

CERIC

PaGES⁷

Planning,
Management and
Execution of a
Scientific Experiment in
an international research
infrastructure

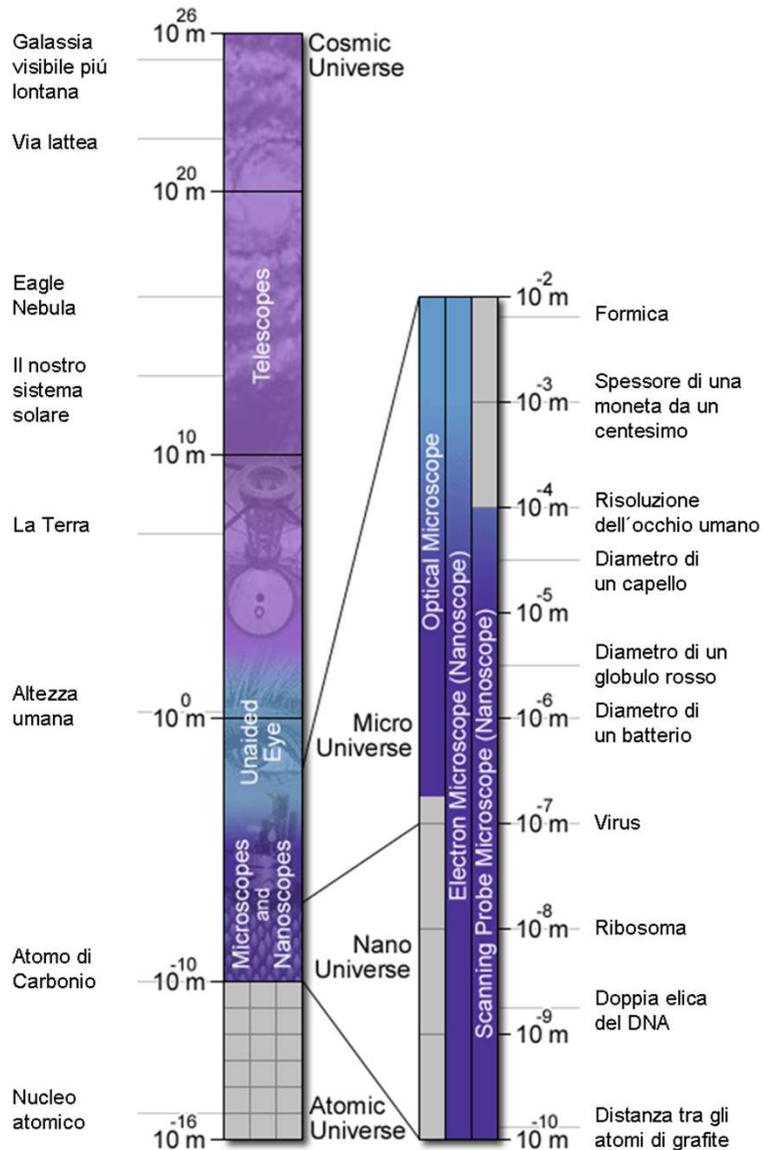
Microfabbricazione e Litografia a raggi x

Come, dove, quando
...ma soprattutto...
perche'?

Benedetta Marmioli, Graz University of Technology



Le dimensioni contano



1 μm = 10^{-6} m (un milionesimo di metro)

1 nm = 10^{-9} m (un miliardesimo di metro!)

Capello: diametro $\sim 80 \mu\text{m}$

Globulo rosso: diametro $\sim 8 \mu\text{m}$

PM10: diametro $< 10 \mu\text{m}$

Luce visibile: lunghezza d'onda tra 400 e 700 nm

Doppia elica del DNA: diametro ~ 2 nm.

L'occhio umano riesce a vedere fino a 30-40 μm

Le dimensioni contano: perche'?

$L = \text{unit\`a di lunghezza}$
 Allora l'unit\`a di superficie diventa
 $S = L \times L$
 e quella di volume diventa
 $V = L \times L \times L$

$L=10$

$L=1/10$

$S=100$

$L= 1/100$

$V =1000$

$L=1/1000$



Forze di volume >> forze di superficie

Forze di volume << forze di superficie !!

MEMS = Micro Electro Mechanical Systems

Microtecnologie in natura: qualche esempio

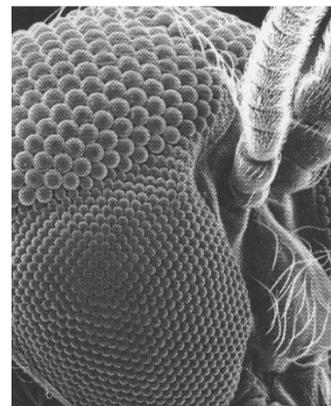
Microfluidica



Micromeccanica



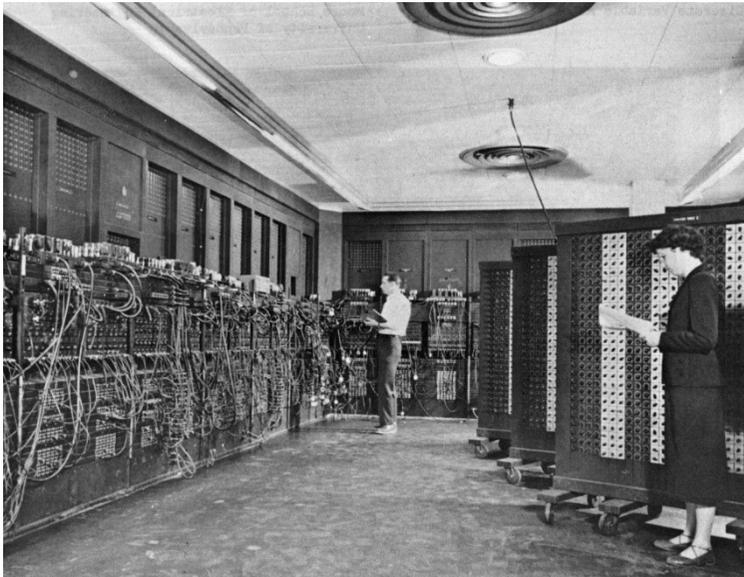
Microottica



Biomimetica!

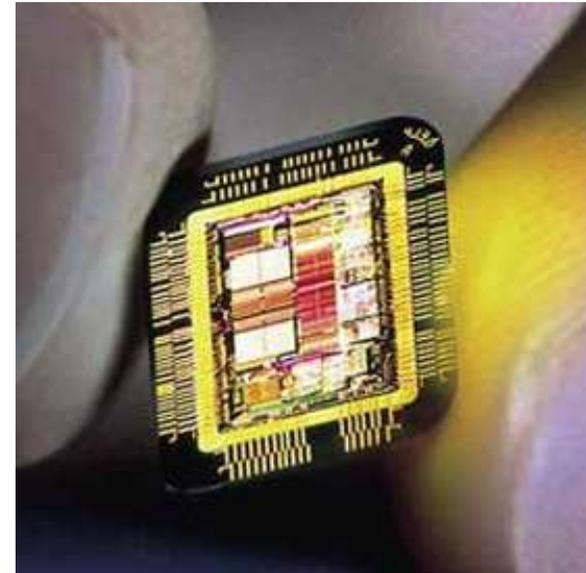
Le origini: la microelettronica

1946



ENIAC (Electronic Numerical Integrator And Computer = integratore e calcolatore numerico elettronico)

oggi



Microprocessore (o microchip) contenuto in una tessera bancomat.

Un po' di storia

1960

Microsensori

1980

Microattuatori

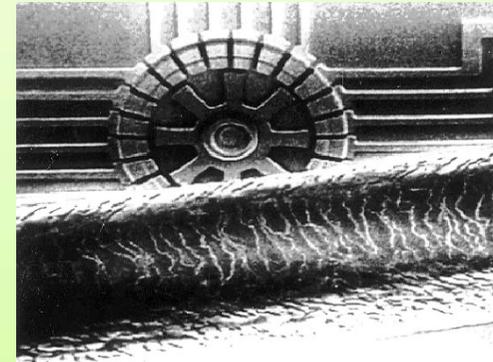
1988

MEMS

2002

Stampanti a getto d'inchiostro
Sistemi automobilistici
Sistemi biomedici
Telecomunicazioni

Primo micro motore
UC Berkeley



Klaus C. Schadow Paper presented at the RTO AVT Lecture Series on "MEMS Aerospace Applications", held in Montreal, Canada, 3-4 October 2002; Ankara, Turkey, 24-25 February 2003; Brussels, Belgium, 27-28 February 2003; Monterey, CA, USA, 3-4 March 2003, and published in RTO-EN-AVT-105.

Cosa possono fare i MEMS?

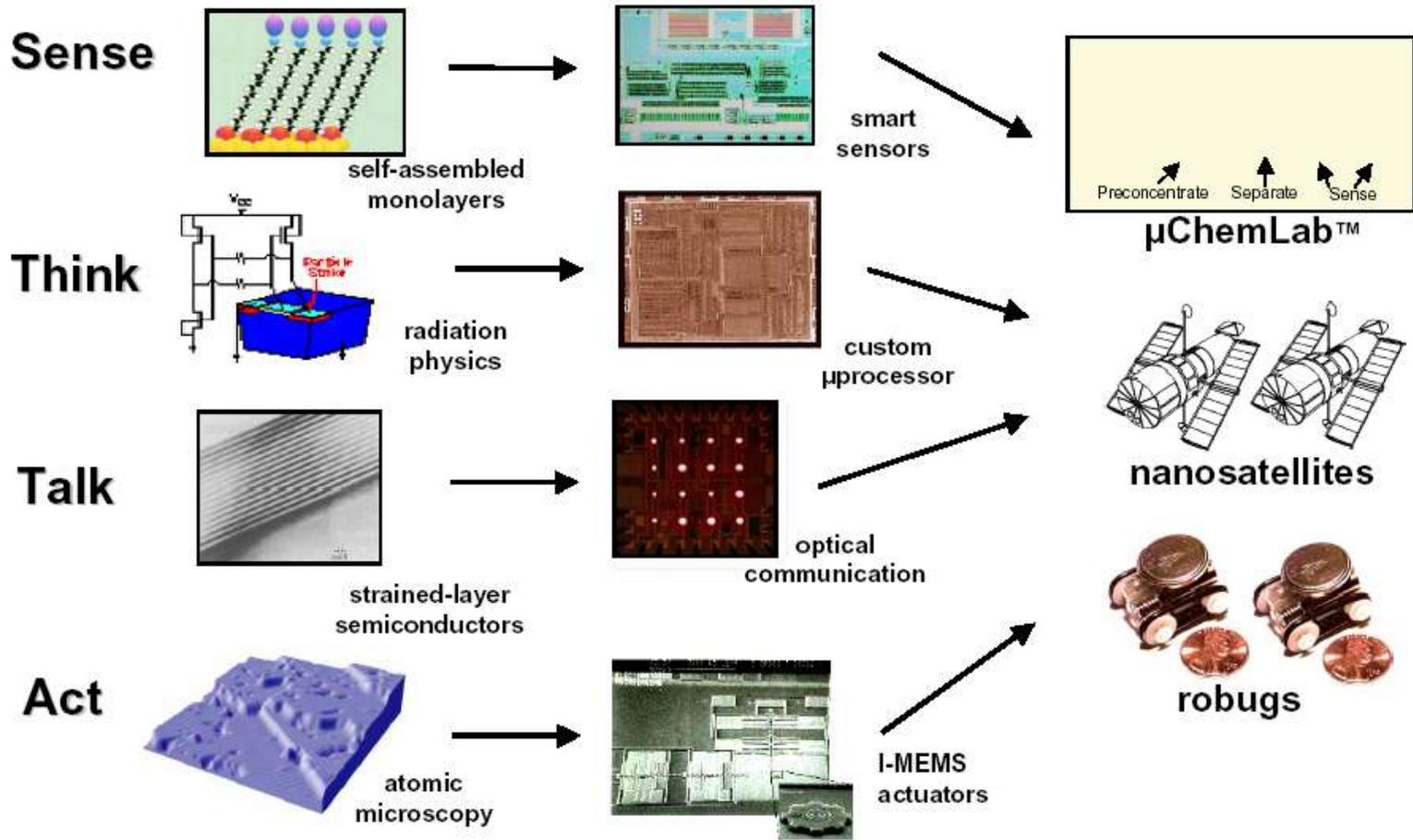
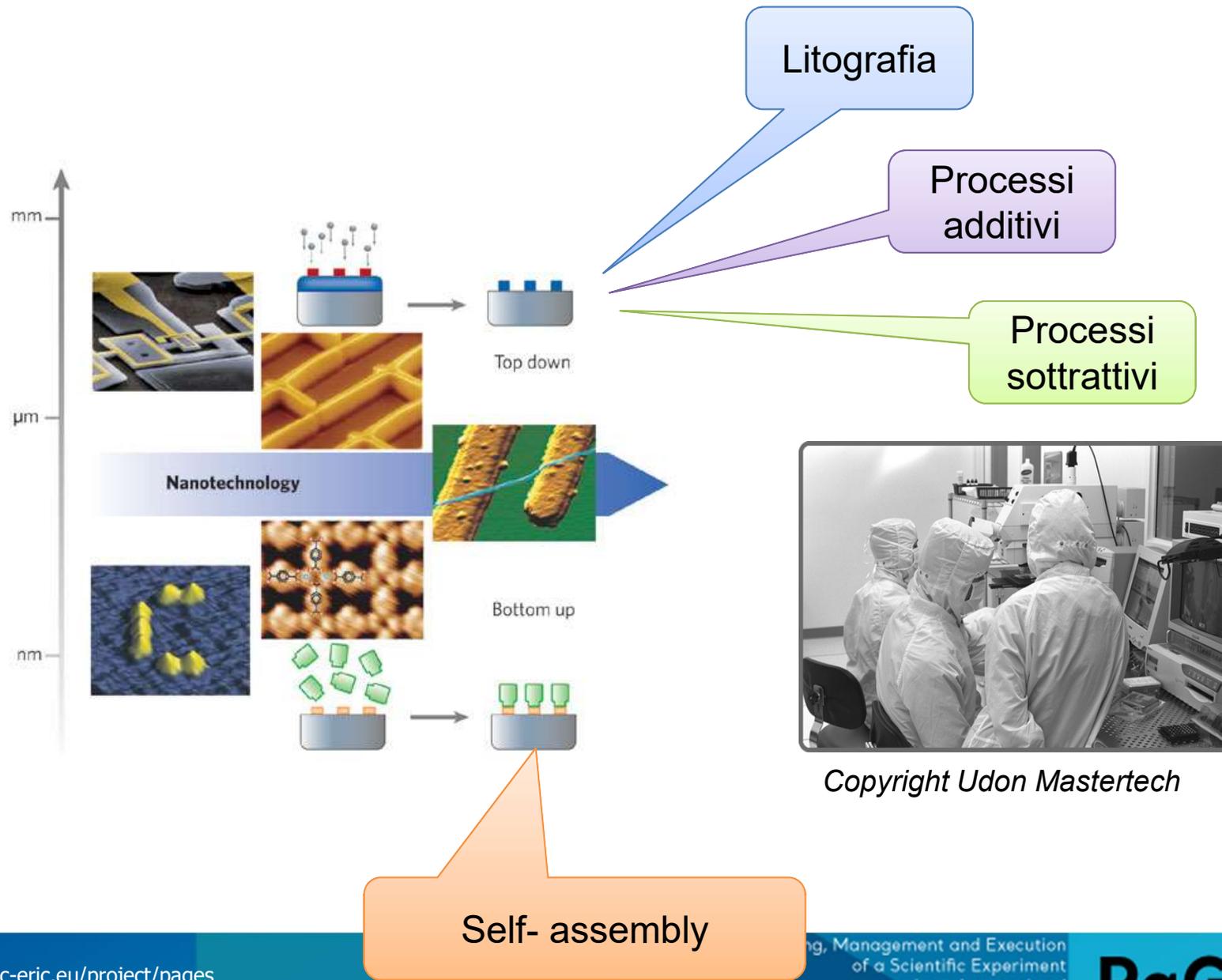
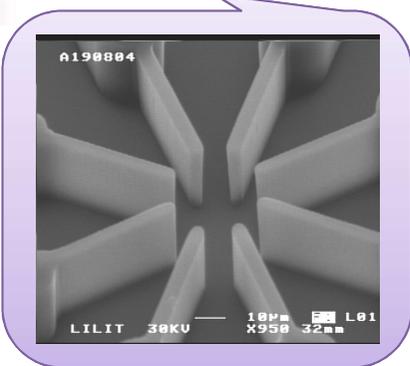
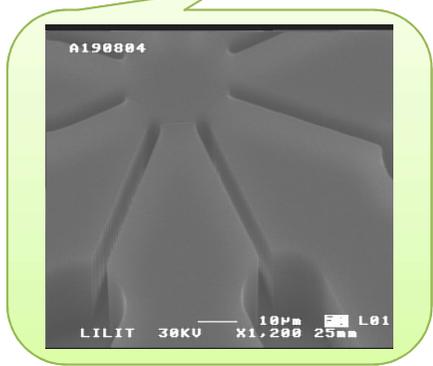
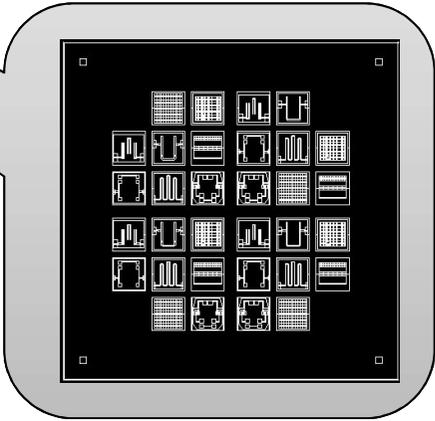
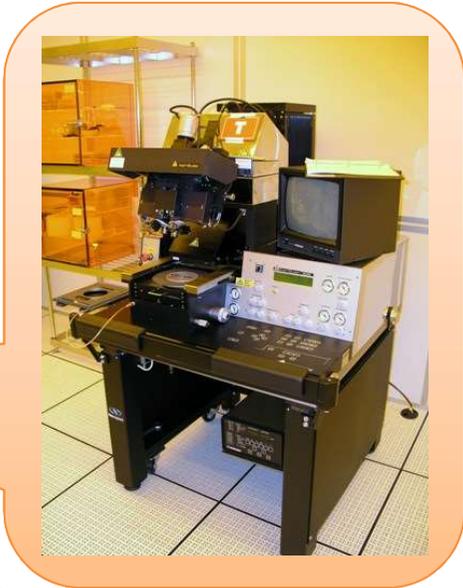
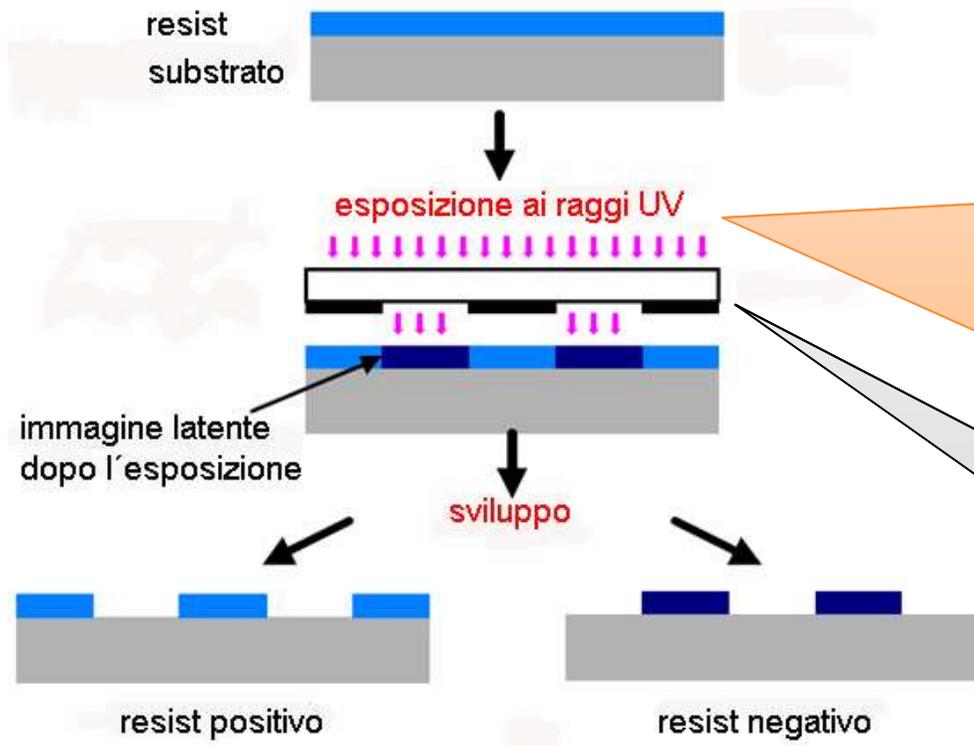


Figure 6.16. The control of mechanical, electrical, optical, and chemical properties at the nanoscale will enable significant improvements in integrated microsystems.

Tecniche di micro/nanofabbricazione



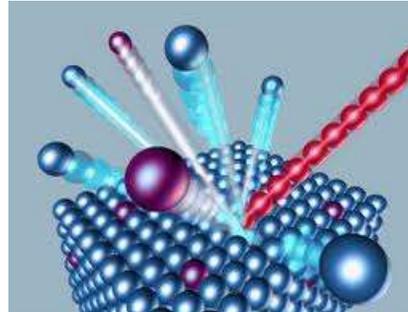
Litografia ottica



Litografia: altre sorgenti di luce



Electron Beam Lithography



Focused Ion Beam Lithography

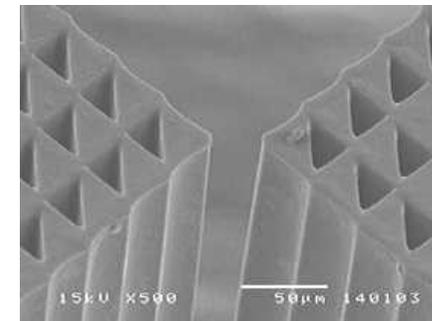
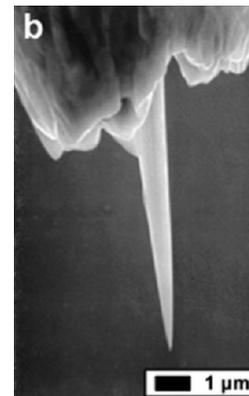
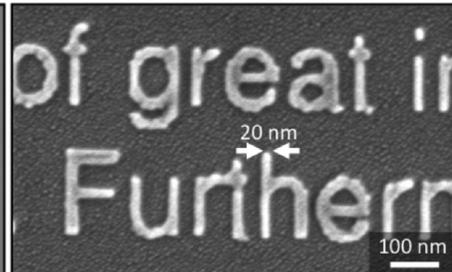


X-ray Lithography

There's Plenty of Room at the Bottom
An Invitation to Enter a New Field of Physics
By Richard P. Feynmann

I imagine experimental physicists must often look with envy at men like Kamerlingh Onnes, who discovered a field like low temperature, which seems to be bottomless and in which one can go down and down. Such a man is then a leader and has some temporary monopoly in a scientific adventure. Percy Bridgman, in designing a way to obtain higher pressures, opened up another new field and was able to move into it and to lead us all along. The development of ever higher vacuum was a continuing development of the same kind.

I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle. This field is not quite the same as the others in that it will not tell us much of fundamental physics (in the sense of "What are the strange particles?") but more like solid-state physics in the sense that it might tell us much of great interest about the strange phenomena that occur in complex situations. Furthermore, a point that is most important is that it would have an enormous number of technical applications.



La luce di sincrotrone

Origine

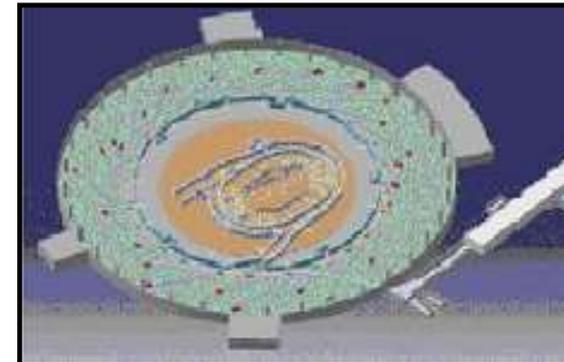
Elettroni relativistici la cui traiettoria viene incurvata da magneti incurvanti (*bending magnets*)



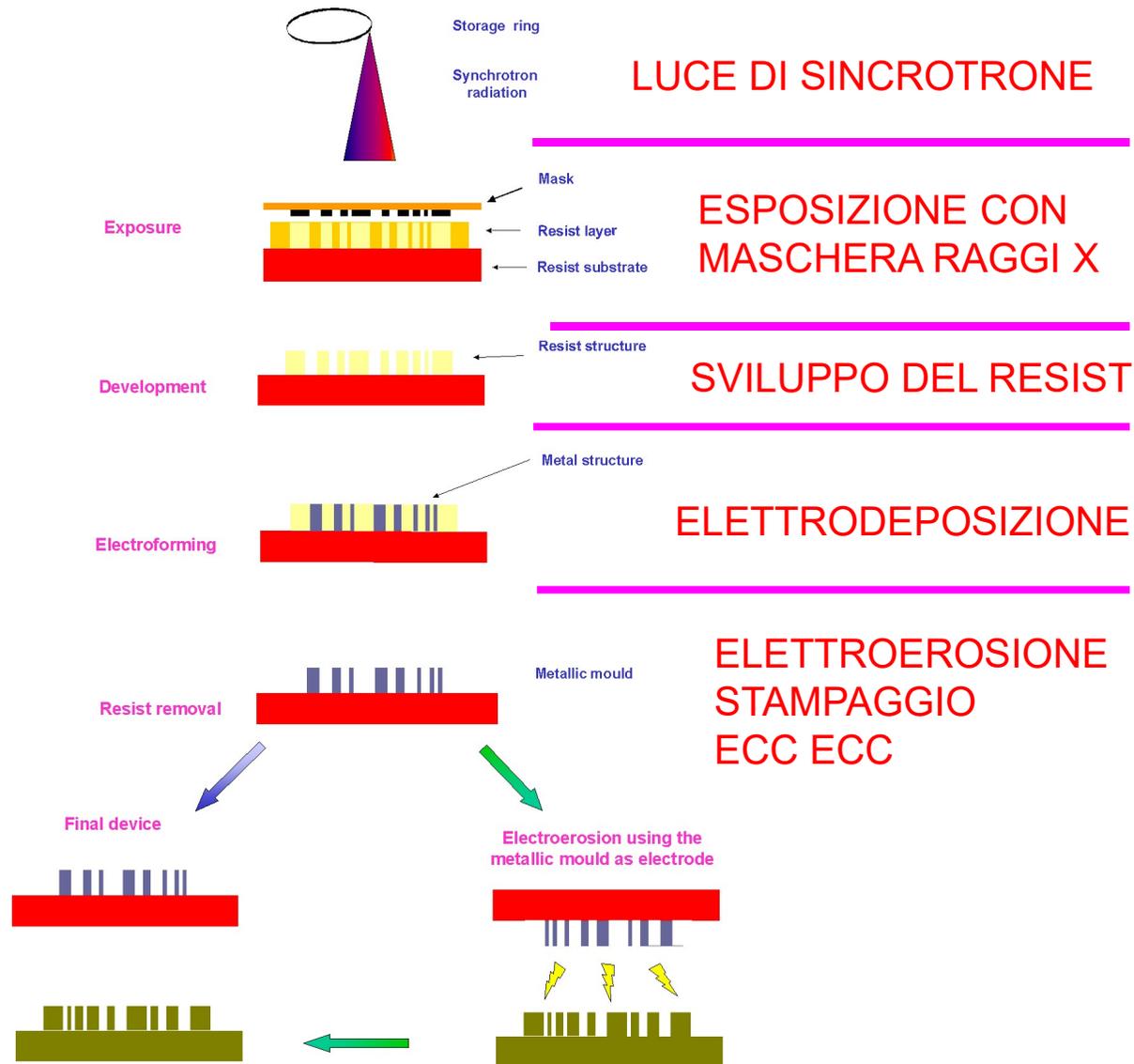
Caratteristiche principali

Ampio ventaglio orizzontale, piccolo angolo di emissione

Elevata intensità e grande parallelismo => elevata profondità di penetrazione, ottima accuratezza, alto rapporto di forma



Litografia a raggi x e tecnica LIGA



Lo scanner a raggi x



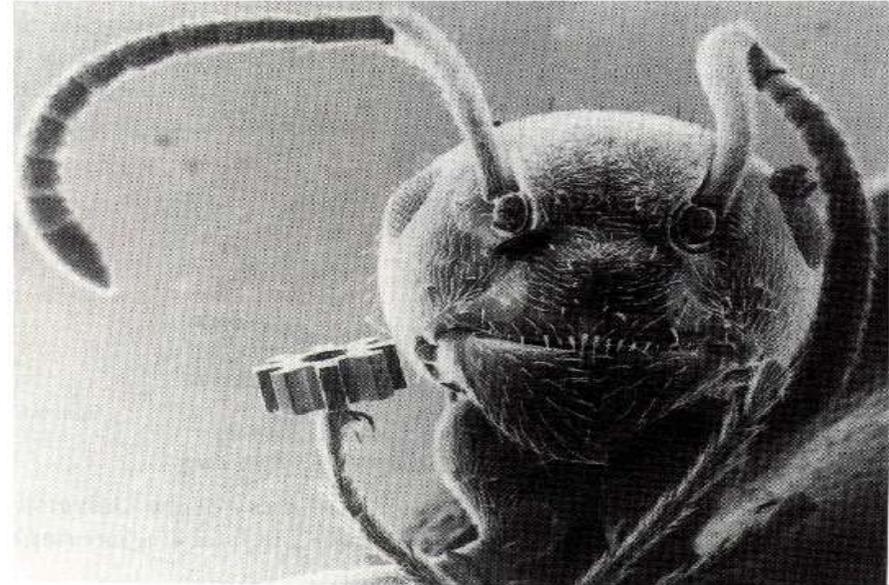
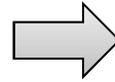
PORTAMASCHERA

PORTACAMPIONE



Cosa si puo' fare?

Litografia a raggi X tradizionale:
Fabbricazione di microdispositivi



Sviluppo di nanomateriali funzionali per dispositivi con prestazioni migliorate



Techniche Top down + bottom up

Sintesi e lavorazione di nuovi materiali mediante irraggiamento controllato

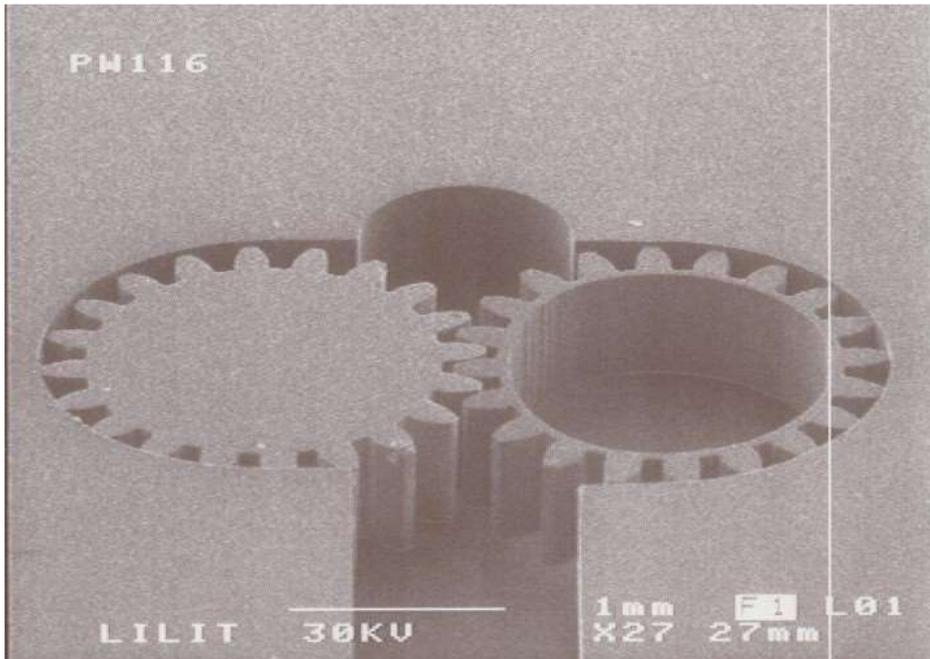
Fabbricazione di microdispositivi



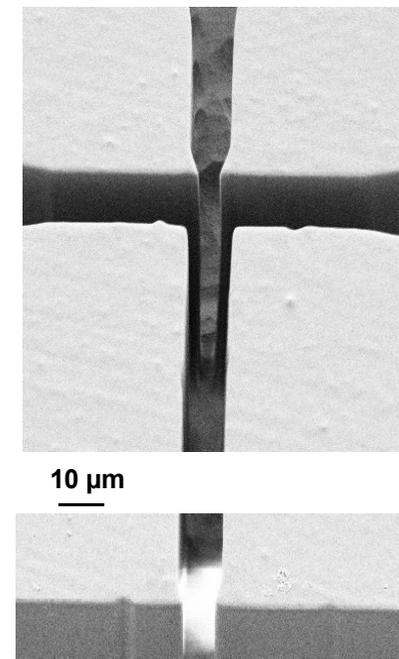
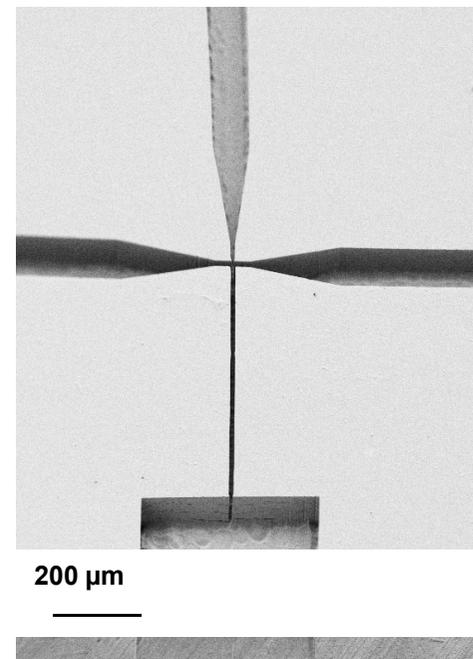
DXRL: irraggiamento coi raggi x



Micropompa a ingranaggi a trascinamento magnetico

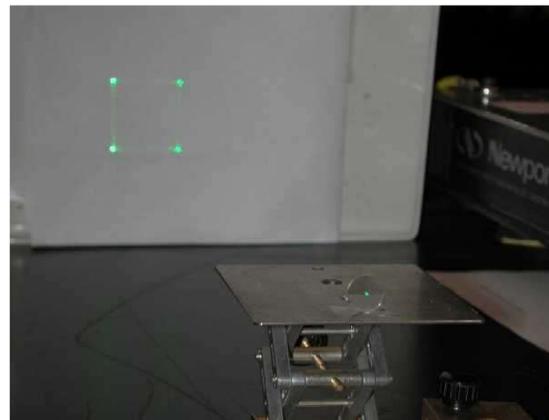
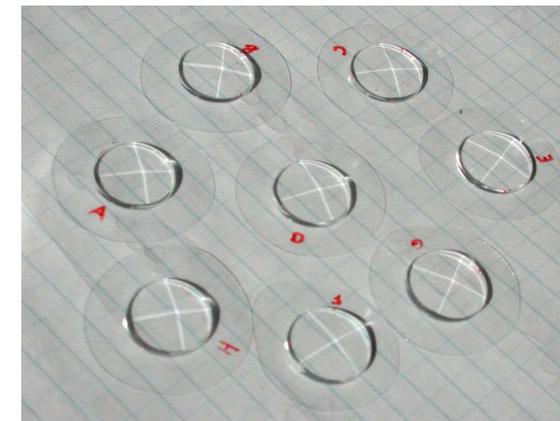
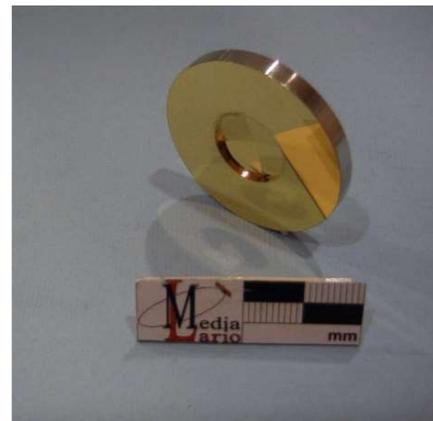
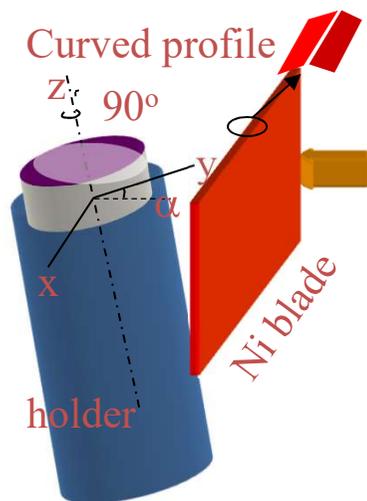


Micromiscelatore



LIGA: irraggiamento + elettrodeposizione + stampaggio

Sensori di fronte d'onda piramidali per ottiche adattive

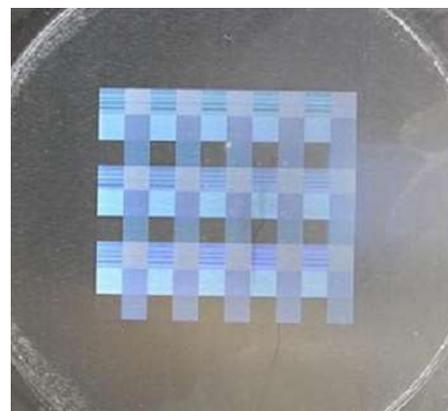
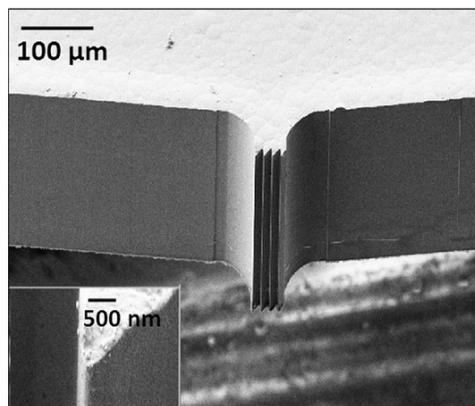
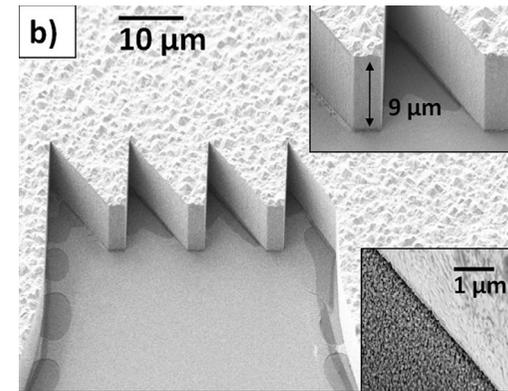
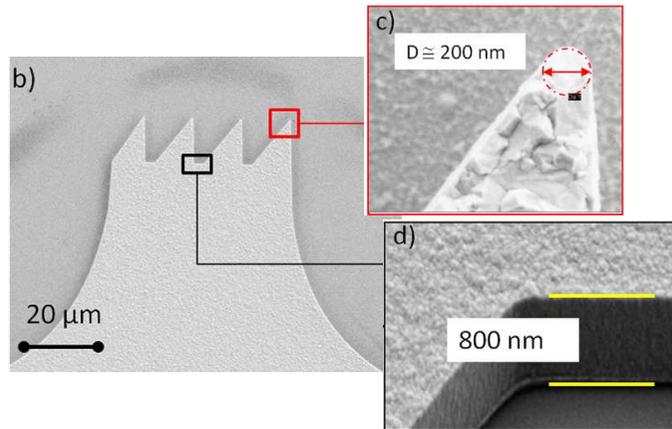


M. Ghigo et al., *Proceedings of SPIE* Vol. 4839, p 259-265 (2002)

M. Ghigo et al., *Proceeding of the Conference: Adaptive Optics for Extremely Large Telescopes*, Venice, Italy, 7-10 May (2001)

LIGA: irraggiamento + elettrodeposizione + hot embossing

Grigile a punta affilata per rivestimenti antiriflesso



T. Mäkelä et al, Microelectronic Engineering, 98, 180-183 (2012)

G. Greci et al., Sensors and Actuators A 205, 111– 118 (2014)

LIGA: irraggiamento + elettrodeposizione + elettroerosione

Rotori di microturbine per applicazioni aerospaziali

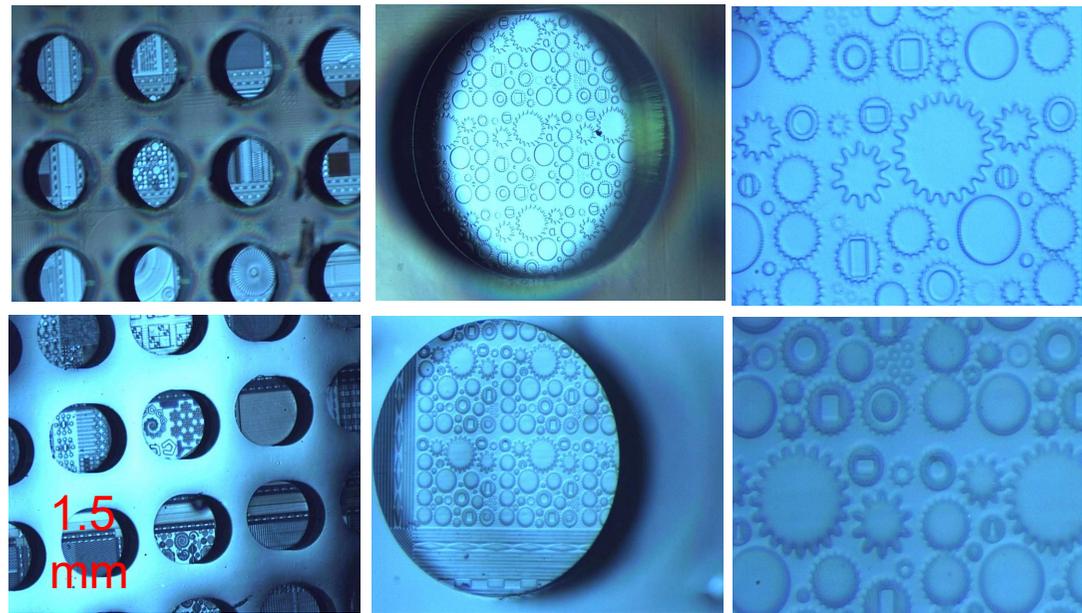


B. Marmioli et al, Proceedings of CANEUS 2004-
Monterey (California), 1-5/11/04, AIAA 2004-6710,
pp 42-48 (2004)

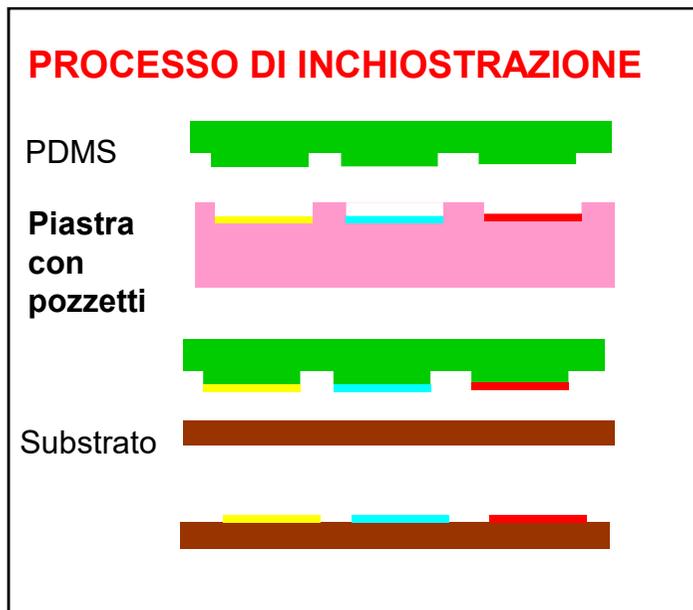
Colata su uno stampo con una struttura gerarchica

Dispositivo per lo stampaggio di diverse funzionalizzazioni chimiche

Stampo di SU8

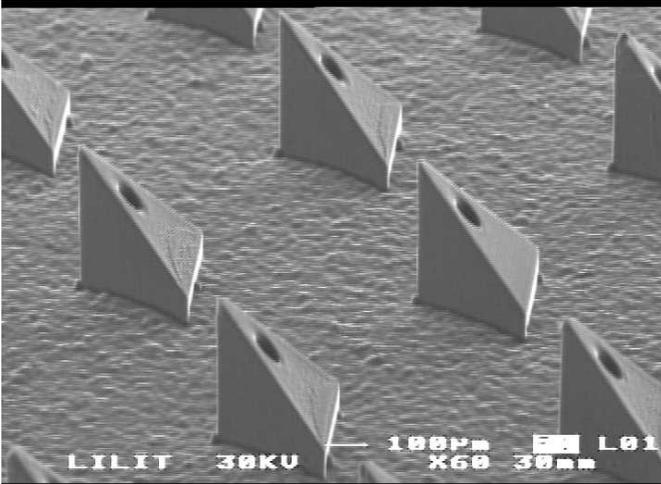
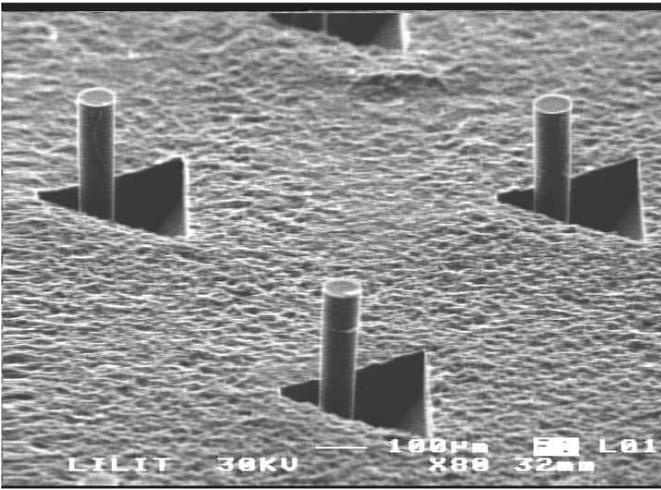
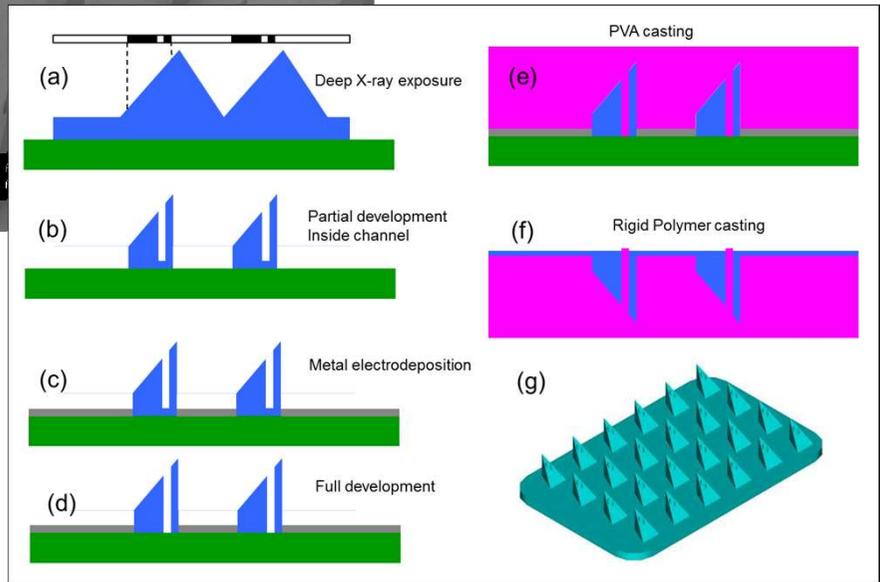
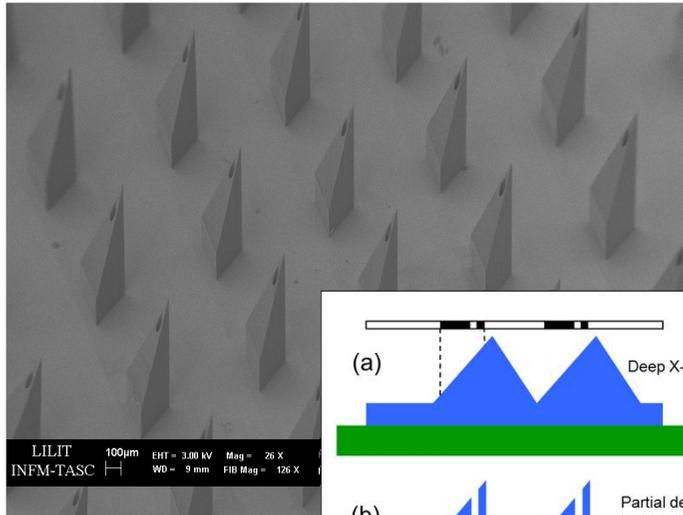


Replica di PDMS



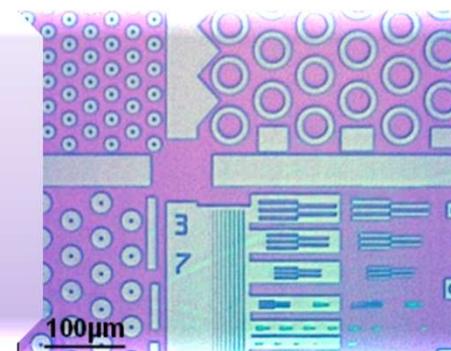
Colata su uno stampo con pareti inclinate e strutture sporgenti

Sistema di rilascio controllato di farmaci basato su microaghi



F. Pérennès et al, J. Micromech. Microeng., 16, 473-479 (2006).

Sintesi e lavorazione di materiali mediante irraggiamento controllato

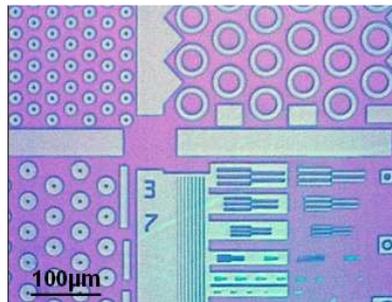


Patterning (modellazione) di film sottili



Film mesoporosi: materiali che contengono pori di diametro tra 2 e 50nm. Sono ottenuti tramite assemblaggio di surfattanti che formano micelle e danno forma al componente inorganico durante la sintesi

SiO₂



sviluppo: etilen glicole + etanolo

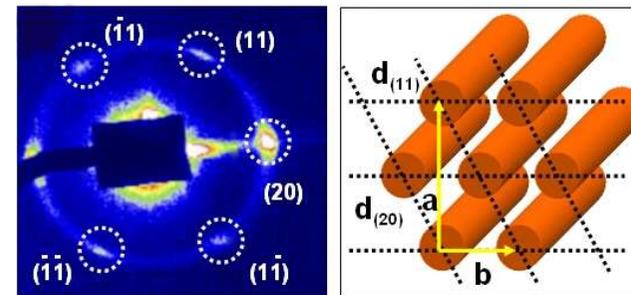
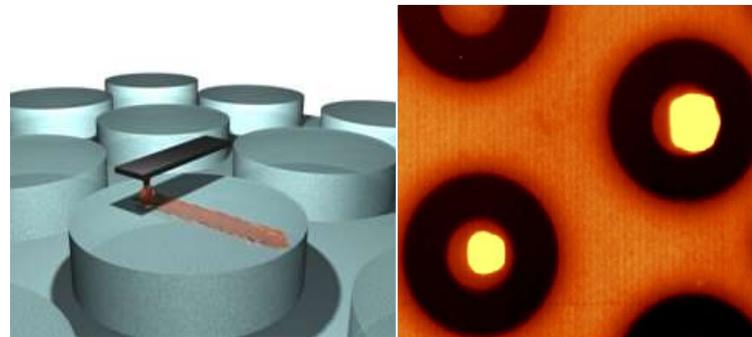
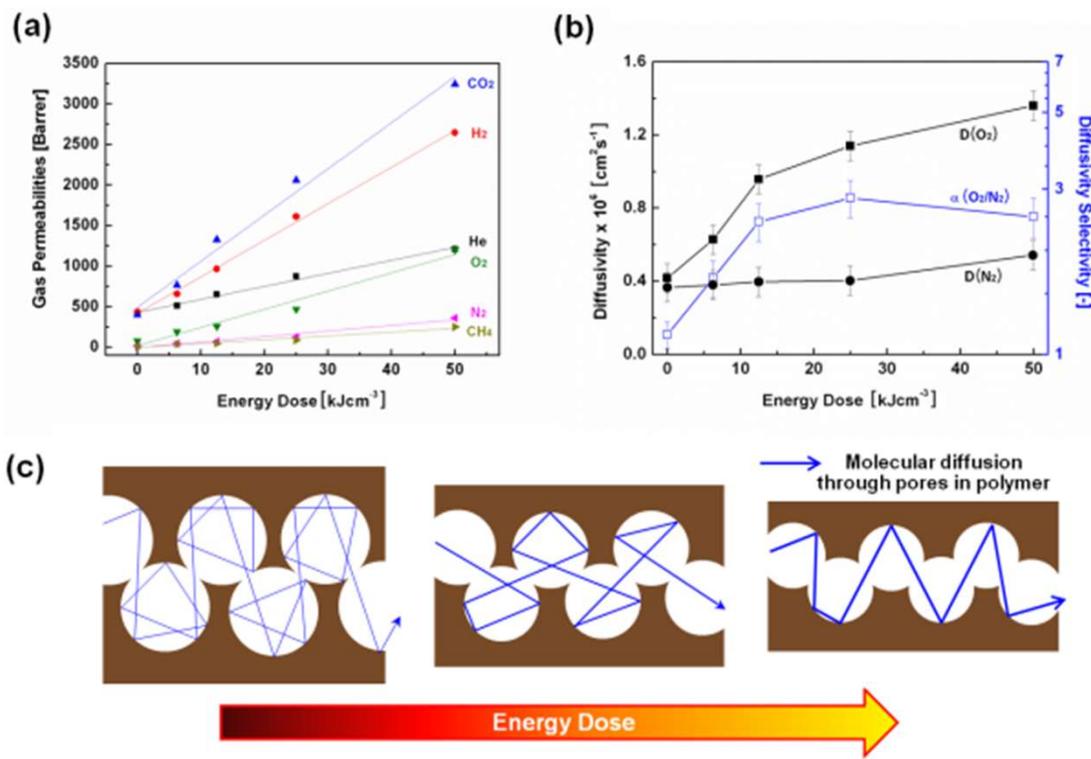
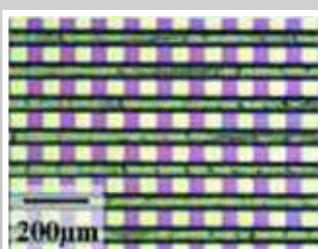
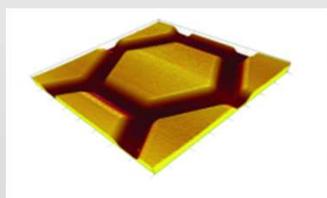


Immagine GISAXS : simmetria p6m



Funzionalizzaione con rodamina 6G con il sistema di dip-pen

Patterning e selezione della permeabilità in polimeri microporosi



S. H. Han et al., *Small*, 9, 13, 2277 (2013)

A deep space photograph of a galaxy, likely a spiral galaxy, with a bright central core and a dense field of stars. The galaxy is oriented horizontally, with the core in the center. The stars are scattered throughout the field, with a higher density near the core. The background is dark, with some faint, diffuse light from the galaxy's structure.

There is plenty of room at the bottom

R. Feynmann