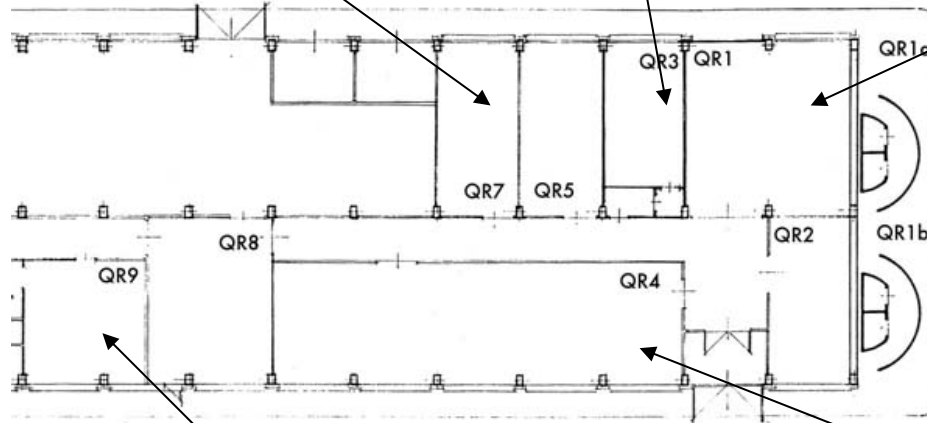
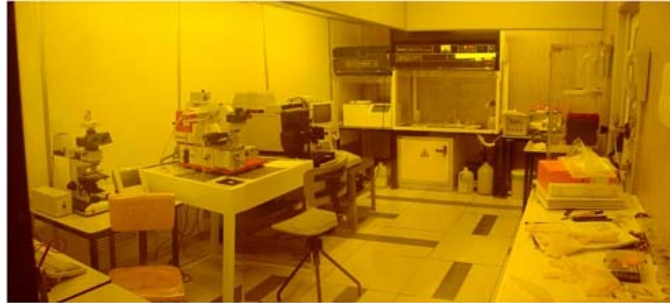
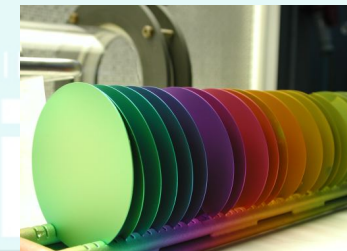


QR Laboratory & Nanofacility Piemonte



2 Gas cabinet
 H_2 , O_2 , SiH_2Cl_2 ,
 NH_3 , N_2

Personnel:
8 researchers & technologists
3 technicians
10 granters & post-doc



Tesi disponibili presso i Laboratori QR e NanoFacility INRiM

Tutore: Giampiero Amato

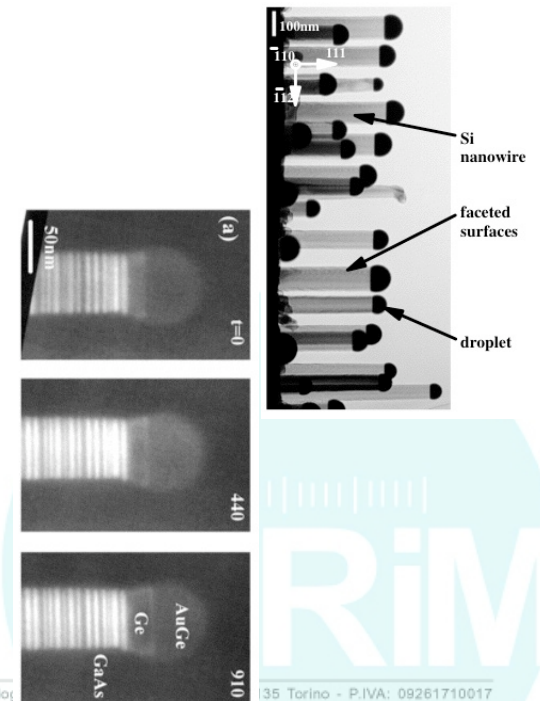
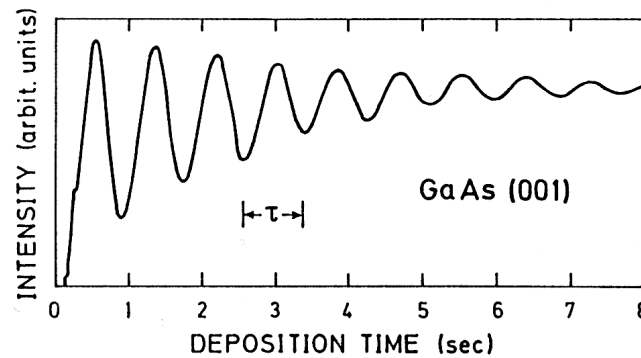
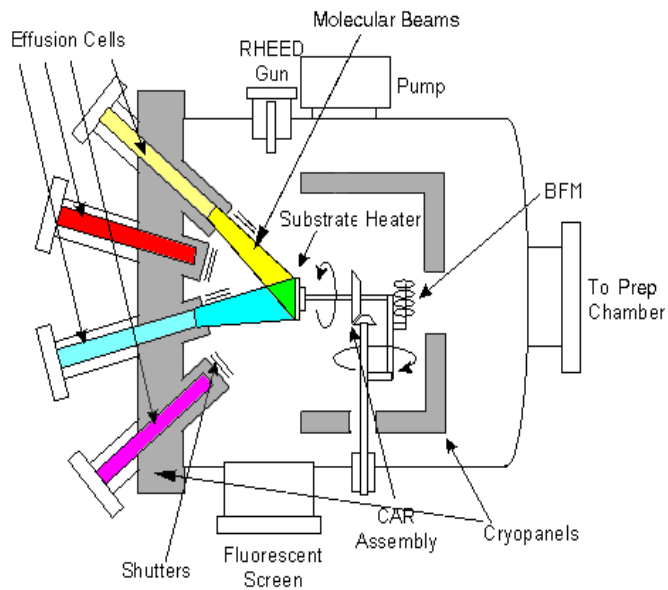
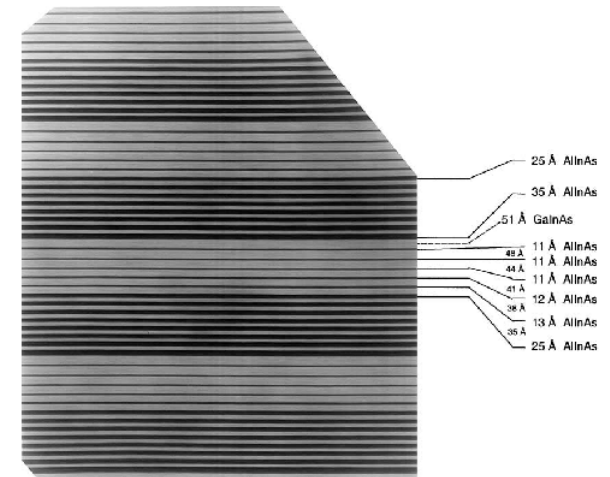
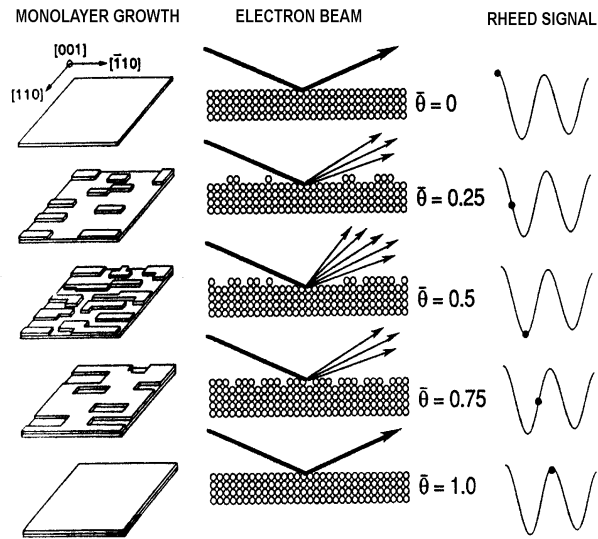
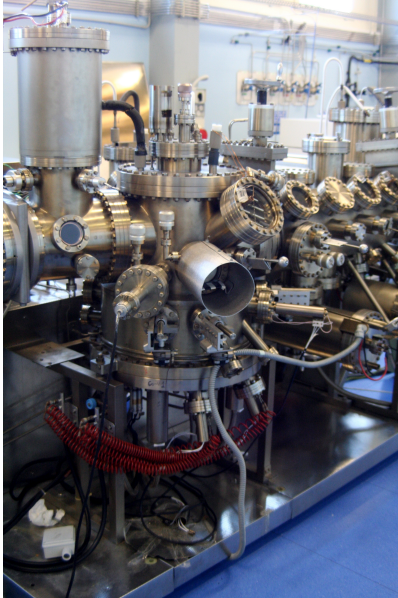
1. Controllo di processi di deposizione al monolayer
2. Sviluppo di un sistema di acquisizione dati e controllo per il Reactive Ion Etching e la deposizione Plasma Enhanced CVD

Tutore: Luca Boarino

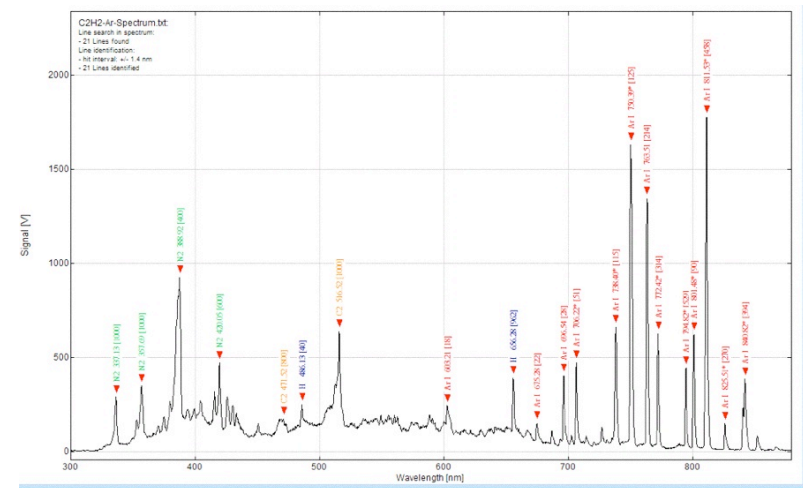
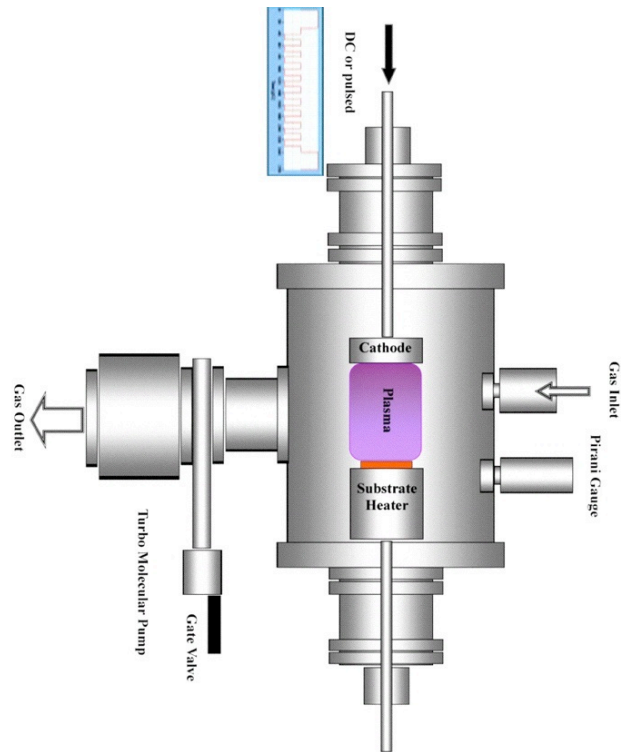
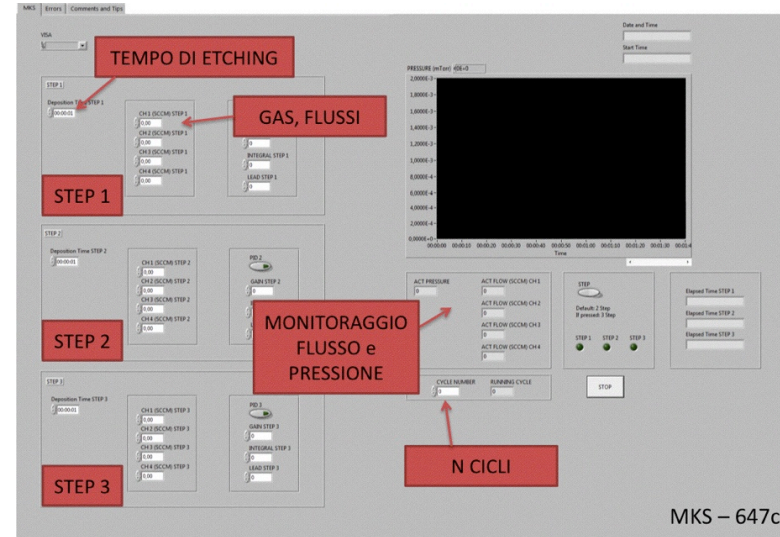
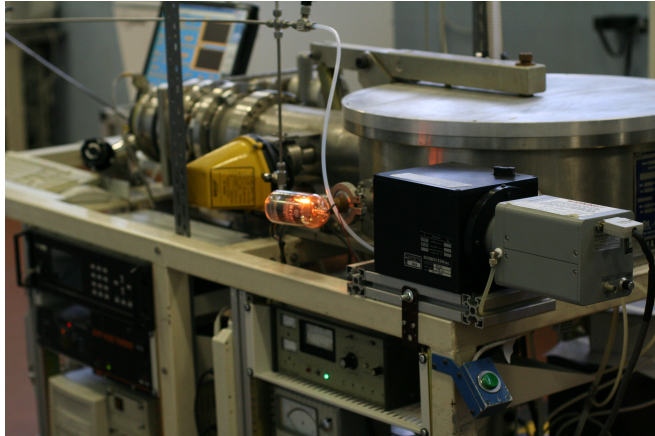
1. Studio del self-assembly di nanosfere
2. Nanostrutture per self-assembly di copolimeri a blocchi e propagazione al silicio mediante RIE e KOH
3. Caratterizzazione di film sottili nanostrutturati mediante ellissometria

Divisione Elettromagnetismo, Istituto Nazionale di Ricerca Metrologica,
Strada delle Cacce 91, 10135 Torino
l.boarino@inrim.it

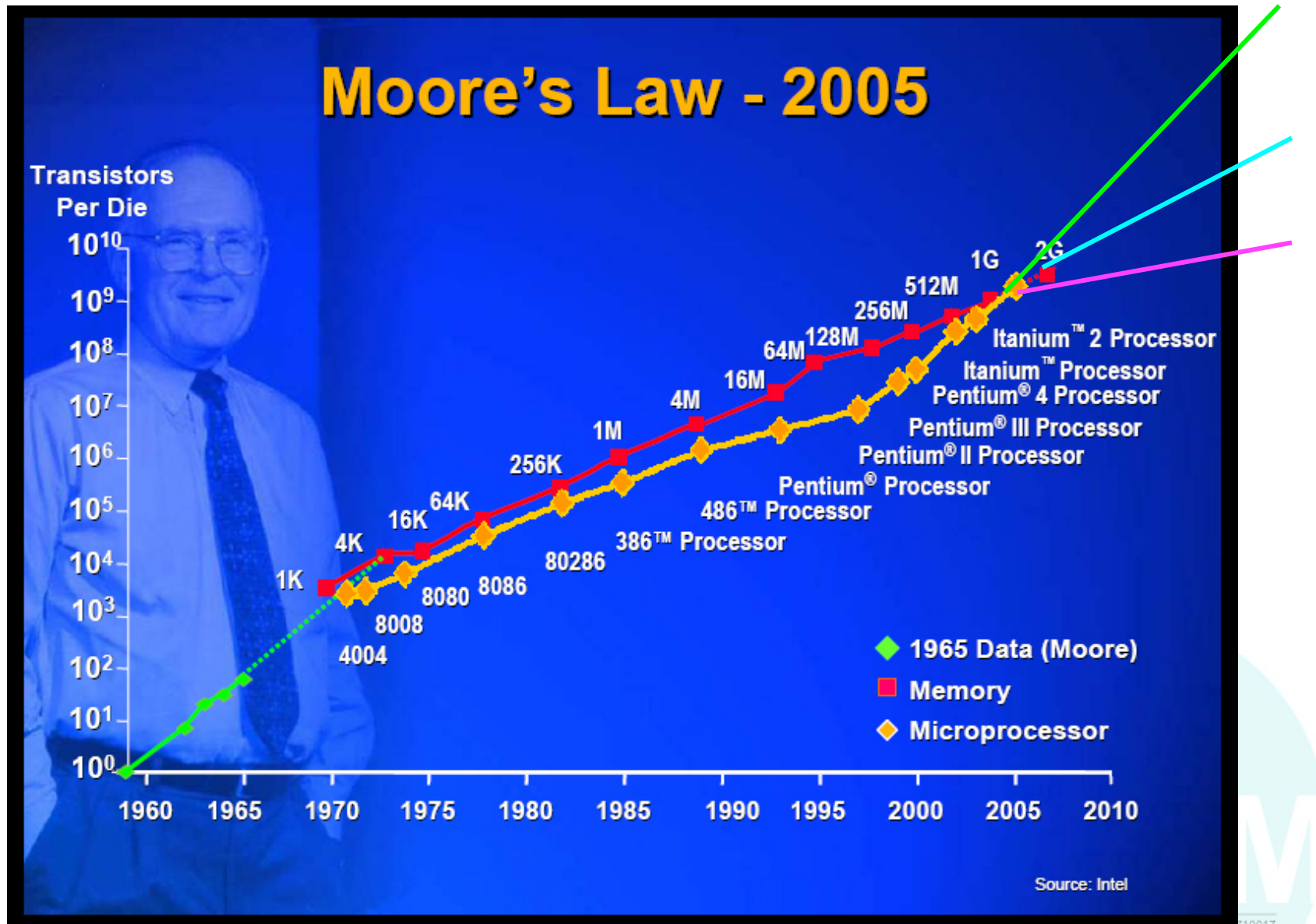
Controllo di processi di deposizione al monolayer



Controllo di processi di Plasma etching e Plasma deposition



Could we maintain the Moore's law slope?





- ▼ Welcome to Estapor
- ▼ Our Products
- ▶ **White Microspheres**
- ▶ Dyed Microspheres
- ▶ Fluorescent Microspheres
- ▶ SuperParamagnetic Microspheres
- ▶ Bio-Estapor Microspheres
- ▶ MagPrep Silica Particles

Product #	Diameter (µm)	Polymer	Catalog No
K007	0,050-0,075	Polystyrene	39 431 081
K010	0,076-0,125	Polystyrene	39 469 081
K015	0,126-0,175	Polystyrene	27 712 084
K020	0,176-0,225	Polystyrene	39 430 087
K025	0,226-0,275	Polystyrene	23 689 083
K030	0,276-0,325	Polystyrene	23 690 087
K035	0,326-0,375	Polystyrene	39 380 084
K045	0,426-0,475	Polystyrene	39 503 001
K050	0,476-0,575	Polystyrene	23 691 081
K070	0,576-0,740	Polystyrene	23 715 084
K080	0,750-0,890	Polystyrene	23 692 084
K100	0,900-1,100	Polystyrene	23 716 087

Large Plain Polystyrene Microspheres

Product #	Diameter (µm)	Polymer	Catalog No
L200	1,800-2,200	Polystyrene	23 694 081
L300	2,700-3,300	Polystyrene	39 480 080

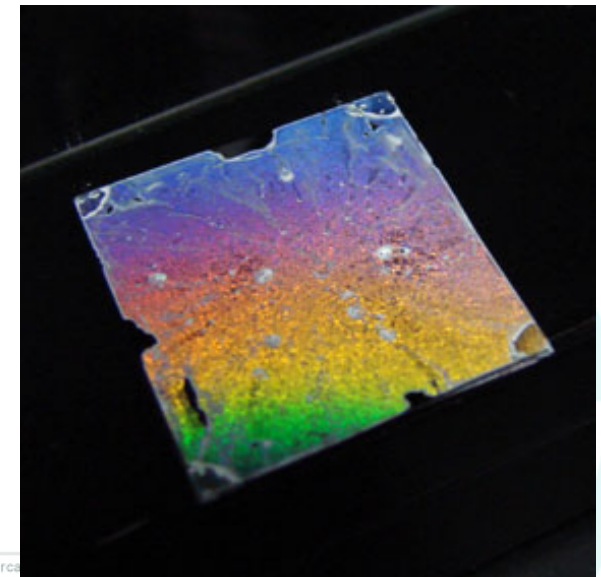
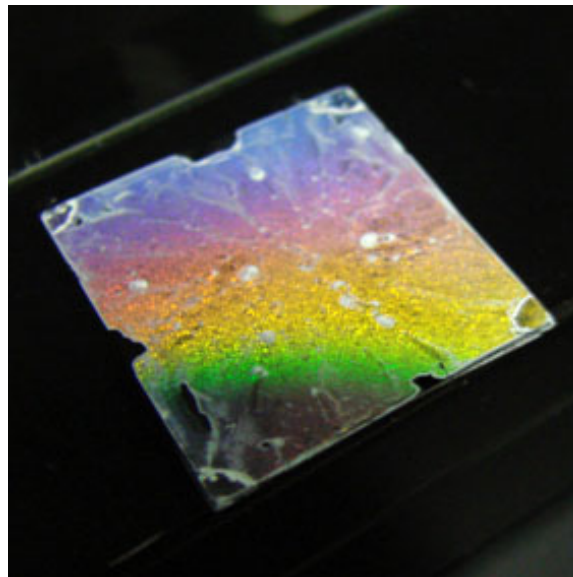
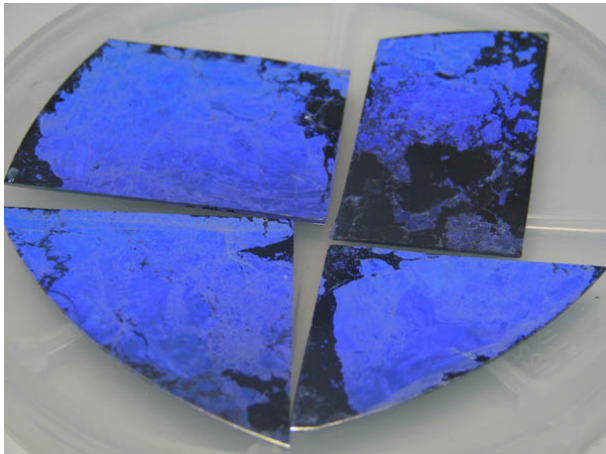
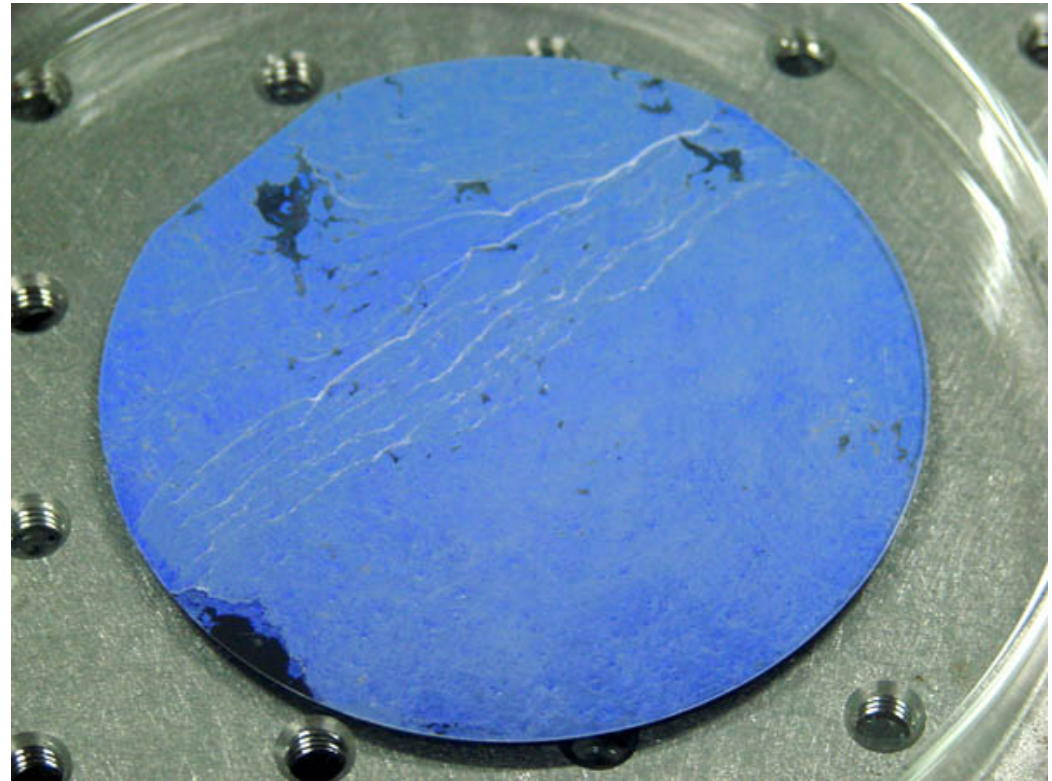
Estapor® Calibrated Standards Microspheres

Product #	Diameter (µm)	Polymer	Catalog No
ECS 030	0,276-0,325	Polystyrene	39 368 082
ECS 050	0,476-0,575	Polystyrene	39 368 085
ECS 080	0,750-0,890	Polystyrene	39 370 080

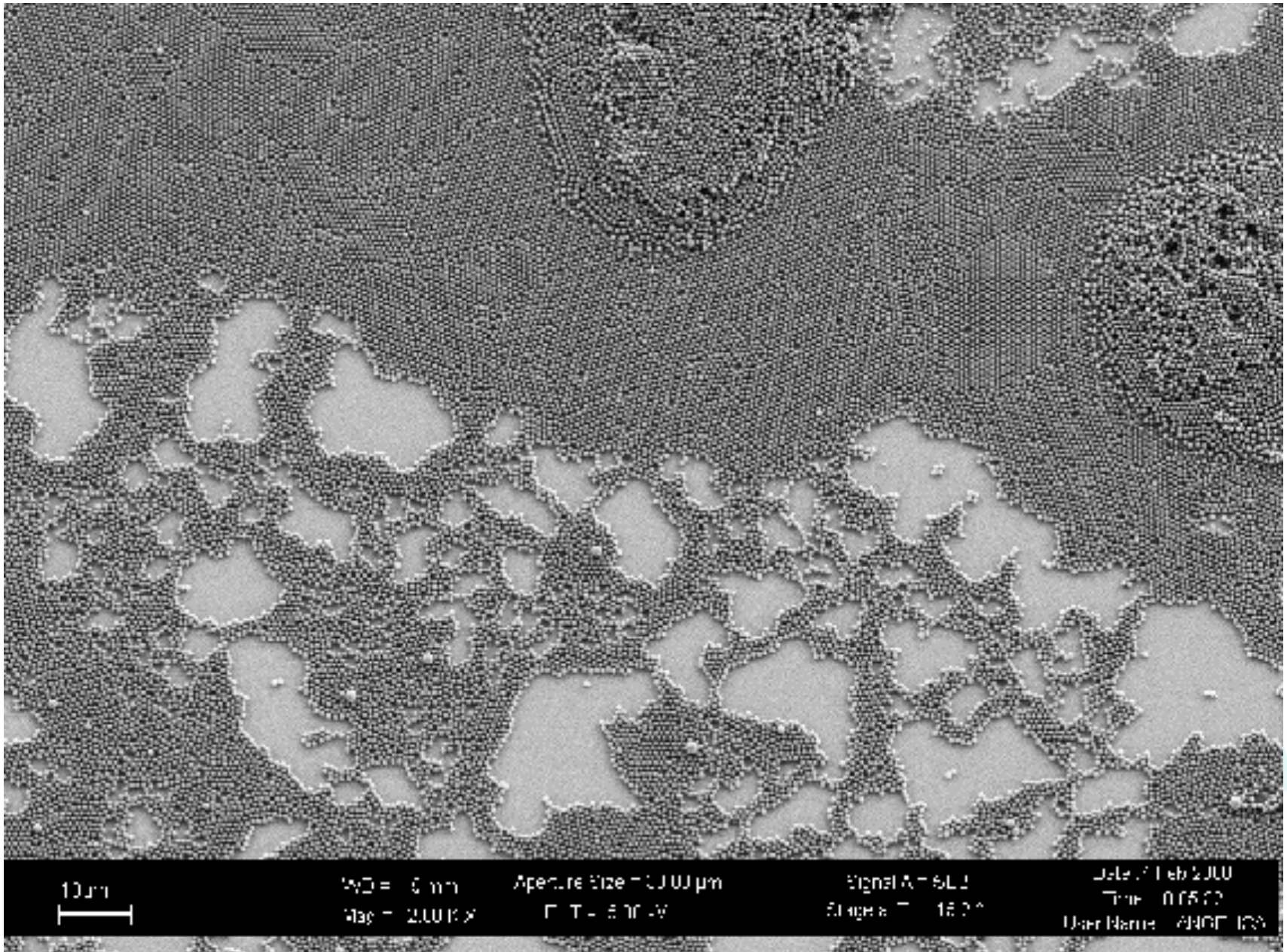




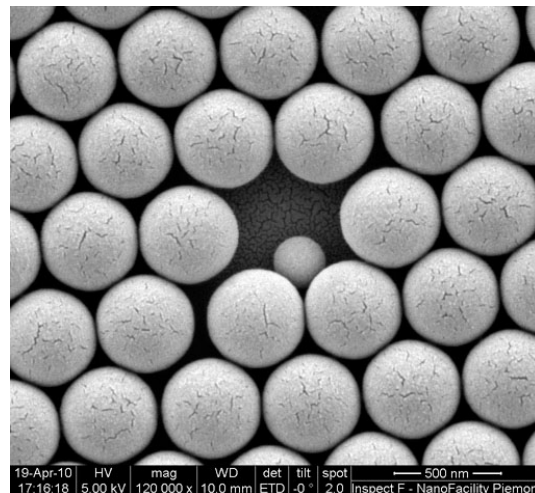
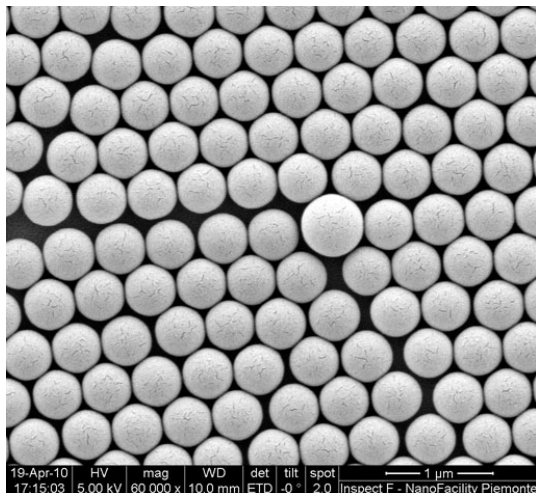
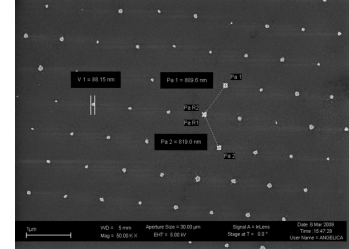
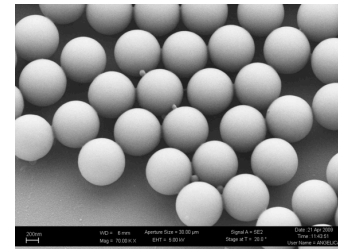
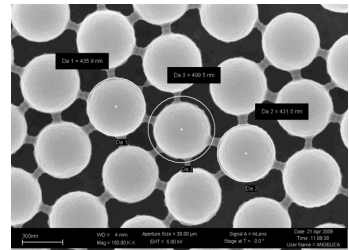
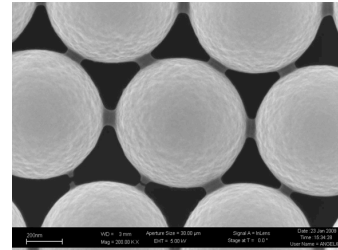
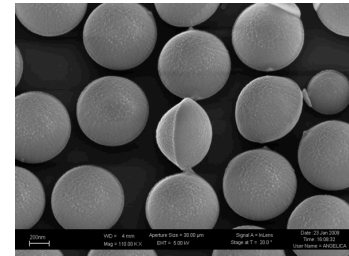
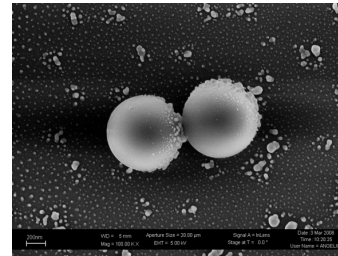
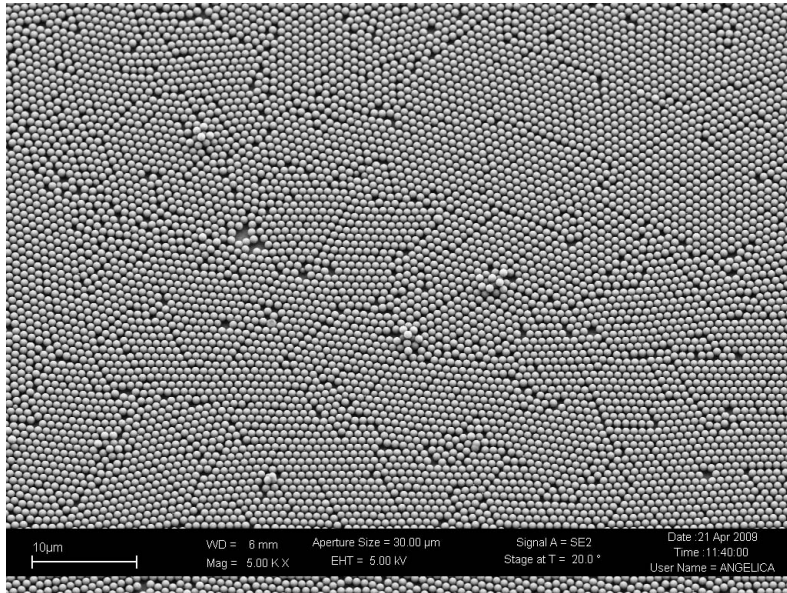
Polystyrene nanospheres (3000-50 nm)



Polystyrene nanospheres

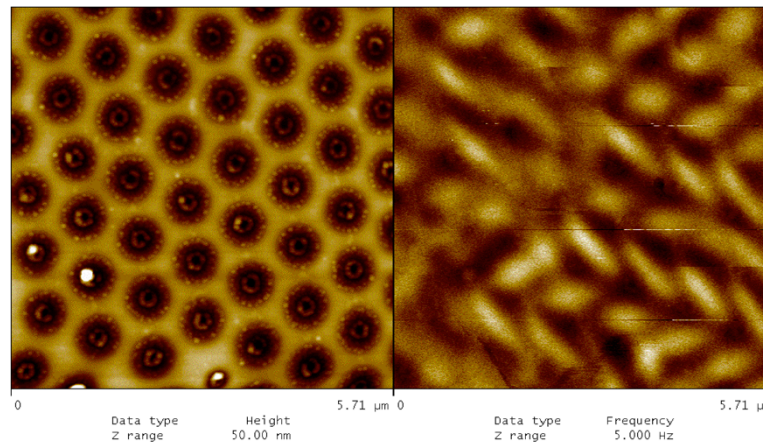
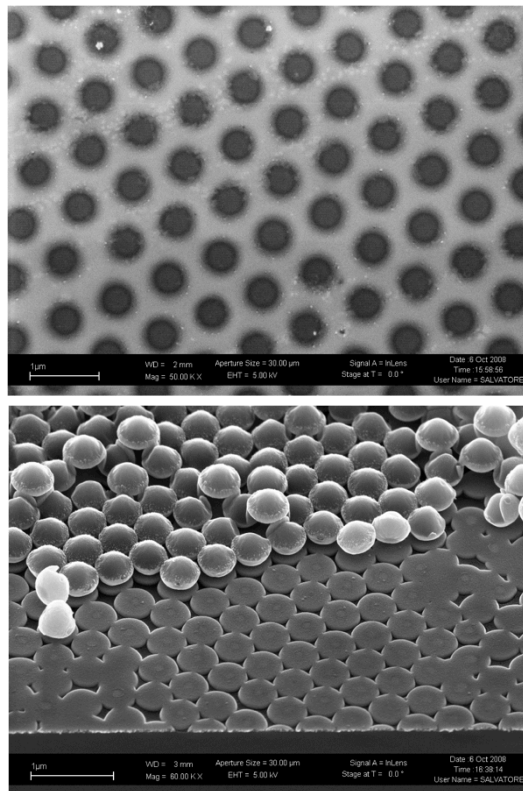


Defects

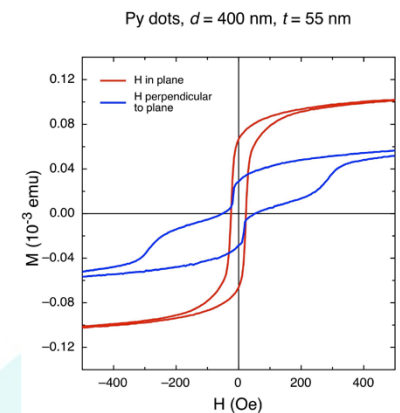
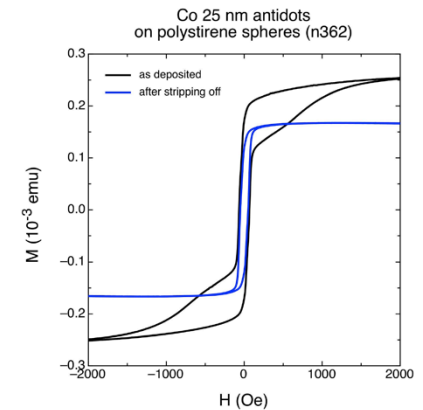


Anti-dot and dot nanostructures

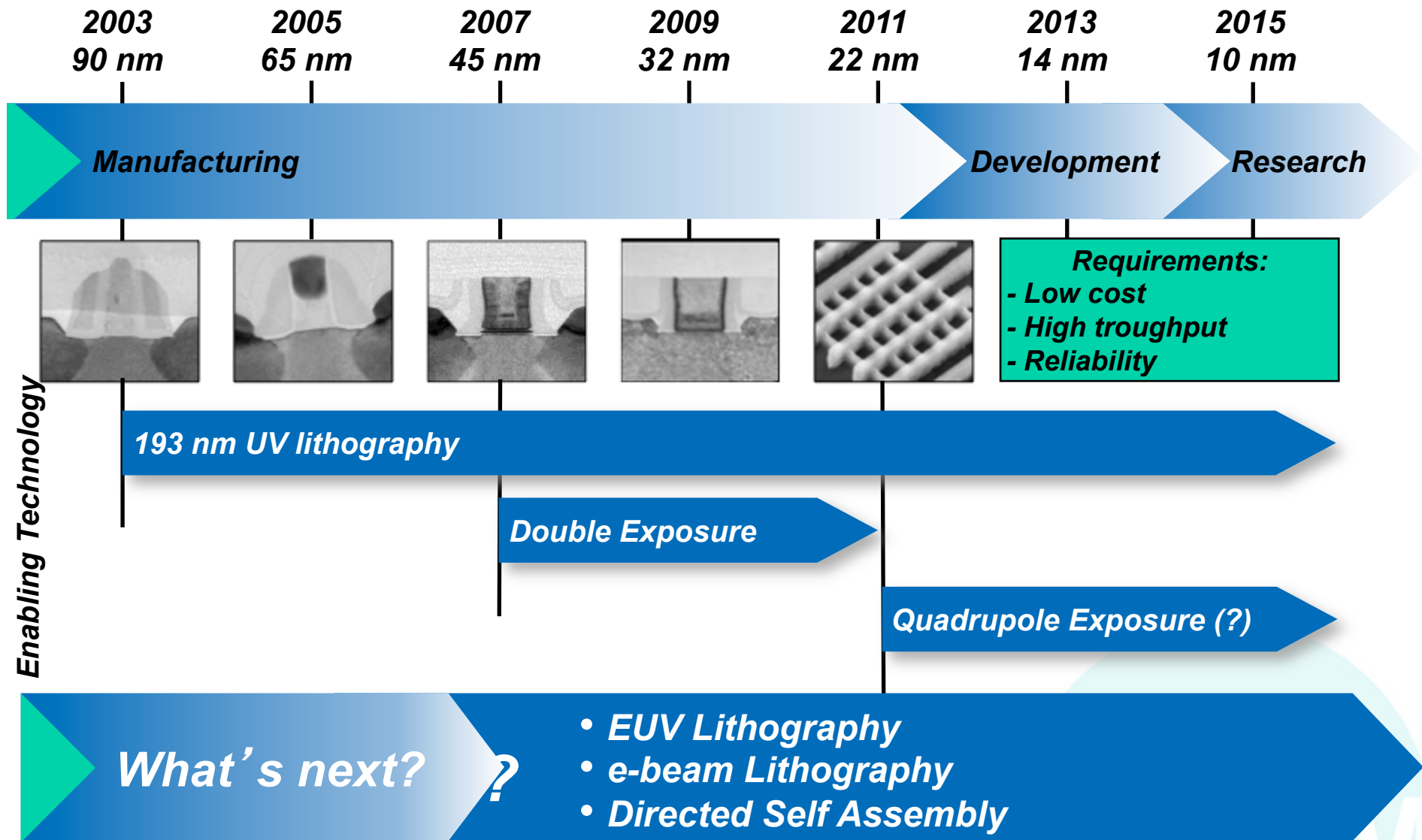
Magnetic thin films nanostructured by self assembly of polystyrene nanospheres



Co, 25 nm



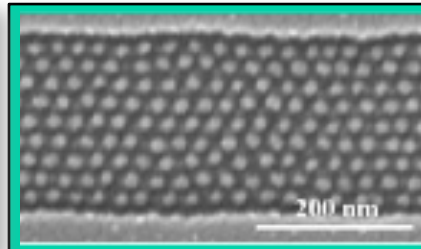
“Magnetic and magnetotransport properties of arrays of nanostructured antidots obtained by self-assembling polystyrene nanosphere lithography”, P. Tiberto, L. Boarino, F. Celegato, M. Coisson, N. De Leo, F. Vinai, P. Allia, accepted for publication on JAP (May 2010).



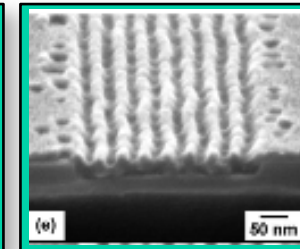
ITRS 2011 Edition: "Emerging Research materials"

Directed Self Assembly

Alignment of *self assembled patterns* in desired location with predictable shapes, controlled dimension, and registered within a lithographically generated pattern



Adv. Mater. 2003, 15, 1599-1602



Adv. Mater. 2007, 19, 607-611

Material Options

- Diblock Copolymers
- Triblock Copolymers
- Polymer Blends
- Hybrid polymers

Applications

- Selective Etch
- Selective Deposition
- Deterministic doping

Critical issues

- Low density of defects
- Process simplification
- Annealing time

ITRS 2011 Edition: "Emerging Research materials"



2000

2002

2004

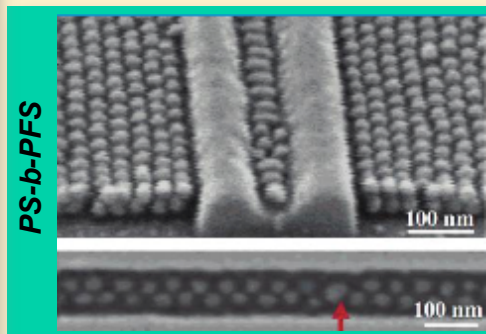
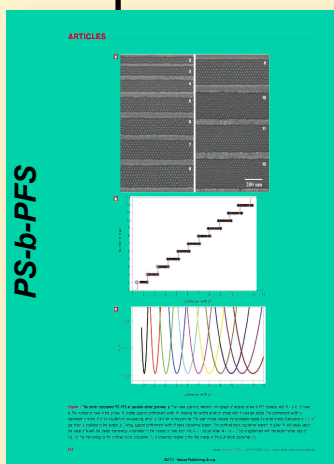
2006

2008

2010

2012

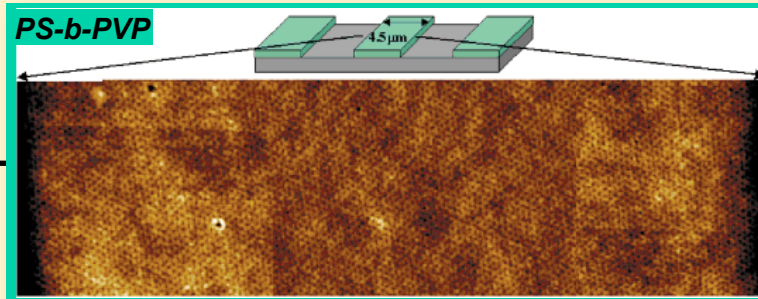
Graphoepitaxy



Cheng et al. *Nano Lett.* 2006, 6 2099

Cheng et al. *Nat. Mater.* 2004, 3 823

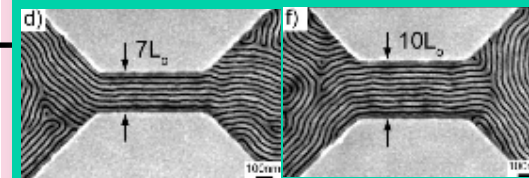
BCC Spheres



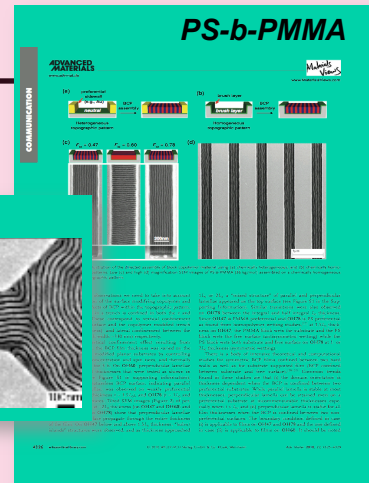
Segalman et al. *Adv. Mater.* 2001, 13 1152

Lamellae

PS-b-PMMA

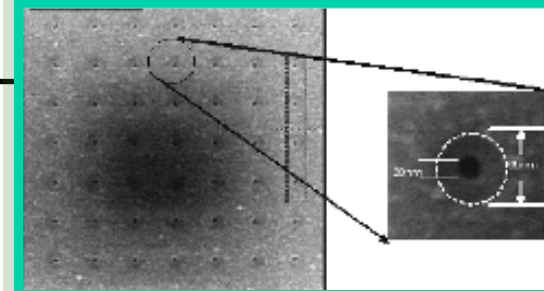


R. Ruiz et al. *Adv. Mater.* 2007, 19 2157



B. Han et al. *Adv. Mater.* 2010, 22 4325

PS-b-PMMA

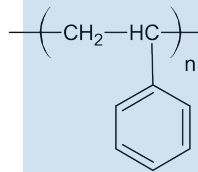


W. Li, S. Yang *J. Vac. Sci. Technol. B* 25, 1982 (2007)

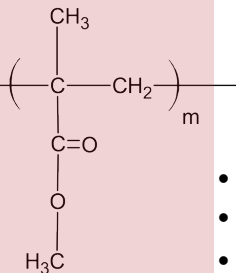
Cylinders

Block Copolymer

PS



PMMA

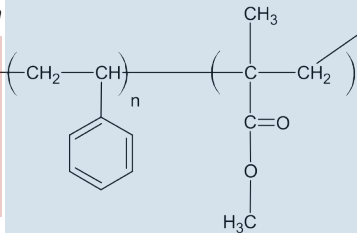
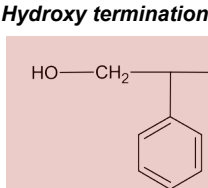


- PS:PMMA = 71:29
- $M_n = 67\text{k g/mol}$
- PDI = 1.09

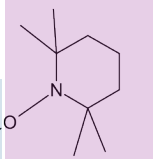
Random Copolymer

PS - *r* - PMMA

Hydroxy termination

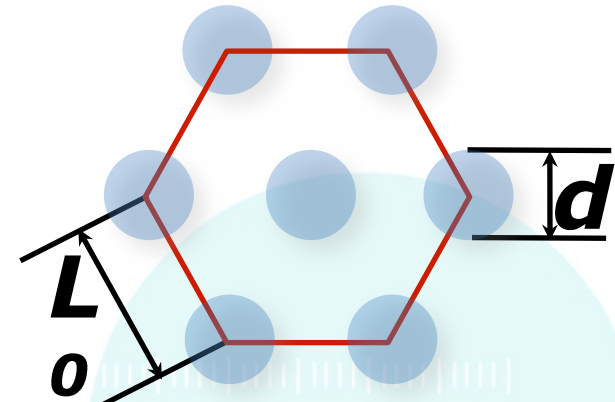
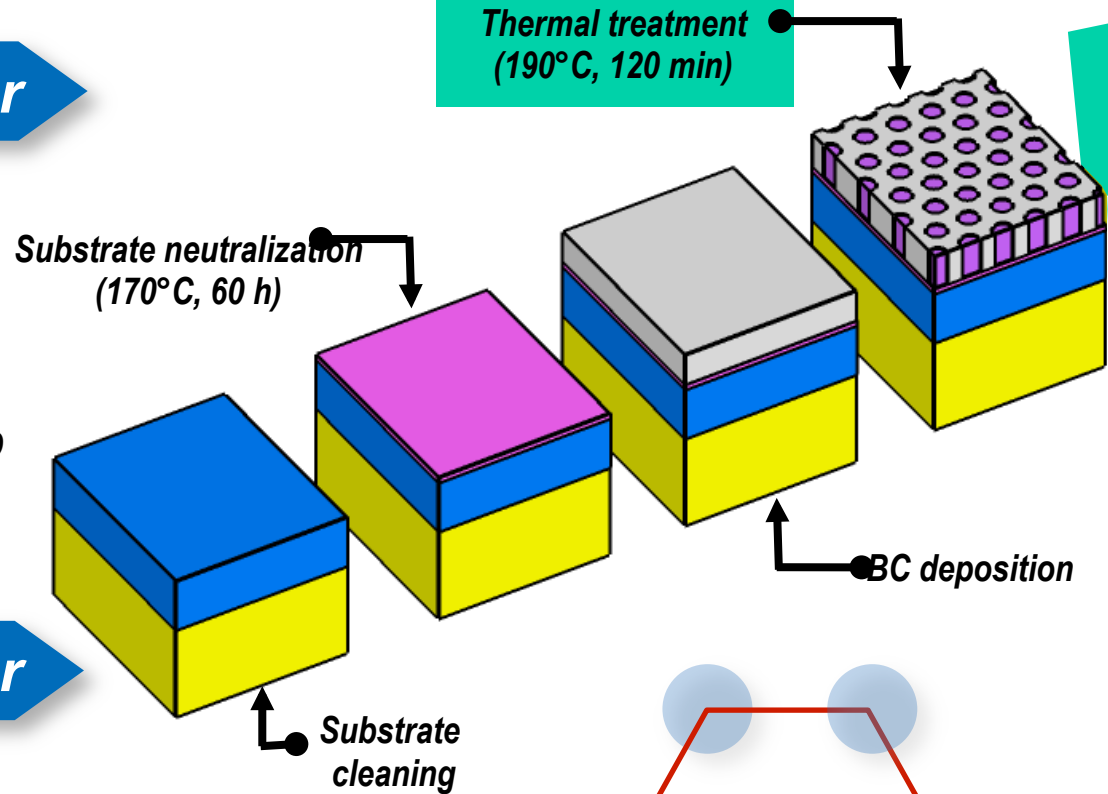


TEMPO group



- PS:PMMA = 62:48
- $M_n = 00\text{ g/mol}$
- PDI = 1.09

A. Andreozzi et al., *Nanotechnology* 22, 185304 (2011)



- $L_0 = 33.1 \pm 0.2\text{ nm}$
- $d = 17.3 \pm 0.4\text{ nm}$

Copolymer represents a way of mixing two immiscible polymers.

ALTERNATING

Definition: A block copolymer can be thought as two immiscible homopolymers joined together at the ends.

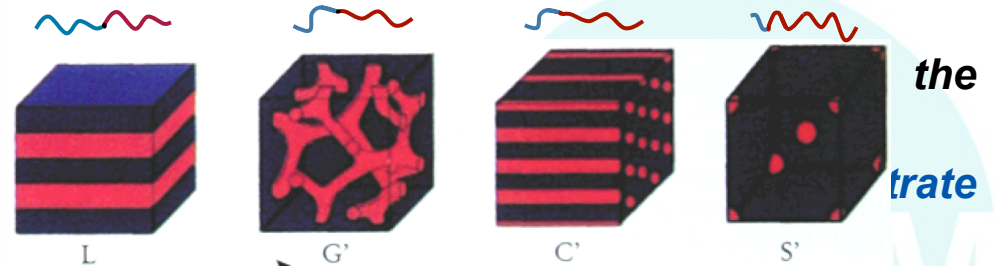


BLOCK



Nano-lithography

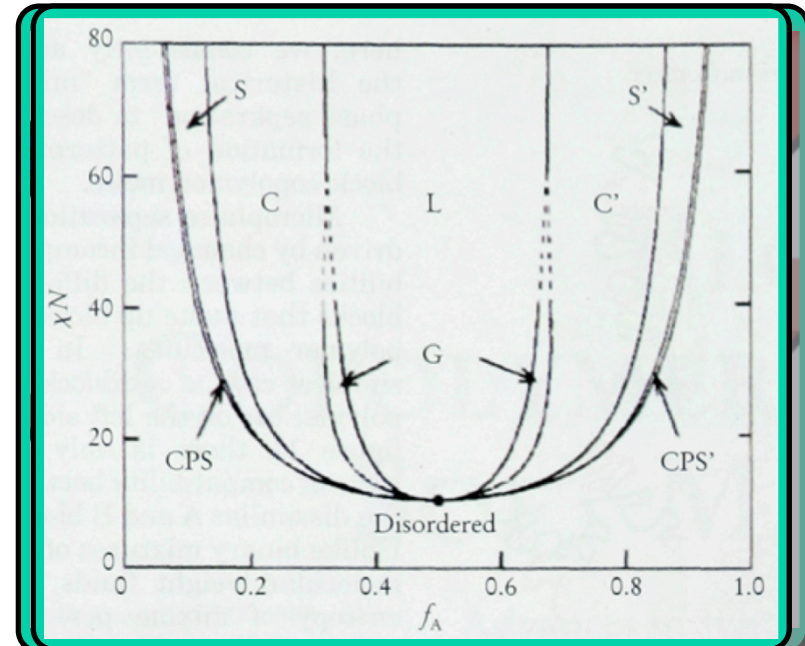
After selective removal of one of the two components the resulting nanostructured polymeric can be used as lithographic mask



The effective orientation of the nanostructures depends on:

the substrate

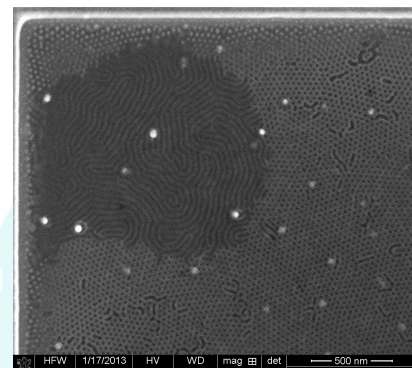
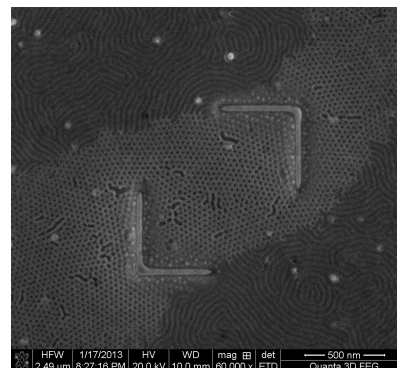
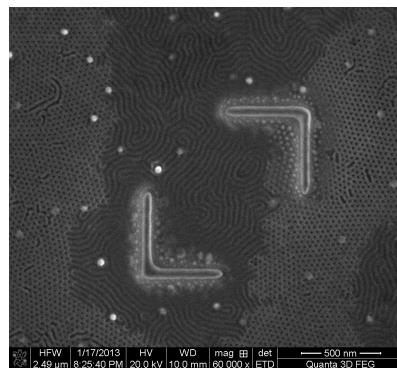
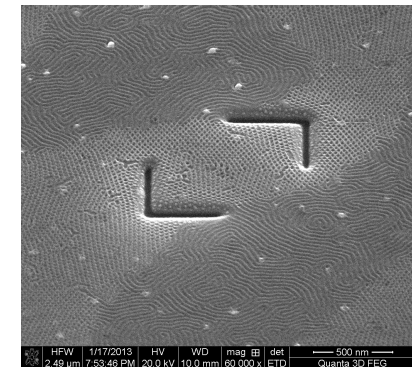
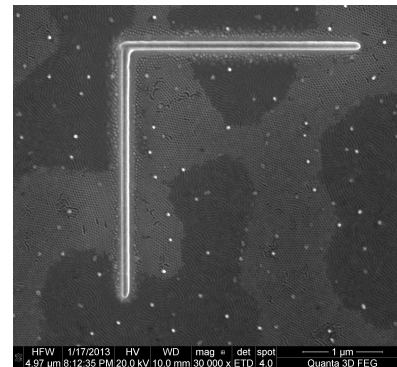
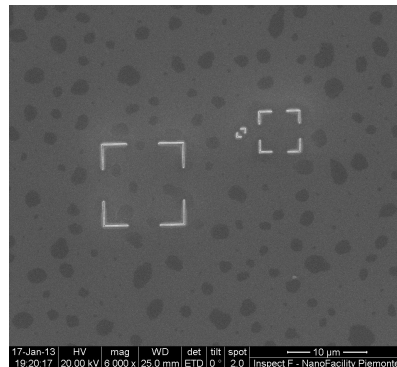
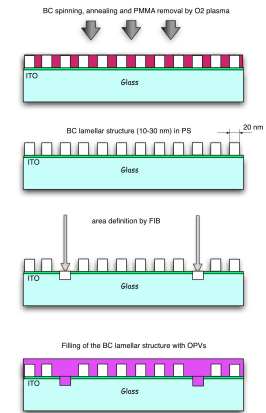
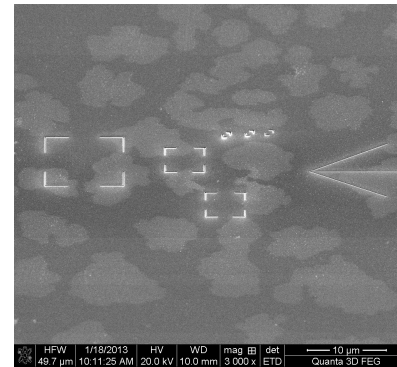
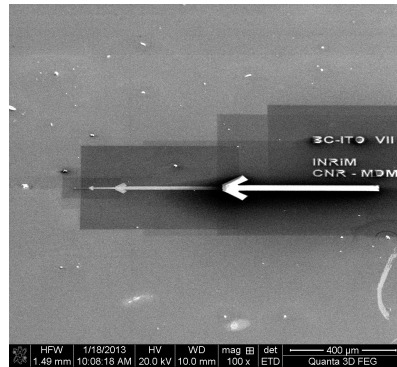
Block copolymer thin films Phase separation



F. S. Bates, G. H. Fredrickson, *Physics Today* 52:32-38(1999)

Standard models based on diblock copolymers <50 nm

WP3



Tesi disponibili presso i Laboratori QR e NanoFacility INRiM

Tutore: Giampiero Amato

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