Institute of microelectronics of Barcelona. IMB-CNM.





Remote meeting of Red Nanolito November 2020





Facilities

- ICTS-Clean room for integrated micro and nano fabrication

Recent research activities

- Si hierarchical structures
- Block copolymer lithography
- SETs by Ion beam induced radiation

ICTS Micro/nano fabrication Clean Room

1.500 m² total area

190 equipment units

3000 Wafers/year

550 Runs/year 40 staff

40 self service

2500 Hours self service

450 registered self service licenses





Equipment

- Thermal processes, CVD and ALD
- Ion Implantation
- PVD and Metallisation (Sputtering and Evaporators)
- Optical Lithography:
 - Proximity Aligners: single and double side
 - Steppers: g-line and i-line
 - Direct laser writing
- Nano-lithography (e-beam, NIL, FIB and AFM)
- Dry etching
- Wet and dry micromachining
- Wet etching and cleaning
- On-line test
- Conventional and advanced packaging
- Electrical characterization









ICTS

- Scientific and Technical Singular Facility (ICTS) is a label given by the Spanish Ministry
- MICRONANOFABS: Integrated Network of Micro and Nano Fabrication Clean Rooms
- It is distributed in three nodes
- <u>https://www.micronanofabs.org/</u>





H2020 Access Program "NFFA"



 an advanced distributed infrastructure to perform growth, nano-lithography, nano-characterization, theory and simulation and fine-analysis with synchrotron, FEL and neutron radiation sources.

NFFA-Europe next Spring will become PILOT for new schemes of Research Infrastructure: NEP (NFFA-Europe-Pilot) : 2021-2025



MICRO Nano F A B S





GOBERNO DE ESPAÑA

<u>COURSE:</u> Standard & Alternative Lithographies (2nd – 3rd December 2020)

ONLINE course. Language: English.

The registration fee is **FREE**. If you are interested, write an email to: <u>y.ryu@upm.es</u>, in order to get the **registration form**. **DEADLINE FOR REGISTRATION: 29th November 2020, 14:00 (CET)**



Fabrication of silicon hierarchical structures

Olga Muntada-López, Francesc Pérez-Murano IMB-CNM (CSIC) Achille Francone, Nikos Kehagias (ICN2)









Plastic Injection Moulding







PLASTFUN

Planta pilot de Peces Plàstiques amb Superficies Funcionals Avançades (RIS3, Generalitat de Catalunya / FEDER)



IME: In-Mold Electronics

- Integrated sensors
- Tactil interfaces
- Luminicent display integration

Nanotexture: Surface functionalization

- Hydrophobic / Hidrophilic
- Color, wavelight guide
- Gecko or Lotus effect

Plastic part with added value





PlastFun fabrication chain

















Hierarchical nanostrucures









MOLD FABRICATION PROCESS THREE LEVEL PHOTOLITHOGRAPHY







COMBINATORIAL APPROACH USING ONE SINGLE MASK

- A single photolithography mask to define all three levels. Allows for multiple combination of patterns
- Stepper UV optical lithography system. Resolution: 0.35 μm



"Nano"	"Micro"	"Macro"
0.4 - 1.2 μm	4 – 12 μm	30 – 60 μm







Nano + micro

Micro + macro



3-Level structures combination

Nano + micro + macro







100 mm wafer patterning without stitching







Polymer sheet replication



PMMA hierarchical micro + nano features



Achille Francone, Nikolaos Kehagias – ICN2

Presented at NNT 2019 Boston

Block co-polymer lithography

L. Evangelio, M. Fernández-Regúlez, S. Gottlieb, M. Lorenzoni, C. Pinto, J. Bausells F. Perez-Murano





Directed self-assembly









M. Lorenzoni et Al. "Sequential Infiltration of Self-assembled Block Copolymers: A Study by Atomic Force Microscopy," J. Phys. Chem. C, 2017.





SEM images taken after SIS + PS etching



PMMA modification by Sequential Infiltration

Synthesis (SIS)

M. Lorenzoni et Al. "Sequential Infiltration of Self-assembled Block Copolymers: A Study by Atomic Force Microscopy," J. Phys. Chem. C, 2017.

















M. Lorenzoni et Al. "Sequential Infiltration of Self-assembled Block Copolymers: A Study by Atomic Force Microscopy," J. Phys. Chem. C, 2017.









Directed self-assembly of block copolymer : processes (i)



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L. Evangelio et al. ACS applied materials & interfaces 11 (3), 3571-3581 2018

Directed self-assembly of block copolymer : processes (ii)



Guiding patterns fabricted by interference extreme-UV lithography



S. Gottlieb et al. Nano-confinement of block copolymers in high accuracy topographical guiding patterns: modelling the emergence of defectivity due to incommensurability. Soft Matter, 2018, 14, 6799-6808. DOI: <u>10.1039/C8SM01045E</u> Guiding patterns fabricted by ______



Self-assembled pattern

S. Gottlieb et al. Self-assembly morphology of block copolymers in sub-10 nm topographical guiding patterns. Mol. Syst. Des. Eng., 2019, 4, 175-185. DOI: 10.1039/C8ME00046H

Directed self-assembly of block copolymer : Characterization



EXCELENCIA SEVERO OCHOA





Self-assembly of block copolymers under non-isothermal annealing conditions as revealed by grazing-incidence small-angle X-ray scattering. M Fernández-Regúlez et al. J. Synchrotron Rad. (2020). 27, 1278-1288 doi.org/10.1107/S1600577520009820



Nanomechanical resonator based on suspended nanowires



Directed self-assembly of block copolymers for the fabrication of functional devices . C. Pinto-Gómez, F. Pérez-Murano, J. Bausells, L. G. Villanueva, M. Fernández-Regúlez Polymers 2020, 12(10), 2432



Nanomechanical resonator based on suspended nanowires



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Single electron transistors based on ion implantation

E. Amat, A. Del Moral, J. Bausells F. Perez-Murano





Ion irradiation induced Si nanodot self assembly for SET fabrication











M.-L. Pourteau et al. Micro and Nano Engineering, 9, 2020, 100074. doi.org/10.1016/j.mne.2020.100074.

IONS4SET Newsletter #1



EFTEM Si plasmon loss image of a Si nanopillar with a single Si QD in the embedded SiO₂ disc.



MC simulations of SiOx phase separation for different pillar diameters. The number of precipitated Si QDs decreases with shrinking pillar diameter where a single Si QD is formed for a mixed volume of about 500 nm³.





Scheme of the main steps of the process flow for the fabrication of the contacted SET.



4 lithography levels. 50 individual process steps





Optimized process



Contacted SET for fabrication of a single electron transistor







50

0 50

1.57

10

15

GUUU®





Ions4SET

More information



Thank you!





www.imb-cnm.csic.es