal Management System, setting the basis for future custom developments.
To continually improve CERIC's operations, ensuring the delivery of excellent service to the research community, the Consortium has been monitoring its performance periodically, through the collection of the data related to all KPIs proposed by the ESFRI working group on Monitoring of RIs Performance. Assessing the impact of CERIC is also vital for demonstrating its value to stakeholders, such as funders, policymakers, and the research community. In 2022, on the basis of the impact pathways report releseased in 2020 in the frane of the H2020 project ACCELERATE, the Consortium started preparing its updated internal report, which will be used as a basis for external impact assessment, to be undertaken in 2023.

Training, Industrial Liaison, Communication, Projects

Training and up-skilling at all levels is strongly prioritised by CERIC. The PaGES7 project enabled 144 pupils from the Italian Region Friuli Venezia Giulia to access a wide programme of lectures on project management, communication and scientific topics. Building on the experience of the pandemic, the 2021/2022 edition took a fully virtual shape, also in connection with the scientists in the labs at the CERIC synchrotron facility in Trieste (Italy) and at the Slovenian NMR Centre in Ljubljana.
Activities also progressed to carry out the CERIC-funded PhD programme, which aims to further the integration of the PFs and contribute to excellent science. In addition to the fourteen PhDs activated in 2020 and 2021, two new scholarships were granted in 2022 in the fields of energy research and life sciences, in collaboration with the Charles University in Prague and Graz University of Technology. Moreover, a post-doc grant was assigned in the frame of a CERIC call specifically addressing Ukrainian researchers.
In 2022, CERIC also continued its capacity building activity for the staff of its PFs and other RIs, in the industrial liaison and technology transfer (IL/TT) field. Organised initiatives included an event offering training sessions and presentations with international experts from public entities and industry, focused on increasing RIs' relations with industry.
In 2022, 5% of total accesses related to projects with industrial interest, and 11% of the articles released in the same year were related to the industry.
In the communication domain, in addition to the regular promotion of the CERIC calls for proposals, the fast-track access and of all activities, opportunities and results achieved by the Consortium, also in the frame of its projects, more videos showcasing the techniques and laboratories available in the open access offer, and two thematic videos on the opportunities available at CERIC for research on batteries and fuel cells, were produced and disseminated to stakeholders in the scientific domain.
CERIC also took part in science dissemination events, such as Trieste Next 2022 and the European Researchers' Night, ESOF 2022, and PARI 2022, with booths, conferences and pitches for the lay public and for the staff at RIs.
In addition to ordinary funding, CERIC also received funding for European projects, in a total amount of 514,052.88 EUR. The decrease by 35,5% in comparison to the previous year is motivated by the closure of the H2020 ACCELERATE project at the end of 2021. By the end of 2022, also the other two H2020 projects, ERIC Forum and PaNOSC, were successfully completed.

Policy, Operations and Finance

Following the discussions started in 2019 at the level of the General Assembly (GA) of CERIC on the proposal to modify the business model of the Consortium, towards a transition from the sole use of in-kind contributions, to annual cash contributions by the Members, a related amendment of the Statutes of CERIC was approved by the GA by written procedure in the first half of 2023.
The GA also approved the proposed modifications to two Internal Regulations (IRs): IR 4 - GA Rules of Procedure, and IR 10 - Rules of Conduct and Disciplinary Code.
Moreover, in compliance with the Horizon Europe Guidance on Gender Equality Plans (GEPs), CERIC released its GEP in 2022, with the involvement of all its staff.
During the year, CERIC's contribution to UN Sustainable Development Goals and to the ERA continued.
CERIC also played a major role in the development of a sustainability plan for the photon and neutron (PaN) European Open Science Cloud (EOSC), based on a previous collection of costs reported by PaN facilities for the data services provided to the community, and on the analysis of possible business models to be adopted.
The sustainability plan presents an overview of the aspects that affect the sustainability of the PaN EOSC and how these will be tackled beyond PaNOSC.
The final section of this report presents the financial and economic situation of the Consortium for the year 2022, outlined through statements presented under the accrual basis of accounting according to International Public Sector Accounting Standards.

*The percentage of CERIC papers among top 10% most cited ones is reported on a three-year basis, with rolling publication dates: for 2019 (publications 2018-2017-2016), for 2022 (publications 2021-2020-2019).
[1]Percentage of publications based on research performed using facilities/resources of the RI that, compared with the publications in the same field and in the same year, belong to the top 10% most frequently cited.

1

Excellent Science

Main Achievements

1. **Implementation of 2 calls for free open access** to which 343 proposals, requesting the use of 511 instruments, were received.
2. **Proposals came from 37 countries and 5 continents**
3. **Continuous fast-track access for feasibility studies and for COVID-related research**
4. **Positive evaluation of the progress of CERIC internal and transnational research projects**

Open Access

CERIC's main aim is to enable excellent science, both as in-house activity and as a service to international users. This is achieved mainly by providing merit-based open access to its research facilities and promoting internal research.

In 2022, CERIC launched two calls for proposals for the use of the Consortium's research instruments: 343 proposals were received (Figure 1). Given their multitechnique character, this corresponds to 511 single instrument access requests. There has been a 16% increase in the number of applications compared to the previous year. Moreover, 2022 has been the year with the highest number of received applications since the set-up of the Consortium.

There were 182 proposals selected for the use of 239 allocated instruments (Figure 2). In 2022, nearly 25331 hours of operation were used to perform measurements. In addition to physical access to the CERIC facilities, some of them (24%) continued to offer the possibility of performing measurements remotely through sample mailing.

Figure 1
Number of proposals and requested methods

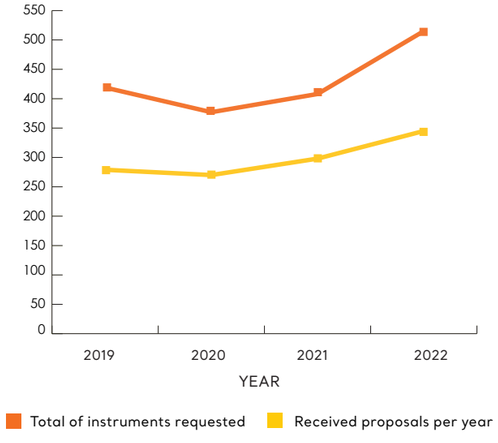
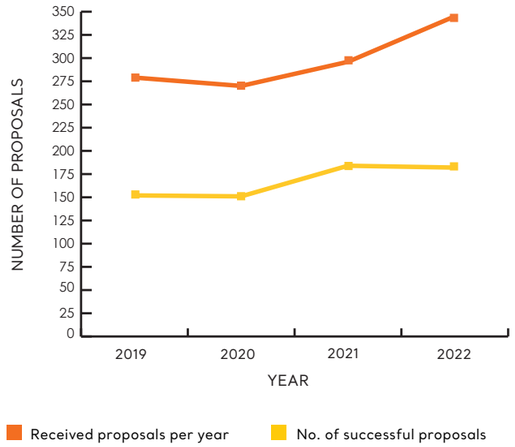
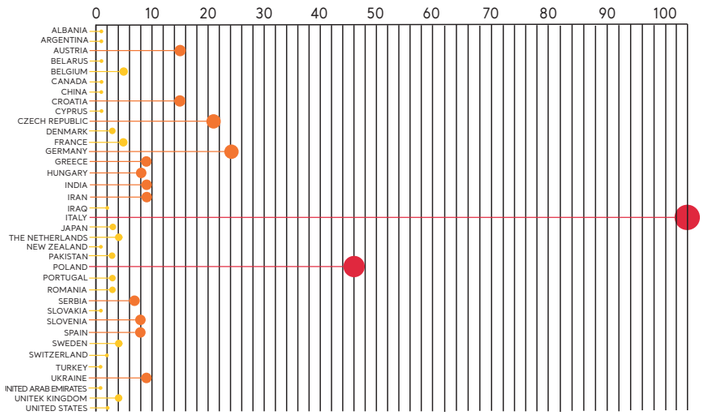


Figure 2
Number of received and successful proposals per year



CERIC remains a highly internationalised research infrastructure, with principal investigators from 37 countries and five continents in 2022 (Figure 3). Moreover, among countries that participated to the 2022 call of proposals, 49% were non-EU countries.

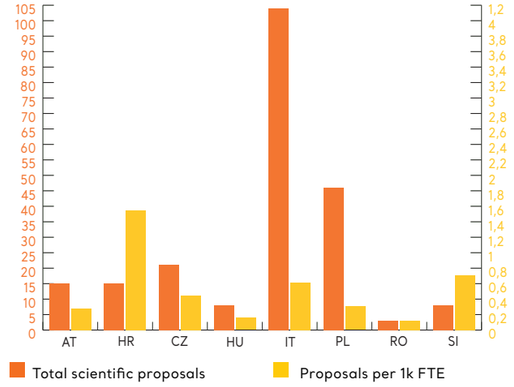
Figure 3
No. of proposals by country



- **2 calls for proposals**
- **343 proposals received**
- **Research groups from 37 countries**
- **239 allocated requests**

The majority (64%) of submitted proposals in 2022 came from CERIC Member Countries, as in the previous year. The most active users, in relation to the fulltime employees in Research & Development in a country, are from Croatia, followed by Slovenia and Italy (Figure 4).

Figure 4
Proposals per 1K full-time employees (FTE) in R&D in Member Countries



In 2022, 42% of the principal investigators (proposers) and 44% of the researchers who performed the measurements at the facilities were women (Figure 5).

Figure 5
Gender distribution of CERIC users

Quantity and quality of the Output

In 2022, the number of publications released from measurements taken at the CERIC facilities slightly increased (+5%) compared to the previous year. On the other hand, the average Impact Factor (IF, 6,52) slightly decreased - by 6% - in comparison to 2021. However, IF is a poor measure of the quality of the output. Therefore, also in 2022, CERIC collected data on the most cited publications, expressed as the share of CERIC's publications among the top 10% most frequently cited ones (top20%). The data of the top10% indicator is presented in Figure 6. One-fourth (25%) of the top 10% papers published in the last three years were in the field of energy, followed by 21% in the field of life sciences, supporting the rationale to further focus on these two domains.

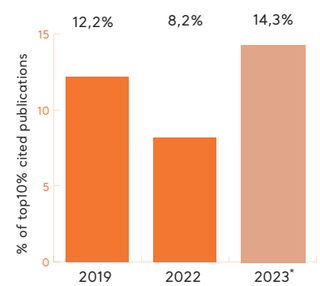


Figure 6
*Share of publications, based on the research performed using facilities/ resources of RI, in top 10% in a comparable field. All the publications tied at the threshold of top10% are taken in consideration. The percentage of CERIC papers among top 10% most cited ones is reported over a period of 3 years, with rolling publication dates: for 2019 (publications 2018-2017-2016), for 2022 (publications 2021-2020-2019).

International Scientific and Technical Advisory Committee - ISTAC

The purpose of the ISTAC of CERIC is to provide the General Assembly (GA) with recommendations on scientific and technical issues that bear on the full and effective utilisation of CERIC as a state-of the-art research infrastructure and on developments required to maintain its scientific productivity at the highest possible level and ensure its relevance to the international scientific community. In particular, the ISTAC evaluates proposals for new partner facilities, and the operation of existing ones, advising the General Assembly on acceptance and continuation. The periodic evaluation of the Czech and Romanian Partner Facilities (PF) was held in October 2022, (read more on page 30), with sites visits by the members of the ISTAC, at the National Institute for Materials Physics in Bucharest and at the Charles University in Prague.

COVID-19 Fast Track Access

Also in 2022, CERIC continued offering a dedicated Fast Track Access to a selected number of instruments to facilitate feasibility studies, commissioning tests and research on COVID-19. In particular, fast access for commissioning was introduced in 2022 at the suggestion of one of the directors. It allows finding friendly users that accept to perform measurements in instruments in commissioning. This is an advantage for both users and facilities, which can optimise the operation of their instruments with the help of experienced researchers. In 2022, the instrument EnviroESCA was made available only for commissioning studies. Four proposals requested the use of this research tool.
The dedicated Fast Track Access stayed open throughout the whole year, allowing access to a set of relevant instruments for research and testing without the necessity to undergo the regular evaluation procedure and to be scheduled within one month from the submission of the proposal, based on an evaluation performed by the PF. During the year, 16 proposals were received for this access mode. A wide number of techniques at the Austrian, Italian, Polish and Slovenian PFs have been devoted to the purpose. All scientific information generated (i.e., peer-reviewed scientific research articles and research data) have been made available and reusable through online access that is free of charge to the end-user.

New instruments available via open access

Starting 2022, the Polish CERIC PF has provided open access to two new research techniques: the Scanning Transmission X-ray Microscope (STMX) and X-ray Absorption Spectroscopy (XAS) beamline optimised for measurements in the soft and tender energy range.

Scientific Highlights

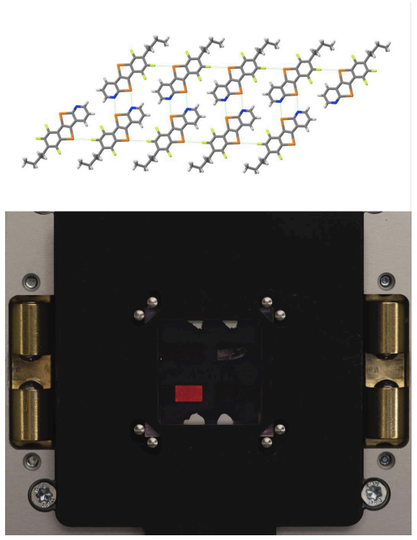
A novel supramolecular approach to engineer Nanoribbons for LECs[1]

Prof. Rubén D. Costa

Prof. Davide Bonifazi

Light-emitting electrochemical cells (LECs) are solid-state devices that generate light from an electric current; at today, they are one of the simplest and cheapest lighting devices available and they are used, for example, as electroluminescent inks and stickers, or to produce displays. However, several research projects are still underway to build more stable and efficient LECs.

Prof. Rubén D. Costa (Technical University of Munich), **Prof. Davide Bonifazi** (University of Vienna) and colleagues developed a novel approach to prepare functional materials exploiting chalcogen bonds, molecular interactions that are emerging as new tools to drive crystal engineering and program polymeric architectures (such as nanoribbons). Researchers designed a 2D polymer that, by embodying two doubly chalcogen-bonded units, assembles at the solid-state into nanoribbons composed of alternating telluro and tellurophene atoms establishing contact with N and F atoms, that act as a semiconductor. In particular, they synthetised two conjugated modules, which undergo programmed self-assembly at the solid-state. Analysis carried out at the Austrian SAXS beamline at the Elettra synchrotron in Trieste have shown that the these chalcogen-bonded supramolecular materials (**i.e., materials composed by several molecules, linked together by specific interactions**) maintain their organisation as multilayer semiconductor into LEC devices when used as a hole transport layer, resulting in a stability enhancement of the device when compared to its analogues integratingclassical semiconducting covalent polymeris.



Given also the lack of electroluminescence signal that characterises the chalcogen bonded nanoribbon layer, this supramolecular approach represents an example of how these intermolecular interactions could be used to design new functional materials, and more stable and efficient LECs.

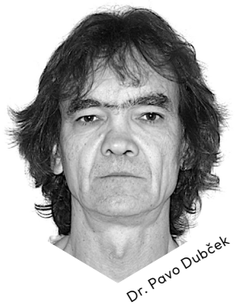
"Intermolecular interactions shaping semiconductors could be used to design new functional materials, and to boost the performance of light-emitting electrochemical cells".

Figure 7
Nanoribbons supramolecular structure and red-emitting nanoribbond-based LEC under operation.

[1] *Supramolecular Chalcogen-Bonded Semiconducting Nanoribbons at Work in Lighting Devices.* Romito D., Fresta E., Cavinato L.M., Kählig H., Amenitsch H., Caputo L., Chen Y., Samorì P., Charlier J.-C., Costa R.D., Bonifazi D. Angewandte Chemie 61(38), 2022, DOI: https://doi.org/10.1002/ange.202202137

Ion beams at small accelerator facilities can effectively serve in material modification studies[2]

Dr. Marko Karlušić



Dr. Pavo Dubček

It's since the 50s that it's possible to employ swift heavy ions, accelerated atoms with a net electrical charge, to create so-called ion tracks in solid materials. Such tracks can be formed with high precision, changing a material's surface and thus create nanostructured materials. However, achieving the formation of ion tracks, especially in radiation resistant materials, would require access to very high energies available only at few accelerator facilities.

Dr. Marko Karlušić, **Dr. Pavo Dubček** and colleagues from the Ruđer Bošković Institute, focused on finding ways to lower the threshold for ion tracks formation, thus expanding the research possibilities available in small and medium-sized accelerator facilities. For this research, the authors irradiated samples of aluminium oxide (Al2O3), magnesium oxide (MgO), and Calcium fluoride (CaF2) with ion beams at different energies. In order to characterise the presence of ion tracks, the authors analysed the samples by Rutherford Backscattering Spectrometry technique in channeling mode, available at the Croatian CERIC PFs at the RuđerBošković Institute, in Zagreb.

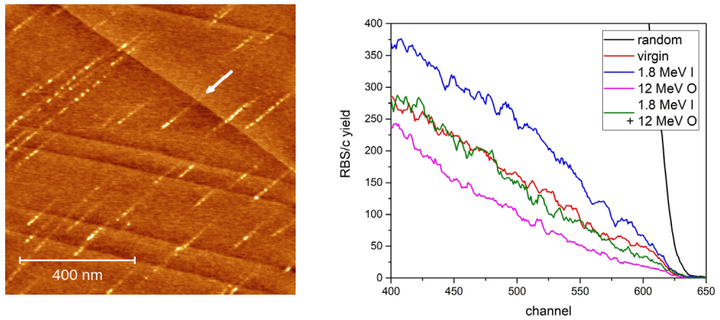


Figure 7
(a) AFM images (1 μm × 1 μm, 1 nm false colour height scale) of ion tracks on CaF_2 surface irradiated with 12 MeV Si ion beams at a grazing incidence angle of 1.5°. The ion beam direction is indicated by an arrow. (b) RBS/c spectra of sequentially irradiated CaF_2 with 1.8 MeV I (6×10^{13} ions/cm2) and 12 MeV O (10^{14} ions/cm^2), smoothened with a moving average of 5 channels.

This study provides experimental evidence that ion beams available at small accelerator facilities can be effectively employed in material modification studies since damage build-up can occur in materials well below the expected threshold. This research provides relevant insights into nanoscale material modification by swift heavy ions, opening up exciting opportunities in materials science, including its applications.

"This study is relevant for understanding material behaviour in radiation harsh environments, as it was shown convincingly that diverse materials can be much more sensitive to the ion irradiation at the surface than they are in the bulk".

[2] *High-Energy Heavy Ion Irradiation of Al_2O_3, MgO and CaF_2,* Hanžek J., Dubček P., Fazinić S., Tomić Luketić K., & Karlušić M., Materials, 2022, DOI: https://doi.org/10.3390/ma15062110

Keeping atoms apart in advances catalysts[3]

Catalysis is becoming increasingly relevant in a wide range of applications, including green energy, automotive emissions, chemical refining, and more. The catalyst is a substance capable of accelerating chemical reactions, and among its more relevant parameters are efficiency and duration. In this regard, single-atom catalysts have remarkable advantages, and experimental techniques and practical approaches have been developed to optimise the catalyst utilisation to improve the understanding of nanoparticle dynamic changes throughout the catalyst lifetime. A common problem in this sense is to prevent the aggregation of metal atoms to metal nanoparticles which will result in a loss of efficiency.

Dr. Stefano Fabris

Dr. Josef Mysliveček

Dr. Stefano Fabris (CNR-IOM), **Dr. Josef Mysliveček** (Charles University) and colleagues performed dedicated surface science experiments and calculations revealing the dynamic character of platinum (Pt) load on a cerium oxide (CeO2) support. With such work, the authors aimed to identify general conditions under which metal nanoparticle catalysts on single-atom catalyst substrates can be optimised and operated stably. The experiments were performed at the Materials Science Beamline available at the Czech CERIC PF at the Elettra synchrotron in Trieste.

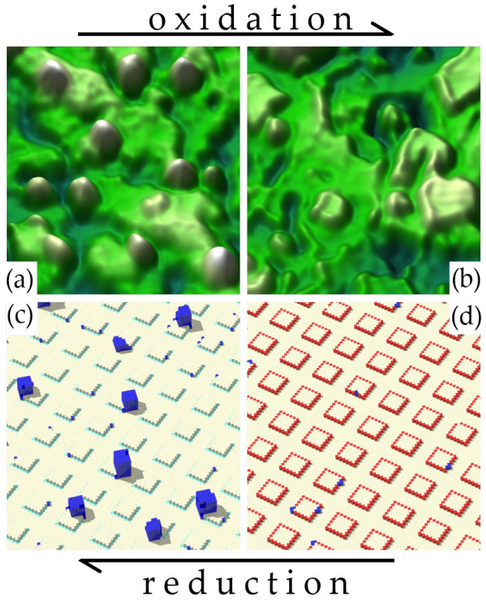


Figure 8
Reversible changes of Pt morphology on CeO2(111) single-atom catalyst substrate as a function of the reaction atmosphere. At reducing conditions, Pt nanoparticles are formed (a). At oxidizing conditions, Pt nanoparticles disintegrate into to Pt single-atoms at ceria step-edges (b). STM micrographs, 30 x 30 nm2. (c, d): theoretical model of the process. Adapted with permission from M. Farnesi Camellone et al., ACS Catal. 12, 4859 (2022). Copyright 2022 American Chemical Society.

"The results of our study allow us to envision regenerating the morphology of Pt/ceria catalysts deactivated in a harsh catalytic process, or even sinter-resistant catalysts working in alternating oxidizing/reducing conditions. Effectively, our study is removing the boundary between single-atom and traditional supported metal catalysts paving ways to dynamic control of on-demand catalyst structure".

The authors demonstrated that for long-term activity in catalytic applications, single-atom catalyst substrates allow efficient redispersion of the supported metal nanoparticles. This possibility is particularly appealing for applications such as automotive catalysts allowing for the abatement of pollutants' emissions such as carbon monoxide (CO) and nitrogen oxides (NOX).

[3] *Adatom and Nanoparticle Dynamics on Single-Atom Catalyst Substrates,* Farnesi Camellone M., Dvořák F., Vorokhta M., Tovt A., Khalakhan I., Johánek V., Skála T., Matolínová I., Fabris S., & Mysliveček J., ACS Catalysis, 2022, DOI: https://doi.org/10.1021/acscatal.2c00291

CERIC users developed a new record-breaking electrode for sodium-ion batteries[4]

Li-ion batteries are among the most important inventions of the past century, enabling a completely new paradigm of portable devices. Such a disruptive innovation was also awarded a Nobel prize in 2019. With the ever-growing diffusion of larger battery-powered items, such as cars and trucks, the debate on the abundance of raw materials, such as lithium and cobalt, needed for their construction is arising. Among the potential solutions for a post-lithium battery era, sodium-based batteries are in the front row. CERIC users developed a vanadium-based positive electrode material for high-voltage sodium-based batteries.

Assistant Prof. Stanislav Fedotov

Assistant Professor Stanislav Fedotov (Skolkovo Institute of Science and Technology), his team and colleagues, including representatives from Lomonosov Moscow State University, proposed a new cathode material for sodium-ion batteries based on sodium and vanadium phosphate fluoride and tested its properties and performance. The work was supported by Russian Science Foundation (20-73-10248).
X-ray powder diffraction experiments, realised at the MCX beamline at the Italian CERIC PFs at the Elettra synchrotron, allowed gathering relevant details of the inner battery material while in function, including the structural evolution of the material and its ion de/insertion mechanism.

"This is a record-breaking cathode that ensures 10%-15% better battery energy density than the top contender among so-called polyanion materials. It was created by exploiting contemporary solid-state chemistry design principles allowed to merge optimal chemical formula with a proper crystal structure that provides fast ionic transport. This work paves the way for further improvement of specific energy and power characteristics of Na-ion battery".

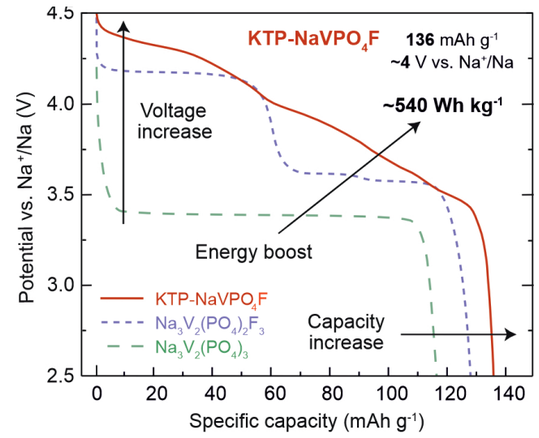


Figure 9
KTP-NaVPO4F provides higher specific energy than benchmarking vanadium-based positive electrodes.

In conclusion, the authors developed and synthesised a new positive electrode material for sodium-ion batteries showing attractive specific capacity and specific currents outcompeting the theoretical capacity of other known vanadium-based positive electrodes. Thanks to this study, a new step was achieved towards a new generation of batteries based on cheap and readily available raw materials, such as sodium.

[4] *Development of vanadium-based polyanion positive electrode active materials for high-voltage sodium-based batteries,* Shraer S. D., Luchinin N. D., Trussov I. A., Aksyonov D. A., Morozov A. V., Ryazantsev S. V., Iarchuk A. R., Morozova P. A., Nikitina V. A., Stevenson K. J., Antipov E. V., Abakumov A. M., & Fedotov S. S., Nature Communications, 2022, DOI: https://doi.org/10.1038%2Fs41467-022-31768-5

A new cathode material for high-performance sodium batteries[5]

Different sectors, including transport and industry, are undergoing electrification, and this transformation requires an increasing battery storage capacity. The current primary battery technology is based on lithium-ion technology, which relies mostly on lithium, nickel and cobalt. However, these elements can be feasibly mined in only a few areas of the world, and their resources are shrinking. Moreover, cobalt and nickel are known with their harmful character for people as well as the environment. Therefore, the need for alternative chemistries for new-generation batteries is pressing. In this regard, there's an increasing interest towards sodium-ion batteries (Na-ion), considering the wide availability of sodium and its low price.


Dr. Katarzyna Walczak

Dr. Katarzyna Walczak and **Prof. Janina Molenda** (AGH University of Science and Technology), together with their colleagues, developed and analysed a novel positive electrode material (cathode) suitable for Na-ion batteries. This complex study included theoretical and experimental elements, and the authors focused on the structure of the cathode material. Among others, a High-Resolution Transmission Electron Microscope (HR-TEM) available at the Romanian CERIC PF at the National Institute of Materials Physics in Magurele (Bucharest) was employed to obtain a deeper understanding of the morphology of the cathode material and its impact on the properties of the sodium cells.


Prof. Janina Molenda

"This electrode material, which has a high specific capacity of 180 mAh·g-1, much higher than the commercially used $LiCoO_2$ cathode material for Li-ion batteries. It can help to develop sodium battery technology, especially for large-scale energy storage".

Figure 10
The $NaMn_{0.2}Fe_{0.2}Co_{0.2}Ni_{0.2}Ti_{0.2}O_2$ as a promising cathode material for Na-ion batteries.

This work proved that this new complex material could find applications in sodium battery technology as a high-performance cathode, especially in large-scale energy storage applications.

[5] *NaMn0. $2Fe_{0.2}Co_{0.2}Ni_{0.2}Ti_{0.2}O_2$ high-entropy layered oxide–experimental and theoretical evidence of high electrochemical performance in sodium batteries*, Walczak K., Plewa A., Ghica C., Zając W., Trenczek-Zając A., Zając M., Toboła J., & Molenda J., Energy Storage Materials, 2022, DOI: https://doi.org/10.1016/j.ensm.2022.02.038

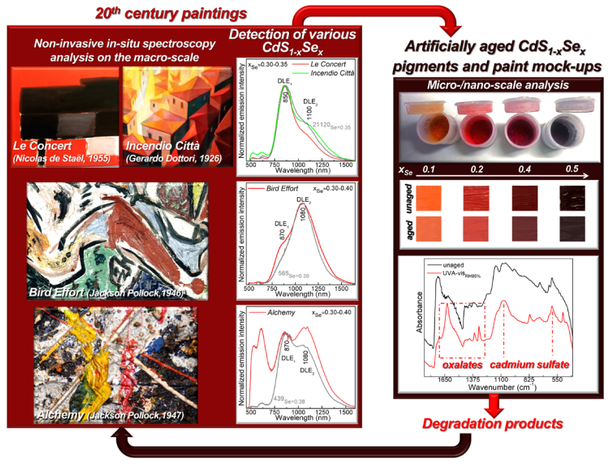
Spectroscopic techniques allowed to gain insights into the ageing and degradation of cadmium reds in priceless artworks[6]

Advanced analytical techniques are increasingly applied to the study of artworks, and paintings' colourings are no exception. Cadmium red is a pigment based on cadmium, sulfur, and selenium, whose content influences its colour properties, varying from red-orange to red-purple. Due to its vibrant hue and excellent covering power, many 20th century artists, including Piet Mondrian, Gerardo Dottori, Joan Mirò, Jackson Pollock, and Nicolas de Staël included this pigment in their masterpieces. Over the last decade, several spectroscopic techniques have been successfully employed to characterise different cadmium red varieties in paintings.


Dr. Letizia Monico

Dr. Letizia Monico (CNR-SCITEC), **Prof. Aldo Romani** (Centre of Excellence S.M.A.Art, University of Perugia), and colleagues, successfully employed non-invasive spectroscopic techniques based on X-rays, ultraviolet, visible light, and infrared radiation to obtain a complete overview of the pigment composition with insights on the current condition of different paints by Gerardo Dottori, Jackson Pollock, and Nicolas de Staël. Analyses were also performed on artificially aged oil paint mock-ups with varying selenium contents. Among the techniques employed in this research work, there is the X-ray absorption spectroscopy performed at the LISA beamline, CERIC associated facility at the European Synchrotron Radiation Facility (ESRF).


Prof. Aldo Romani



"Our findings provide deeper insights into the photoluminescence properties of cadmium red pigments as well as significant hints about their degradation mechanism in paintings by contributing to the optimization of preventive conservation strategies of a series of twentieth-century artworks".

Figure 11
Graphical abstract of the study

The analyses realised on the paint mock-ups and the non-invasive spectroscopic investigations on the paint masterpieces allowed to gain fundamental insights into the ageing and the degradation processes of the cadmium red pigments. These results are particularly relevant for the optimisation of preventive conservation strategies for priceless artefacts.

[6] *Deeper Insights into the Photoluminescence Properties and (Photo)Chemical Reactivity of Cadmium Red (CdS1−xSex) Paints in Renowned Twentieth Century Paintings by State-of-the-Art Investigations at Multiple Length Scales*, Monico L., Rosi F., Vivani R., Cartechini L., Janssens K., Gauquelin N., Chezganov D., Verbeek J., Cotte M., d'Acapito F., Barni L., Grazia C., Pensabene Buemi L., Andral J-L., Miliani C., & Romani A., The European Physical Journal Plus, 2022, DOI: https://doi.org/10.1140/epjp/s13360-022-02447-7

Scientists reveal the effect of nano-plastics on model cell membranes[8]

Four hundred million tons! This is the global amount of plastic produced each year, and a considerable percentage is made of disposable products that might end up in the environment. Plastics, in fact, constitute up to 80% of marine litter. The disgregation of plastic fragments produces micro- and nano-sized pieces, which constitute a subtle but severe menace to animal health, including human beings. Understanding the biological effect of nano-plastics is of paramount importance. The potential harm caused by the incorporation of micro- and nano-plastics should not be underestimated.


Prof. Elena Del Favero

Professors Elena Del Favero (University of Genoa) and **Giulia Rossi** (University of Milan), together with colleagues and collaborators, investigated the effect of polystyrene nano-fragments on model membranes. Polystyrene is among the most widely employed plastics in many industrial sectors, from food packaging to construction. The authors combined a broad spectrum of experimental techniques with computer simulations to understand polystyrene's effect on a model membrane. X-ray scattering experiments realised at the SAXS beamline at the Austrian CERIC PF at the Elettra synchrotron in Trieste revealed the structural properties of the model membrane in the presence of polystyrene. Computer-driven simulations and calorimetry calculations then confirmed this result. Moreover, molecular dynamics simulations and neutron scattering experiments indicated the polystyrene's effect on lipid mobility and the membrane's mechanical properties.


Prof. Giulia Rossi

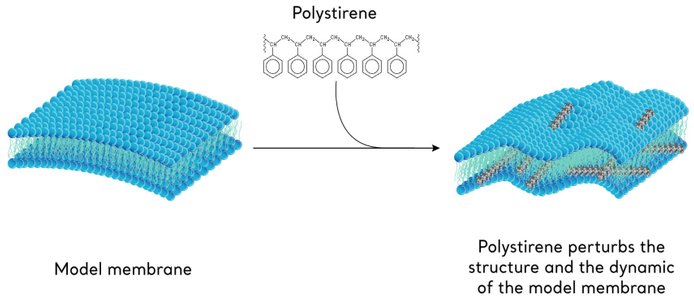


Figure 12
Graphical abstract of the study.

The combination of experimental and computational approaches revealed that doping doses of polystyrene interact with the model membrane, affecting their architecture and dynamics in a concentration-dependent fashion. Further studies will assess the effects of plastics covered by organic and inorganic molecules that crowd the water environments and their impact on membrane properties, which are fundamental for several cellular functions.

"Our research shows that polystyrene chains, a constituent of every-day use plastic materials, can interact with biological membranes, affecting their architecture and dynamics even at low doses".

[8] *Polystyrene perturbs the structure, dynamics, and mechanical properties of DPPC membranes: An experimental and computational study.* Bochicchio D., Cantu L., Cadario M. V., Palchetti L., Natali F., Monticelli L., Rossi G., & Del Favero E., Journal of Colloid and Interface Science, 2022, DOI: https://doi.org/10.1016/j.jcis.2021.07.069

Scientists discover new drugs against COVID by virtual screening and UV analyses[9]

Thanks to vaccines, the COVID-19 pandemic is under control, and now it's possible to experience a normal life after two years of severe restrictions. However, despite the success of the vaccination, the research for new drugs against COVID is still an urgent matter.

Three professors from the University of Napoli "Federico II", **Jussara Amato**, **Bruno Pagano** and **Federica Moraca**, applied with their co-authors an innovative approach to identify new drugs against SARS-CoV-2 infections. This approach consists of a virtual screening of drugs already approved by the Food and Drug Administration (FDA), which might prove effective against SARS-CoV-2. Moreover, the authors set their target on the virus' genome instead of its surface proteins, as typically happens with most antivirals. The SARS-CoV-2 genome can fold into specific structures called G-quadruplexes, which constitute a potential therapeutic target. Ultraviolet (UV)-based analyses, realised at the IUVS beamline, available at the Italian CERIC PF at the Elettra Synchrotron in Trieste, allowed to investigate how drugs bind to the RNA structures of the virus.

With such an innovative method, the authors identified three drugs, already approved by the FDA, that can be employed to treat SARS-CoV-2 infections.


Prof. Jussara Amato
Prof. Bruno Pagano

"This research work demonstrates that the combination of ligand-based virtual screening strategy and biophysical techniques can be effective in finding existing therapeutic molecules capable of targeting viral RNA secondary structures".

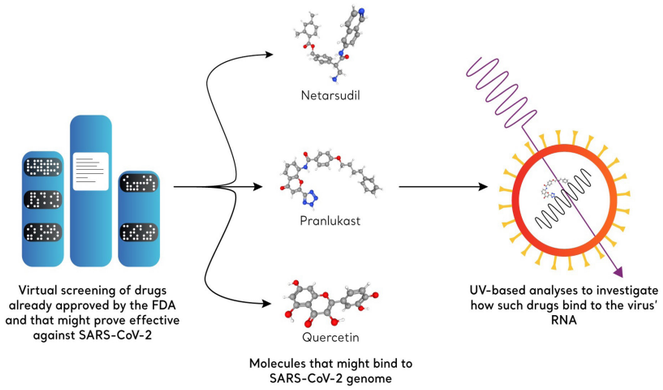


Figure 13
General abstract of the study.

Another aspect of the virtual screening applied in this research is that it allows for a fast and low-cost screening process. This work lays the basis for future clinical studies to evaluate the antiviral activity of such drugs and could also prove impactful for targeting viral RNA beyond SARS-CoV-2.

[9] *Ligand-based drug repurposing strategy identified SARS-CoV-2 RNA G-quadruplex binders.* Moraca F., Marzano S., D'Amico F., Lupia A., Di Fonzo S., Vertecchi E., Salvati E., Di Porzio A., Catalanotti B., Randazzo A., Pagano B. & Amato J., Chemical Communications, 2022, DOI: https://doi.org/10.1039/D2CC03135C

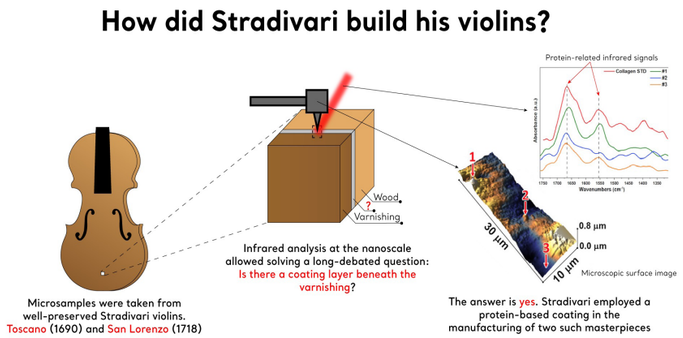
Scientists defined a long-debated detail of Antonio Stradivari's violins[9]

Centuries after the passing of the master luthier Antonio Stradivari, scientists and estimators are still trying to understand the secrets that make his instruments so unique. A recent study solved a long-lasting debate unveiling the nature of the coating below the varnishing of his violins.

Chiaramaria Stani (CERIC), **Giacomo Fiocco** (University of Pavia), **Lisa Vaccari** (Elettra Sincrotrone Trieste), **Marco Malagodi** (University of Pavia) and colleagues analysed two masterpieces by Antonio Stradivari, the Toscano (1690) and the San Lorenzo (1718). For years, experts debated the presence of a coating beneath the varnishing layer of Antonio Stradivari's instruments. While Recent studies pointed out that such a layer could be present, its composition remained undefined.
In the current study, scientists applied a sophisticated approach to combine microscopic images of the surface and chemical data by infrared-based techniques. The experiments were realised at the SISSI beamline, available at the Italian CERIC PF at the Elettra synchrotron. The experimental results allowed to evidence the unmistakable presence of a protein-based coating, probably an animal glue based on collagen or casein, directly applied to the wood. Such a treatment could also influence the sound, contributing to the unique clarity of such masterpieces.


Chiaramaria Stani


Giacomo Fiocco



"The applications of the Infrared nano-spectroscopy to the study musical instruments of inestimable value opens new fascinating scenarios for further detailed investigations of very small and complex samples in the field of Cultural Heritage".

Figure 14
General abstract of the study.

It's still not possible to unequivocally define Antonio Stradivari's constructive technique. However, this research work marks a significant step forward in comprehending how his unique instruments were built.

[9] *Nanofocused Light on Stradivari Violins: Infrared s-SNOM Reveals New Clues Behind Craftsmanship Mastery*. Stani C., Invernizzi C., Birarda G., Davit P., Vaccari L., Malagodi M., Gulmini M., & Fiocco G., Analytical Chemistry, 2022, DOI: https://doi.org/10.1021/acs.analchem.2c02965

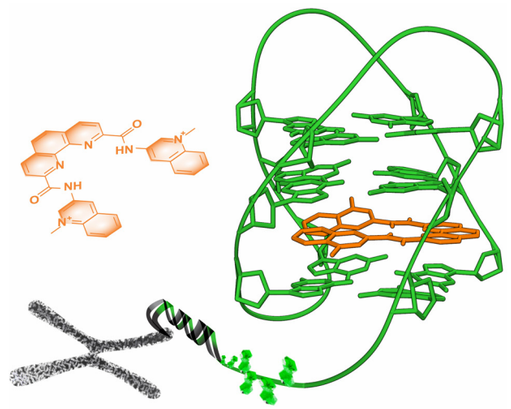
Insights into ligand-DNA binding to provide awareness on the role of G-rich sequences in Life and disease[10]

One of the biggest challenges that modern medicine must overcome when facing complex and severe disease such as tumors is to find specific drug targets, on which medicines can bind and express their therapeutic action. Telomeric G-quadruplex DNA structures (elements characterized by the formation of square planar guanine quartets, that play a crucial role in replication, recombination, transcription, translation, and telomere maintenance) are among the attractive anti-cancer drug targets.


Prof. Janez Plavec

In fact, stabilising G4s with small-molecule ligands can inhibit telomerase or interrupt telomere capping and maintenance, resulting in cancer cell apoptosis; however, their polymorphism complicates the drug design: different ligands prefer different folds, and very few complexes have been solved at high resolution. **Prof. Valérie Gabelica** (Université de Bordeaux), **Prof. Janez Plavec** (National Institute of Chemistry), **Dr. Marko Trajkovski**, PhD, and colleagues studied how Phen-DC3, a U-shaped heterocyclic compound (i.e. a cyclic molecule in which one or more atoms in the cycle aren't carbon) with high affinity for G4s structures, binds to these genomic tracts, revealing an intercalative binding mode of Phen-DC3 and a change of topology of G4: analysis carried out with the use of 600 and 800 MHz NMR spectrometers at the Slovenian CERIC Partner Facility in Ljubljana have shown for the first time a true ligand intercalation into an intramolecular G-quadruplex, followed by a transformation of telomeric G4 from hybrid to an antiparallel, chair-type conformation.


Dr. Marko Trajkovski



"We have shown for the first time how a specific molecule, that is widely used in laboratories worldwide, interacts with G-quadruplex DNA implicated in cell replication and cancer".

Figure 16
Intercalation of Phen-DC3 between quartets within the G-quadruplex formed by telomeric DNA

Even if further studies are needed in order to understand the driving force for the preferential binding of Phen-DC3 to specific G4 conformations, the disclosure of the complex's high-resolution details at the DNA-ligand interface provides a starting point for the use of Phen-DC3 analogs targeting specific G4 structures in vitro and in vivo, hopefully allowing to implement more efficient anti-cancer treatments.

[10] *Phen-DC3 Induces Refolding of Human Telomeric DNA into a Chair-Type Antiparallel G-Quadruplex through Ligand Intercalation*, Ghosh A., Trajkovski M., Teulade-Fichou M.-P., Gabelica V., Plavec J., Angewandte Chemie 61(40), 2022, DOI: https://doi.org/10.1002/anie.202207384

Internal Research Projects

Two CERIC internal research projects came to an end in 2022:

- **MAG-ALCHEMI** (Magnetic Anisotropy Grafting by Means of Atomic Level Chemical Engineering at Film Interfaces), focusing on magnetic materials and aims at developing tools to control thin magnetism via interfacial engineering;
- **INTEGRA** (with Heinz Amenitsch as principal investigator), that aims to reinforce, enlarge and better integrate the offer of CERIC's PFs in the field of Life Sciences, covering a wide range of biological targets, from molecules to tissues and organisms.

Valuable scientific outputs (i.e., publications derived from previous experiments) have been further produced and released in 2022, both in the frame of MAG-ALCHEMI and INTEGRA, as well as in the frame of another project ended in 2021, **CEROP**.

A **call for CERIC's PhD students** was launched in 2020. Most of the Doctoral programmes started in 2020 and 2021. During the year 2022, two more PhD programmes began: one in collaboration with the Charles University in Prague, on the “Development of ceria-based electrochemical sensors for biomolecule detection”, and one in collaboration with the Graz University of Technology and focused on “Enzymes@ZIFs: synthesis and characterisation of new bio-composites for Biocatalysis”. All PhD students had the chance to showcase the progress of their work to the ISTAC of CERIC in the frame of the Contact-Science@CERIC event (read more on page 31).
In 2022, several papers stemming from the work carried out in the frame of the CERIC internal research projects were published (see section below).
Moreover, PhD students had the opportunity to participate and present their work both in national and international workshops and events.

In 2022, for solidarity with the Ukrainian population, CERIC also launched a **call for 18 Ukrainian post-doc researchers**, for them to continue with their research activities at CERIC's PFs. The call aimed to attract collaborative proposals, bringing together one or more PFs, as well as non-CERIC institutions.
One project has been approved by the ISTAC and started in 2022, with **Dr. Anatolii Nagornyi** as principal investigator, and has the goal of investigating novel fuel cell materials using the SAXS (and XAFS) beamlines at the Elettra synchrotron in Trieste, as well as at the NORMA neutron imaging and the Yellow Submarine SANS instrument at the Budapest Neutron Centre.
The main focus of this proposal will be the improvement of the methods in the CERIC project CEROP and current research, and extend it to SANS and Neutorn imaging. As a result various, cell designs will be developed and tested on model systems.

Nano-analytics provide a helping hand for improving drug formulations[11]

Is it possible to improve the effectiveness of a drug while reducing its side effects? The Nano-Analytics for Pharmaceutics (Nano-Pharma) project by CERIC aims at improving drug formulation by applying and developing advanced nano-analytical instruments.


Dr. Aden Hodzic

Dr. Aden Hodzich, principal investigator of the research project, and colleagues published in the Journal of Drug Delivery Science and Technology a research about one of the most common over-the-counter medications, ibuprofen. Such work verified that the ibuprofen molecule might degrade under certain preparatory conditions. Many of the analytical instruments available at CERIC’s partner facilities were employed for this research. For instance, X-ray-based experiments realised at the SAXS beamline of the Austrian CERIC Partner Facility at the Elettra synchrotron allowed to identify parameters compatible with the degradation of the ibuprofen molecule. Other experiments based on Infra-Red (IR) and NMR were realised at the Italian and Slovenian PFs at the Elettra synchrotron in Trieste and the National Institute of Chemistry, respectively.
The combination of such analyses with further experiments and calculations

“Thanks to our nanoanalytical approach, it was possible for the first time using the SAXS method, to highlight the degradation of the ibuprofen molecule into the toxic part under certain preparation conditions, hence promoting the formulation and production of safer and more effective drugs".

How to produce safer drugs?

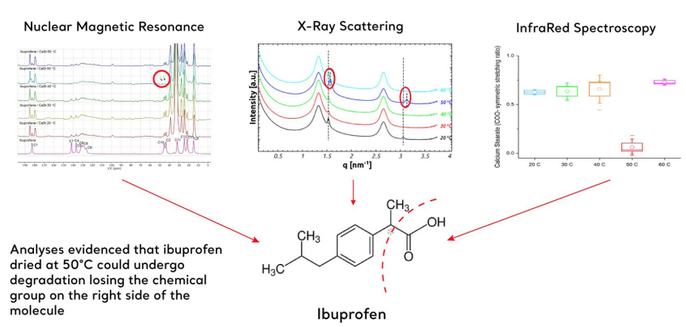


Figure 15
Graphical abstract of the study

from the laboratory at TU-Graz allowed the identification of traces of a toxic molecule resulting from ibuprofen degradation. Previous studies could not detect such degradation due to the lack of high-resolution analytical laboratories and synchrotron tools. However, the nano-analytical approach can enable the analysis, formulation and production of safer and more effective drugs to meet the most stringent criteria of the medicine regulatory agencies.

[11] *Revealing hidden molecular nanostructure details in the pellet formulation of ibuprofen by combining Synchrotron and laboratory sources,* Hodzic A., Birarda G., Juraic K., Sket P., Eder S., Kriechbaum M., D'amico F., De Giacomo O., & Roblegg E., Journal of Drug Delivery Science and Technology, 2022, DOI: https://doi.org/10.1016/j.jddst.2022.103114

Scientists tested a complementary approach to assess the magnetic properties at the interface of different materials[12]


Prof. Michał Ślęzak

"Our results highlight the possibility to control magnetic properties of specific materials. Further advancements in this field and potential applications in magnetic recording techniques can impact modern spintronics and future ICT applications".

Modern and future applications of Information and Communication Technology (ICT) will increasingly rely on controlling the magnetic properties of materials, allowing memory devices with faster access, increased storage density and reduced energy consumption. Potential applications include spin valves, an essential element in magnetic sensors, such as modern hard-disk drives. A spin valve can exploit the change in electrical resistance caused by the alignment of the magnetisation in thin-layer materials with different magnetic properties. In this regard, the internal research project MAG-ALCHEMI mainly focuses on the atomic-scale engineering of magnetic materials.

Within the MAG-ALCHEMI project, **Prof. Michał Ślęzak** (AGH University of Science and Technology), and colleagues, successfully applied a complementary approach exploiting the nature of two different techniques, XMLD (X-ray Magnetic Linear Dichroism) and MOKE (Magnetooptic Kerr Effect) to assess the magnetic properties at the interface of different materials. The experimental work was realised at the PIRX beamline of the Polish CERIC PFs at the SOLARIS Synchrotron in Krakow.

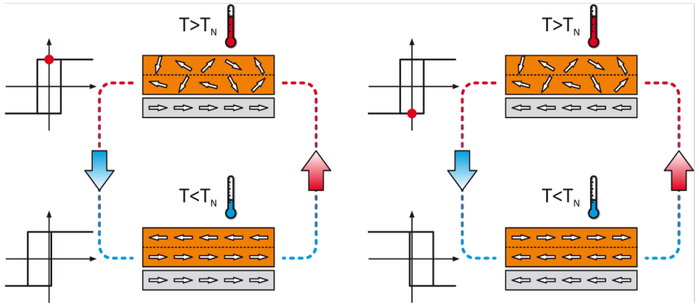


Figure 15
Schematic presentation of memory effects and frozen antiferromagnetic spins in CoO(111)/Fe bilayer.

This scientific work highlights the peculiarities of each of the employed techniques and provides a relevant contribution to controlling magnetic properties of different materials that could have disruptive applications in the spintronics sector where, in addition to charge state, also the spin of the electrons is exploited to improve data storage and transfer performances.

[12] *Tailorable exchange bias and memory of frozen antiferromagnetic spins in epitaxial CoO (1 1 1)/ Fe (1 1 0) bilayers,* Ślęzak M., Dróżdż P., Janus W., Szpytma M., Nayyef H., Kozioł-Rachwał A., Zając, M., & Ślęzak, T., Journal of Magnetism and Magnetic Materials, 2022, DOI: https://doi.org/10.1016/j.jmmm.2021.168783

Scientists successfully characterised an innovative Pt-ceria catalyst for PEMFCs[13]


Dr. Simone Pollastri

"Reducing the use of platinum group metals is one of the most promising way to lower the cost of catalysts and hence of fuel cells systems. The best way to characterise them is by means of in operando measurements, which represent the closest reaction conditions to the realistic working ones".

Batteries and fuel cells play an undeniable role in a sustainable energy future. However, fuel cell systems are still not employed worldwide mainly because of their cost due to the large amount of Pt used in the catalyst layers. Polymer Electrolyte Membrane Fuel Cells (PEMFCs) are among the most promising candidates to power electric mobility, particularly automotive. PEMFC potential is, among others, due to their high energy conversion efficiency and power density. The path toward the massive production and distribution of PEMFCs requires overcoming two significant technical challenges: I) the reduction in the use of Platinum Group Metals (PGMs) as catalyst and II) increase in the durability of the catalyst itself.
In this frame, catalysts composed of Pt ions encapsulated in a ceria (CeOx) support are of interest because, despite having up to 100-time lower Pt load, they show an exceptionally high activity and durability compared to standard Pt/C catalysts.

Dr. Simone Pollastri and colleagues investigated an innovative Pt-ceria anode catalyst for applications in PEMFC by means of *in-situ*, *ex-situ* and *operando* X-ray-based experiments. The study, conducted in the frame of the CEROP project, focused on the stability of the innovative catalyst layer deposited on two different supports, a Carbon-Ionomer Layer (CIL) and a nano-Gas Diffusion Layer (nGDL). The experiments have been conducted, among others, at the SAXS and XAFS beamlines at the Austrian and the Italian CERIC PFs, respectively; both of them available at the Elettra synchrotron. SAXS experiments revealed the catalyst particle morphology, while XAFS allowed to deepen investigate the chemical environment of both Pt and Ce.

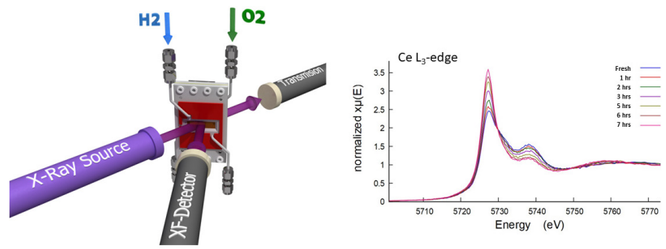


Figure 16
Graphical abstract of the study.

The electrochemical characterisation evidenced similar performances in the long-term for both systems, but the nGDL-supported anode showed better efficiency in the first 36 hours of operation. XANES data collected ex-situ also confirmed the stability of the catalyst when sputtered on nGDL whereas it is not stable when sputtered on CIL. Moreover, preliminary test experiments conducted in operando using a special cell developed on purpose, confirmed that the instability of CIL samples is water-driven.
This study, performed in the framework of the CERIC research project CEROP, provide valuable indications about the best support to be employed for the fabrication of stable and more durable Pt-ceria catalysts for PEMFCs.

[13] *Characterization of innovative Pt-ceria catalysts for PEMFC by means of ex-situ and operando X-Ray Absorption Spectroscopy,* Pollastri S., Bogar M., Fiala R., Amenitsch H., Yakovlev Y., Lavacchi A., Aquilanti G., & Matolin V., International Journal of Hydrogen Energy, 2022, DOI: https://doi.org/10.1016/j.ijhydene.2021.12.241

Synchrotron light and AI to prevent age-related fractures[14]

During the last century, improvements in food, health care, and hygiene allowed a relevant increase in life expectancy, especially in western countries. Consequently, chronic conditions among older people, such as osteoporosis, are set to escalate. Therefore, it is essential to understand better and even anticipate fracture propagation in human bones to prevent fractures with consequent long-term care and negatively impacting the quality of life.

In a study supervised by **professor Laura Maria Vergani** (Polytechnic of Milan), with the contribution, among others, of the CERIC funded PhD student **Lorenzo D'Amico** (Elettra Sincrotrone Trieste), the authors provided novel insights into the comprehension of micro-damage in human bones exploiting synchrotron scans of human bone fragments under increasing compression levels. The tests were realised on bone fragments from femoral heads collected during routine hip replacement surgeries. This specific anatomical site was selected because fractures in the femoral head are reported to be the most widespread osteoporosis-related fractures. The samples were analysed at the SYRMEP beamline at the Italian CERIC PF at the Elettra synchrotron in Trieste, and the collected images were then processed using Artificial Intelligence tools to detect micro-fractures automatically.

This study provided a new methodology for interpreting what happens on the micro-scale in osteoporotic bones. Future applications will favour a better quality of life for a population increasingly subject to age-related pathologies.

Prof. Laura Maria Vergani

" In our work we exploited synchrotron scans in combination with micro-mechanical tests and AI analysis, to offer a mechanics-based approach for quantifying critical fractures in healthy and osteoporotic bones. This could contribute to enhance quality of life of people affected by this disorder".

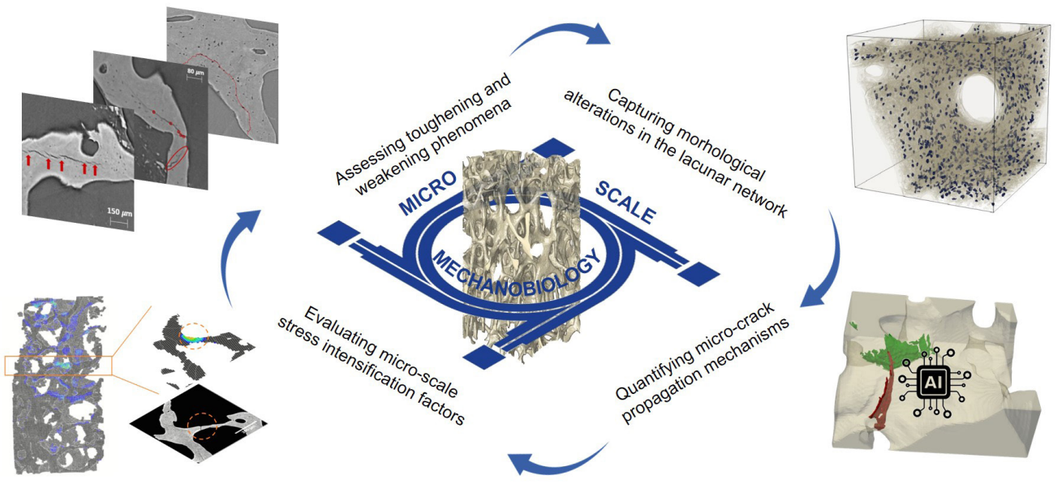


Figure 17
A multi-disciplinary approach to tackle the bone fragility fracture crisis.

[14] *Assessing the intimate mechanobiological link between human bone micro-scale trabecular architecture and micro-damages, Buccino F., Bagherifard S., D'Amico L., Zagra L., Banfi G., Tromba G., Vergani L.M., Engineering Fracture Mechanics, 2022, DOI: https://doi.org/10.1016/j.engfracmech.2022.108582*

New study identifies residues on Palaeolithic stone tools[12]

Advanced technologies based on synchrotron light can profoundly impact cultural heritage research, including the study of prehistoric finds. Infrared-based investigations, for instance, can help identify the presence of different types of organic residues, with the advantage of allowing the analysis of minute samples that cannot be characterised with any other method.

The CERIC funded PhD student **Clarissa Dominici** (University of Siena), in collaboration with **Chiara Stani** (CERIC), **Matteo Rossini** (University of Siena) and **Lisa Vaccari** (Elettra Sincrotrone Trieste), analysed samples of residues coming from seven stone tools dating about 19,000-18,000 years before present. The stone tools were retrieved from layer 9c2 of Grotta Paglicci (Rignano Garganico, Apulia, Italy), a key archaeological site for the Upper Palaeolithic in Mediterranean Europe. The infrared-based microscopy analyses carried out at the SISSI beamline at the Italian CERIC PF at Elettra synchrotron in Trieste allowed to highlight the presence of organic compounds mainly of animal origin, as well as soil particles from the burial environment. Among the former, the scientists widely identified the presence of adipocere, a wax-like compound that originates when bacteria degrade fat tissues in the absence of air, like in underground conditions.

Clarissa Dominici

"This is the first work that exploits synchrotron radiation-based infrared analyses for the chemical characterisation of ancient residues coming from Palaeolithic stone tools connected with both hunting and domestic activities: new, innovative techniques to discover how our ancestors lived".

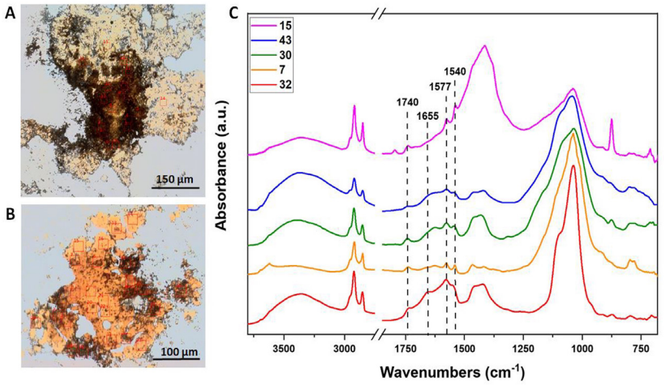


Figure 18
A, B. Optical images of samples no. 7 and 43, respectively, with indication of the spots corresponding to the collected spectra. C. Example of IR spectra of sample no. 15, 43, 30, 7, 32 showing the main peaks discussed in the text.

Such finding suggests that the stone tools from Grotta Paglicci could have been employed in hunting as well as domestic activities, like butchering and/or hide working. Moreover, this study lays the foundation for designing specific protocols for synchrotron radiation-based infrared analyses on prehistoric finds.

[15] *SR-FTIR microscopy for the study of residues on Palaeolithic stone tools: looking for a methodological protocol*, Dominici C., Stani C., Rossini M., & Vaccari L., Journal of Physics: Conference Series, 2022, DOI: https://doi.org/10.1088/1742-6596/2204/1/012050

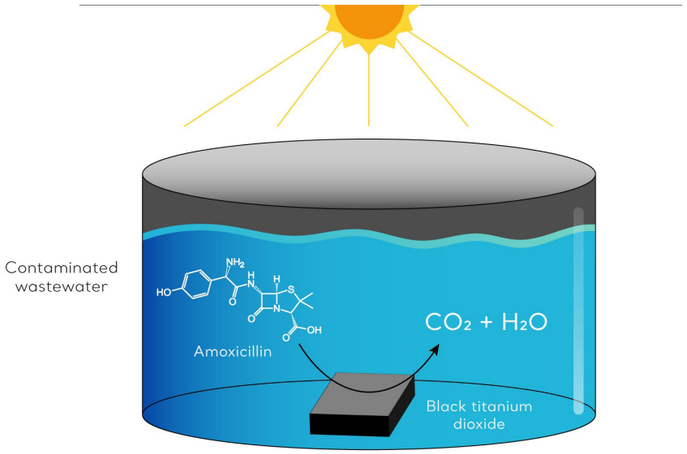
Scientists tested a potential solution to face antibiotics' contamination in water bodies[16]

Antibiotics are among the most popular pharmaceuticals, allowing incredible achievements in numerous sectors such as farming, veterinary care and human health. However, their ever-growing employment is causing the contamination of water bodies such as wastewater, municipal sewages, and treatment plants. This aspect is particularly problematic since it's one of the primary sources of antibiotic resistance, a threat to public health. Therefore, effectively removing antibiotics from water bodies is a pressing issue.

Prof. Luminita Andronic

Dr. Mariana Stefan

Prof. Luminita Andronic (Transilvania University of Brasov), **Dr. Mariana Stefan** (National Institute of Materials Physics) and colleagues tested the effectiveness of black titanium dioxide in promoting the degradation of amoxicillin, a common antibiotic. This innovative material, like other photocatalysts, can increase the antibiotic's degradation rate under light irradiation. However, differently from its white counterpart is more effective in the range of visible light, making black titanium dioxide an attractive option for applications under sunlight conditions. Samples of this material, prepared in various conditions, were analysed with different techniques to characterise their properties, including Electron Paramagnetic Resonance (EPR), available at the Romanian CERIC PF at the National Institute of Materials Physics in Magurele.



"Chemical reduction significantly increases the efficiency of the anatase nanoparticles for the photocatalytic degradation of antibiotic contaminants such as amoxicillin in water under sunlight conditions."

Figure 19
Graphical abstract of the study.

Electron paramagnetic resonance investigations showed that the formation of surface Ti3+ defects in high concentration occurred mainly in the anatase sample annealed at 400 oC. Furthermore, they exhibited over 90% efficiency in the degradation of amoxicillin after 6h under simulated solar irradiation compared with pristine TiO2. Such achievement provides an attractive option to reduce the risk of antibiotic resistance, which risks becoming a paramount issue soon.

[16] *Visible-Light-Active Black TiO2 Nanoparticles with Efficient Photocatalytic Performance for Degradation of Pharmaceuticals,* Andronic L., Ghica D., Stefan M., Mihalcea C. G., Vlaicu A. M., & Karazhanov S., Nanomaterials, 2022, DOI: https://doi.org/10.3390/nano12152563

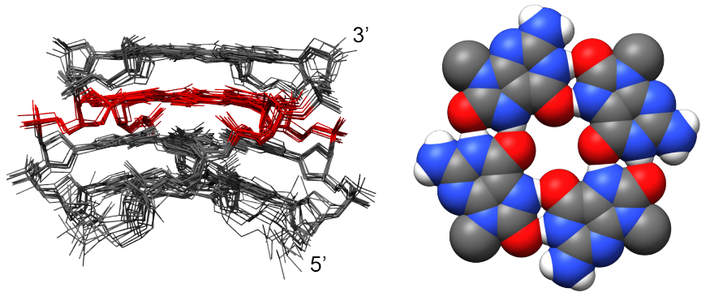
New insights into the effect of oxidative stresses on specific DNA structures[17]

The genetic information in DNA is coded by four nucleobases commonly indicated by letters A (adenine), T (thymine), C (cytosine), and G (guanine). In some specific regions of the genome, such as promoter regions of genes, or terminal parts of chromosomes, there's an abundance of Gs which are believed to form non-canonical DNA structures, such as G-quadruplexes (image below). This is relevant since the structure of DNA can affect gene expression and DNA replication.

Peter Podbevšek

Simon Aleksič

Prof. Janez Plavec, **Peter Podbevšek**, and **Simon Aleksič**, CERIC-funded PhD student, from the National Institute of Chemistry in Ljubljana, tested the effects of guanine oxidation in a simple G-quadruplex model system. Guanine nucleotides are prone to oxidation by Reactive Oxygen Species (ROS), a byproduct of cellular metabolism that can damage DNA structure. It is believed that G-rich regions may act as DNA damage sinks, preventing oxidation in other areas. To test how oxidized guanine nucleotides affect the structure of a model G-quadruplex, authors employed Nuclear Magnetic Resonance (NMR) spectroscopy available at the Slovenian CERIC PF at the National Institute of Chemistry in Ljubljana.



"A detailed insight into the effect of oxidative damage on nucleic acid structures may uncover pos-sible connections between oxidation and disease onset. Furthermore, the properties of oxidized DNA structures may benefit the design of nanotechnological devices."

Figure 19
Superposition of G-quadruplex cores with an incorporated 8-oxoguanine nucleotide (in red) of ten lowest-energy structures (left). A DFT-optimized quartet, composed of four 8-oxoguanine moieties is shown on the right, exhibiting a change in hydrogen bonding in comparison to G-quartets.

This work showed that the introduction of an oxidized guanine nucleotide to a G-quadruplex can cause structural rearrangement resulting in a larger central cavity without significantly affecting backbone structure of the DNA. However, this distortion may also have functional effects. Insights into the impact of guanine oxidation on structural changes in functionally essential genomic regions could reveal possible disease origins.

[17] *V8-Oxoguanine Forms Quartets with a Large Central Cavity,* Aleksič S., Podbevšek P., Plavec J. Biochemistry 61 (21), 2022. DOI: https://doi.org/10.1021/acs.biochem.2c00478

2

Improving the Quality of CERIC's Services

Main Achievements

1. **Positive evaluation of the Romanian and Czech CERIC Partner Facilities**
by the international team of experts led by CERIC's International Scientific and Technical Advisory Committee (ISTAC).

2. **CERIC's contribution to energy research**
with the purchase of new instruments and networking activities

3. **CERIC steps forward towards more FAIR data science**
with the adoption of a FAIR data policy and of new FAIR data services

4. **CERIC "mini-EOSC" in the making**

5. **Upgrade of the Proposal Management System**

6. **Performance Monitoring and Impact Assessment**
Updates and future plans

Infrastructure Evaluation and Upgrade

ISTAC's evaluation of CERIC's Czech and Romanian PFs

On 26th and 27th October, 2022, the members of the ISTAC of CERIC performed the periodical evaluation of the Czech and Romanian PFs of the Consortium.

At the Czech PF at the Charles University in Prague (CUP) and in Trieste, **Andrew Harrison, Karsten Horn and Sara Cavaliere**[13] have been very impressed by the achievements of the PF and evaluated the work carried out as of a very high quality. The facilities and services provided are considered to be very important for CERIC and particularly aligned with key strategic objectives in the field of energy materials. Also the scientific output has been very positively evaluated, due to the large number of publications released, many of which are of high impact and in general with a world-class output. The same is true for the instruments of the facility, which are among the most requested ones in the CERIC portfolio. Their periodical upgrade has indeed been crucial to maintain competitivity, and is an added value for the CERIC open access offer. In fact, the facility has been successful in attracting excellent researchers, also from countries with well-equipped research institutions, such as Germany, and also during the Covid-19 pandemic period, when more remote access was provided, requiring quite an effort by the PF's staff.
A particular point of strength introduced relatively recently, is open access to the characterisation platform of fuel cells and electrolysers. The ability to test systems or materials in a device is crucial for materials scientists, most of whom only have access to *ex situ* electrochemical measurements. Also the support in preparing the membrane–electrode assembly to be tested is excellent.
Another strong point is the recently developed cell for *operando* ESCA measurements during electrolysis, which provides much more detailed information in a membrane-electrode assembly configuration, i.e., in real device conditions.
ISTAC also expressed appreciation in respect to the training activities offered to young scientists at the facility, as well as through the training activities proposed by CERIC. Also the good integration between CUP and CERIC has been positively noted, as well as the PF's participation in CERIC funding initiatives.

At the Romanian PF, the Laboratory of Atomic Structures and Defects in Advanced Materials (LASDAM) at the National Institute of Materials Physics in Magurele, the Committee of Evaluators composed of **Andrew Harrison**, **Luis Fonseca and Vega Lloveras**[14] has assessed the scientific output from the work associated with CERIC as good to excellent, with a significant volume of diverse work from transmission electron microscopy (TEM) measurements and some high impact output from both (TEM) and Electronic Paramagnetic Resonance (EPR) studies.
The excellence of the technical support staff has also been pointed out for TEM, EPR and sample preparation, whereas, although instruments are well maintained and perform very well, an upgrade has been recommended, particularly with regard to TEM.

[13] Andrew Harrison (Extreme Light Infrastructure ERIC), Karsten Horn (Fritz Haber Institute of the Max Planck Society in Berlin), Sara Cavaliere (University of Montpellier).
[14] Andrew Harrison (Director of Science at ELI ERIC), Luis Fonseca (CSIC in Barcelona - nanoscience and nanomaterials), Vega Lloveras (Institut de Ciència de Materials de Barcelona ICMAB-CSIC).

CERIC's Associated Facilities

In 2022, new instruments and laboratories have been made available to the international scientific community through CERIC call for proposals. Following the evaluation of the ISTAC of CERIC, new Associated Facilities have joined the Consortium. Although not being formally part of it, they collaborate by taking part in the CERIC calls on a trial basis for a limited duration of up to 3 years, which ISTAC can prolong. Access is offered on the same (free) basis as the other CERIC Facilities.

CERIC's Associated Facilities include the following:

- **JRC Nanobiotechnology Laboratory** in Ispra (Italy), allowing interdisciplinary studies with a special emphasis on the characterisation of nanomaterials, nanomedicines, advanced materials and micro(nano)plastics. The facility is also equipped with a chemistry laboratory and facilities for the sample preparation necessary to carry out the experiments. The provided service also includes scientific and technical support, thanks to a multidisciplinary team of scientists, including chemists, physicists, biologists, and materials scientists with extensive experience in the fields of physico-chemical characterisation of materials and nanobiosciences.

- **Bio Open Lab (BOL)** is a collection of facilities distributed across universities and institutes at three centres in Italy – in Salento, Salerno and Trieste – that aims to provide an integrated system of research equipment and instruments dedicated to investigations in the field of biological and biomedical research.
  This initiative has been coordinated by the AREA Science Park in Trieste (Italy), and supported by the Italian National Operational Programme (PON) on Research and Innovation 2014-2020, with integration of some of their capacity into CERIC a key element of the proposal. The expert group judged that all three centres would offer new, complementary capabilities and scientific opportunities for life scientists – in holographic electron microscopy in Salento, in a wide range of spectrometry in Salerno, and next generation genetic sequencing in Trieste. At the same time, CERIC would bring these laboratories expertise in encouraging and supporting user access, support for students and technique development, and a much wider network of scientists to bring yet more diverse life-sciences challenges to BOL, and strengthen their science output.

- **X-ray absorption spectroscopy beamline at ESRF** (France)

- **Ultraviolet Laser Facility of the Foundation for Research and Technology** – Hellas (ULF-FORTH) in Greece

Moreover, in December 2022, the **PRP@CERIC project (Pathogen Readiness Platform for CERIC-ERIC Upgrade)** started. Coordinated by AREA Science Park, the project is iunded by the Italian PNRR (PNRR Piano Nazionale di Ripresa e Resilienza) with the goal of further enhancing the RI of CERIC through the implementation of a geographically distributed and scientifically integrated digital ecosystem, which will offer interconnected skills and tools to tackle emerging human, animal and plant pathogens of potential impact on health, safety or the economy. This ambitious goal implies the implementation of new structures and the upgrading of already existing instruments and services, and their interconnection in a network of thematic platforms and interoperable macro-platforms, based on complementary disciplines such as biology, biochemistry, chemistry, structural biology, physics, bioelectronics, omics sciences, medicinal chemistry and data science.

CERIC's contribution to energy research

Following the publication of reports on batteries1 and fuel cells2 in 2020 and 2021, CERIC has continued to implement recommendations from two external scientific advisory groups of appointed experts in these fields, positioning itself as a cutting-edge research infrastructure (RI) for energy research. The primary goal is to become a key contributor in achieving a paradigm shift toward renewable energy.

CERIC's advanced analytical techniques enable a wide variety of experiments for developing a new generation of batteries with improved performance, extended lifetimes, and diversified materials, as well as more efficient energy storage solutions like fuel cells.

In line with CERIC's Research and Infrastructure Roadmap, which incorporates the aforementioned reports and envisions enhancements to CERIC's energy research infrastructure, the procurement of new instruments has begun. The acquisitions completed in 2022 will expand offerings at the Czech, Romanian, and Slovenian PFs, including instruments for characterisation, in-situ and operando measurements, and heating and applying electrical fields to observed micro-objects. One example is a new high-current potentiostat to be installed at Charles University in Prague, Czech PF, for advanced analysis of batteries and battery stacks (optionally redox flow battery, fuel cell, and electrolyzer stacks) requiring broad measuring intervals of current (up to 95 A). Potential experimental procedures encompass (but are not limited to) cyclic voltammetry, linear sweep voltammetry, chronoamperometry, chronopotentiometry, staircase voltammetry, and impedance electrochemical spectroscopy up to 10 kHz.
At the Romanian PF at the National Institute of Materials Physics in Magurele, the existing HRTEM infrastructure has been extended to enable in-situ and operando experiments. This upgrade allows TEM observations while heating or applying an electrical field on the observed sample, for experiments on battery materials in real operation conditions.
Finally, at the Slovenian PF at the NMR Centre in Ljubljana, a new automatic tuning/matching static single-channel in-situ 400 MHz NB probe was installed for electrochemistry measurements.
More purchases are scheduled in the following year for both research on batteries and on fuel cells, also at the other PFs.

CERIC infrastructural development is complemented with investment in research on the battery and fuel cells topics by supporting different PhD projects in the field. Below are the ongoing PhD projects in this field:

- Recovery and characterisation of layered oxides materials from spent batteries: a step forward towards sustainability (University of Bologna)
- Morpho-chemical and structural changes of electrodes and electrolytes in all-ceramic solid-state lithium batteries (Polytechnic University of Milan)
- Unravelling the electrochemical mechanisms of battery degradation by operando NMR and X-ray absorption spectroscopy (University of Ljubljana)
- Linking chemistry and phase evolution in metal-O2/S batteries via in-situ SAXS and XAS (Graz University of Technology)
- Unravelling deterioration of fuel cell catalysts (Charles University Prague)

To raise awareness among the CERIC user community and the global research community about the analytical facilities and energy research opportunities within the Consortium, two new sections focusing on these research domains were introduced, along with two thematic videos highlighting CERIC's contributions to research in these areas. Additionally, the CONTACT - Science@CERIC event, which centered on analytical techniques for fuel cell and electrolyser research, was organised in November 2022 (read more in the following paragraph).

[1]B. Bozzini, A. Iadecola, L. Stievano, *Report on CERIC's Expert Group on Batteries*, 2020, https://doi.org/10.5281/zenodo.3891479
[2]B. Bozzini, S. Cavaliere, J. Drnec, M. Tromp, *CERIC-ERIC Expert Group on Fuel Cells*, 2021, https://doi.org/10.5281/zenodo.5720332

Increasing the quality of services for fuel cell research

In 2022, following the recommendation of the CERIC's Expert Group on Fuel Cells, CERIC organised the workshop Science@CERIC - co-funded by the Central European Initiative (CEI) - in the spirit of enhancing CERIC's role in the fuel cell and electrolysers community. The two-day event has been a unique opportunity to bring together directors and instrument scientists from different PFs with diverse expertise, to boost interaction among stakeholders on ongoing activities, joint research topics, achievements and future development plans.
The first day focused on energy research, fuel cells and electrolysers, with specialised training sessions designed for the instrument scientists of the CERIC PFs. Most of the analytical techniques offered for research in this domain were showcased, with panellists giving practical tips based on their extensive experience in other institutions and RIs with similar techniques. The second day was dedicated to presentations by distinguished researchers of the PFs involved in hydrogen technologies research activities and by leading experts from external institutions.
Overall, more than 30 researchers, including four CERIC-funded PhDs and one Post-Doc, attended the presentations provided by thirteen speakers. Attendees expressed an overall favourable opinion about the workshop, and more than 80% of the responders expressed a positive, or highly positive opinion about the amount and usefulness of new information, the quality of the presentations and the networking possibility.
The continuous exchange of experiences and information, even beyond the training session, will undoubtedly impact future collaborations and research works.

A step ahead towards more FAIR data science

Thanks to EC funding, and in the frame of the Horizon 2020 PaNOSC project, which ended in November 2022, CERIC and the project's partners have further contributed to making more data FAIR (Findable, Accessible, Interoperable, Reusable) for their community of users and for scientists from all domains. One more brick was added to the construction of the European Open Science Cloud, by addressing the FAIR principles in the workflows of photon and neutron (PaN) facilities, via software development and unification, as well as by developing the required legal and administrative frameworks, such as the PaN FAIR Research Data Policy Framework.
At CERIC, also the facilities offering instruments and techniques based on probes which are different from photons and neutrons (e.g., ion beams in Zagreb, NMR in Ljubljana, HRTEM in Magurele) have been benefiting from the work implemented in the fields of data policy, data transfer, (meta)data catalogues, DOIs, landing pages, and more).
In the paragraphs below, the key results towards the adoption of FAIR data practices at CERIC and its facilities are presented.

FAIR data policy and data stewardship

CERIC, together with the PaNOSC and ExPaNDS projects' partners, have paved the way to make data produced at PaN facilities across Europe easily accessible: data has started to be curated and made available under an Open FAIR Data policy based on the PaNOSC FAIR research data policy framework released in the frame of the project.
The framework serves as guidance for FAIR data stewardship by defining the curation of (meta)data, from the generation of raw data from each experiment, to analysis, through to publication and re-use. At the end of the project in November 2022, seven among the PaN facilities in Europe, including CERIC, have adpted it. Nine more are in the process of adopting it, and another one has planned to adopt it.
The benefits stemming from the adoption of a FAIR data policy range from the need to make science reproducible and replicable by adopting an Open Science approach, to improving the quality of scientific data, by implementing FAIR principles to enable data re-use, and providing scientists with new data services and archiving important datasets.
Data stewardship also implies the implementation of effective Data Management Plans (DMPs) to ensure that RIs' users and support teams are aware of the data volumes that will be produced and how to process them throughout the whole data lifecycle. Such information is also beneficial to make a forecast of the IT infrastructure required to support an experimental programme based on a more detailed understanding of users' needs. This is why a solution for generating and managing DMPs for each experiment has been proposed and implemented across PaN facilities. In this respect, CERIC implemented a DMP service based on DS-Wizard.

FAIR Data Catalogue

Prior to the start of PaNOSC, CERIC and other the PaN facilities in Europe had their own data catalogues and search tools for users to retrieve their datasets and related metadata at single facilities. However, to make PaN data easily findable and accessible across a multitude of PaN facilities in Europe, domain-specific searches across the PaNOSC data repositories needed to be enabled. This has happened by developing and adopting a **federated search API (Application Programming Interface)** for PaN data catalogues, as well as a common protocol for harvesting data and metadata, to make public datasets available to third-party EOSC cross-discipline repositories. This service provides a unified way across facilities for PaN scientists to find, filter and score/rank datasets and publications from any number of configured sites based on relevant domain-specific metadata using a variety of parameters (source characteristics, sample information, detector details, etc.), and can be used by third parties to find data released from any facility after the embargo period. By the end of the project, CERIC has been able to deploy a search API that complies with the agreed minimum functionality.
The federated serach API is key for the functioning of the **Open Data portal** (https://data.panosc.eu/), a custom graphical search user interface developed in the frame of PaNOSC, and which consists in the implementation of a metadata catalogue and data repository to upload, search and download open data across most PaN RIs in Europe.
To make data reusable, a community **metadata standard for PaN sources (NeXus/HDF5)** has been widely adopted at some of the CERIC instruments. Also, resources have been dedicated to generating DOIs (Digital Object Identifiers) for each experiment and for one or more specific datasets to be cited in publications, to allow reusability of the same datasets by other research teams from the same or different domains.

Data Analysis

In addition to data generation, collection, processing, storage and management, data need to be visualised, analysed and interpreted. Given the increased data amounts and volumes, this not only requires an increasing level of computer power and storage space, but also makes a download and local computation for data analysis by single users partly unfeasible. To further lower the barriers towards re-use of open data, users should be enabled to explore data through their web browser, after having identified a dataset of interest. To this aim, PaNOSC partners have provided a remote access infrastructure to enable and contain FAIR data services for users of the PaN community, and ideally scientists from across domain borders, through the EOSC. This has been achieved by making available and developing two types of data analysis services: **remote desktops for graphical software use**, and **Jupyter Notebook** for programmatic data analysis. These run in virtual machines and can be accessed remotely via the open source data analysis online portal, **VISA – Virtual Infrastructure for Scientific Analysis**. VISA offers remote control, data analysis and simulation services of experiments and experimental set-ups, and allows analysis of data available in the open data portal. Users can select their experiment and resource options (memory, cpu, display) for the virtual machine to be used, and the type of analysis service to use within the virtual machine: a Jupyter notebook or a remote desktop with access to the software stack contained in the virtual machine image.
Among the services for data analysis specifically developed by CERIC is the **h5nuvola framework**, which has been integrated to the data catalogue of the VUO service, so that data exploration is augmented by visual inspection.

Data Simulation

Free open-source software and services for simulation and modelling of PaN sources, beamlines and experimental instruments, and start-to-end simulations to describe entire experiments, are also accessible via VISA, as part of the **Virtual Neutron and X-ray Laboratory – ViNYL** developed within PaNOSC, also with CERIC's contribution. ViNYL enables PaN users to rapidly implement simulation and analysis workflows specific to their facilities, instruments, and experiments. This is important, as simulations of the various parts and processes involved in complex experiments play an increasingly important role in the entire lifecycle of scientific data generated at RIs.

CERIC contributed in particular to the development of OASYS (OrAnge SYnchrotron Suite), an open source environment for modelling X-ray beamlines and experiments. Below the key achievements in this respect are listed:

[3]European Commission, Directorate-General for Research and Innovation, Assessment on the implementation of the Eric Regulation, Publications Office of the European Union, 2021, DOI: https://data.europa.eu/doi/10.2777/747211

1. **Wiser** is a new package for wavefront propagation calculations based on Python implementation of WISE calculation code. Wiser has been optimised to allow X-ray mirror simulations in reasonable times in interactive OASYS sessions. Moreover, more optical elements are now supported and work on a Wiser GUI widget has started.
2. **COMSYL** (COherent Modes for SYnchrotron Light) is a software package to perform numerically the coherent mode decomposition of undulator radiation in a storage ring. Most importantly, a reimplementation of COMSYL in python is now fully integrated in OASYS. The COMSYL addon has received a number of updates.
3. **SHADOW**, the main raytracing engine in OASYS, and the corresponding add-on ShadowOui have been upgraded to allow simulations for monochromators using crystals with high d-spacing, which is of particular interest for storages-rings producing soft X-rays.

A number of the developed services are now accessible via the EOSC, using a single AAI - Authorisation and Authentication Infrastructure service (Umbrella ID), which enables users to log in to multiple applications and websites with one single set of credentials:

- **PaNOSC Software Catalogue**, with over a hundred standard software tools used for analysing data from PaN RIs;
- **PaNOSC open data portal**
- **Search API service**
- **PaN e-learning platform**

OCRE funding for CERIC's mini-EOSC implementation

Following the selection of CERIC, in 2021, to receive funding for the adoption of commercial cloud solutions in the frame of the H2020 OCRE project, the Consortium has carried out the work with the goal of seting up a “mini-EOSC”, supporting all its members in developing their own FAIR (Findable, Accessible, Interoperable, and Reusable) enabled workflow.

The OCRE framework has been a very useful exercise in helping the IT Team of CERIC benchmark the systems and technical standards of the Consortium against the IT Industry standards. In the initial setup, the IT Team installed the essential data analysis software, proving that Public Cloud, such as AWS (Amazon Web Services) could be a reliable resource able to provide a reliable computing infrastructure for CERIC users and staff.

In January 2023, AWS and Rackspace - the providers of commercial cloud resources selected by the Consortium in the previous year for a period of 12 months - granted CERIC another year to use all the remaining resources. In this context, by the end of 2023, it is expected to be able to run tests using Amazon Cloud techniques and technology to test a scientific data management pilot project inspired by the Open Science collaborations.

The pilot project is called “TRE – Trusted Research Infrastructure”. The architecture of such project has been drafted by AWS experts and will soon be deployed for tests, allowing to ingest data and identify how the Industry standard Data Management Pipelines could help CERIC users perform and accelerate the Data Analysis process. This upgrade will be extremely useful in particular for highly interdisciplinary experiments (i.e., combining several of CERIC’s techniques in one proposal), and will contribute to further strengthening CERIC’s competence and visibility in the key areas of energy storage and life science research.

Upgrade of the Proposal Management System

A Proposal Management System is core to the operation of experiments' administration, for the subsequent allocation of beamtime to accepted proposals, and for all the follow-up operations (e.g., user satisfaction survey, request of experimental form, publications, etc..).

Currently, to manage proposals, CERIC utilises the Virtual Unified Office (https://vuo.elettra.eu), the platform made available by the Italian PF at Elettra in Trieste. So far this has worked well, but in order to maximise flexibility and align with current infrastructure/operations paradigms, CERIC is interested in developing its own. This would allow adopting a more dynamic stance in the pursuit of streamlining the work-flow and experience of CERIC users, as well as afford great agility in adapting to the unique architectural challenges that such a heterogeneous consortium gives rise to.

During the year 2022, in a first phase, some platforms alternative to Elettra’s VUO have been identified and evaluated by means of tests and meetings with the developers and project managers/coordinators of the corresponding platforms.
At the end of this phase, CERIC decided to join the development of the User Office Project (https://github.com/UserOfficeProject), which is an international collaboration started by the European Spallation Source (ESS) to build a flexible web software to effectively run and organise user programmes at a variety of science facilities.
To better structure the activities and size the development efforts, the members of the User Office Collaboration are now preparing an MoU, which will further facilitate the sharing of software and user office best practices between the member facilities.

The IT group of CERIC has studied at a high level the inner workings of the platform and a publicly available testing instance has been deployed to be used as a starting point for the customization. CERIC future plans is to extend the User Office Project with custom developments that will meet the needs of the consortium.

Performance Monitoring and Impact Assessment

CERIC is committed to providing free merit-based access to cutting-edge instruments and resources located in various countries. As a leading research infrastructure, we strive to continually improve and grow our operations, ensuring that we deliver excellent service to the research community. To this end, we recognise the importance of performance monitoring and impact assessment in our annual report. These processes allow us to evaluate our performance, identify areas for improvement, and demonstrate our value to stakeholders.

Performance Monitoring

Performance monitoring is essential for the effective management and operation of our research infrastructure. It enables us to:

- **Track progress:** By collecting and analysing data on, e.g., the usage of our facilities and resources, we can determine whether we are meeting the needs of our users and achieving our organisational goals. This information helps us to make informed decisions about resource allocation and investment in new equipment or services.
- **Identify trends and patterns:** Regular monitoring of key performance indicators (KPIs), such as the number of users, projects supported, and publications resulting from our resources, allows us to identify trends and patterns in research areas and user needs. This information informs our strategic planning and guides our future development.
- **Ensure quality and efficiency:** Performance monitoring helps us to identify potential bottlenecks or

inefficiencies in our processes and operations, enabling us to address them proactively. By continuously improving our services, we ensure that our users receive the highest quality support and that our resources are utilized effectively.

CERIC's Key Performance Indicators are largely based on the on the ones proposed by ESFRI. They are collected annually and reported to the bodies – Board of Directors, ISTAC and General Assembly.

Impact Assessment

Assessing the impact of our research infrastructure is vital for demonstrating our value to stakeholders, such as funders, policymakers, and the research community. Impact assessment allows us to:

- **Showcase success stories:** By documenting the outcomes and impacts of the research supported by CERC, we can showcase the real-world benefits and contributions of our services. These success stories can be used to secure future funding, attract new users, and raise the profile of our organization.
- **Quantify our contributions:** Impact assessment helps us to measure the tangible and intangible benefits of our infrastructure, such as increased research productivity, collaboration, knowledge transfer, and innovation. By quantifying these contributions, we can demonstrate the return on investment (ROI) provided by our services and justify continued support from stakeholders.
- **Inform future strategy:** Understanding the impact of our research infrastructure allows us to identify areas of strength and potential gaps in our offerings. This information can be used to inform our future strategy, ensuring that we continue to deliver maximum value to our users and stakeholders.

CERIC has developed its approach to impact assessment within the EC funded project ACCELERATE, and has published its impact pathways report in 2020. In 2022, it started preparing its updated internal report, which will be used as a basis for external impact assessment, to be undertaken in 2023.

3

Training, Industrial Liaison, Communication, Projects

Main Achievements

1 **Educational projects**
Successful implementation of the 7th edition of the training programme for five scientific high schools (PaGES 7).

2 **18 PhD grants co-funded**
in collaboration with 8 universities in Europe. Two new PhD projects started in 2022.

3 **Organisation of events**
to increase awareness of CERIC's mission, offer and services among both scientific and industrial communities, as well as lay publics.

4 **Transnational cooperation**
in three EU-funded projects.

5 **Production and release of 8 promotional videos**
on the CERIC techniques and on battery and fuel cell research

Training Activities

Education and skills development is a core activity of CERIC. The promotion of training activities was supported in 2022 through the organisation of webinars, lectures and workshops. Due to the pandemic, all events were held in virtual format. The CERIC PhD programme started in 2020 also continued in 2022, in collaboration with eight European universities. Some of the implemented actions are presented below.

Training high-school pupils. The PaGES 7 project

PaGES 7 is an educational project targeting pupils from scientific high schools in the Italian region Friuli Venezia-Giulia, aimed at acquainting them with the basic tools to plan, manage, execute and evaluate a research project, and disseminate its results. The project has been strengthening links among schools in the regional area and has been setting the basis for implementing similar actions in the future.
In the 2022 edition, pupils had direct experience of the scientific activity carried out in a research infrastructure, by joining a virtual tour of the Italian and Austrian CERIC facilities at the synchrotron in Trieste, as well as of the NMR facility at the National Institute of Chemistry in Ljubljana. Scientists and professionals in the fields of project management and communication had onsite lectures in the schools partner in the project, to allow pupils increasing their knowledge about the wide variety of professional careers offered by a research infrastructure, while empowering them to make more conscious choices for their future. During 2022, PaGES 7 involved 144 students from five high schools of Friuli Venezia-Giulia.

Training PhD students and young researchers

A call for CERIC's PhD students was launched in 2020 and most of the Doctoral programmes started in 2020 and 2021. During 2022, two more PhD programmes began, one with Charles University of Prague which topic is “Development of ceria based electrochemical sensors for biomolecule detection”, and the other one with the Graz University of Technology focused on “Enzymes@ZIFs: Synthesis and characterization of new bio-composites for Biocatalysis”.
In 2022, PhD students got access to CERIC facilities, laboratories and instruments to perform state-of-the art, multidisciplinary approach-based studies on a broad variety of scientific fields, including: energy and electrochemistry (fuel cells, Zn-air and Na-Ion batteries, electrodes development, electrochemical biosensors), materials science (recovery of precious metals from hardmetal scrap through electrochemical techniques, nanoparticles characterization, graphene growth), biomedicine (research on DNA and complex proteins, effect of long-term nanoplastics exposure, drug discovery against SARS-CoV2), cultural heritage evaluation and conservation.
All the PhDs (currently, 18 students) had the chance to present their activity to the International Scientific and Technical Advisory Committee (ISTAC) of CERIC in the frame of Contact-Science@CERIC event, during which our PhD students researching in fuel cells has been invited as speakers. Moreover, during 2022 several papers of the various studies have been published, and PhD students had the opportunity to participate and present their work both in national and international workshops and events.

Talent development within CERIC and beyond

Also in 2022, CERIC has continued carrying out the activities related to the capacity building of Partner Facilities and Representing Entities in the industrial liaison and technology transfer field. On 4 October 2022, an international event has been organised offering training sessions and presentations with international experts from public entities and industry, focused on Increasing Research Infrastructures’ relation with Industry. Following a holistic approach, the event has been organised in collaboration with the ENRIITC project and a community involving industrial Liaison and Contact Officers (ILOs/ICOs) of other European Research Infrastructures to exchange experiences, best practices and knowledge.

Industrial Liaison Activities

In 2022, CERIC continued to bolster the European innovation ecosystem, involving both public and private stakeholders, and creating opportunities to enhance the Consortium's impact on industry.

CERIC's Industrial Liaison Office (ILO) aided Partner Facilities (PFs) by showcasing their analytical scientific services to the industrial sector. CERIC also facilitated technology and knowledge transfer among its Representing Entities (REs), primarily from Croatia, Slovenia, and Poland. This collaboration led to greater exposure for various technologies and spin-outs from the REs, so far materialising in collaboration with one large energy sector company.

CERIC participated in the Inditech 2022 Conference in Grenoble, which focused on Industrial Technologies. As part of the "Research Infrastructure Village," CERIC presented a poster displaying its capabilities for testing new catalysts and battery materials. Additionally, CERIC organized a workshop in October 2022 to increase Research Infrastructure (RI) visibility and potential toward the industry. This event included training sessions, presentations from international experts, and opportunities to strengthen collaboration between European RIs and industry representatives.

CERIC also took part in the Big Science Business Forum 2022, with some of its RIs showcasing their technologies in the "Technology Transfer Track" session. Two technologies from Jagiellonian University and CERIC's Renewals project were selected to be introduced to potential investors and collaborators.

These initiatives led to initial discussions with two different companies involving Austrian, Czech, Italian, Polish, and Romanian PFs. Negotiations for future collaboration are ongoing. Furthermore, in 2022, CERIC reached a commercial agreement with BASF for characterizing innovative materials.

As for industrial usage of CERIC PFs via open access in 2022, 5% of total accesses were related to industry-linked projects. Regarding publications, 8% of articles released in 2022 were industry-related, accounting for publications with company-affiliated authors or those connected to industry proposals.

Communication and Dissemination

CERIC's communication team has actively supported the user office in promoting research opportunities at CERIC infrastructure to researchers worldwide. Throughout the year, the team also managed work packages dedicated to communicating and disseminating the results of three European H2020 projects: PaNOSC, ERIC Forum, and ReMade@ARI. Various events, including annual meetings, symposia, webinars, and summer schools were organised and promoted, alongside the continuous release and distribution of newsletters, brochures, infographics, video interviews, position papers, and open access publications.
The communication and dissemination activities for these projects have been positively assessed.
As stated in the EC final review of PaNOSC, the project "*has implemented an ambitious dissemination plan that have achieved significant results. It has disseminated and communicated its results to different audiences using a wide range of channels, including social media, workshops, interactions and clustering with stakeholders, training events and summer schools, and more*".
EC evaluators of the ERIC Forum project, with reference to its communication and dissemination activities, stated that the project "*successfully managed continuous updates and improvements of the communication activities, increasing the Forum and the individual ERICs' visibility and widening the audience reached*".

In September 2022, CERIC participated in the 11th edition of Trieste NEXT, a science dissemination event, to raise public awareness about the work of RIs in promoting scientific discoveries and technological advancements. CERIC's program focused on hydrogen research, opportunities, applications, and the Consortium's role in the European Green Deal. Interactive events and experiments were organised for the European Researchers' Night, engaging families and science enthusiasts in hands-on activities.

Recognising CERIC's growing contribution to battery and fuel cell research, two new website sections were published, providing detailed information about the available analytical techniques for scientific research in these areas. In 2022, CERIC also produced and disseminated videos on energy research and beamline technologies through its channels.

With a stronger emphasis on the UN's Societal Development Goals, and other social's objectives, CERIC has observed an increase in the number of non-expert users accessing its facilities. To address this trend, CERIC has produced a series of explanatory videos that explain its analytical techniques. These videos are designed to help non-expert users better understand the available methods and tools. These informative resources can be easily accessed through the CERIC website, ensuring that users at all levels of expertise can effectively utilise the facilities and services offered by CERIC.

Outreach Events

To increase awareness among the scientific community worldwide about the research opportunities that it offers and the scientific outputs it produces, in 2022 CERIC was present at a number of events, including:

ESOF 2022 poster session
Leiden - The Netherlands, 15 July 2022

PaGES @ PARI 2022
Online, 19 July 2022

Trieste Next 2022
Trieste - Italy, 12 September 2022

BSBF 2022Big Science Business Forum
Granada - Spain, 4 October 2022

CONTACT-Science@CERIC 2022
Treviso - Italy, 8-9 November 2022

PaNOSC Closing Event
Grenoble - France, 29-30 November 2022

Transnational Cooperation

In 2022, transnational cooperation has also been implemented through CERIC's transnational projects. Two EU funded projects (PaNOSC and ERIC Forum) finished, and a new Horizon Europe project (ReMade@ARI) kicked off.

Horizon 2020 PaNOSC
Photon and Neutron Open Science Cloud

The Photon and Neutron Open Science Cloud (PaNOSC) project is an EU funded project which aimed to provide common policies, strategies and solutions for enabling Open Science through the adoption of FAIR principles across European photon and neutron facilities.
The 4-year project, which ended with the closing event held in Grenoble in November 2022, had the goal of addressing FAIR principles in the workflows of large-scale PaN facilities and equipping them with all the necessary tools and software, as well as the required legal and administrative frameworks. Throughout its implementation, PaNOSC provided common policies, strategies and solutions for enabling Open Science through the adoption of FAIR principles across three European PaN RIs and three European Research Infrastructure Consortia (ERICs), helping to make their data open and available to the EOSC.
By closely working together for the PaN community, PaNOSC and its sister project, ExPaNDS, have paved the way to make data produced at PaN facilities across Europe easily accessible: data has started to be curated and made available under an Open FAIR Data policy.
Overall, all facilities have adopted, or are in the process of adopting, the PaNOSC FAIR research data policy framework, which serves as guidance for FAIR data stewardship by defining the curation of (meta)data, from the generation of raw data from each experiment, to analysis, through to publication and re-use.
There are many reasons and benefits for PaN facilities to adopt a FAIR data policy. These range from the need to make science reproducible and replicable by adopting an Open Science approach, to improving the quality of scientific data. Data stewardship also implies the implementation of effective Data Management Plans (DMPs) to ensure that RIs' users and support teams are aware of the data volumes that will be produced and how to process them throughout the whole data lifecycle. Such information is also beneficial to make a forecast of the IT infrastructure required to support an experimental programme based on a more detailed understanding of users' needs. This is why a solution for generating and managing DMPs for each experiment has been proposed and implemented across PaN facilities.
Moreover, to make PaN data easily findable and accessible across a multitude of PaN facilities in Europe, domain-specific searches across the PaNOSC data repositories needed to be enabled. This happened by developing and adopting a federated search API (Application Programming Interface) for PaN data catalogues, as well as a common protocol for harvesting data and metadata, to make public datasets available to third-party EOSC cross-discipline repositories.
An Open Data portal (https://data.panosc.eu/) has also been developed, through the implementation of a metadata catalogue and data repository to upload, search and download open data across most PaN RIs in Europe.
To make data reusable, a community metadata standard for PaN sources (NeXus/HDF5) has been widely adopted, and electronic logbooks have been developed to capture what happens during experiments, and keep track of the various steps and settings of the experiments for future usage. Also, facilities have dedicated resources to generating DOIs (Digital Object Identifiers) for each experiment and for one or more specific datasets, to be cited in publications. This would allow reusability of the same datasets by other research teams from the same or different domains.
PaNOSC has also provided VISA – Virtual Infrastructure for Scientific Analysis, a remote access infrastructure to enable and contain FAIR data services for users of the PaN community, and ideally scientists from across domain borders, through the EOSC. Free open-source software and services for simulation and modelling of PaN sources, beamlines and experimental instruments, and start-to-end simulations to describe entire experiments, are also accessible via VISA, as part of the Virtual Neutron and X-ray Laboratory – ViNYL developed within the project.
The PaNOSC Software Catalogue, the PaNOSC open data portal, the open data portal of 3D scans of human organs with micron resolution for different pathologies - Human Organ Atlas, the e-learning platform hosting free education and training for scientists and students, and the Search API service are now accessible via the EOSC using a single AAI - Authorisation and Authentication Infrastructure service (Umbrella ID), which enables users to log in to multiple applications and websites with one single set of credentials.

Horizon 2020 ERIC Forum implementation project

The ERIC community has been expanding in the last ten years, and until now, it counts 22 established ERICs and 10 European Research Infrastructures (RIs) aspiring to become an ERIC. The variety and diversity of ERICs make them important players in European Science excellence that respond to various societal challenges, supporting science diplomacy and creating bridges between research communities in Europe and worldwide.

The ERIC Forum was formed in 2017 and brings together the ERIC community with the aim of strengthening its coordination, advancing ERICs' operations, collectively responding to common challenges, and effectively interacting with the European Commission and key stakeholders. The Forum also strategically contributes to the development of ERIC-related policies, making it one of the leading science policy voices in Europe. The ERIC Forum implementation project has been supporting the Forum's activities since its launch in January 2019.

In 2022, the ERIC Forum developed several reports and organised a set of events providing guidance and best practices on key areas of interest for RIs and ERIC communities, including: sustainability, performance monitoring, quality management and reproducibility, human resources, accounting principles, VAT exemption, contracting, insurance and intellectual property. In addition to that, the ERIC Forum supported fostering ERICs' visibility through targeted promotional campaigns, video interviews and events. Through these activities, the ERIC Forum has been showcasing ERICs' added value, scientific achievements and contribution to the UN SDGs (Sustainable Development Goals).
Moreover, the project's WP5 (Communication and Dissemination) led by CERIC organised: a) a panel discussion in the frame of ESOF2022 around RIs' contribution to environmental sustainability; b) a hybrid side event at ICRI 2022 in collaboration with ELIXIR.

Finally, the ERIC Forum Toolkit was officially released on the ERIC Forum website, to collect the wealth of knowledge accumulated during the ERIC Forum in a user-friendly online platform, that could be helpful to ERICs in different stages of their lifecycle and to Research Infrastructures aspiring to gain the ERIC status, as well to funders and other interested stakeholders.

Horizon Europe ReMade@ARI project
Recyclable Materials Development at Analytical Research Infrastructures

The European Union's Circular Economy Action Plan (EU) is based on the assumption that up to 80 percent of a product's environmental impact is determined during the design phase. In order to adopt a comprehensive approach to sustainable production and products, the European research infrastructure project ReMade@ARI was kicked off in September 2022. It focuses on innovative, sustainable materials for key components in the most diverse sectors, such as electronics, batteries, vehicles, construction, packaging, plastics, textiles and food.
The aim is to develop new materials that are both competitively functional and highly recyclable. To this end, the potential of more than 50 analytical research infrastructures all over Europe is due to be harnessed.

ReMade@ARI started on 1 September, 2022, under the coordination of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR). CERIC is project partner involved in activities such as project management, academic and industrial access support, and four of its Partner Facilities are involved in providing access: CUP, NIMP, SloNMR and SOLARIS.
ReMade@ARI id funded by the European Union as part of the Horizon Europe call HORIZON-INFRA-2021-SERV-01 under grant agreement number 101058414 and co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding and by the Swiss State Secretariat for Education, Research and Innovation (SERI).

4

Operations and Finance

Main Achievements

1. **Adoption of the new CERIC business model introducing Members' fees**
2. **CERIC's Gender Equality Plan (GEP) published**
3. **Internal Regulations 4 and 10 updated**
4. **CERIC's contribution to UN SDGs and the ERA**
5. **Contribution to EOSC Sustainability**
6. **IKCs, VAT, excise exemptions and employment policies**
   Progress and updates.
7. **Financial and in-kind annual account**
   for 2022 and estimate of the auditable values to be included in the Annual CERIC Account.

Adoption of the new CERIC business model introducing Members' fees

Following the discussions started in 2019 at the level of the General Assembly (GA) of CERIC on the proposal to modify the business model of the Consortium, towards a transition from the sole use of in-kind contributions, to annual cash contributions by the Members, a related amendment of the Statutes of CERIC has been approved by the GA by written procedure in the first half of 2023.

The new contribution model, applicable starting from the financial year 2024, foresees that total annual contribution of the country presently hosting the Statutory Seat will be maintained at 5,5 MEUR including its Member contribution and the Host premium. The Host premium will be used for CERIC's integration and operation, including training, technology transfer and communication, as well as for the operation of the Statutory Seat.

The annual monetary contribution by each Member consists of a fixed contribution of 30.000 EUR plus a variable contribution proportional to its GDP calculated according to the formula attached to this Resolution and which is to be annexed to the CERIC Statutes.

The formula to calculate the annual cash contribution for each Member is the following:

$$\text{Contribution (EUR)} = (A \times B/C + D) + E \times (A \times B/C + D)$$

where:

- A = total variable contribution of the Members (set at 680.000 EUR for 2024);
- B = GDP of a Member, as share of EU total (first five years: GDP for 2021 at market prices in Million EUR, as in Table I);
- C = GDP of all CERIC Members in 2021, as share of the EU GDP (first five years: GDP for 2021 at market prices in Million EUR as in Table I);
- D = fixed contribution, 30.000 EUR per Member for 2024;
- E = EUROSTAT's Harmonised Indices of Consumer prices – inflation rate for the EU for the previous year, if above 2%, but with a maximum cap at 3%.

The total of the variable contributions by the Members (A in the formula) is set at 680.000 EUR for 2024.

Amendments also clarify the following:

- The total annual contribution by each Member is kept constant unless the annual inflation rate in the European Union (EU) is above 2%, in which case this amount should be updated based on the official annual inflation rate of the EU for the previous year (EUROSTAT's Harmonised Indices of Consumer prices – inflation rate), but with a maximum cap at 3%, unless decided otherwise by the GA.
- The host contribution shall always include, in addition to its Member's contributions, a specific Host premium to be defined by the GA, ensuring the longer-term sustainability of the statutory operations.
- As long as the contribution by the Host Member State of CERIC allows covering the statutory operations fully, 90% of the Members annual contributions is dedicated to supporting actions integrating the capabilities of the Members PFs, such as PhDs, post-docs, joint research projects, infrastructure investments dedicated to CERIC use and activities, and promotion of CERIC PFs research offer. These annual contributions will be agreed upon by the GA, assuring that, over a 5-year average, this support to each Partner Facility will equal at least 90% of the cash contribution provided by the relevant Member during this period.
- In case of accession of a new Member to CERIC, it shall contribute to the CERIC budget according to the formula above. In well justified cases, the GA may agree on a different contribution, or that the total annual monetary contribution of a new Member is capped at a fixed amount for a given number of years.
- The GA may agree on a one-year grace period, during which a Member is relieved from delivering full annual cash contribution, which is to be repaid over the next three years.

Approval and publication of the CERIC Gender Equality Plan (GEP)

In September 2022, CERIC released its Gender Equality Plan (GEP), a 3-year policy document describing the actions that the Consortium shall implement to reduce gender inequalities, ensuring inclusiveness with women and men in all their diversity.
The GEP is a tool aimed at addressing eventual gender inequalities, building a honest and communicative learning and working environment where people are treated equally without discrimination.
The guidelines and process for drafting the GEP were concerted within a specific working group created within the ERIC Forum. The structure of the plan involves the five content areas indicated by the European Commission as essential factors for gender equality[1].
The adopted methodology included a gender equality audit, and the delivery of an analytic report. Findings allowed identifying the areas of intervention to be addressed in the GEP, as well as defining objectives and specific targets, indicators and measures for evaluating progress and implementing actions via objective indicators. Based on the findings from the audit, the working group organised an awareness-raising kick-off meeting with the whole CERIC staff in April 2022.
An external consultant was also engaged to conduct face-to-face interviews with all staff members. The primary outcomes of the interviews and recommended future actions have been released in a report delivered in May 2022.
The GEP is thus fully evidence-based.
The GEP, which was presented to the GA in November 2022 by the Executive Director of CERIC, will be implemented over three years (September 2022 - August 2025). The GEP, which is addressed to all employees and collaborators of the Consortium, is available on the CERIC website and has been widely disseminated within the Consortium.

Updated CERIC Internal Regulations (IR4 - IR10)

In 2022, the GA of CERIC discussed and approved the modification of two Internal Regulations (IR), and specifically of IR 4 - General Assembly Rules of Procedure, and of IR 10 - Rules of Conduct and Disciplinary Code.
With reference to IR4 - GA Rules of Procedure, it has been agreed that the delegates to the GA are appointed by the Members or the Observers in writing (also by electronic certified means) to the Chair. If not otherwise expressly specified in the appointment, the ordinary term of the appointment of the delegates to the GA is three years. In case of renewal of the appointment of the outgoing delegate, the new appointment will be effective as of the date after the expiry of the previous appointment, if not otherwise expressly provided in the renewal.
As for the general rules of conduct and the disciplinary code as defined in IR10, in November 2022 the CERIC GA approved the updates which take into account what stated in the CERIC Gender Equality Plan approved in 2022.

ERICs' contribution to the ERA

The success of the European Research Area (ERA) strongly relies, among others, on ERICs and on the implementation of the ERIC Regulation.
In 2022, following the release, in 2021, of the EGERIC report[2] by a European Commission expert group, the main results and recommendations presented in the document were further disseminated to the ERICs' community. An online meeting was organised in January 2022, to discuss and collect the ERIC Forum community's feedback on the report, in preparation for the following ERIC Forum Meeting, where the key conclusions have been presented.

[1]Horizon Europe guidance on gender equality plans - Publications Office of the EU (europa.eu)
[2]European Commission, Directorate-General for Research and Innovation, Assessment on the implementation of the Eric Regulation, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2777/747211

CERIC's contribution to UN Sustainable Development Goals

As part of its mission, CERIC delivers innovative solutions to societal challenges in areas such as energy, health, food, cultural heritage, and more, actively contributing to the United Nations' Sustainable Development Goals (SDGs). The 17 UN SDGs serve as a blueprint for a better future for both people and the planet, guiding collective efforts at national and international levels toward sustainability by 2030.
Collaboration is vital for developing and implementing sustainable solutions. In this context, Research Infrastructures (RIs) play significant roles as multi-actor initiatives that integrate research activities across borders and stimulate innovation in the private and public sectors through their services. The proposed Brno Declaration acknowledges the contributions RIs make to global challenges. RIs contribute to the development of scientific knowledge, data, and solutions across various fields, such as biodiversity organizations, marine ecosystems, ocean environments, greenhouse gas, earth science, drug development, biobanks, translational medicine, food security, climate change, and social sciences, resulting in groundbreaking achievements.

CERIC has increased its efforts to develop a broader range of services in the fields of energy and life sciences, primarily linked to the following SDGs: SDG3 - Good Health and Well-being, SDG 7 - Affordable and Clean Energy, SDG 12 - Responsible Consumption and Production, and SDG 15 - Life on Land.
Besides the scientific results from research conducted at the Consortium's facilities, CERIC, in collaboration with other ERICs involved in the ERIC Forum, organized two events in July and October 2022 to further inform and raise awareness about the importance of RIs in addressing societal challenges. To this end, several examples of how ERICs tackle the UN SDGs were presented at significant events, such as ESOF 2022, targeting scientists, journalists, and science enthusiasts, and ICRI 2022, aimed at policymakers and RI staff and managers.

Enabling transnational access to RIs

In October 2022, in the frame of the ICRI 2022 event, CERIC deputy director, Ornela de Giacomo, was invited to join the panel discussion on Transnational Access to RIs, with a focus on the principles for enabling international access to RIs.

Her presentation focused on the importance of open access as a driver for scientific excellence, innovation, and long-term sustainability of RIs like CERIC. It highlighted how CERIC successfully implemented the recommendations of the EC to simplify and harmonise access, and those of the European Charter for Access to Research Infrastructures, promoting transparent access. CERIC, putting users at the center, is committed to providing high-quality services, offering the possibility to perform multi-technique experiments choosing any combination from over 60 techniques through a single proposal submission. Harmonized access is sustainable through commitments from the countries (members of the ERIC) and the efforts for improvement and further integration are justified by the long term perspective. However, when challenges require a fast reaction, since including a new member in the ERIC may require years, CERIC has established collaborations with associated facilities, which can temporarily expand the offer to meet specific objectives and build trust and understanding with potential new member facilities.

Finally, enabling international access requires dedicated effort in outreach and training, for regions where many researchers are not familiar with this kind of infrastructures, their offer and their procedures. An example is the creation of the CERIC outpost in Ukraine, funded by the H2020 ACCELERATE project. This collaboration led to a significant increase in proposals from Ukrainian researchers, showcasing the positive impact of promoting open access and international collaboration in RIs.

Contribution to EOSC sustainability

A sustainable PaN EOSC should have common tools and services adopted by most Photon and Neutron (PaN) facilities and researchers. It should have a high degree of interoperability with EOSC and with other science clusters and communities. It should be technically sustainable, maintaining its functionality over time and must have enough resources to operate, develop and provide high quality services to researchers of the PaN community and, in a vision of EOSC, to any user interested. The resources PaN facilities count on are mostly from their ordinary budget, with some limited project funding available for new developments and networking activities. However, none of these resources can cover the costs to operate tools and services for a wider community.
A sustainably PaN EOSC should also have an appropriate governance that ensures inclusiveness and participation, but at the same time provides the direction.

Sustainability is thus a core multifaceted and complex issue to be addressed throughout the whole steps of the ambitious plan to make research data and services FAIR and connected to the European Open Science Cloud (EOSC). CERIC , as leader of the PaNOSC project's work package (WP) on Sustainability, has had a major role in developing a suitable sustainability strategy of the PaN Open Science Cloud.

In 2022, with the collaboration of all partners in the project, CERIC delivered three documents in the frame of such WP. The first one, PaN EOSC metrics and costs model, reports the result and analysis of the collection of costs reported by partners for the data services provided to the community, including the costs involved in data management, provision of FAIR data and participation to the EOSC. The collection was performed by five PaNOSC partners that run very different infrastructures in terms of their nature (synchrotrons, neutron sources, free electron lasers, lasers), size, FAIRness level achieved at the moment of the cost collection and services provided, lifecycle and accounting practices. However, although it has been a challenging exercise, the information collected could help other RIs to estimate the costs involved in the provision of these services, following the same procedure, or could help newcomers in estimating the investments. Among the findings, it has been highlighted that, with the current budget, RIs will provide services, including long-term storage and curation, on a best effort basis, and that if a wider community will need to benefit, funding will need to be increased proportionally.

The second document delivered in 2022 explored three possible business models to make the PaN EOSC sustainable. A higher number of business models has been considered, and will be further analysed in the future.

1. **Business model I: Complete environment for data search, analysis, simulation and storage**
   This business model is quite similar to the current interactions with commercial users that use some of the RIs, the difference being that rather than making their own experiment and working with their own data, the commercial user would not perform an experiment and just use existing open data.
2. **Business model II: Improving company's staff skills on data analysis and access to related tools**
   This business model focuses on partnering with commercial users in order to train and support their staff in data analysis.
3. **Business model III: Complete consultancy service**
   This business model focuses on offering consultancy services to private entities, for example to understand which kind of results have been obtained with PaN facilities on certain materials, and eventually make the data re-analised by facilities' staff using different software, to find new valuable information and insights from existing open data. This can lead not only to saving experiments costs for companies, but also to better focusing on their research.

Finally, the PaN EOSC Sustainability Plan submitted at the end of 2022, presents an overview of the aspects that affect the sustainability of the PaN EOSC and how these will be tackled beyond PaNOSC. Although there are various possible strategies to achieve sustainability in the-long term, the one chosen by the majority of PaNOSC and ExPaNDS partners implies to leverage the LEAPS and LENS initiatives, adopting the open source collaboration approach, and where necessary negotiate Memorandums of Understanding (MoUs) for the outputs individually.

CERIC and its Members have also been engaged in the development of national policies, since the data policy and data management practices of RIs/ERICs will need to be compliant with the policies of the country/-ies where the RIs/ERICs are located. Many aspects of the sustainability of the PaNOSC and ExPaNDS achievements were discussed in the frame of the LEAPS and LENS initiatives, which gather and represent most PaN facilities in Europe. This is the setup proposed to follow the path for sustainability in the future, after the project ends, and the MoUs that are being discussed are being brought forward mostly in this joint LEAPS+LENS working group. CERIC, which is not member in these organisations, has been taking part in the meetings as observers and will keep the collaboration running actively.

Finally, CERIC has also widely contributed to maintaining a useful interaction with other stakeholders, by taking part in working groups of the EOSC and the EOSC Association, becoming member of the association, producing position papers, replying to consultations, participating in workshops and interacting with the other clusters.
Several discussions about PaN EOSC sustainability took place at European, national and PaN level, such as the ESFRI stakeholders meeting, a RItrainPlus workshop, the workshop “EOSC un atout pour la science”, the EOSC Symposium, ICRI 2022, the EOSC Association and other cluster projects' meetings. In addition to the exchange of good practices, common solutions across clusters were explored and proposed to be developed in the upcoming calls (Horizon Europe).

Thanks to the direct involvement of the deputy director of the Consortium, Ornela De Giacomo, in the EOSC-A Task Force “Financial sustainability of EOSC”, CERIC's widely contributed to the PaN EOSC Symposium organised as an ICRI 2022 satellite event in October 2022. The first panel, which involved the Science Clusters (PaNOSC, ENVRI, EOSC Life, ESCAPE and SSHOC), focused on the sustainability of the EOSC Data Federation, and was developed in collaboration with the EOSC-A Task Force “Financial sustainability of EOSC”. The following panel focused on sustainability models for the PaN Data Commons session, involving PaNOSC, ExPaNDS and the LEAPS and LENS initiatives. These initial discussions led to more targeted ones during the PaNOSC final event held in November 2022, during which the clusters where invited to contribute to a common vision and explain what the EOSC projects had brought for them.

IKCs, VAT and Excise Exemptions, and employment practices

ERICs’ capabilities depend on the full implementation of the ERIC Regulation, also with reference to the fiscal exemptions granted to international organisations.
The relevance of fiscal exemption issues at European level is described in a report from the Commission to the European Parliament and the Council on the Application of Council Regulation – (EC) No 723/2009 dated 14.07.2014, in a chapter dedicated to “pending issues and next steps”. In this document, it was clearly stated that “*There are also questions to clarify as concerns in-kind contributions to an ERIC by its members, in particular as to whether these contributions could benefit from the VAT and excise duty exemption and, if so, under what conditions*”.

The VAT and excise exemptions issues have been addressed in a specific deliverable in the frame of the ERIC Forum project (D3.2 Procurement rules, VAT exemptions practices and economic activities - in work package WP3 led by CERIC), the objectives of which were completed in December 2022.
The path that started in the frame of the ERIC Forum project funded by the EC between 2019 and 2022, will be further developed through the second implementation project, ERIC Forum 2, which – if funded – is planned to start in 2023. In the next four years, CERIC and its project partners will work to further structure the cooperation between ERICs also with reference to the implementation of the VAT/duties exemptions. This topic will be addressed by setting up specific working groups to tackle joint challenges regarding VAT exemption practises. The main goal consists in delivering a set of policy recommendations and mitigation strategies about the implementation/revision of the ERIC Regulation.

In the frame of the ERIC Forum 2 project, in WP 11 – Implementation of the ERIC Regulation: strategy on European employment contracts – the results achieved in the previous project will be used to identify the main issues in developing attractive careers for researchers and personnel in support of research activities in ERICs, also proposing a common legal framework to be approved at EU level and applied to the whole personnel working in the ERICs.

Financial Statements 2022

Balance Sheet - Assets and Liabilities	2022	2021
ASSETS	**8,116,872.46**	**7,773,568.77**
Non-current Assets	**1,467,891.79**	**1,613,618.00**
Plant, property and equipment	1,434,146.36	1,559,914.69
Intangible assets	33,745.43	53,703.31
Investments in associates	-	-
Current Assets	**6,648,980.67**	**6,159,950.77**
Inventories	-	-
Long-term credits	-	-
Short-term credits	201,782.42	100,461.51
Other current credits and receivables	-	-
Cash and cash equivalents	6,090,060.82	5,528,436.50
Prepayments and accrued income	357,137.43	531,052.76
EQUITY AND LIABILITIES	**8,116,872.46**	**7,773,568.77**
Equity	**-**	**-**
Equity	-	-
Capital and other permanent contributions from Members	-	-
Reserves	-	-
Accumulated profits	-	-
Non-current Liabilities	**259,132.09**	**191,586.78**
Long-term financial debts and loans	-	-
Other long-term debts and liabilities	-	-
Advance payments for externally funded projects	44.469.05	-
Pensions funds and other benefits for compensation employment	214,663.04	191,586.78
Long-term provisions	-	-
Current Liabilities	**7,857,740.37**	**7,581,981,99**
Short-term financial debts	-	-
Other short-term debts and liabilities	347,584.03	422,623.13
Advance payments for externally funded projects	53,343.75	207,845.41
Other current payables	336,741.75	281,682.08
Contingent liabilities	40,783.62	40,783.62
Deferred income and accrued expenses	7,079,287.22	6,629,047.75

Profit and loss account		2022	2021
Revenues		**3,050,142.07**	**2,593,690.94**
	National and international grants and contributions	3,044,978.65	2,593,091.99
	Contributions in-kind	-	-
Other revenues	Other revenues	5,163.42	598.95
Operating costs		**2,579,533.96**	**2,248,918.89**
	Costs for raw materials, supplies and goods	14,138.10	30,934.14
	Costs for services	988,795.22	807,520.69
	Resources committed in-kind to CERIC from contributors	-	-
	Staff costs	1,557,763.98	1,399,038.84
	Costs of rents, concessions and royalties for trademarks	-	-
Other operating costs	Costs for institutional activities	18,836.66	11,425.22
Ebitda (Earnings before Interest, Taxes, Depreciations and Amortizations)		**470,608.11**	**344,772.05**
Depreciation		433,704.18	307,963.82
Write-downs for impairment of tangible and intangible assets		-	-
Ebit (Earnings before interest and taxes)		**36,903.93**	**36,808.23**
Financial income and expenses		**401.07**	**-1,719.23**
	Financial income	569.4	482.52
	Financial charges	-168.33	2,201.75
Income from investments		-	-
Value adjustments to financial assets		-	-
Result before tax		37,305.00	35,089.00
Taxes		37,305.00	35,089.00
Result for the year		**-**	**-**

Notes to the Financial Statements as at December 31, 2022

Accounting Criteria

These annual Financial Statements have been compiled in conformity with the IPSAS (International Public Sector Accounting Standards) international accounting standards issued by the International Public Sector Accounting Standard Board (IPSASB), and in process of being adopted by the European Commission within the meaning of Council Directive No 2011/85/EU of 8 November 2011, on requirements for budgetary frameworks of the Member States.
The decision voluntarily to adopt an accounting system that can be connected to international principles is consistent with the process of harmonization started some time ago by the EU Commission, but not yet completed. For this purpose, it is relevant to recall the “Report from the Commission to the Council and the European Parliament towards implementing harmonised public sector accounting standards in Member States. The suitability of IPSAS for the Member States”, published in March 2013.
The IPSAS can in general function as a basis for a harmonised accrual-basis accounting standard passing through its transformation into EPSAS (European Public Sector Accounting Standards). The aforementioned EU Directive states that “by 14 December 2018 the Commission shall make public a review of the sustainability of the Directive (see art.16).
CERIC-ERIC is set up as an international organization with scopes of general interest typical of an entity referable to the public sector. CERIC-ERIC should therefore be able to relate to its Members in different countries in a common language. This should be adopted in all matters and at all levels, and thus also in the model of presentation of economic-financial topics that support annual accounts and budgets.
The use of international accounting standards referable to the public sector, taking-into account the specific character and scopes of CERIC-ERIC, adequately conforming to the legal characteristics of the entity and to its functions and scope, allows the development of well-defined best practices, the impact of which on the financial aspects is measurable and effective. The use of international accounting standards, in fact, allows information on the financial statements to be presented in a common way for users/stakeholders of different nationalities.

It is possible in this way to ensure that:

- The information is relevant, reliable, comparable and understandable;
- The terminology used is common, appropriate and explanatory among Members and for similar international organisations outside Europe;
- The financial statements are auditable by the International Standard of Audit by auditors from different nations;
- A host country change - and thus any site change - is not relevant for the comparability of information and models, books and records of the accounting system;
- The accounting system is able to present the in-kind contribution model, and to provide analytical accounting for projects and separate accounting for economic activities.

The aim of the annual financial statements is to provide information on the assets and liabilities, the profit or loss and changes in the financial structure of the Consortium, useful to a wide range of users.
The financial statements are prepared within a general-purpose framework.
The financial statements have been compiled in accordance with the principles of clarity and transparency and provide a correct and exhaustive framework of information on property relations, as well as economic and financial relations implemented by the Consortium in carrying out its activities.

It has been compiled taking-into account international accounting standards for the public sector (IPSAS), where applicable, and integrated in order to be consistent with the legal and effective structure of CERIC.
Of the various options allowed by IPSAS 1, the Consortium has chosen to present the layout of the balance sheet distinguishing between current and non-current items, and the layout of the profit and loss account classifying the expenses by nature.

In its drawing-up, the following principles have been observed:

- The items have been evaluated prudently, taking into account the perspective of the continuity of the activities, as well as the economic function of an asset or liability;
- Only incomes and expenditures related to the financial year have been accounted, independently on the day of encashment or payment;
- The risks and losses related to the financial year have been accounted for, even if known after the end of the financial year.

These Notes have been compiled with the aim of clarifying, completing and detailing the information contained in the balance sheet and in the profit and loss account, in addition to providing information on the applied evaluation criteria, on movements that have taken place, and changes in various assets and liabilities.
The explanatory notes are an integral part of the following documents, to present these financial statements and provide descriptive and schematic information, with particular reference to property aspects, as well as economic and financial aspects of the overall management.

The financial statements comprise the following parts:

- Balance sheet
- Profit and loss account
- Explanatory notes
- Management report
- Reconciliation between final budget and Annual Accounts
- Statement of cash flow
- Trend of the net financial position (NFP)

Evaluation Criteria

The financial statements have been compiled in accordance with the principles of clarity and transparency and provide a correct and exhaustive framework of information on property relations, as well as economic and financial relations implemented by the Consortium in carrying out its activities. They have been compiled taking into account international accounting standards for the public sector (IPSAS), where applicable.

Balance Sheet

Items in the balance sheet are classified into/distinguished as current/non-current.

Assets

Assets have been classified as current assets when:

- They have been realised during the normal operating cycle of the institution;
- They are cash or equivalent complement not restricted in its use.

Assets realisable within the operating cycle have been classified as current, regardless of whether they have actually been realised within 12 months from the balance sheet date.

Non-current assets include tangible assets, intangible assets (licenses and in general all assets not related to the operating cycle and realizable after 12 months from the balance sheet date).

Liabilities

Liabilities have been considered current liabilities when:

a) They are extinct in the course of the normal operating cycle of the institution;

b) Extinction is due within 12 months from the balance sheet date.

Other liabilities, i.e., those not related to the operating cycle and all other institutional liabilities, are classified as current if their extinction is due within 12 months from the balance sheet date. Otherwise, they are recognized as non-current liabilities.

Deferred Incomes and Accrual Expenses

This item includes the amount of funds received up to December 2022 and not yet fully used by 31.12.2022 for the purposes for which they were intended. They will therefore continue to provide utility in coming years, for the same purposes. This item represents the carry-over for balances of the subsequent year to that under review. In this regard, the Consortium is obliged to operate in future years in fulfilment of the mandate required by the Italian Ministry of Education, University and Scientific Research, who assigned the financial funds (FOE) under which CERIC activities were carried out in 2022.

In-kind Contributions

Contributions in-kind will be included in the financial statements on the basis of the details contained in the document entitled "Methodology for Defining the Values Involved in CERIC-ERIC Activities, and to Detail In-kind Contributions", under the conditions specified therein and only as a result of auditing carried out by local auditors, which will be comparable with that of CERIC auditors.

Profit and Loss Account

The drawing-up of the profit and loss account is regulated by the IPSAS, integrated and conformed to be consistent with the characteristics and scopes of CERIC-ERIC.

Incomes

Incomes are increases of benefits connected to the administrative year.

Costs/Expenses

Costs/expenses are decreases of economic benefits of the administrative year. The analysis of costs has been explained in the overview of profit and loss account using a classification based on their nature.

In-kind Contributions

In-kind non-monetary contributions will be distinguished (when realised) between:

1) Those strictly related to the cost of the production factors (exhausting their utilities during the ordinary cycle).

2) Those strictly related to covering investments (in intangible and tangible assets).

Assets

Non-current Assets

Tangible Assets

Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
1,559,914.69	1,434,146.36	-125,768.33

Most of the represented increase refers to purchases linked to the research project INTEGRA and to the investments related to the batteries plan. The residual part refers to supplies for the central seat.

The following flow chart shows the change in individual items summarised in the present note.

Description	Property	Technical furniture	Electronic office machines	Office furniture	Mobile phone	Equipment in progress	Total
Balance as at 31/12/2021	**-**	**1,443,640.64**	**30,024.23**	**15,883.98**	**1,356.74**	**69,009.10**	**1,559,914.69**
Acquisitions during the year	-	45,411.96	6,275.10	-	897.69	234,343.07	286,927.82
Increases during the year	-	188,866.15	-	-	-	-	188,866.15
Decreases during the year	-	-	-670.56	-	-	-188,866.15	-189,536.71
Depreciation for the year	-	-395,482.48	-10,672.93	-5,305.75	-564.43	-	-412,025.59
Balance as at 31/12/2022	**-**	**1,282,436.27**	**24,955.84**	**10,578.23**	**1,690.00**	**114,486.02**	**1,434,146.36**

The balance sheet items “Decreases during the year” is referred to the completion in 2022 of the supply of scientific instruments. Its value is included in under the acquisition made during the year.

Intangible Assets

Balance as at 31/12/2021	Balance as at 31/12/2022	Difference
53,703.31	33,745.43	-19,957.88

Historical costs at 31/12/2022 are as follows:

Description	Balance as at 31/12/2021	Operating increments	Operating decreases	Depreciation for the year	Value on 31/12/2022
Concessions, licenses, trademarks	53,703.31	1,720.71	-	-21,678.59	33,745.43
Intangible assets in progress	-	-	-	-	-
Total	**53,703.31**	**1,720.71**	**-**	**-21,678.59**	**33,745.43**

Current Assets

Short-term Credits

The balance is divided according to the deadlines of the credits:

Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
100,461.51	201,782.42	101,320.91

The negative variation in the item "Inventories" (to be referred to on-going commercial activities started in 2020) follows the completion of a commercial contract signed with the Italian representing entity, with a duration of over a year.

The composition of the amount as at 31/12/2022 is as follows:

Description	Within 12 months	Over 12 months	Over 5 years	Total
Advances to Universities	48,000.00	-	-	48,000.00
Other receivables	1,554.47	-	-	1554.47
Tax advances	32,142.66	-	-	32,142.66
Advances to suppliers	15,000.00	-	-	15,000.00
Receivables from customers	38,002.00	-	-	38,002.00
Receivables from projects funded by other institutions	67,083.29	-	-	67,083.29
Total	**201,782.42**	**-**	**-**	**201,782.42**

- The balance sheet item "Advances to Universities" represents the part of the expenses paid to Universities for activities that will be implemented in relation to the PHD programmes in the period 2023-2025.
- The balance sheet item “Other receivables” refers to payments made in relation to the destination of the severance indemnity of an employee to supplementary pension funds
- The balance sheet item “Tax advances” mainly refers to advance payments made in June and November 2022. (€ 30,800.50). These advance payments have been calculated on the basis of the fiscal charge for the previous year. The remaining part (€ 1,342.16) refers to tax advances related to the severance indemnities calculated for 2022.
- The balance sheet item “Receivables from customers” refers the completion of a commercial contract (€ 18,000.00) and to the advance invoicing of commercial services that are supposed to be completed within December 2023. (€ 20,002.00)
- The balance sheet item Receivables from projects funded by other institutions refers to the credits related to the completion of the projects ERIC FORUM (€ 55,594.71) and PaNOSC (€ 6,971.47). The remaining part refers to a credit related to a project funded by the Central Europe Initiative (€ 4,517.03).

Inventories

No values are entered for this item.

Cash and Cash Equivalents

The balance represents cash at the bank at the end of the financial year. It represents liquid assets and cash equivalents at the end of the year.

Cash deposited at the bank Unicredit Banca Spa:

Description	Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
Bank deposits	5,528,436.50	6,090,060.82	561,624.32

In this context, the Consortium is in a credit position towards the Institute Unicredit, Agency of Trieste, where it has opened a current account for financial management. In July 2022, a sum of € 3,005,000.00 was delivered to this account by the Ministry of Education, University and Scientific Research through AREA di Ricerca of Trieste, to support the Consortium’s activities for the year reviewed, according to the Collaboration Framework Agreement signed with Elettra-Sincrotrone Trieste S.c.p.A. In April 2022, CERIC received from the EU an amount of € 228,816.49, as interim payment for the PaNOSC project. In September 2022, CERIC received from the EU an amount of € 100,256.37, as advance payment for the RE-MADE project.

Prepayments and Accrued Income

Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
531,052.76	357,137.43	-173,915.33

This item measures income and expenses whose competence is delayed or advanced with respect to cash or documentary; they disregard the date of payment or collection of related income and expenses common to two or more years and distributable on time. The main part of this amount (€350,808.96) represents prepaid expenses related to costs for three-years PHDs program referring, on an accrual basis, to the period 2023- 2025. The objective of this activity is to further the integration of the partner facilities and to contribute to excellent science.
The remaining part (€6,328.47) refers to prepaid expenses related to the general costs of the Consortium) .

Reserves

No values are entered for these items.

Accumulated Profits

No values are entered for these items.

Non-current Liabilities

Other Long-term Debts and Liabilities

Advance Payments received for externally funded projects

The item "Advance payments for externally funded projects" includes the amounts listed in the table referring to the project RE-MADE which conclusion is foreseen in September 2026.

Description	ReMade
Balance as at 31/12/2021	-
Advance payment received from the EU during the year	100,256.37
Advance payment portion that is expected to be reported within December 2023	-53,343.75
Transfer of funds to project partners	-
Accrual progress report for the year 2022	-2,443.57
Balance as at 31/12/2022	**44,469.05**

Pensions Fund and Other Benefits for Compensation Employment

Severance indemnities for employees.

Description	Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
Severance indemnities for employees	191,586.78	214,663.04	23,076.26

The item is made up as follows:

Description	Initial value 31/12/2021	Plan balance 2022	Severance in-demnities transferred to complementary social security funds	Substitutive tax	Contribution to national funds for employees (FPLD)	Severances paid during the year	End value 31/12/2022
Severance indemnities for employees	191,586.78	59,059.30	2,106.98	-2,750.74	-3,351.87	-31,987.41	214,663.04

The severance set aside figure represents the actual debt of the Consortium at 31/12/2022, to employees in force at that date. The contribution to FPLD refers to the sum withheld from the severance indemnities of employees in favour of national social security institutions as a contribution to general social security purposes. The amount of the severance indemnities paid refers to the conclusion of two fixed-term contracts during 2022 for € 13,566.19; an amount of €8,800.96 refers to an advance paid to an employee and an amount (€ 9,320.51) refers to the consensual termination of a permanent contract. The remaining part (€ 299.75) refers to the destination of the severance indemnity to other forms of pension funds.

Current Liabilities

Other Short-term Debts and Liabilities

Debts

Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
422,623.13	347,584.03	-75,039.10

Debts are valued at their nominal value. The composition of the aforementioned amounts is as follows:

Description	31/12/2021	31/12/2022	Variation
Debts to providers	298,520.28	207,655.34	-90,864.94
Tax liabilities	76,672.54	89,644.25	12,971.71
Payables to social security institutions	47,430.31	50,284.44	2,854.13
Total	**422,623.13**	**347,584.03**	**-75,039.10**

“Debts to providers” are stated net of possible trade discounts.

The item “Debts to providers” (€ 207,655.34) includes debts to third parties, mainly relating to services purchased on credit. This item appears on the entity's balance sheet as a current liability, since the expectation is that the liability will be met in less than a year.

The item "Tax payables" includes liabilities for specific taxes, and is composed of withheld taxes for employees, associates and collaborators amounting to € 51,314.68, together with € 1,024,57 of VAT to be paid in 2023, and taxes due by the Consortium (€ 37,305.00). With reference to this last item, an advance payment was made in 2022 to a total amount of € 30,800.50.

“Payables due to social security institutions" includes the amount of social security contributions relating to employees, accrued but not paid as at 31 December 2022, amounting to € 50,284.44.

"Other payables" includes remaining debts, which by nature cannot be described above, including amounts due by CERIC to staff for all liabilities accrued to them, in accordance with current legislation and Personnel Regulations, including the value of accrued vacation paid at the time of reporting. This account at 31/12/2022 was as follows:

Description	31/12/2022
Payables to employees (holidays and leave not taken)	85,010.34
Advances related to commercial services	20,002.00
Payables to bodies	25,000.00
Other debts of a different nature	206,729.41
Total	**336,741.75**

The item “Payables to bodies” relates to the fee due by the Consortium to an internal auditor.

Debts are evaluated at their nominal value.

Description	31/12/2021	31/12/2022	Variation
Other payables	281,682.08	336,741.75	55,059.67

The final value as at at 31.12.2022 refers mainly to the following expenses:

- Costs for the spaces charged by Elettra for hosting the statutory seat in 2022 (€ 49,327.76)
- Costs for seconded personnel charged by Elettra, within the H2020 project PaNOSC (€ 82,695.17)
- Access costs related to beamline LISA located at ESRF and managed by CNR. (€ 60,000.00)

Advance Payments received for externally funded projects

The item "Advance payments for externally funded projects" includes the amounts listed in the table referring to the following running projects:

Description	ReMade
Balance as at 31/12/2021	-
Advance payment received from the EU during the year	100,256.37
Advance payment portion that is expected to be reported within December 2023	-44,469.05
Transfer of funds to project partners	-
Accrual progress report for the year 2022	-2,443.57
Balance as at 31/12/2022	**53,343.75**

Contingent liabilities

Description	Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
Contingent liabilities	40,783.62	40,783.62	-

The final value as at 31.12.2022 refers to the potential credit claimed by a fiscal consultancy firm. At the end of the financial year, the definition of the actual debt is not yet completed.

Deferred Income and Accrued Expenses

For accounting the contribution provided by Italy, the indirect method has been chosen and the stated amount is representative of the portion attributable to future financial years.

Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
6,629,047.05	7,079,287.22	450,240.17

The item breaks down as follows:

Description	31/12/2022
Deferred income	7,061,598.66
Accrued expenses	17,688.56

The balance sheet item "Deferred income" measures the portion of the contribution funded by the Italian MIUR for the activities of the CERIC statutory seat, deferred to the following years.
The amount of € 7,061,598.66 is derived as follows:

Category	Deferred incomes as at 31.12.2021	Italian Contribution for 2022	Consortium general expenses for 2022 covered by FOE	Consortium investments made in 2022 covered by FOE ante 2022	Depreciation quotes to be covered by external projects	Deferred incomes as at 31.12.2022
Deferred income	6,599,618.19	2,955,672.24	-2,043,469.50	-442,456.27	-7,766.00	7,061,598.66

The Italian contribution for 2022 (€ 3,005,000.00) initially defined in the collaboration framework agreement signed by CERIC and its Italian Representing Entity for the period 2020-2022, was recalculated taking into account the additional activities performed by Elettra-Sincrotrone Trieste S.c.p.A. (€49,327.76) for spaces rented to CERIC.
The amount of the carry-over for 2022 is composed as follows:

Description	Amount
Resources committed to cover the depreciation quotes covered by FOE starting from 2023	167,834.50
Orders issued as at 31.12.2022 but not closed at the end of the year	23,203.24
Resources committed to cover the depreciation costs for orders 2021 completed as at 31.12.2022	4,414.35
Resources committed to the project INTEGRA	1,949,009.20
Resources committed to cover the depreciation costs to investment made within the internal research project MAG ALCHEMI	156,065.10
Carry over 2022 committed to ordinary activities (FOE)	826,487.04
Free carry over from the previous years committed to EoI investment plan (FOE)	3,707,240.24
Resources committed to cover the investments made within the Battery Plan Programme	227,344.99
Total deferred income as at 31.12.2022	**7,061,598.66**

- The residual amount of the free carry-over resulting from 2019-2020-2021 will be used to cover the investment plan related to the CERIC EoI, together with the carry over for 2022 (EUR 826,487.04).
- The balance sheet item "Accrued expenses" measures the expenses that are recognized on the books before they have been paid. These expenses are recorded in the accounting period in which they are incurred. In particular they referred to the costs arising from the activities foreseen within the PhDs programmes agreed with the Universities.

Income Statement

Financial Revenues

Revenue items primarily identify the portion of the contribution for the financial year allocated by Italy for the Consortium's activities through the public company Area di Ricerca, to cover the expenses of management, as well as the revenues related to projects externally funded. The Italian contribution for 2022 (€ 3,005,000.00), recalculated considering the additional activities performed by Elettra-Sincrotrone Trieste S.c.p.A. (€ 49,327.76) for the spaces used by CERIC for its statutory seat, corresponds to € 2,955,672.24 . The portion of the FOE 2022 spent in the current financial year corresponds to € 2,043,469.50. This amount mainly covers the operational costs of the Consortium (staff costs, general services, consumables for the seat). Part of the general costs in 2022 were covered by the accumulated revenues related to the project funded by the EU. (€ -101,887.55). The major part of the depreciation costs are related to CERIC investment plans (Battery Plan, INTEGRA, internal research grants). These costs were instead covered by FOE funds of the previous year.

Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
2,955,392.73	2,955,672.24	279.51

The composition of the amount at 31.12.2022 is as shown in the following tables:

Category	31/12/2021	31/12/2022	Variation
MIUR ordinary contribution	3,005,000.00	3,005,000.00	0
Cost charged by the Italia RE for the spaces used by CERIC for the statutory seat	-49,607.27	-49,327.76	279.51
FOE funds 2022 used to cover Battery Plan investment to be completed in the following years	-	-76,673.22	-76,673.22
FOE funds 2022 used to cover the depreciation costs related of the investment made in 2022	-	-9,042.48	-9,042.48
FOE funds of the current financial year to be spent in the following years	-1,626,054.39	-826,487.04	799,567.35
Subtotal	**1,329,338.34**	**2,043,469.50**	**714,131.16**
Use of the carry over from previous years	412,699.10	442,456.27	29,757.17
Subtotal	**1,742,037.44**	**2,485,925.77**	**743,888.33**

Category	31/12/2021	31/12/2022	Variation
H2020 ACCELERATE Project	274,493.10	-	-274,493.10
H2020 ERIC Forum Project	58,546.55	68,371.44	9,824.89
H2020 PaNOSC Project	463,131.89	438,622.72	-24,509.17
Commercial services	102,709.10	45,000.00	-57,709.10
CEI HCS Project	-	4,615.15	4,615.15
H2020 RE-Made Project	-	2,443.57	2,443.57
Changes in inventories	-47,826.09	-	47,826.09
Other incomes	598.95	5,163.42	4,564.47
Total other incomes	**851,653.50**	**564,216.30**	**-287,437.20**

Contributions for Operating Expenses

The amount of the Italian contribution 2022 for the activities of the statutory seat of the Consortium is € 2,043,469.50. It will be reported to the Italian Ministry according to the FOE reporting rules.
This amount covered the costs for personnel, bodies, consultancies, and other costs of the seat not covered by specific externally funded projects.

Contributions In-Kind

No values are entered for these items.

Costs

Operating Costs

Costs for Raw materials, Supplies, Consumables and Goods

This category includes costs incurred for the supply of consumables. The increase in the year is a direct result of the increased activities of CERIC, in particular with reference to internal research grants.

Category	Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
Costs for raw materials, supplies, consumables and goods	30,934.14	14,138.10	-16,796.04

Most of the total value for 2022 refers to costs incurred to support the internal research project INTEGRA.

Services Costs

It has been decided to divide the item service costs, to facilitate the clarity of the budget, into the following categories of expenses:

Category	31/12/2021	31/12/2022	Variation
Legal, fiscal and administrative consultancy	13,476.91	16,809.85	3,332.94
Technical consultancies	5,351.94	1,352.00	-3,999.94
Administrative collaborators	22,540.00	30,648.00	8,108.00
Scientific and technical collaborators	105,080.00	100,914.27	-4,165.73
Social security contributions of collaborators	38,967.98	43,927.91	4,959.93
Health contribution for collaborators	468.00	472.64	4.64
ISTAC remunerations	17,857.11	20,505.83	2,648.72
Travel costs for employees, collaborators, and bodies	23,516.19	95,819.20	72,303.01
Travel costs for users	18,967.43	69,782.37	50,814.94
Insurances	10,995.20	11,503.02	507.82
Representation costs	3,091.38	3,940.51	849.13
Consulting and salaries processing	30,719.18	28,977.88	-1,741.30
Mobile phones	8,614.20	7,762.64	-851.56
Annual software licenses	2,300.88	603.59	-1,697.29
Workshops, seminars and publications	12,104.10	35,619.42	23,515.32
Canteen expenses	22,568.35	22,475.95	-92.40
Bank charges	1,715.59	1,485.45	-230.14
Postal charges	1,977.00	1,196.78	-780.22
Agreement with Universities to support PHDs	278,687.86	383,924.06	105,236.20
Maintenances	2,654.81	4,521.70	1,866.89
Training costs	619.60	328.79	-290.81
Transportation services	1,000.00	1,003.00	3.00
Other costs	184,246.98	78,620.36	-105,626.62
Technical services	-	26,600.00	26,600.00
Total	**807,520.69**	**988,795.22**	**181,274.53**

The item “Other costs” includes mainly costs related to the access costs to external research infrastructures, transportation services, proofreading services, and other minor costs.

Personnel Costs

Personnel expenses: breakdown

Category	31/12/2021	31/12/2022	Variation
Wages and salaries	659,356.59	744,116.03	84,759.44
Social security charges	194,860.08	213,489.97	18,629.89
Seconded personnel (IKCs against payment)	61,090.04	82,695.17	21,605.13
Severance indemnities	56,010.89	69,838.46	13,827.57
Allowances to be paid	81,332.83	85,010.34	3,677.51
Director	175,871.97	175,878.39	6.42
Social security charges of bodies	23,516.44	23,516.44	-
Auditors and IAEC	150,000.00	163,219.18	13,219.18
Total	**1,402,038.84**	**1,557,763.98**	**155,725.14**

Use of Third-Party Materials or Property

No values are entered for these items

Other Operating costs

Other operating costs: breakdown

Category	31/12/2021	31/12/2022	Variation
Membership fees	10,000.00	10,000.00	-
Rounding	156.08	180.65	24.57
Other taxes	225.46	248.05	22.59
Other expenditures	1,043.68	3,407.96	2,364.28
Donations	-	5,000.00	5,000.00
Total	**11,425.22**	**18,836.66**	**7,411.44**

Depreciation of Tangible and Intangible Assets

Depreciation is calculated on the basis of the useful life of the asset and its use in production. For the first year of use, the percentages applied have been reduced by half.

Intangible Assets

Description	Depreciation Rate	Amount
Concessions and licenses	20%	21,678.59
Total amortisation of intangible assets		**21,678.59**

Tangible Assets

Description	Depreciation Rate	Amount
Office machinery	20%	10,672.93
Equipment	20%	395,482.48
Telephony and mobile telephony	20%	564.43
Office furniture	15%	5,305.75
Total amortisation of fixed assets		**412,025.59**

Total amount (intangible and tangible)	**433,704.18**

Taxation

Current tax	Balance as at 31/12/2021	Balance as at 31/12/2022	Variation
IRAP	35,089.00	37,305.00	2,216.00
Total	**35,089.00**	**37,305.00**	**2,216.00**

The annual tax related to institutional activity (IRAP) is calculated on the amount of salaries paid to employees, the amount of fees paid to collaborators and the costs of contracts for temporary employment, with the exception of remunerations paid for researchers. The fiscal charge related to the commercial activity is equal to zero.

The Consortium, in the context of purchases realized, and within the limits following from the Statute, may use VAT exemptions granted on the basis of Article 143(1)(g) and Article 151(1)(b) of Council Directive 2006/112/EC, and in accordance with Articles 50 and 51 of Implementing Regulation (EU) No. 282/2011 of the Council, and on the basis of Article 12 of Directive 2008/118 /EC.

Financial Costs and Revenues

Under “Financial management”, accrued interest income on the bank account of the Consortium is stated as of 31.12.2022.

Interest on Current Account, Rounding and Exchange Rate Costs

The item represents remuneration on deposits of the Consortium on current account N. 000103334723 opened at Unicredit Banca.

Category	31/12/2021	31/12/2022	Variation
Interest on current account	482.52	569.4	86.88
Exchange rate costs	-2,201.75	-168.33	2,033.42
Total	**-1,719.23**	**401.07**	**2,120.30**

Report of the commercial activities

The limited commercial activities of the Consortium have been managed through a separate account. In 2022, one commercial contract was concluded for the value of € 45,000.00.

Revenues	
Commercial services	45,000.00
Costs	
Collaboration contracts related to the commercial activity	44,408.07
General costs*	1,002.49
Final balance	-410.56

*General costs have been calculated according to the Italian fiscal rules for commercial activities performed by non-commercial entities.

In particular, the calculation refers to the incidence of the commercial activities (€45.000.00) compared to the total amount of the revenues accounted for 2022 (€3,044,978.65). The ratio corresponds to 1.48%

The resulting percentage has been applied to the amount of €67,735.62, corresponding to the following general cost categories, common to both institutional and commercial activities and not reported within project externally funded.

Category	31/12/2022	%
Legal, fiscal and administrative consultancy	16,809.85	248.79
Insurances	11,503.02	170.24
Consulting and salaries processing	28,977.88	428.87
Mobile phones	7,762.64	114.89
Bank charges	1,485.45	21.98
Postal charges	1,196.78	17.71
Total	**67,735.62**	**1,002.49**

Events after the reporting date

Following IPSAS 14, this paragraph reports about events that occurred between the reporting date (31.12.2022) and the date when these Financial Statements were approved by the General Assembly.
The main relevant event that occurred relates to the war in Ukraine. It is relevant to state that this event can be classified among the "non-adjusting events after the reporting date" and that it does not influence the assessment of the appropriate assumption of the ongoing concern of CERIC.
The temporary consequences connected to the aforementioned event in terms of increase of the raw materials price, including energy costs, did not affect the values represented in the annual accounts 2022.
With reference to the financial year 2023 on the basis of currently available information,there are no valid reasons to believe that the aforementioned event could influence the Italian cash contribution from FOE.
With reference to the in-kind contributions provided by the Italian Representing Entity, in 2023 their amount shall be affected as a consequence of the machine downtime countermeasures taken to fight the energy cost increases in the first quarter of the financial year.

Management Report

Comparison between Final Budget and Annual Accounts

Starting from the budget for 2022 approved by the GA in November 2021, some changes were necessary as the result of the following:

EXPENDITURE COMMITMENTS, COSTS and INVESTMENTS:

1. The start of the activities related to new project funded by the EU / Central Europe Initiative
2. The acquisition of a commercial contract signed with the Italian RE.
3. The additional funds assigned to the investment plans during 2022 in relation to the calculation of the actual carry over for 2021;
4. The remodulation of the expenses within some project funded by the EU.

REVENUES

1. The calculation of the actual carry-over for 2022. The 2022 budget was approved in November 2021 by the GA taking in to account an estimation of the carry-over for the year at closing.
2. The recalculation of the revenues related to projects externally funded.
3. The additional funds related to the acquisition of new projects funded by the EU / Central Europe Initiative.

Incurred and planned expenses

EXPENSES FOR 2022					
Description	Initial budget	Changes	Final budget	Total expenses	% of expenditure
Collaboration Agreement IT PF and CERIC	2,525,000.00	-	2,525,000.00	2,525,000.00	100%
Bodies - Remuneration	197,000.00	-	197,000.00	199,951.45	101%
Remuneration for Employees	853,000.00	150,000.00	1,003,000.00	985,796.01	98%
Communication	84,000.00	-	84,000.00	42,284.51	50%
Travel Expenses	140,000.00	9,000.00	149,000.00	76,318.71	51%
External Services, Consultants, Consumables	594,000.00	-177,875.60	416,124.40	279,535.80	67%
Fixed assets	15,000.00	-	15,000.00	10,214.93	68%
Taxes	40,000.00	-	40,000.00	41,540.47	104%
Support of Italian RE to S.S.	50,000.00	-	50,000.00	49,327.76	99%
Access Costs	120,000.00	-	120,000.00	69,990.16	58%
Investment Projects (facilities)	4,260,000.00	111,240.24	4,371,240.24	112,264.71	3%
Investment Projects (HR)	350,000.00	-	350,000.00	348,332.57	100%
Commercial Activity	-	45,000.00	45,000.00	44,408.07	99%
ERIC Forum H2020	50,000.00	-	50,000.00	51,301.30	103%
PaNOSC H2020	360,000.00	-	360,000.00	407,426.05	113%
PaGES 7	-	1,000.00	1,000.00	261.87	26%
CEI - CONTACT Science@CERIC	-	34,445.00	34,445.00	22,621.96	66%
ReMade@ARI Horizon Europe	-	24,217.50	24,217.50	1,945.86	8%
TOTAL BUDGET	**9,638,000.00**	**197,027.14**	**9,835,027.14**	**5,268,522.19**	**54%**
INTEGRA	730,000.00	-	730,000.00	139,128.65	19%

VAT INTEGRA	160,000.00	-	160,000.00	28,836.12	18%
TOTAL + resources committed in previous years	**10,528,000.00**	**197,027.14**	**10,725,027.14**	**5,436,486.96**	

Revenues

Description	Initial Budget	Implemented Changes	Final Budget	Accrued Revenues	%
Carry over from previous years (incl. carry over estimation for 2021)	3,596,000.00	111,240.24	3,707,240.24	-	n.a.
Commercial activities	-	45,000.00	45,000.00	45,000.00	100%
FOE 2022 (CERIC)	5,530,000.00	-	5,530,000.00	5,530,000.00	100%
Carry over from 2022 to be spent in the following years				(826,487.04)	n.a.
PaNOSC project	450,000.00	-	450,000.00	438,622.72	97%
ERIC Forum project	62,000.00	-	62,000.00	68,371.44	110%
CEI project	-	10,000.00	10,000.00	4,615.15	46%
ReMADE project	-	24,217.50	24,217.50	2,443.57	10%
Other minor incomes	-	6,000.00	6,000.00	5,163.42	86%
Bank interests	-	569.40	569.40	569.40	100%
TOTAL	**9,638,000.00**	**197,027.14**	**9,835,027.14**	**5,268,298.66**	
Carry over committed to INTEGRA	890,000.00	-	890,000.00	167,964.77	19%
TOTAL + resources committed in previous years	**10,528,000.00**	**197,027.14**	**10,725,027.14**	**5,436,263.43**	

The following table includes the reconciliation of the expenses indicated in the final budget 2022 and the costs resulting from the Financial Statements 2022.

RECONCILIATION between BUDGET and FINANCIAL STATEMENTS – COSTS	
Description	**Amount**
TOTAL Expenses (Contract signed, incurred costs and investments)	5,436,486.96
Accrued costs for 2022	-3,050,711.47
Collaboration Agreement CERIC - Italian RE	-2,525,000.00
Support of Italian RE to S.S.	-49,327.76
Capital loss 2022	447.04
Investment	-288,648.53
(-) Contracts 2018-2021 completed as at 31.12.2022	43,049.58
Depreciation costs	433,704.18
Balance	0.00

The following table includes the reconciliation of the revenues indicated in the final budget 2022 and the revenues resulting from the Financial Statements 2022.

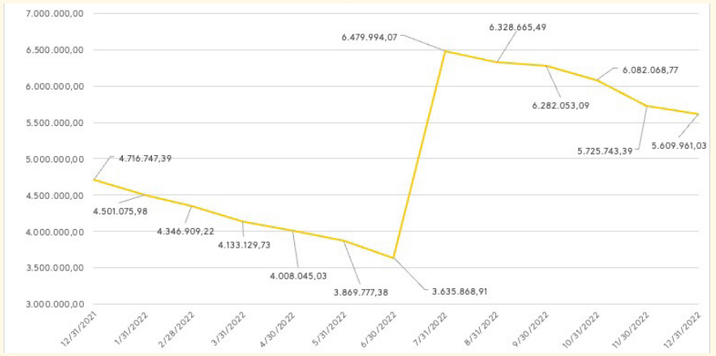
RECONCILIATION between BUDGET and FINANCIAL STATEMENTS - REVENUES	
Description	**Amount**
Total Revenues	5,436,263.43
Accrued revenues for 2022	-3,050,711.47
Collaboration Agreement CERIC - Italian RE	-2,525,000.00
Support of Italian RE to S.S.	-49,327.76
Carry over committed to INTEGRA	-167,964.77
FOE funds from the previous year spent	442,456.27
FOE funds 2022 spent to cover battery plan investment	-76,673.22
FOE funds 2022 spent to cover depreciation costs of investments made in 2022 (FOE)	-9,042.48
Balance	0.00

Statement of Cash Flow

The cash flow statement identifies the sources of cash inflows, the items on which cash was expended during the year and the cash balance as at the end of the year. Inflows and outflows are classified on the basis of their (operating or investment) nature. In the following table is included the information about the historical changes in cash (and cash equivalent) referring to operating, investing and financing activities.

Statement of cash flows for the years	2022	2021
Cash flows from operating activities		
Receipts		
CERIC externally funded projects	329,170.98	487,877.78
Commercial activities	47,000.00	40,000.00
Contribution from the host country	3,005,000.00	3,005,000.00
Interest received	421.35	357.06
Other receipts	2,515.25	9,544.19
Payments		
Payments to staff	-827,985.80	-746,877.49
Other operating payments	-1,597,620.90	-1,933,862.36
Payments to project partners	-	-383,576.49
Net Cash from Operating Activities	**958,500.88**	**478,462.69**
Cash flows from investment activities		
Purchase of plant and equipment	-397,100.08	-773,165.21
Sale of plant and equipment	223.52	-
Other	-	-
Net Cash Flow from Investment Activities	**-396,876.56**	**-773,165.21**
Cash flows from financing activities	-	-
Proceeds from borrowings	-	-
Repayment of borrowings	-	-
Other	-	-
Net Cash Flow from Financing Activities	-	-
NET INCREASE/(DECREASE) IN CASH	**561,624.32**	**-294,702.52**
CASH, BEGINNING OF THE YEAR	**5,528,436.50**	**5,823,139.02**
CASH, END OF THE YEAR	**6,090,060.82**	**5,528,436,50**

Net Financial Position - Trend for the period Jan-Dec 2022



The Net Financial Position represents the net debt position of the Consortium during the year, through comparison of the following balance items: + cash and cash equivalent | + short-term monetary credits | - short-term monetary debts

Additional disclosures on in-kind resources (with reference to Directive 2013/34/EU)

In relation to in-kind contributions, which statutorily constitute a particularly significant element in terms of the resources and organization that can be used by the Consortium, it should be noted that it was not possible to acquire all the accounting values for 2022 according to the principles of consistency and auditability on the basis of the revised "Methodology for Defining the Values Involved in the CERIC-ERIC Activities, and to Detail In-kind Contributions" approved by the General Assembly in June 2018.
However, it needs to be highlighted that, even before the set-up of the Consortium, some of the concerned PFs manifested themselves through this particular mode of contribution, which then allowed the immediate and consistent start of activities.
These values were quantified, albeit with the limitations set forth above, by the various PFs and are shown in the tables below in order to provide supplementary information, which enables a better understanding of the relevance of the total resources used by CERIC in the whole financial year 2022.

Value of the PFs and in-kind contribution. Consolidated data (2022)

Total costs of the ordinary scientific/technical activities of the Partner Facilities in 2022 - COMMITTED IN-KIND									
	Recurrent costs								
PF	**Personnel costs**	**Travel & accommo-dation and similar**	**Consumables**	**Services**	**Utilities**	**Overheads**	**Technical devaluation & maintenance, lease/rent costs of equipment & spaces**	**Cost of access committed to CERIC**	**Total**
AT	413,017.09	654.87	23,714.93	5,020.62	-	97,385.43	-	486,927.14	**539,792.94**
HR	-	-	-	-	-	-	-	41,276.73	**41,276.73**
CZ	306,122.00	28,014.00	224,912.00	81,276.00	-	187,926.75	111,383.00	9,076.75	**948,710.50**
HU	-	-	-	-	-	-	-	127,531.50	**127,531.50**
IT	24,969.91	-			-	-	-	3,261,269.69	**3,286,239.60**
PL	-	-	-	-	-	-	-	178,346.35	**178,346.35**
RO	-	-	-	-	-	-	-	-	**-**
SI	-	-	-	-	-	-	-	260,701.38	**260,701.38**
Tot.	**744,109.00**	**28,668.87**	**248,626.93**	**86,296.62**	**-**	**285,312.18**	**111,383.00**	**3,878,202.40**	**5,382,599.00**

By the time in which the notes to the financial statements have been elaborated, the Romanian PFs did not provide the requested data

5 CERIC Overview

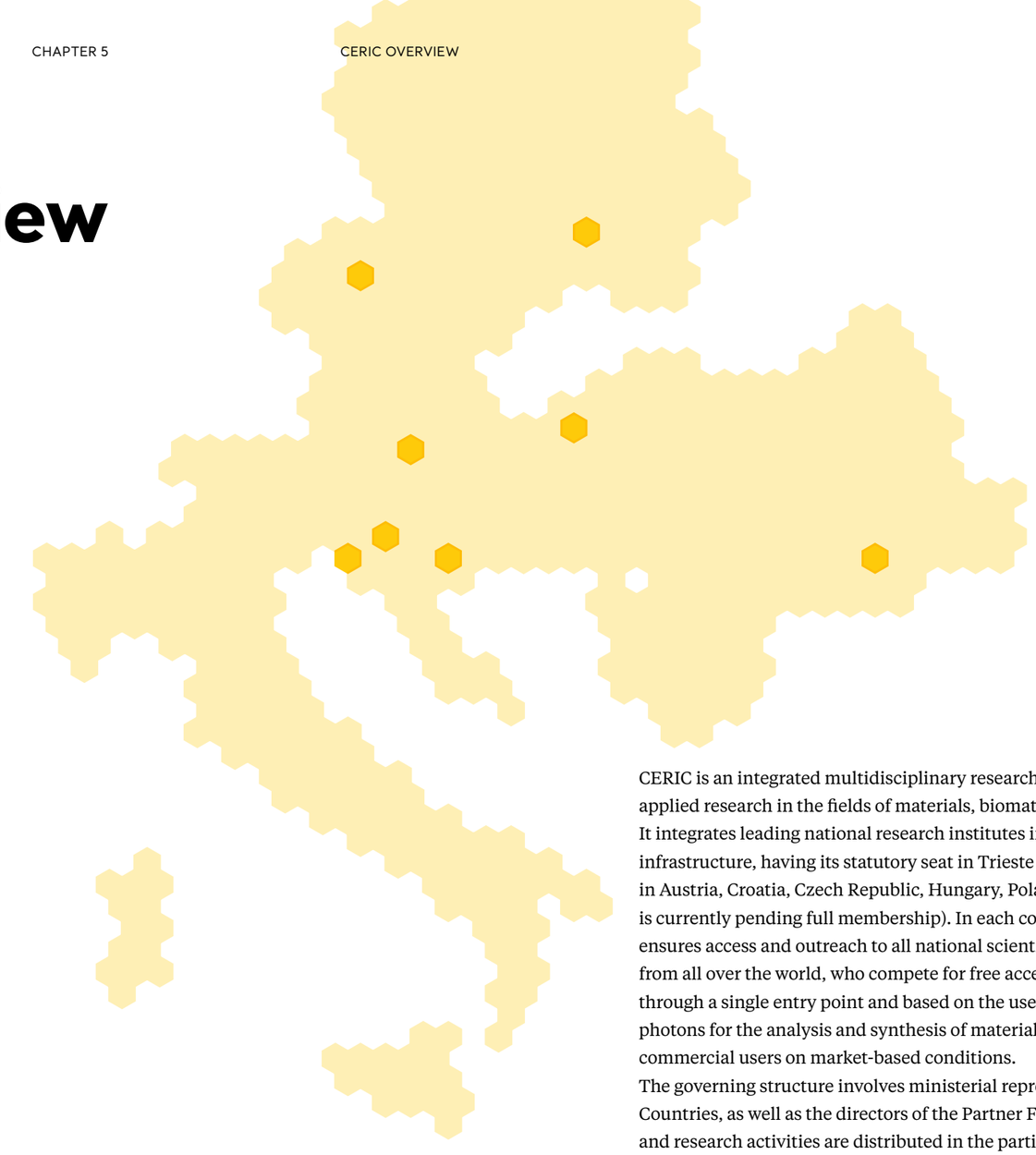
The mission and main purpose of CERIC, in line with the ERIC Regulation (EC No 723/2009), is to establish and operate a multidisciplinary distributed research infrastructure on a non-economic basis.

Mission

CERIC is a research infrastructure integrating and providing open access to some of the best facilities in Europe, to help science and industry advance in all fields of materials, biomaterials and nanotechnology. It enables the delivery of innovative solutions to societal challenges in the fields of energy, health, food, cultural heritage and more.

Vision

CERIC co-creates the European Research Area by enabling the best global researchers to realize their ideas in a multicultural research environment with a worldwide reach. By expanding insight into materials on the nano-scale, CERIC contributes to solving contemporary societal challenges.



CERIC is an integrated multidisciplinary research infrastructure for basic and applied research in the fields of materials, biomaterials and nanotechnology. It integrates leading national research institutes into a unique international infrastructure, having its statutory seat in Trieste – Italy, and its nodes distributed in Austria, Croatia, Czech Republic, Hungary, Poland, Romania and Slovenia (Serbia is currently pending full membership). In each country, a Partner Facility (PF) ensures access and outreach to all national scientific communities and to users from all over the world, who compete for free access to 50 techniques available through a single entry point and based on the use of electrons, ions, neutrons and photons for the analysis and synthesis of materials. This service is also open to commercial users on market-based conditions.

The governing structure involves ministerial representatives of the Member Countries, as well as the directors of the Partner Facilities. CERIC management and research activities are distributed in the participating countries and cover administration, communication, technology transfer and project management. A common support system allows the distributed staff to operate in an integrated way for transnational and cooperative projects and joint ventures.

Each Member Country contributes to CERIC by making available and supporting a high-quality PF, which is continuously improved by being exposed to international users competing for access through peer-review evaluation and selection of their proposals, based on excellence. The PFs are strongly complementary to each other and act as a whole as an international agency providing support to the best researchers and research projects, contributing access to advanced analytical and synthesis facilities.

CERIC's international, pan-European approach, in line with ERIC Regulation EC No 723/2009, avoids duplication and fragmentation in the research system, and increases the integration and competitiveness of the European Research Area (ERA), speeding up East-West alignment in the ERA.

CERIC Partner Facilities, Instruments and Techniques

AUSTRIA

Graz University of Technology

is dedicated to the structural characterisation of nanosystems with scattering techniques covering topics such as advanced materials, (bio-)polymers, proteins in solids, surfaces, liquids and in the gas phase. The facility provides access to its light and X-ray scattering laboratories, as well as to the Austrian SAXS beamline and Deep X-ray Lithography beamline, both at Elettra.

CROATIA

Ruđer Bošković Institute

develops and allows access to ion beam techniques for materials' modification and characterization, such as PIXE and RBS, as well as a heavy ion microprobe, dual beam irradiation chamber with RBS/channeling, and TOF ERDA spectrometer.

CZECH REPUBLIC

Charles University Prague

has expertise in surface analysis, thin film growth and studies of the reaction mechanism on catalyst surfaces. It offers Photoelectron Spectroscopy (XPS, XPD, ARUPS) with Low Energy Ion Scattering Spectroscopy and LEED, Field Emission Gun Scanning Electron Microscope, Near Ambient Pressure XPS and access to the Materials Science Beamline at synchrotron Elettra dedicated to soft X-ray photoelectron spectroscopy and NEXAFS.

HUNGARY

Budapest Neutron Centre

performs and offers R&D in nuclear science and technology, studying the interaction of radiation with matter and doing isotope and nuclear chemistry, radiography and radiation chemistry, surface chemistry and catalysis (PGAA, NAA, RAD). Neutron scattering instruments allow investigation of the microscopic properties of solids, liquids, soft materials, biological objects and condensed matter (PSD, SANS, TOF, GINA, MTEST, BIO, TAST).

ITALY

Elettra Sincrotrone Trieste

covers a wide range of experimental techniques and scientific fields, including photoemission, spectromicroscopy, crystallography, dichroic absorption spectroscopy, x-ray imaging, etc.

POLAND

Polish Ministry of Science and Higher Education

offers techniques based on synchrotron radiation: the PEEM/XAS beamline (200-2000 eV photon energy range) is equipped with PEEM - Photoemission Electron Microscopy - and XAS, devoted to spectroscopy studies by absorption of soft X-rays. The UARPES undulator beamline (8-100 eV photon energy range) is equipped with an ARPES end-station, allowing precise studies on the structure of energy bands of solids and their surfaces. The new cryo transmission electron microscope FEI Titan Krios 3Gi enables researchers to look at the macromolecules almost in their natural environment.

ROMANIA

National Institute of Materials Physics

offers access to HRTEM and EPR laboratories for research in solid state physics and materials science, including the synthesis and characterisation of advanced materials for applications in microelectronics, catalysis, energy industry and ICT.

SLOVENIA

National Institute of Chemistry

offers NMR spectroscopy for chemical analysis and identification, for determining 3D structures and studying the dynamics of small and larger bio-macro-molecules, for tracking chemical reactions in analytical and bioanalytical procedures, for studying polycrystallinity and identifying metabolites and various amorphous forms.

Associated Facilities

FRANCE

X-ray absorption spectroscopy beamline at ESRF

GREECE

Ultraviolet Laser Facility of the Foundation for Research and Technology (ULF-FORTH)
a multi-disciplinary scientific laboratory dedicated to laser-based science, supporting high quality basic and technological research.

ITALY

European Commission's Joint Research Centre (JRC) Nanobiotechnology Laboratory in Ispra
allowing interdisciplinary studies with a special emphasis on the characterisation of nanomaterials, nanomedicines, advanced materials and micro(nano)plastics.

Bio Open Lab (BOL) in Salento, Salerno and Trieste
providing an integrated system of research equipment and instruments dedicated to investigations in the field of biological and biomedical research

Scientific Publications

One hundred and twenty (120) articles were published in 2022, with a cumulative impact factor of 762,92 (versus 727,9 in 2021) and an average impact factor of 6,52 (versus 6.93 in 2021):

(1) *Biocompatibility and antibacterial properties of TiCu (Ag) thin films produced by physical vapor deposition magnetron sputtering*, Rashid S., Vita G. M., Persichetti L., Iucci G., Battocchio C., Daniel R., Visaggio D., Marsotto M., Visca P., Bemporad E., Ascenzi P., Capellini G., Sebastiani M., & Di Masi A., Applied Surface Science, 2022.

(2) *Structural specificity of groove binding mechanism between imidazolium-based Ionic Liquids and DNA revealed by synchrotron-UV Resonance Raman spectroscopy and molecular dynamics simulations*, Fadaei F., Tortora M., Gessini A., Masciovecchio C., Catalini S., Vigna J., Mancini I., Mele A., Vacek J., Reha D., Minofar B., & Rossi B., Journal of Molecular Liquids, 2022.

(3) *The effect of lanthanum in Cu/La(-Zr)-Si oxide catalysts for aqueous ethanol conversion into 1,3-butadiene*, Kyriienko P. I., Larina O. V., Balakin D. Y., Vorokhta M., Khalakhan I., Sergiienko S. A., Soloviev S. O., Orlyk S. M., Molecular Catalysis, 2022.

(4) *Benzohydroxamic acid on rutile TiO2 (110)-(1× 1)–a comparison of ultrahigh-vacuum evaporation with deposition from solution*, Köbl J., Fernández C. C., Augustin L. M., Kataev E. Y., Franchi S., Tsud N., Pistonesi C., Estela Pronsato M., Jux N., Lytken O., Williams F. J., & Steinrück H. P., Surface Science, 2022.

(5) *Thiolate end-group regulates ligand arrangement, hydration and affinity for small compounds in monolayer-protected gold nanoparticles*, Pellizzoni E., Şologan M., Daka M., Pengo P., Marson D., Posel Z., Franchi S., Bignardi L., Franchi P., Lucarini M., Posocco P., & Pasquato L., Journal of Colloid and Interface Science, 2022.

(6) *Characterization of innovative Pt-ceria catalysts for PEMFC by means of ex-situ and operando X-Ray Absorption Spectroscopy*, Pollastri S., Bogar M., Fiala R., Amenitsch H., Yakovlev Y., Lavacchi A., Aquilanti G., & Matolin V., International Journal of Hydrogen Energy, 2022.

(7) *Revealing hidden molecular nanostructure details in the pellet formulation of ibuprofen by combining Synchrotron and laboratory sources*, Hodzic A., Birarda G., Juraic K., Sket P., Eder S., Kriechbaum M., D'amico F., De Giacomo O., & Roblegg E., Journal of Drug Delivery Science and Technology, 2022.

(8) *Progress and perspective on different strategies to achieve wake-up-free ferroelectric hafnia and zirconia-based thin films*, Silva J.P.B., Sekhar K.C., Negrea R.F., MacManus-Driscoll J.L., Pintilie L., Applied Materials Today, 2022.

(9) *Metal Sulfide Thin Films with Tunable Nanoporosity for Photocatalytic Applications*, Vakalopoulou E., Rath T., Krauter M., Torvisco A., Fischer R. C., Kunert B., Resel R., Schröttner H., Coclite A. M., Amenitsch H., & Trimmel, G., ACS Applied Nano Materials, 2022.

(10) *Taurine Stabilizing Effect on Lysozyme, Mastrella L.*, Moretti P., Pieraccini S., Magi S., Piccirillo S., & Ortore M. G., Life, 2022.

(11) *SAXS Reveals the Stabilization Effects of Modified Sugars on Model Proteins*, Piccinini A., Lourenço E. C., Ascenso O. S., Ventura M. R., Amenitsch H., Moretti P., Mariani P., Ortore M. G., & Spinozzi F., Life, 2022.

(12) *Redox-mediated C− C bond scission in alcohols adsorbed on CeO2-x thin films*, Lykhach Y., Johánek V., Neitzel A., Skála T., Tsud N., Beranová K., Myslivecek J., Brummel O., & Libuda J., Journal of Physics: Condensed Matter, 2022.

(13) *Pushing Stoichiometries of Lithium-Rich Layered Oxides Beyond Their Limits*, Celeste A., Brescia R., Greco G., Torelli P., Mauri S., Silvestri L., Pellegrini V., & Brutti S., ACS Applied Energy Materials, 2022.

(14) *Patterning a cellulose based dual-tone photoresist via deep X-ray lithography*, Andreev M., Marmiroli B., Schennach R., & Amenitsch H., Microelectronic Engineering, 2022.

(15) *Surface Zn enrichment induced by excimer laser annealing in ZnO nanorods*, Carlomagno I., Lucarini I., Secchi V., Maita F., Polese D., Mirabella S., Franzò G., Notargiacomo A., Di Santo G., Gonzalez S., Petaccia L., & Maiolo L., Applied Surface Science, 2022.

(16) *Synthesis, crystal structure and electronic structure of Ag_xZrTe_2*, Shkvarina E. G., Merentsov A. I., Shkvarin A. S., Postnikov M. S., Titov A. A., Tsud N., Yarmoshenko Yu.M., Patrakov E. I., & Titov A. N., Journal of Alloys and Compounds, 2022.

(17) *X-Ray Lithography for Nanofabrication: is there a Future?*, Bharti A., Turchet A., & Marmiroli B, Frontiers in Nanotechnology, 2022.

(18) *Deeper Insights into the Photoluminescence Properties and (Photo)Chemical Reactivity of Cadmium Red (CdS1−xSex) Paints in Renowned Twentieth Century Paintings by State-of-the-Art Investigations at Multiple Length Scales*, Monico L., Rosi F., Vivani R., Cartechini L., Janssens K., Gauquelin N., Chezganov D., Verbeek J., Cotte M., d'Acapito F., Barni L., Grazia C., Pensabene Buemi L., Andral J-L., Miliani C., & Romani A., The European Physical Journal Plus, 2022.

(19) *Conformational plasticity of DNA secondary structures: probing the conversion between i-motif and hairpin species by circular dichroism and ultraviolet resonance Raman spectroscopic*, Amato J., Iaccarino N., D'Aria F., D'Amico F., Randazzo A., Giancola C., Cesàro A., Di Fonzo S., & Pagano B., Physical Chemistry Chemical Physics, 2022.

(20) *High-Energy Heavy Ion Irradiation of Al_2O_3, MgO and CaF_2*, Hanžek J., Dubček P., Fazinić S., Tomić Luketić K., & Karlušić M., Materials, 2022.

(21) *Evidence of hybridization states at the donor/acceptor interface: case of m-MTDATA/PPT*, Zhang T., Wang T., Grazioli C., Guarnaccio A., Brumboiu I. E., Johansson F. O., Beranová K., Coreno M., de Simone M., Brena B., Liu L., Wang Y., & Puglia C., Journal of Physics: Condensed Matter, 2022.

(22) *m-MTDATA on Au (111): Spectroscopic Evidence of Molecule–Substrate Interactions*, Zhang T., Grazioli C., Guarnaccio A., Brumboiu I. E., Lanzilotto V., Johansson F. O., Beranová K., Coreno M., de Simone M., Brena B., & Puglia C., The Journal of Physical Chemistry C, 2022.

(23) *Clarifying the Adsorption of Triphenylamine on Au (111): Filling the HOMO–LUMO Gap*, Zhang T., Svensson P. H., Brumboiu I. E., Lanzilotto V., Grazioli C., Guarnaccio A., Johansson F. O., Beranová K., Coreno M., de Simone M., Floreano L., Cossaro A., Brena B. & Puglia C., The Journal of Physical Chemistry C, 2022.

(24) *Cu (I) and Cu (II) Complexes Based on Lonidamine-Conjugated Ligands Designed to Promote Synergistic Antitumor Effects*, Del Bello F., Pellei M., Bagnarelli L., Santini C., Giorgioni G., Piergentili A., Quaglia W., Battocchio C., Iucci G., Schiesaro I., Meneghini C., Venditti I., Ramanan N., De Franco F., Sgarbossa P., Marzano C., & Gandin V., Inorganic Chemistry, 2022.

(25) *Adatom and Nanoparticle Dynamics on Single-Atom Catalyst Substrates*, Farnesi Camellone M., Dvořak F., Vorokhta M., Tovt A., Khalakhan I., Johánek V., Skála T., Matolínová I., Fabris S., & Myslivecek J., ACS Catalysis, 2022.

(26) *SR-FTIR microscopy for the study of residues on Palaeolithic stone tools: looking for a methodological protocol*, Dominici C., Stani C., Rossini M., & Vaccari L., Journal of Physics: Conference Series, 2022.

(27) *Improved stabilization scheme for extreme ultraviolet quantum interference experiments*, Uhl D., Wituschek A., Bangert U., Binz M., Callegari C., Di Fraia M., Plekan O., Prince K. C., Cerullo G., Giannessi L., Danailov M., Sansone G., Laarmann T., Michiels R., Mudrich M., Piseri P., Squibb R. J., Feifel R., Stranges S., Stienkemeier F., L. Bruder, Journal of Physics B: Atomic, Molecular and Optical Physics, 2022.

(28) *Insight into the interdependence of Ni and Al in bifunctional Ni/ZSM-5 catalysts at the nanoscale*, Vu H-T., Arčon I., de Souza D. O., Pollastri S., Dražić G., Volavšek J., Mali G., Logar N. Z., Tušar N. N., Nanoscale Advances, 2022.

(29) *Interfacial Water and Microheterogeneity in Aqueous Solutions of Ionic Liquids*, Bottari C., Almásy L., Rossi B., Bracco B., Paolantoni M., Andrea Mele A., Journal of Physical Chemistry B, 2022.

(30) *Investigation on a MMACHC mutant from cblC disease: The c. 394C> T variant*, Passantino R., Mangione M. R., Ortore M. G., Costa M. A., Provenzano A., Amenitsch H., Sabbatella R., Alfano C., Martorana V., & Vilasi S., Biochimica et Biophysica Acta (BBA)-Proteins and Proteomics, 2022.

(31) *Supramolecular Chalcogen-Bonded Semiconducting Nanoribbons at Work in Lighting Devices*, Romito D., Fresta E., Cavinato L. M., Kählig H., Amenitsch H., Caputo L., Chen Y., Samorì P., Charlier J-C., Costa R., & Bonifazi D., Angewandte Chemie, 2022.

(32) *Polylactide-Grafted Metal-Alginate Aerogels*, Raptopoulos G., Choinopoulos I., Kontoes-Georgoudakis F., & Paraskevopoulou P., Polymers, 2022.

(33) *Effect of the sintering temperature on microstructure and optical properties of reactive sintered YAG: Sm3+ ceramics*, Timoshenko A. D., Doroshenko A. G., Parkhomenko S. V., Vorona I. O., Kryzhanovska O. S., Safronova N. A., Vovk O. O., Tolmachev A. V., Baumer V. N., Matolinova I., & Yavetskiy R. P., Optical Materials: X, 2022.

(34) *Influence of relative humidity on CO2 interaction mechanism for Gd-doped SnO2 with respect to pure SnO2 and Gd2O3*, Ghica C., Mihalcea C. G., Simion C. E., Vlaicu I. D., Ghica D., Dinu I. V., Florea O. G., & Stanoiu A., Sensors and Actuators B: Chemical, 2022.

(35) *Tailorable exchange bias and memory of frozen antiferromagnetic spins in epitaxial CoO (1 1 1)/Fe (1 1 0) bilayers*, Ślęzak M., Dróżdż P., Janus W., Szpytma M., Nayyef H., Kozioł-Rachwał A., Zając, M., & Ślęzak, T., Journal of Magnetism and Magnetic Materials, 2022.

(36) *Chemical Doping of the Organic Semiconductor C8-BTBT-C8 Using an Aqueous Iodine Solution for Device Mobility Enhancement*, Li J., Babuji A., Temiño I., Salzillo T., D'Amico F., Pfattner R., Ocal C., Barrena E., & Mas-Torrent M., Advanced Materials Technologies, 2022.

(37) *Efficient Co-NC electrocatalysts for oxygen reduction derived from deep eutectic solvents*, Pariiska O., Mazur D., Cherchenko K., Kurys Y., Koshechko V., & Pokhodenko V., Electrochimica Acta, 2022.

(38) *$NaMn_{0.2}Fe_{0.2}Co_{0.2}Ni_{0.2}Ti_{0.2}O_2$ high-entropy layered oxide–experimental and theoretical evidence of high electrochemical performance in sodium batteries*, Walczak K., Plewa A., Ghica C., Zając W., Trenczek-Zając A., Zając M., Toboła J., & Molenda J., Energy Storage Materials, 2022.

(39) *Polystyrene perturbs the structure, dynamics, and mechanical properties of DPPC membranes: An experimental and computational study*, Bochicchio D., Cantu L., Cadario M. V., Palchetti L., Natali F., Monticelli L., Rossi G., & Del Favero E., Journal of Colloid and Interface Science, 2022.

(40) *Human Virus Genomes Are Enriched in Conserved Adenine/Thymine/Uracil Multiple Tracts That Pause Polymerase Progression*, Ruggiero E., Lavezzo E., Grazioli M., Zanin I., Marušič M., Plavec J., Richter S. N., & Toppo S., Frontiers in Microbiology, 2022.

(41) *Thiolated Chitosan Conjugated Liposomes for Oral Delivery of Selenium Nanoparticles*, Selmani A., Seibert E., Tetyczka C., Kuehnelt D., Vidakovic I., Kornmueller K., Absenger-Novak M., Radatović B., Vinković Vrček I., Leitinger G., Fröhlich E., Bernkop-Schnürch A., Roblegg E., & Prassl R., Pharmaceutics, 2022.

(42) *Growing and stabilizing metallic nanoparticles inside mesoporous oxide thin films*, Zalduendo M. M., Steinberg P. Y., Coneo-Rodríguez R., Bordoni A. V., & Angelomé P. C., Science Talks, 2022.

(43) *In Situ Study of Nanoporosity Evolution during Dealloying AgAu and CoPd by Grazing-Incidence Small-Angle X-ray Scattering*, Goßler M., Hengge E., Bogar M., Albu M., Knez D., Amenitsch H., & Wurschum R., The Journal of Physical Chemistry C, 2022.

(44) *The Unexpected Helical Supramolecular Assembly of a Simple Achiral Acetamide Tecton Generates Selective Water Channels*, Dumitrescu D. G., Rull-Barull J., Martin A. R., Masquelez N., Polentarutti M., Heroux A., Krajnc A., Legrand B., Legrand, Y.M., Mali G., & Legrand B., Chemistry–A European Journal, 2022.

(45) *Effects of Calcination Temperature on CO-Sensing Mechanism for NiO-Based Gas Sensors*, Stanoiu A., Ghica C., Mihalcea C. G., Ghica D., Somacescu S., Florea O. G., & Simion C. E., Chemosensors, 2022.

(46) *Effect of lithium substitution with sodium on electrical properties in La0. 5Li0. 5-xNaxTiO3 and La0. 67Li0. 2-yNayTi0. 8Al0. 2O3 solid solutions*, Plutenko T., V'yunov O., Yanchevskii O., Fedorchuk O., Belous A., & Plutenko M., Solid State Communications, 2022.

(47) *SAXS measurements of azobenzene lipid vesicles reveal buffer-dependent photoswitching and quantitative Z-> E isomerisation by X-rays*, Ober M. F., Müller-Deku A., Baptist A., Ajanović B., Amenitsch H., Thorn-Seshold O., & Nickel B., Nanophotonics, 2022.

(48) *Role of Phase Stabilization and Surface Orientation in 4, 4'-Biphenyl-Dicarboxylic Acid Self-Assembly and Transformation on Silver Substrates*, Makoveev A. O., Procházka P., Blatnik M., Kormoš L., Skala T., & Čechal J., The Journal of Physical Chemistry C, 2022.

(49) *Conformational Properties of New Thiosemicarbazone and Thiocarbohydrazone Derivatives and Their Possible Targets*, Georgiou N., Katsogiannou A., Skourtis D., Iatrou H., Tzeli D., Vassiliou S., Javornik U., Plavec J., & Mavromoustakos T., Molecules, 2022.

(50) *Chitosan-Hyaluronan Nanoparticles for Vinblastine Sulfate Delivery: Characterization and Internalization Studies on K-562 Cells*, Cannavà C., De Gaetano F., Stancanelli R., Venuti V., Paladini G., Caridi F., Ghica C., Crupi V., Majolino D., Ferlazzo G., Tommasini S., & Ventura C. A., Pharmaceutics, 2022.

(51) *Phenylene-Bridged Perylene Monoimides as Acceptors for Organic Solar Cells: A Study on the Structure–Property Relationship*, Schweda B., Reinfelds M., Hofinger J., Bäumel G., Rath T., Kaschnitz P., Fischer R. C., Flock M., Amenitsch H., Scharber M. C., & Trimmel G., Chemistry–A European Journal, 2022.

(52) *Honeycomb-structured copper indium sulfide thin films obtained via a nanosphere colloidal lithography method*, Vakalopoulou E., Rath T., Warchomicka F. G., Carraro F., Falcaro P., Amenitsch H., & Trimmel G., Materials Advances, 2022.

(53) *Human antimicrobial peptide triggered colloidal transformations in bacteria membrane lipopolysaccharide*, Hong L., Gontsarik M., Amenitsch H., & Salentinig S., Small, 2022.

(54) *Anchoring of phthalic acid on MgO (100),* Kataev E. Y., Fromm L., Tariq Q., Wechsler D., Williams F. J., Tsud N., Franchi S., Steinrück H-P., Görling A., & Lytken O., Surface Science, 2022.

(55) *Understanding self-assembly at molecular level enables controlled design of DNA G-wires of different properties,* Pavc D., Sebastian N., Spindler L., Drevenšek-Olenik I., Podboršek G. K., Plavec J., & Šket P., Nature communications, 2022.

(56) *Unravelling the phase transition of 2H-MoS2 to 1T-MoS2 induced by the chemical interaction of Pd with molybdenum disulfide–graphene hybrids*, Tsikritzis D., Tsud N., Skála T., & Sygellou L., Applied Surface Science, 2022.

(57) *Structural Diversity in Multicomponent Nanocrystal Superlattices Comprising Lead Halide Perovskite Nanocubes*, Cherniukh I., Sekh T. V., Rainò G., Ashton O. J., Burian M., Travesset A., Athanasiou M., Manoli A., Rohit Abraham J., Svyrydenko M., Morad V., Shynkarenko Y., Montanarella F., Naumenko D., Amenitsch H., Grigorios I., Rainer F. M., Rolf E., Kovalenko M. V., & Bodnarchuk M. I., ACS nano, 2022.

(58) *Unraveling the nature of sulfur-bearing silicate-phosphate glasses: Insights from multi-spectroscopic (Raman, MIR, 29Si, 31P MAS-NMR, XAS, XANES) investigation*, Berezicka A., Szumera M., Sułowska J., Jeleń P., Olejniczak Z., Stępień J., Zając M., Pollastri S., & Olivi L., Ceramics International, 2022.

(59) *Cell medium-dependent dynamic modulation of size and structural transformations of binary phospholipid/ω-3 fatty acid liquid crystalline nano-self-assemblies: Implications in interpretation of cell uptake studies*, Bor G., Salentinig S., Şahin E., Ödevci B. N., Roursgaard M., Liccardo L., Hamerlik P., Moghimi S. M., & Yaghmur A., Journal of Colloid and Interface Science, 2022.

(60) *Charge State Effects in Swift-Heavy-Ion-Irradiated Nanomaterials*, Tomić Luketić K., Hanžek J., Mihalcea C. G., Dubček P., Gajović A., Siketić Z., Jakšić M., Ghica C., & Karlušić M., Crystals, 2022.

(61) *Copper Adatoms Mediated Adsorption of Benzotriazole on a Gold Substrate*, Grillo F., Gattinoni C., Larrea C. R., Lacovig P., & Richardson N. V, Applied Surface Science, 2022.

(62) *In Situ Observation of Morphological and Oxidation Level Degradation Processes within Ionic Liquid Post-treated PEDOT: PSS Thin Films upon Operation at High Temperatures Oechsle*, A. L., Heger J. E., Li N., Yin S., Bernstorff S., & Müller-Buschbaum P., ACS Applied Materials & Interfaces, 2022.

(63) *Development of vanadium-based polyanion positive electrode active materials for high-voltage sodium-based batteries*, Shraer S. D., Luchinin N. D., Trussov I. A., Aksyonov D. A., Morozov A. V., Ryazantsev S. V., Iarchuk A. R., Morozova P. A., Nikitina V. A., Stevenson K. J., Antipov E. V., Abakumov A. M., & Fedotov S. S., Nature Communications, 2022.

(64) *Long-term sulfate resistance of synthesized cement systems with variable C3A/C4AF ratio at low temperature or ambient conditions: Insights into the crystalline and amorphous phase assemblage*, Sotiriadis K., Mróz R., Mácová P., Mazur A. S., & Krajnc A., Cement and Concrete Research, 2022.

(65) *There is life after coking for Ir nanocatalyst superlattices*, Martínez-Galera A. J., Guo H., Jiménez-Sánchez M. D., Franchi S., Prince K. C., & Gómez-Rodríguez J. M., Nano Research, 2022.

(66) *Thermal stability and protective properties of phenylphosphonic acid on Cu (111)*, Kalinovych V., Rahman M. S., Piliai L., Kosto Y., Mehl S. L., Skála T., Matolínová I., Matolín V., Prince K. C., Xu Y., & Tsud N., Applied Surface Science, 2022.

(67) *Particle Size and Shape Effects in Electrochemical Environments: Pd Particles Supported on Ordered Co3O4 (111) and Highly Oriented Pyrolytic Graphite*, Kastenmeier M., Fusek L., Deng X., Skála T., Mehl S., Tsud N., Grau S., Stumm C., Uvarov V., Johánek V., Libuda J., Lykhach Y., Mysliveček J., & Brummel O., The Journal of Physical Chemistry C, 2022.

(68) *A multitechnique approach to unveil redox behaviour and potentiality of homoleptic CuI complexes based on substituted bipyridine ligands in oxygenation reactions*, Centrella B., Deplano G., Damin A. A., Signorile M., Tortora M., Barolo C., Bonomo M., & Bordiga, S., Dalton Transactions, 2022.

(69) *Visible-Light-Active Black TiO2 Nanoparticles with Efficient Photocatalytic Performance for Degradation of Pharmaceuticals*, Andronic L., Ghica D., Stefan M., Mihalcea C. G., Vlaicu A. M., & Karazhanov S., Nanomaterials, 2022.

(70) *Deep X-ray lithography on "sol–gel" processed noble metal mesoarchitectured films*, Gayrard M., Marmiroli B., Chancerel F., Decorse P., Amenitsch H., Peron J., Cattoni A. & Faustini M., Nanoscale, 2022.

(71) *Improving the Efficiency of Gallium Telluride for Photocatalysis, Electrocatalysis, and Chemical Sensing through Defects Engineering and Interfacing with its Native Oxide*, Bondino F., Duman S., Nappini S., D'Olimpio G., Ghica C., Menteş T. O., Mazzola F., Istrate M. C., Jugovac M., Vorokhta M., Santoro S., Gürbulak B., Locatelli A., Boukhvalov D., W., & Politano A., Advanced Functional Materials, 2022.

(72) *Operando study of structure degradation in solid-state dye-sensitized solar cells with a TiO2 photoanode having ordered mesopore arrays*, Li N., Guo R., Oechsle A. L., Reus M. A., Liang S., Song L., Wang K., Yang D., Allegretti F., Kumar A., Nuber M., Berger J., Bernstorff S., Iglev H., Hauer J., Fischer R. A., Barth J. V., & Müller-Buschbaum P., Solar RRL, 2022.

(73) *Metal–Support Interaction and Charge Distribution in Ceria-Supported Au Particles Exposed to CO*, Bezkrovnyi O., Bruix A., Blaumeiser D., Piliai L., Schötz S., Bauer T., Khalakhan I., Skála T., Matvija P., Kraszkiewicz P., Pawlyta M., Vorokhta M., Matolínová I., Libuda J., Neyman K. M., & Kepiński L., Chemistry of Materials, 2022.

(74) *Struvite-K crystal growth inhibition by citric acid: Formation of complexes in solution and surface adsorption effects*, Viani A., Zárybnická L., Ševčík R., Mácová P., Machotová J., Veltruská K., Journal of Crystal Growth, 2022.

(75) *Thermal Decomposition Pathways of Zn x Fe3–x O4 Nanoparticles in Different Atmospheres*, Kuciakowski J., Stepień J., Zukrowski J., Lachowicz D., Żywczak A., Gajewska M., Przybylski M., Pollastri S., Olivi L., Sikora M. & Kmita A., Industrial & Engineering Chemistry Research, 2022.

(76) *Ligand-based drug repurposing strategy identified SARS-CoV-2 RNA G-quadruplex binders*, Moraca F., Marzano S., D'Amico F., Lupia A., Di Fonzo S., Vertecchi E., Salvati E., Di Porzio A., Catalanotti B., Randazzo A., Pagano B. & Amato J., Chemical Communications, 2022.

(77) *Organoselenium compounds as functionalizing agents for gold nanoparticles in cancer therapy*, Lorenzoni S., Cerra S., Angulo-Elizari E., Salamone T. A., Battocchio C., Marsotto M., Scaramuzzo F. A., Sanmartín C., Plano D., & Fratoddi I., Colloids and Surfaces B: Biointerfaces, 2022.

(78) *Investigation of diclofenac release and dynamic structural behavior of non-lamellar liquid crystal formulations during in situ formation by UV-Vis imaging and SAXS*, Mertz N., Bock F., Østergaard J., Yaghmur A., & Larsen S. W., International Journal of Pharmaceutics, 2022.

(79) *A Nanofocused Light on Stradivari Violins: Infrared s-SNOM Reveals New Clues Behind Craftsmanship Mastery*, Stani C., Invernizzi C., Birarda G., Davit P., Vaccari L., Malagodi M., Gulmini M., & Fiocco G., Analytical Chemistry, 2022.

(80) *The intriguing dose-dependent effect of selected amphiphilic compounds on insulin amyloid aggregation: Focus on a cholesterol-based detergent*, Chobimalt, Siposova K., Petrenko V. I., Garcarova I., Sedlakova D., Almásy L., Kyzyma O. A., Kriechbaum M., & Musatov A., Frontiers in Molecular Biosciences, 2022.

(81) *Improved stabilization scheme for extreme ultraviolet quantum interference experiments*, Uhl D., Wituschek A., Bangert U., Binz M., Callegari C., Di Fraia M., Plekan O., Prince K. C., Cerullo G., Giannessi L., Danailov M., Sansone G., Laarmann T., Michiels R., Mudrich M., Piseri P., Squibb R. J., Feifel R., Stranges S., Stienkemeier S. & Bruder L., Journal of Physics B: Atomic, Molecular and Optical Physics, 2022.

(82) *A multi-technique approach to unveil the redox behaviour and potentiality of homoleptic Cu I complexes based on substituted bipyridine ligands in oxygenation reactions*, Centrella B., Deplano G., Damin A., Signorile M., Tortora M., Barolo C., Bomono M., & Bordiga S., Dalton Transactions, 2022.

(83) *Ge/Al and Ge/Si3N4/Al Core/Shell Quantum Dot Lattices in Alumina: Boosting the Spectral Response by Tensile Strain*, Periša I., Tkalčević M., Isaković S., Basioli L., Ivanda M., Bernstorff S., & Mičetić M., Materials, 2022.

(84) *Multiple Exciton Generation in 3D-Ordered Networks of Ge Quantum Wires in Alumina Matrix*, Tkalčević M., Boršćak D., Periša I., Bogdanović-Radović I., Šarić Janković I., Petravić M., Bernstorff S. & Mičetić M., Materials, 2022.

(85) *Removal of the As (V) and Cr (VI) from the Water Using Magnetite/3D-Printed Wollastonite Hybrid Adsorbent*, Popović M., Veličković Z. S., Bogdanov J., Marinković A. D., Casas Luna M., Trajković I., Obradović N., & Pavlović V., Science of Sintering, 2022.

(86) *C-doped TiO2 nanotubes with pulsed laser deposited Bi2O3 films for photovoltaic application*, Bjelajac A., Petrović R., Stan G. E., Socol G., Mihailescu A., Mihailescu I. N., Veltruska K., Matolin V., Siketić Z., ProvatasG., Jakšić M., & Janaćković D., Ceramics International, 2022.

(87) *Magnetic Levitation Patterns of Microfluidic-Generated Nanoparticle–Protein Complexes*, Digiacomo L., Quagliarini E., Marmiroli B., Sartori B., Perini G., Papi M., Capriotti A. L., Montone C. M., Cerrato A., Caracciolo G. & Pozzi D., Nanomaterials, 2022.

(88) *X-ray imaging and micro-spectroscopy unravel the role of zincate and zinc oxide in the cycling of zinc anodes in mildly acidic aqueous electrolytes*, Kazemian M., Rossi F., Casaroli A., Caielli T., Kaulich B., Kiskinova M., Sgura I., & Bozzini B., Journal of Power Sources, 2022.

(89) *4'-SCF3-Labeling Constitutes a Sensitive 19F NMR Probe for Characterization of Interactions in the Minor Groove of DNA*, Li Q., Trajkovski M., Fan C., Chen J., Zhou Y., Lu K., Li H., Su X., Xi Z., Plavec J., & Zhou C., Angewandte Chemie, 2022.

(90) *Phen-DC3 Induces Refolding of Human Telomeric DNA into a Chair-Type Antiparallel G-Quadruplex through Ligand Intercalation*, Ghosh A., Trajkovski M., Teulade-Fichou M. P., Gabelica V., & Plavec J., Angewandte Chemie, 2022.

(91) *Mechanism of magnesium phosphate cement retardation by citric acid*, Viani A., Mácová P., Ševčík R., & Zárybnická L., Ceramics International., 2022.

(92) *An Unusual Cu/Te Hybridization in the Cu0. 3zrte2 Intercalation Compound*, Shkvarin A., Merentsov A. I., Titov A. A., Tsud N., Shkvarina E. G., Agzamova P. A., Postnikov M. S., & Titov A. N., Journal of Alloys and Compounds, 2022.

(93) *Low Temperature Epitaxy of In Situ GaDoped Si1-XGex: Dopant Incorporation, Structural and Electrical Properties*, Rengo G., Porret C., Hikavyy A. Y., Coenen G., Ayyad M., Morris R. J., Pollastri S., Oliveira De Souza D., Grandjean D., Loo R., & Vantomme A., ECS Transactions, 2022.

(94) *Lipid nanoparticles with erythrocyte cell-membrane proteins*, Bóta A., Fehér B., Wacha A., Juhász T., Szabó D., Turiák L., Gaál A., Varga Z., Amenitsch H., & Mihály J., Journal of Molecular Liquids, 2022.

(95) *8-Oxoguanine Forms Quartets with a Large Central Cavity*, Aleksič S., Podbevšek P., & Plavec J., Biochemistry, 2022.

(96) *Ferroelectricity induced by oxygen vacancies in rhombohedral ZrO2 thin films*, Lenzi V., Silva J. P., Šmíd B., Matolín V., Istrate C. M., Ghica C., J. L. MacManus-Driscoll & Marques L., Energy & Environmental Materials, 2022.

(97) *Properties of SiC and Si3N4 Thin Films Containing Self-Assembled Gold Nanoparticles*, Isaković S., Đekić M., Tkalčević M., Boršćak D., Periša I., Bernstorff S., Mičetić M., Crystals, 2022.

(98) *Ferroelectric properties of ZrO2 films deposited on ITO-coated glass*, SilvaJ.P.B., Sekhar K.C., Negrea R.F., Ghica C., Dastan D., Gomes M.J.M., Ceramics International, 2022.

(99) *Formation of calcium phosphate nanoparticles in the presence of carboxylate molecules: a time- resolved in situ synchrotron SAXS and WAXS study*, Siliqi D., Adamiano A., Ladisa M., Giannini C., Iafisco M., Degli Esposti L., CrystEngComm, 2022.

(100) *Tunable energy-level alignment in multilayers of carboxylic acids on silver*, Stara V., Prochazka P., Planer J., Shahsavar A., Makoveev A.O., Skala T., Blatnik M., Cechal J., Physical Review Applied, 2022.

(101) *Exploring the antitumor potential of copper complexes based on ester derivatives of bis(pyrazol-1-yl)acetate ligands*, Pellei M., Santini C., Bagnarelli L., Battocchio C., Iucci G., Venditti I., Meneghini C., Amatori S., Sgarbossa P., Marzano C., De Franco M., Gandin, V. International Journal of Molecular Sciences, 2022.

(102) *In situ spectroscopy and microscopy insights into the CO oxidation mechanism on Au/CeO2(111)*, Piliai L., Matvija P., Dinhova T. N., Khalakhan I., Skala T., Dolezal Z., Bezkrovnyi O., Kepinski L., Vorokhta M., Matolinova I., ACS Applied Materials and Interfaces, 2022.

(103) *Spotting local environments in self-assembled monolayer-protected gold nanoparticles*, Gabellini C., Şologan M., Pellizzoni E., Marson D., Daka M., Franchi P., Bignardi L., Franchi S., Posel Z., Baraldi A., Pengo P., Lucarini M., Pasquato L., Posocco P., ACS Nano, 2022.

(104) *Photo-induced lattice distortion in 2H-MoTe2 probed by time-resolved core level photoemission*, Costantini R., Cilento F., Salvador F., Morgante A., Giorgi G., Palummo M., Dell'Angela M., Faraday Discussions, 2022.

(105) *Polyvinylidene Fluoride Aerogels with Tailorable Crystalline Phase Composition*, Torres-Rodriguez J., Bedolla D.E., D'Amico F., Koopmann A.K., Vaccari L., Saccomano G., Kohns R., Huesing N., Gels, 2022.

(106) *Subcellular elements responsive to the biomechanical activity of triple-negative breast cancer-derived small extracellular vesicles*, Senigagliesi B., Bedolla D.E., Birarda G., Zanetti M., Lazzarino M., Vaccari L., Parisse P., Casalis L., Biomolecular Concepts, 2022.

(107) *Efficient Delivery of DNA Using Lipid Nanoparticles*, Cui L., Renzi S., Quagliarini E., Digiacomo L., Amenitsch H., Masuelli L., Bei R., Ferri G., Cardarelli F., Wang J., Amici A., Pozzi D., Marchini C., Caracciolo G., Pharmaceutics, 2022.

(108) *Tailoring Lipid-Based Drug Delivery Nanosystems by Synchrotron Small Angle X-ray Scattering*, Sartori B., Marmiroli B., Pharmaceutics, 2022.

(109) *Femtosecond induced third-order optical nonlinearity in quasi 2D Ruddlesden-Popper perovskite film deciphered using Z-scan*, Mushtaq A., Pradhan B., Kushavah D., Zhang Y., Naumenko D., Amenitsch H., Hofkens J., Pal S.K., Materials Advances, 2022.

(110) *Opsonin-Deficient Nucleoproteic Corona Endows UnPEGylated Liposomes with Stealth Properties In Vivo*, Giulimondi F., Vulpis E., Digiacomo L., Giuli M.V., Mancusi A., Capriotti A.L., Laganà A., Cerrato A., Zenezini Chiozzi R., Nicoletti C., Amenitsch H., Cardarelli F., Masuelli L., Bei R., Screpanti I., Pozzi D., Zingoni A., Checquolo S., Caracciolo G., ACS Nano, 2022.

(111) *Unraveling the timescale of the structural photo-response within oriented metal-organic framework films*, Klokic S., Naumenko D., Marmiroli B., Carraro F., Linares-Moreau M., Dal Zilio S., Birarda G., Kargl R., Falcaro P., Amenitsch H., Chemical Science, 2022.

(112) *Interaction of Metallic Nanoparticles With Biomimetic Lipid Liquid Crystalline Cubic Interfaces*, Cardellini J., Montis C., Barbero F., De Santis I., Caselli L., Berti D., Frontiers in Bioengineering and Biotechnology, 2022.

(113) *On the nanoscale structural evolution of solid discharge products in lithium-sulfur batteries using operando scattering*, Prehal C., von Mentlen J.M., Drvarič Talian S., Vizintin A., Dominko R., Amenitsch H., Porcar L., Freunberger S.A., Wood V., Nature Communications, 2022.

(114) *In situ small-angle X-ray scattering reveals strong condensation of DNA origami during silicification*, Ober M.F., Baptist A., Wassermann L., Heuer-Jungemann A., Nickel B., Nature Communications, 2022.

(115) *PEGylation of Phosphatidylglycerol/Docosahexaenoic Acid Hexosomes with d -a-Tocopheryl Succinate Poly(ethylene glycol)2000Induces Morphological Transformation into Vesicles with Prolonged Circulation Times*, Bor G., Lin J.H., Lin K.Y., Chen H.C., Prajnamitra R.P., Salentinig S., Hsieh P.C.H., Moghimi S.M., Yaghmur A., ACS Applied Materials and Interfaces, 2022.

(116) *Optical tweezer platform for the characterization of pH-triggered colloidal transformations in the oleic acid/water system*, Manca M., Zhang C., Scheffold F., Salentinig S., Journal of Colloid and Interface Science, 2022.

(117) *Thermo-responsive lipophilic NIPAM-based block copolymers as stabilizers for lipid-based cubic nanoparticles*, Balestri A., Lonetti B., Harrisson S., Farias-Mancilla B., Zhang J., Amenitsch H., Schubert U.S., Guerrero-Sanchez C., Montis C., Berti D., Colloids and Surfaces B: Biointerfaces, 2022.

(118) *Impact of PEGylation on the degradation and pore organization in mesoporous silica nanoparticles: A study of the inner mesoporous structure in physiologically relevant ionic conditions*, Ramírez M.D.L.Á., Bindini E., Moretti P., Soler Illia G.J.A.A., Amenitsch H., Andreozzi P., Ortore M.G., Moya S.E., Colloids and Surfaces B: Biointerfaces, 2022.

(119) *Glycol bearing perylene monoimide based non-fullerene acceptors with increased dielectric permittivity*, Fürk P., Hofinger J., Reinfelds M., Rath T., Amenitsch H., Scharber M.C., Trimmel G., Monatshefte fur Chemie, 2022.

(120) *Self-Assembly of Oriented Antibody-Decorated Metal–Organic Framework Nanocrystals for Active-Targeting Applications*, Alt K., Carraro F., Jap E., Linares-Moreau M., Riccò R., Righetto M., Bogar M., Amenitsch H., Hashad R.A., Doonan C., Hagemeyer C.E., Falcaro P., Advanced Materials, 2022.

Abbreviations

BoD	Board of Directors
CERIC	Central European Research Infrastructure Consortium
ED	Executive Director
EGERIC	Commission expert group to assess the implementation of the ERIC Regulation
ERA	European Research Area
EOSC	European Open Science Cloud
ERIC	European Research Infrastructure Consortium, a legal framework created by the European Commission to allow the operation of Research Infrastructures of pan-European interest.
FOE	Fondo Ordinario per il finanziamento degli Enti e istituzioni di ricerca (Ordinary Fund for the Financing of Research Entities and Institutions)
GA	General Assembly
IF	Impact Factor
IL&TT	Industrial Liaison and Technology Transfer
IR	Internal Regulations
ISTAC	International Scientific and Technical Evaluation Committee
MIUR	Italian Ministry of Education, University and Research
OA	Open Access
PaN	Photon and Neutron
PI	Principal Investigator
PF	Partner Facility
RE	Representing Entity
RI	Research Infrastructure
R&D	Research & Development
S&T	Science & Technology
TBAB	Technical Bettery Advisory Board

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