

Simpozionul:

“De la excelenta la competitivitate: tehnologiile generice esentiale”

Aula Academiei Romane, Bucuresti 15 mai 2014.

Laser and Plasma-based Nanotechnologies

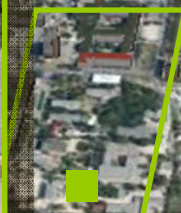
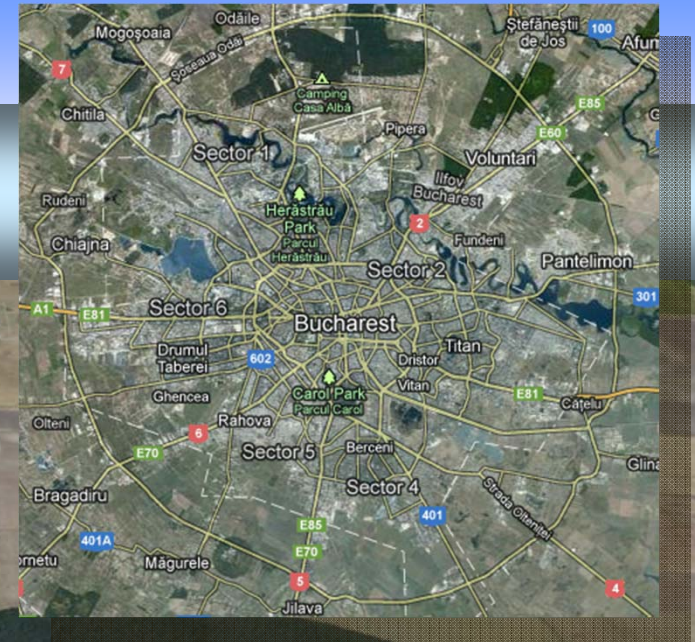
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INFLPR

Center for Advances Laser Technologies, CETAL

Faculty of Physics, University of Bucharest

IFA and ELI-NP Head Office

National Institute for Materials Physics

National Institute of Physics and Nuclear
Engineering, Department of Computational
Physics and Information Technologies

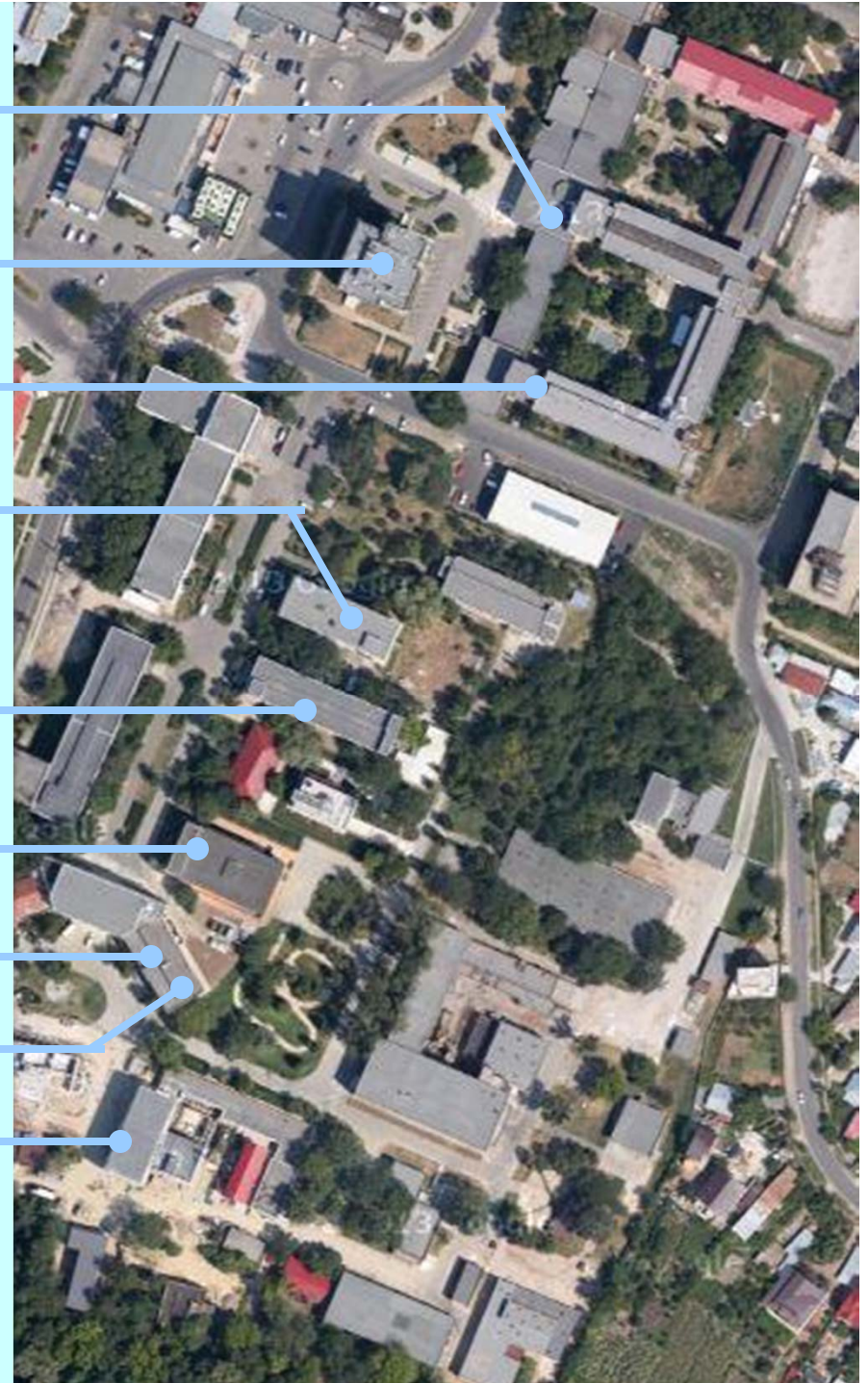
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Nanotechnologies and advanced materials at INFLPR

Synthesis of nanomaterials

Laser photochemistry.
Plasma synthesis.

Functionalization of nanomaterials

Plasma processes for functionalization.
Hydrophobic/ hydrophilic laser processed nanostructured surfaces.

Surface nanostructuring

Laser-surface-plasma interactions.
Laser processing of nanostructured thin films.
Nanostructured films by thermionic vacuum arc.

New micro- and nano-scale laser processing technologies.

1D, 2D, 3D Direct laser writing.
Optical near-field laser processing.
Self-organization of laser induced nanostructures.

Nanophotonics

Quantum dots.
Metamaterials.
Photonic bandgap structures.

Applications of nanostructures in biology

Nanostructured surfaces for tissue engineering.
Nanomaterials for drug delivery .

The synthesis of nanomaterials by laser pyrolysis, LCVD and plasma

- Oxides, carbides, nitrides nanoparticles ($\gamma\text{-Fe}_2\text{O}_3$, TiO_2 , SnO_2 , CN_x , Fe_3C ,)
- Metallic nanoparticles (Ti, Sn, Fe)
- Core-Shell iron-carbon nanocomposites
- Carbon nanotubes
- Carbon nanowalls
- Carbon nanofibers

Applications

Magnetic separation of proteins

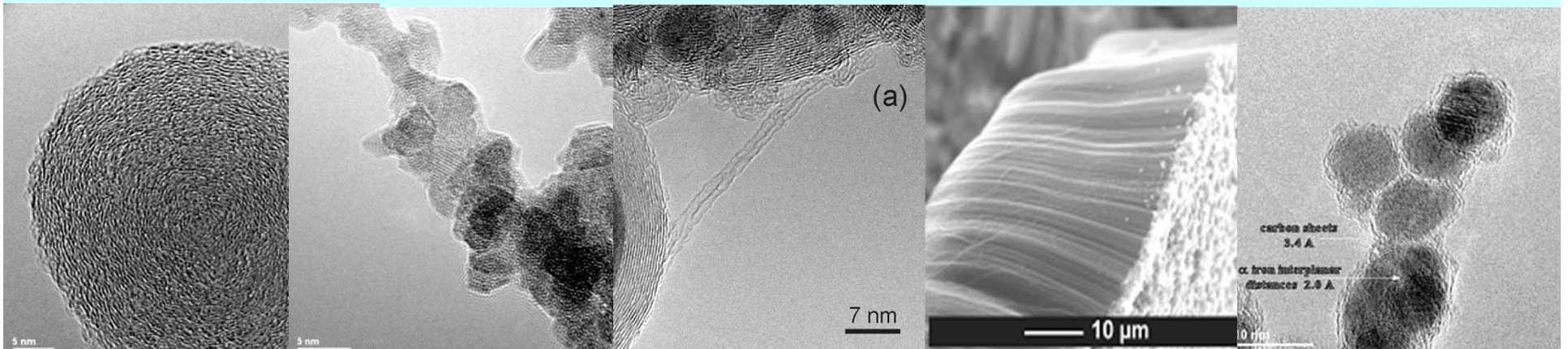
Magnetic sealing

Thermal nanofluids

Catalysts

Composite fillers

Drug delivery and contrast agent for MRI



Nanostructures obtained by pulsed lasers

- Nanometric ceramic and metallic powder (AlN, Cu, Si quantum dots).
- Porous materials fabrication by laser (Al_2O_3 , SiO_2 , TiO_2 , ZrO_2).
- Thin films for photonic crystals.
- Thin films of bio-organic materials and Polymers (MAPLE, PLD).
- Thin films and heterostructures (ferroelectrics, piezoelectrics).

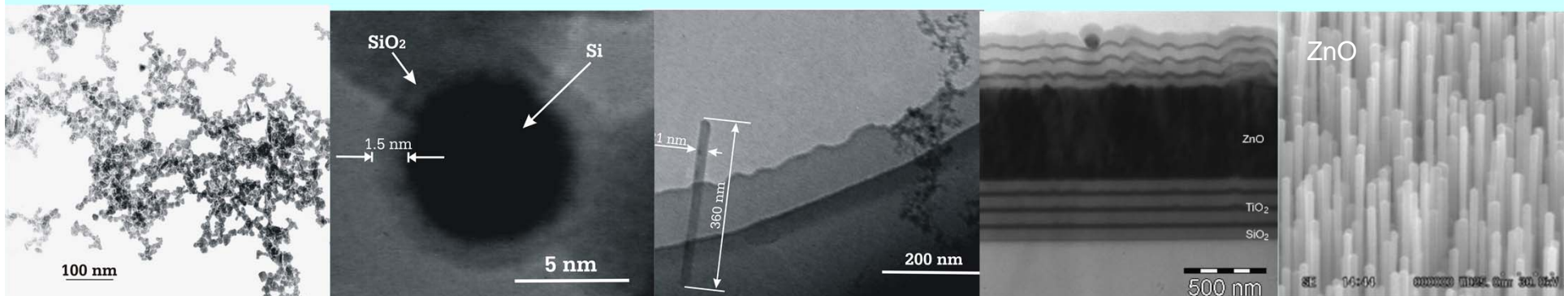
Applications

Nanomaterials for catalytic and biological applications.

Heterostructures for light emitters and detectors.

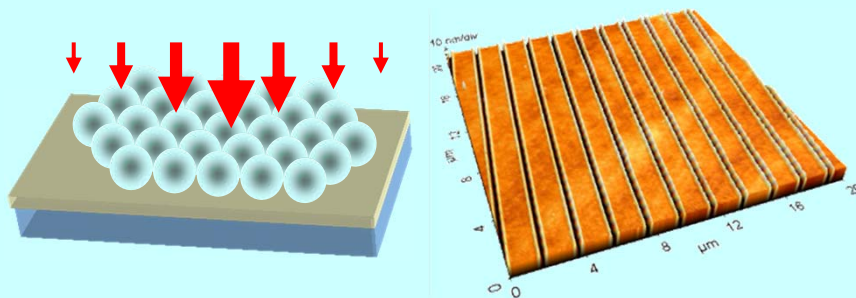
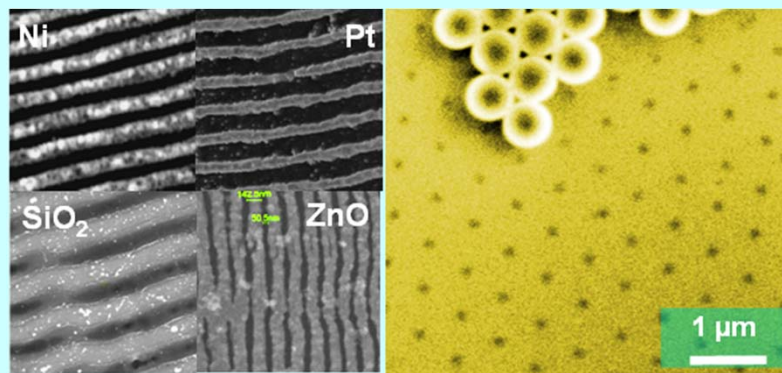
Gas sensors.

Nanotoxicology – markers.



Nano-scale laser processing technologies on large surfaces

- Self-organization of laser induced periodical nanostructures (metals, dielectrics, polymers)
- Near-field laser processing of large surfaces.



Applications

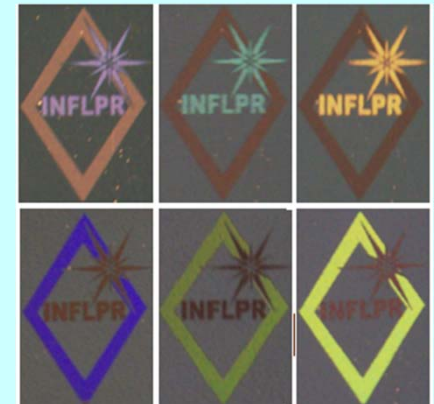
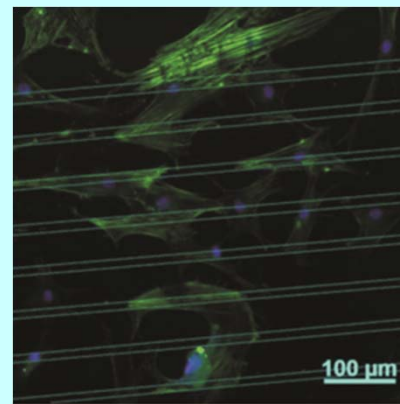
Bio-mimetic surfaces for tissue engineering.

Surfaces with controlled wettability.

Surfaces with increased effective area for sensors.

Nanostructured surfaces for SERS.

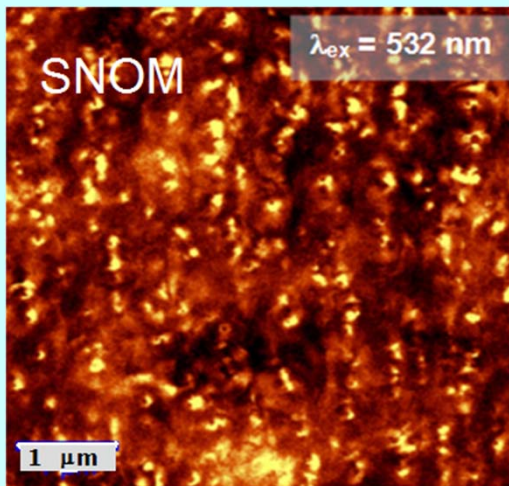
Colour coding for surface marking.



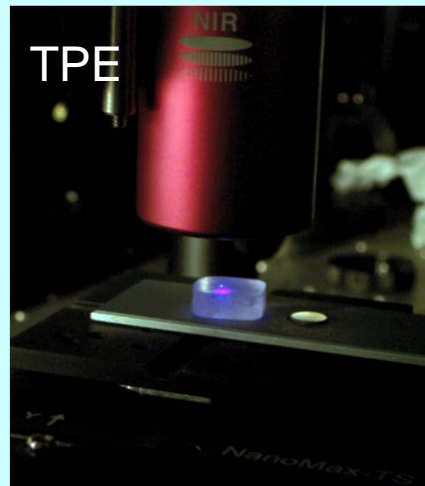
Nanophotonics

- Nonlinear optical characterization of the nanostructures.
- Metamaterials & Photonic bandgap structures.
- Plasmonic nanostructures.
- Quantum dots characterization (Z-scan, SNOM).
- High resolution optical characterization by Two-Photon Emission (TPE).

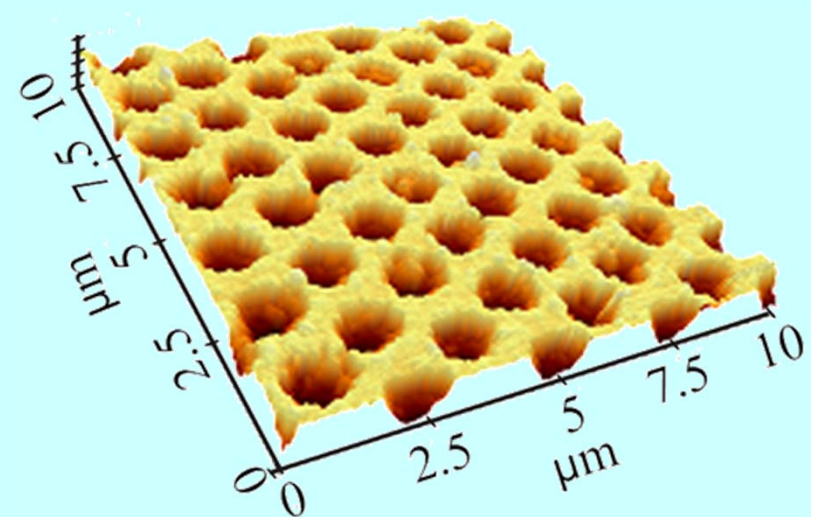
Plasmon nanostructures



TPE microscopy



TiO₂ fs laser patterned film



Center for Advances Laser Technologies

CETAL

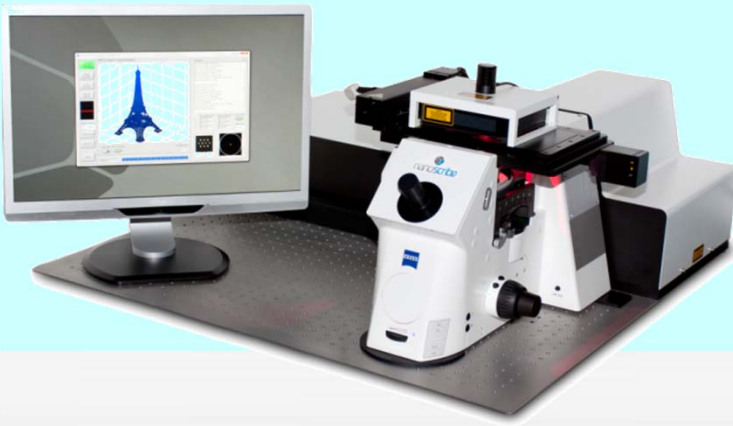
- L1 – High intense laser fields (1 PW laser system)
- L2 – Laser macro- and micro-processing
- L3 – Photonics-based investigations

Main infrastructure of CETAL-L2

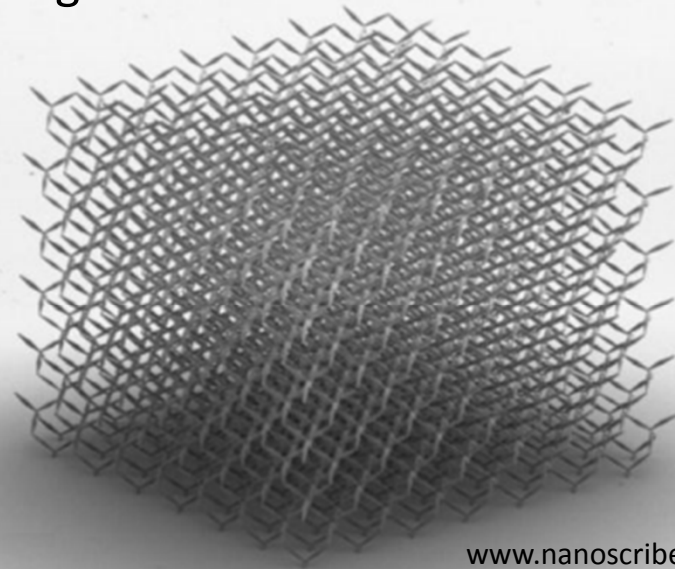
Laser facility for micro- and nanoprocessing

- Laser system for 2D and 3D laser lithography.
- Picoseconds laser for micromachining.
- Pulsed laser deposition system, RHEED compatible.
- Continuum wave and pulsed CO₂ laser for photochemistry and nanomaterials synthesis.
- Clean Room ISO7 (class 10.000) – 100 m²

Laser system for 2D and 3D laser lithography

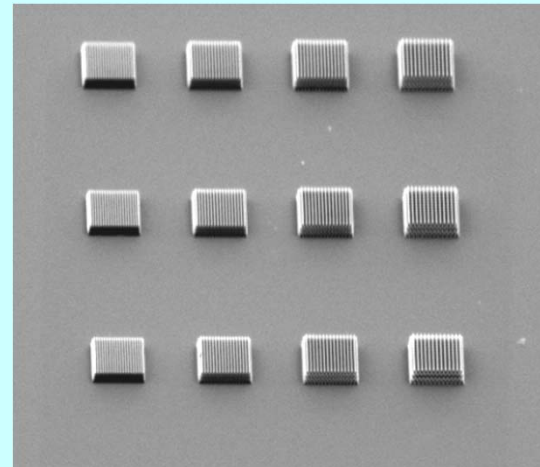
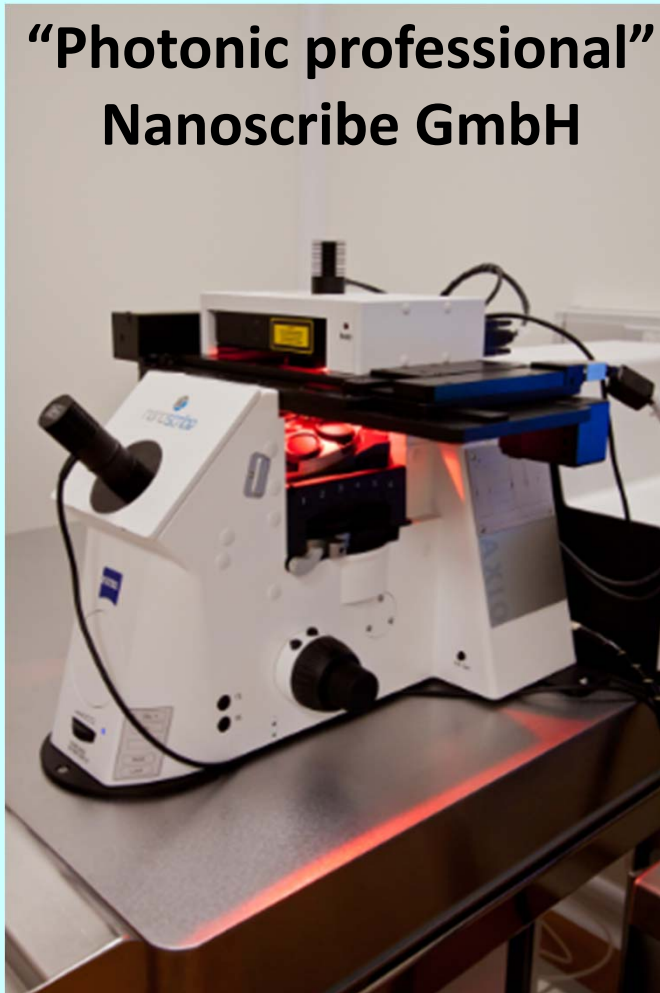


- micro-optics
- photonic crystals and metamaterials
- scaffolds for tissue engineering
- micro-fluidics
- wire bonding
- 2D masks

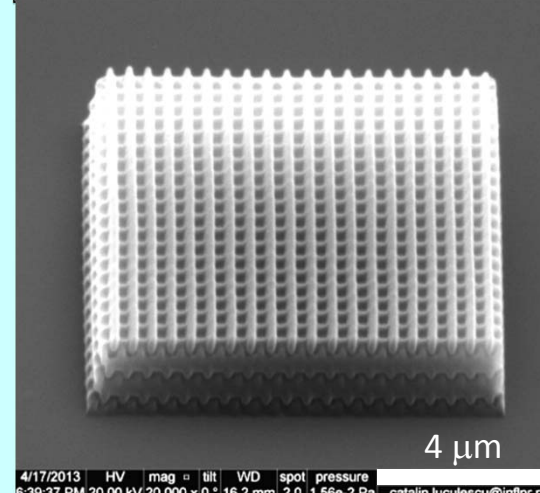


Laser system for 2D and 3D laser lithography

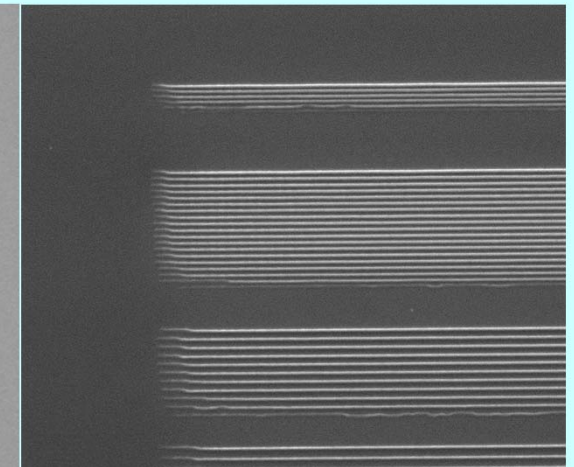
**“Photonic professional”
Nanoscribe GmbH**



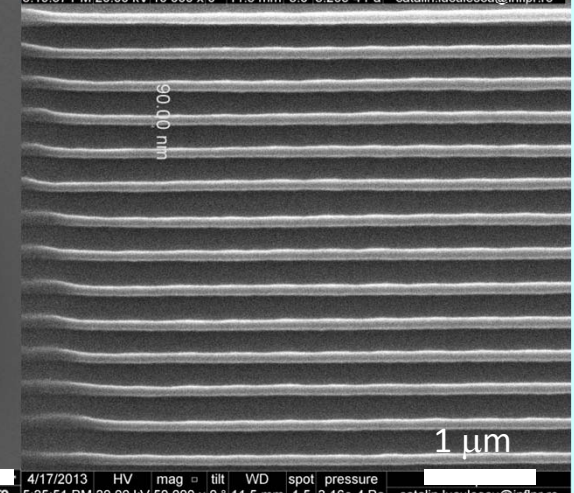
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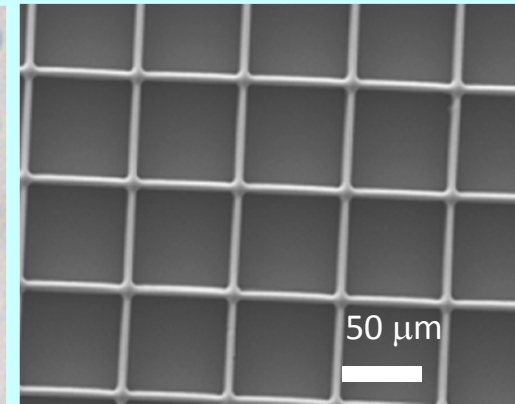
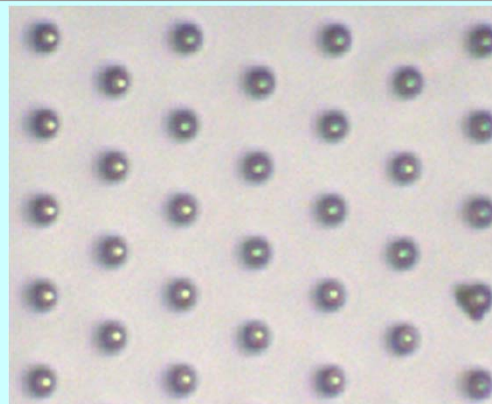
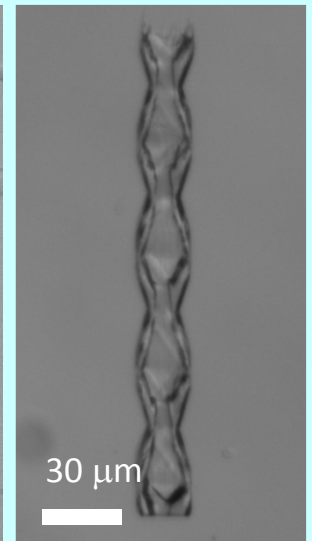
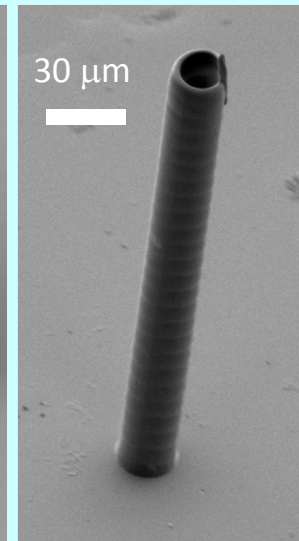
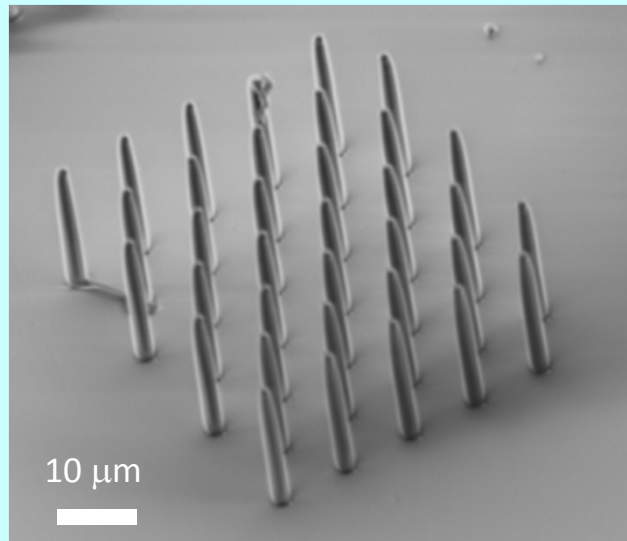
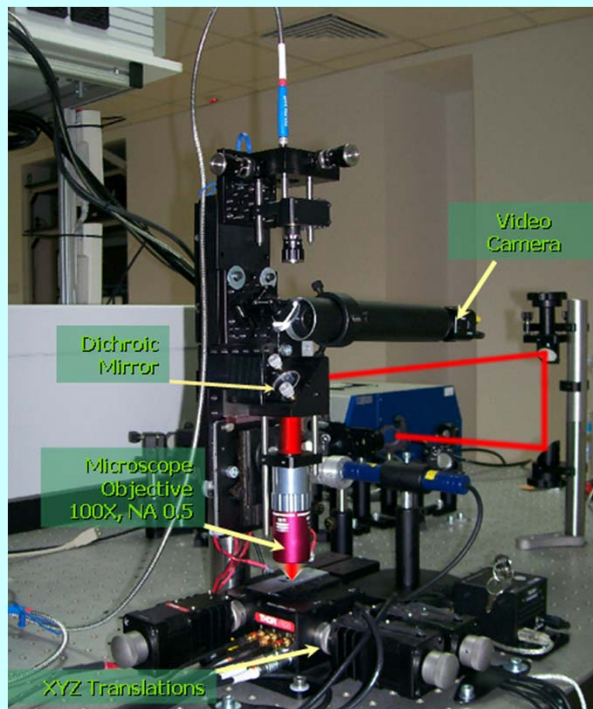
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4/17/2013 HV mag □ tilt WD spot pressure 1 μm
5:25:51 PM 20.00 kV 50 000 x 0 ° 11.5 mm 1.5 3.16e-4 Pa catalin.luculescu@infipr.ro

Laser system for 2D and 3D laser lithography

Microstructures previously produced at INFLPR



Femtosecond and Picoseconds laser ablation

- Cutting, drilling, dicing
- Laser Induced Forward Transfer (LIFT)
- Matrix-assisted pulsed laser evaporation direct writing (MAPLE-DW)
- Laser ablation with sub-micrometer resolution



LUMERA HYPER RAPID 50

Pulse duration <15 ps

1065 nm - 50 W

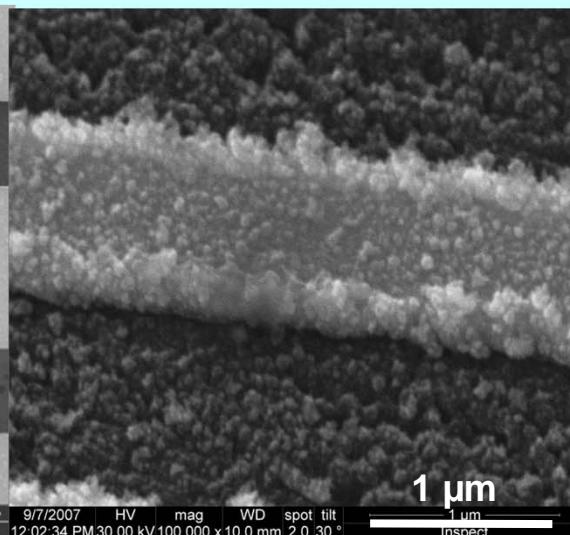
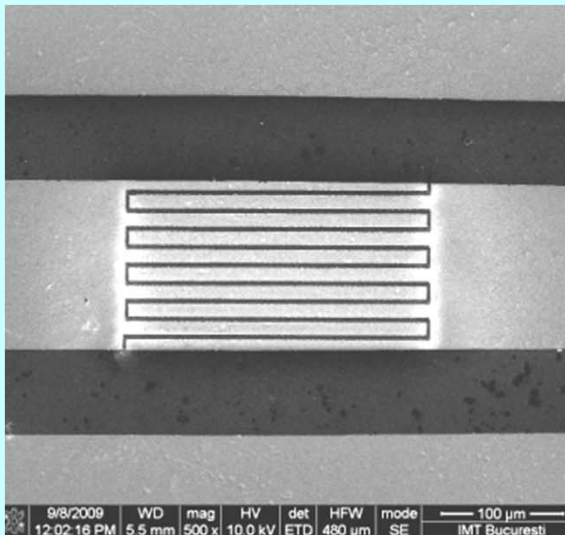
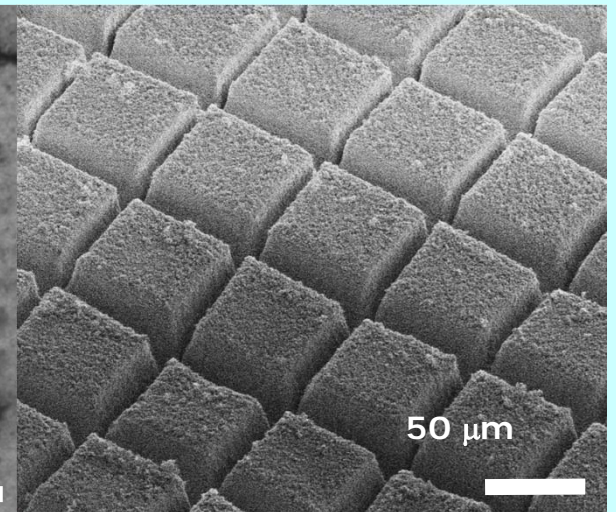
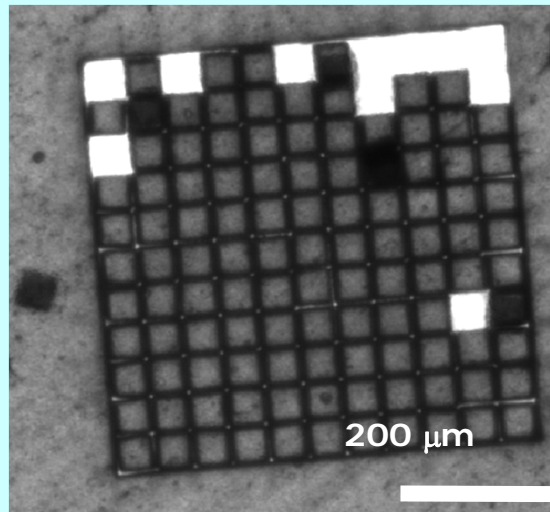
532 nm

355 nm

500 kHz

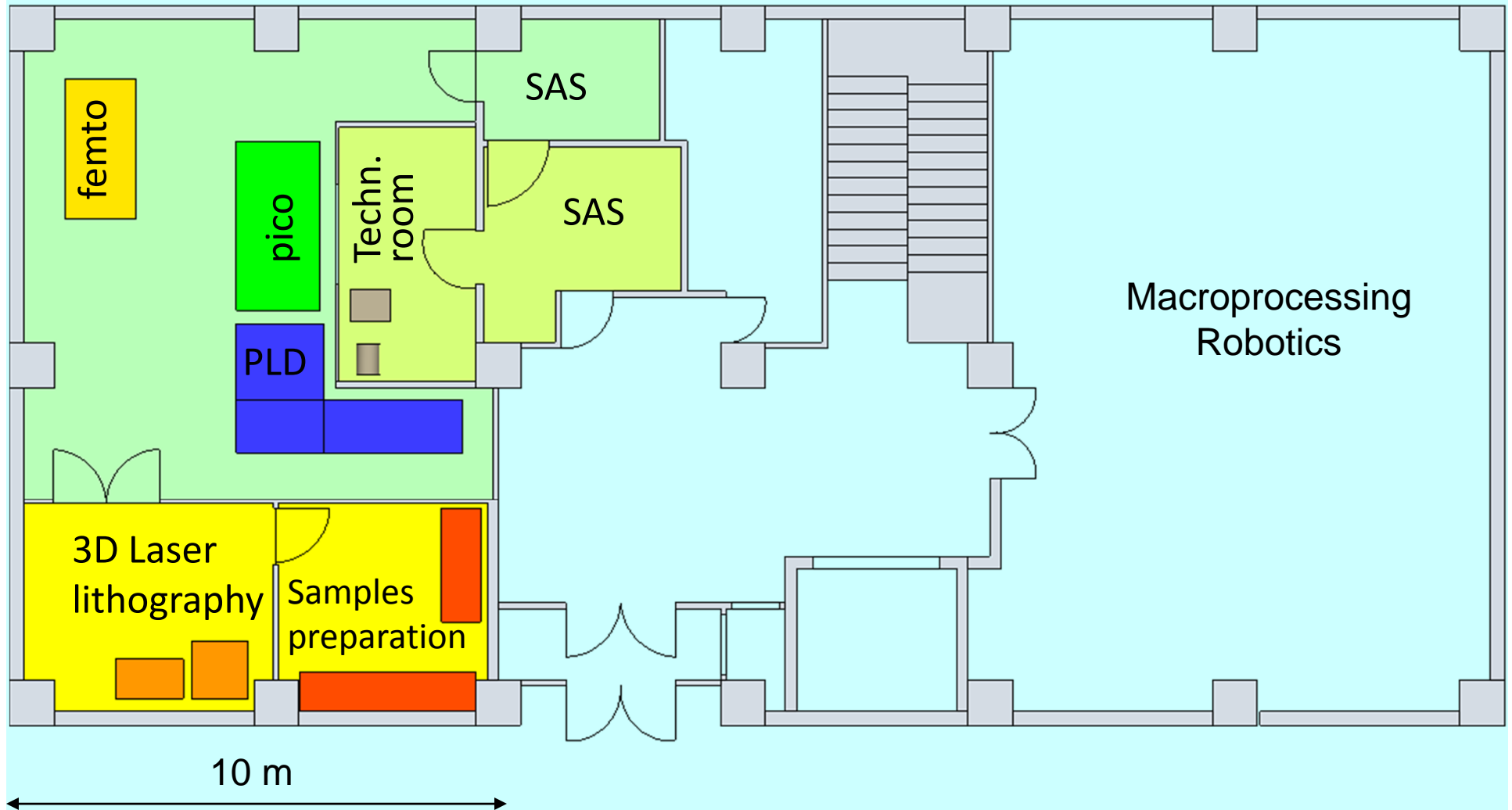
Microstructures fabricated by femtosecond laser ablation

- **Cutting, drilling, dicing :**
Alumina wafers
(100 μm thickness)



- **Laser ablation with sub-micrometer resolution**
Gold interdigital capacitors,
electrodes for micro-sensors,
microwave circuits, etc.

Clean Room class 10.000 (ISO7)



Main infrastructure of CETAL-L2

Laser facility for macroprocessing

TruLaser Cell 3010



TruLaser Robot 5020



TruDisk 3001

TruPulse 62

TruMicro 7050

Main infrastructure of CETAL-L3

Photonics-based investigations

- Raman spectroscopy for imaging and chemical identification.
- Laser-induced breakdown spectroscopy (LIBS) system.
- THz spectrometers.
- Frequency comb laser system 2.5×10^{-12} uncertainty; Vis.-IR.
- CW & pulsed tunable stabilized lasers: 200 -10800 nm
- Spectro-radiometers.
- Spectral analyzers.
- Etalons and software.
- Lambdameter for pulsed lasers.
- Laser beam diagnosis.



1 PW Laser system - CETAL-L1

High intense laser fields



Output 1:	Peak Power	1 PW
	Pulse duration	25 fs
	Rep. Rate.	0.1 Hz
Output 2:	Peak Power	45 TW
	Pulse duration	25 fs
	Rep. Rate.	10 Hz
Output 3:	Peak Power	1GW
	Pulse duration	30 fs
	Rep. Rate.	1 KHz

Conclusions

INFLPR:

- ❑ has expertise on nanomaterials synthesis and functionalization of various materials.
- ❑ developed new laser based technologies for nanostructuring.
- ❑ is involved in applications of nanomaterials and nanostructures on optics, electronics, medicine, chemistry etc.
- ❑ offers the acces to a new research infrastructure (CETAL), and provides research services to industrial entities.
- ❑ is ready to join the EU efforts to develop regional R&D activities.



Thank you!

www.inflpr.ro
cetal.inflpr.ro

INFLPR

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