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Université de Liège

Surface & Nanoengineering Division

Laser and Ion Beams for Materials Nanoengineering

Presented by Dr. K. Fleury-Frenette

Outline

- *CSL overview*
- *Ion-induced nanostructures*
- *Laser ablation in liquids for nanoparticles production*

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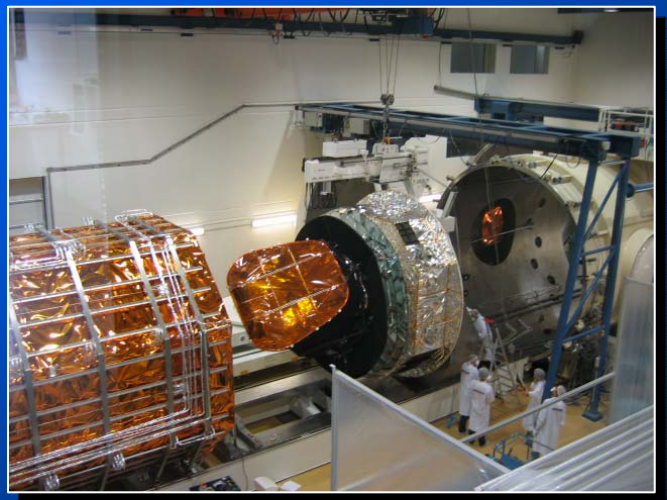
Centre Spatial de Liège

- ESA Coordinated Facility (Optical Testing)
- Largest Centre of the University of Liège

- Departments :
  - » Tests
  - » Space Instrumentation (R&D)
  - » Advanced Technologies



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Advanced Technologies Department

directed by Jean-Hervé Lecat

- **Solar Technologies**
- **Microfabrication**
- **Sensors & Smart Structures**
- **Surface & Nanoengineering** **(formerly Advanced Surfaces)**

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The Team

Scientists	***Technicians***	***Students***
K. Fleury-Frenette	*P. Chalon*	*V. Bruno*
P. Gailly	*P. Skutnik*	*J. Charignol*
J. Hastanin	*J. Rosin*	
F. Rabecki		
D. Wildéria		

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From 'traditional' surface treatment activities

- **Ion Beam Figuring – Texturing**
- **Plasma Beam Etching – Functionalisation**
- **Thin-Films Coating**

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Micro and Nanostructure Characterisation

Hardware

- Scanning Electron Microscope
- Atomic Force Microscope
- Optical Profiler
- Ellipsometer
- X-ray Diffractometer

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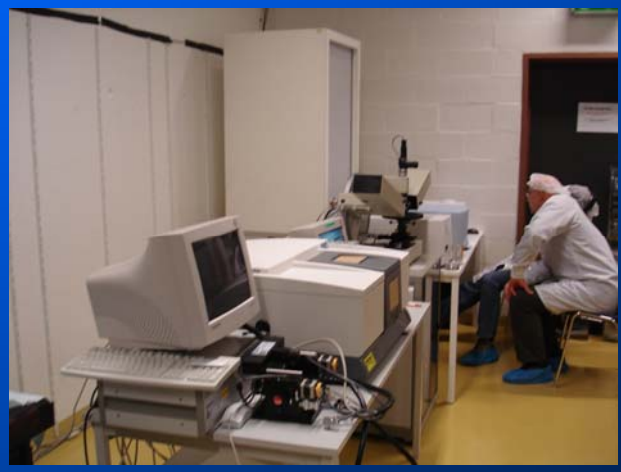
Optical Characterisation

Properties

- Transmission (190nm-3300nm)
- Specular and Diffuse Reflectivity (250nm-2500nm)
- Solar Absorbance
- Complex Refractive Index (280nm-25µm)

Hardware

- UV-VIS-NIR Spectrometer
- UV-VIS ellipsometer
- IR ellipsometer



Ion-induced periodical nanostructures

- ***Broad beams (macroscopic)***
- ***Low energy (100 eV – 1keV)***
- ***Spontaneous or self-arranged***
- ***Sub-micron scale (vertical & lateral)***

Phenomenology

- Competition between erosion and surface diffusion

Process Parameters

- Ion nature
- Ion energy
- Angle of incidence
- Substrate (target) temperature

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Ion-induced nanostructures facility

- 3cm and 10cm-Kaufman ion sources
- Ne^+, Kr^+ , Ar^+, Xe^+
- 5-axis source displacement system

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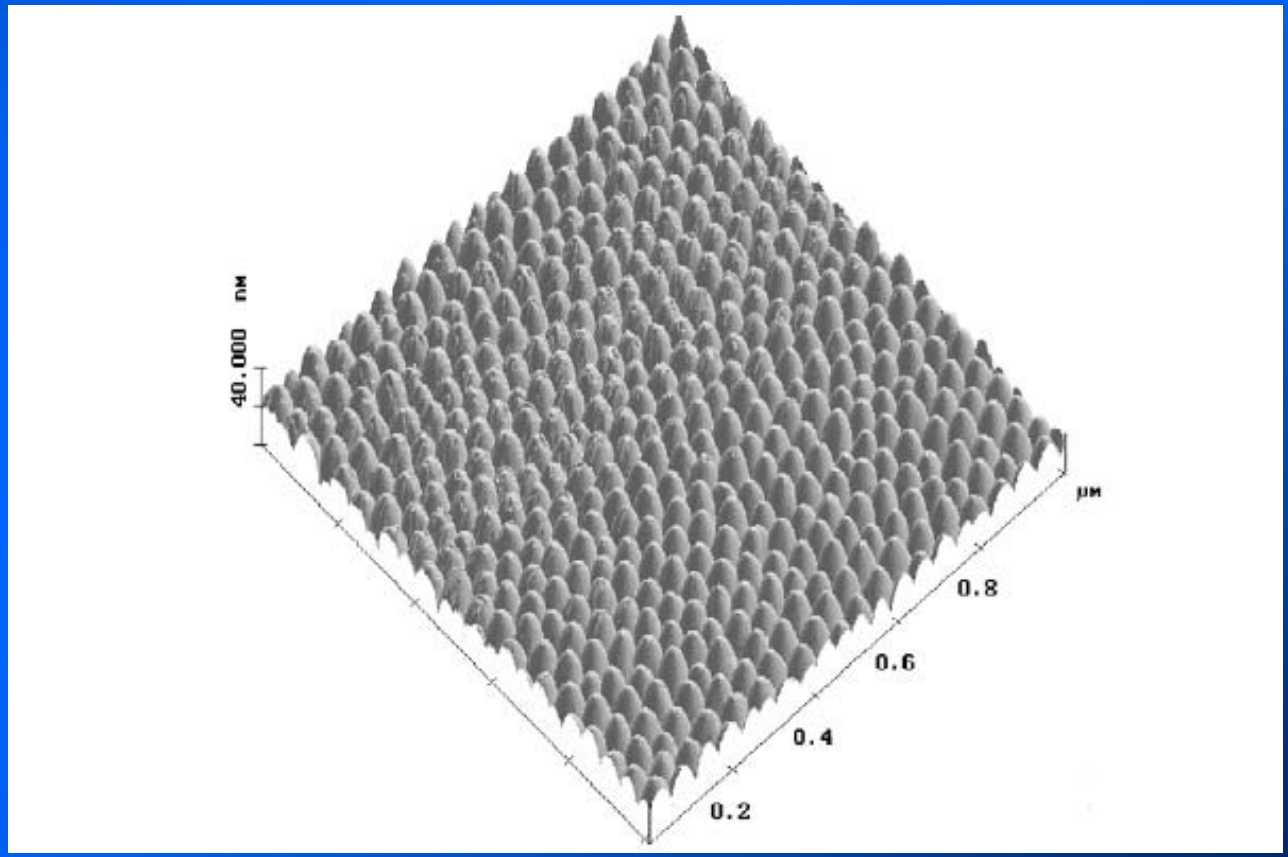
Dots

500eV $Ar^+ \rightarrow GaSb$

Normal incidence

λ ~ 40 nm



T. Bobek, S. Facsko, T. Dekorsy, H. Kurz, Nuclear Instruments and Methods in Physics Research B 178 (2001) 101-104.

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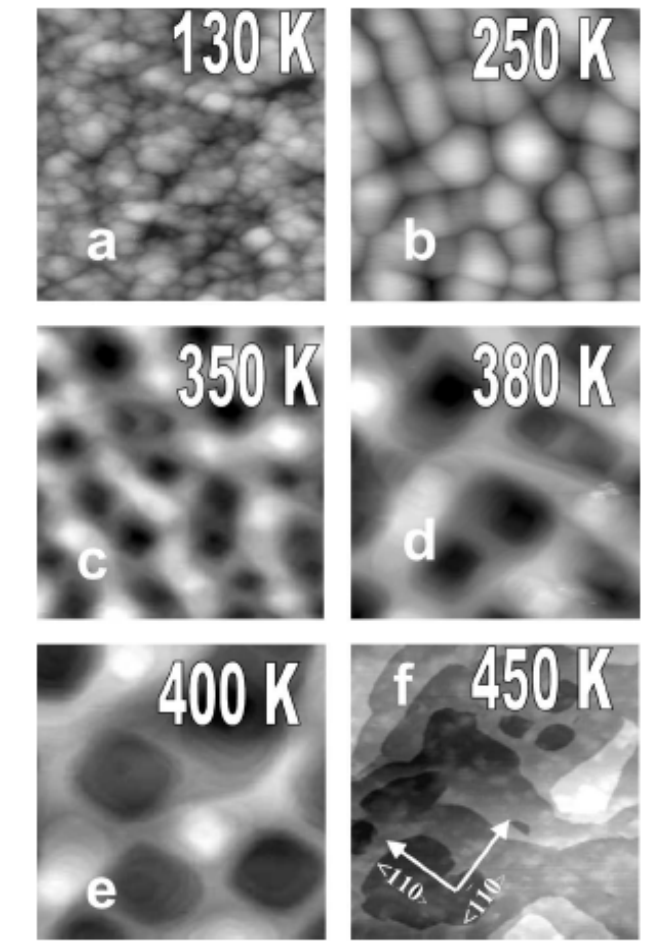
Chessboards

1keV $Ne^+ \rightarrow Ag\ (001)$

Normal incidence



U. Valbusa, C. Boragno, F. Buatier de Mongeot,, Materials Science and Engineering, C23 (2003) 201-209 .

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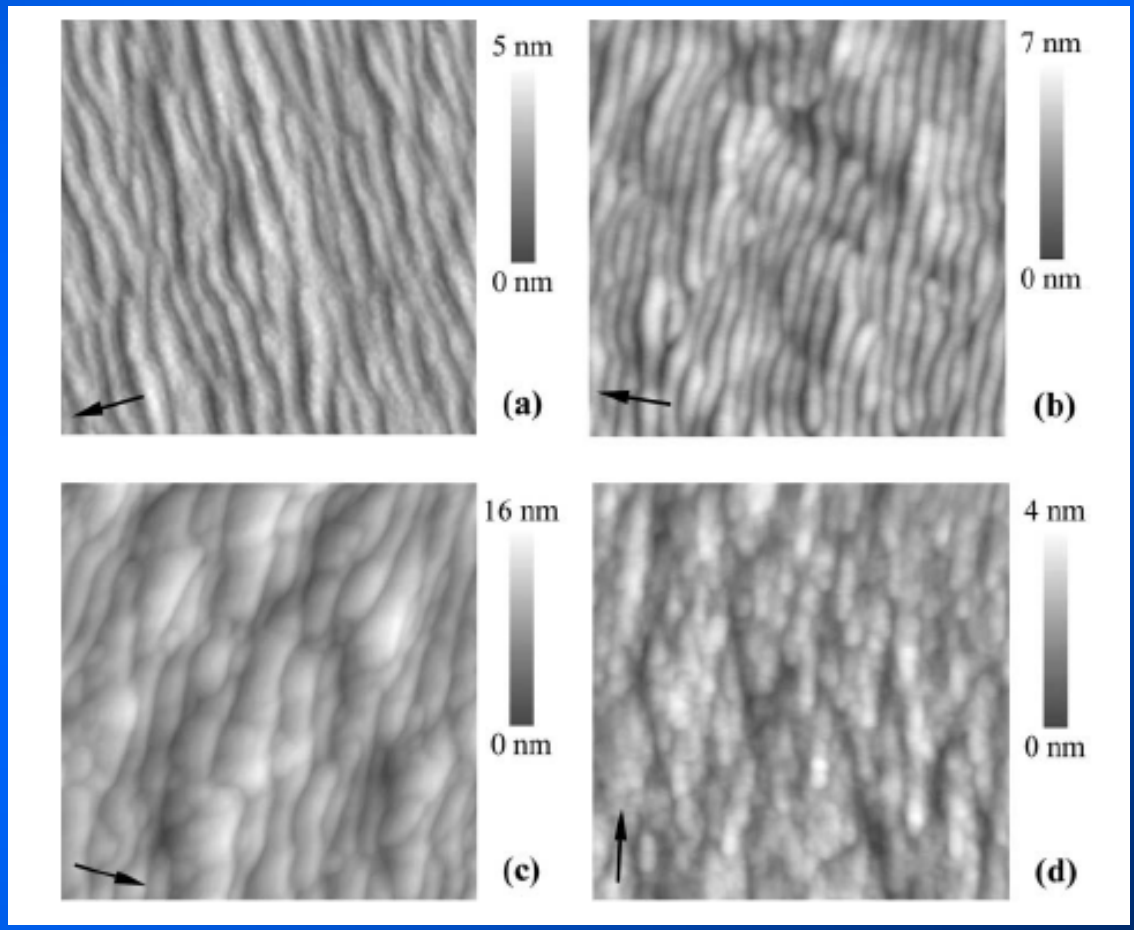
Wavelets

800eV Ar^+ → Fused Silica

λ ~ 10 nm – 100 nm



D. Flamm, F. Frost, D. Hirsch, Evolution of surface topography of fused silica by ion beam sputtering, Appl. Surf. Sci. 179 (2001) 95.

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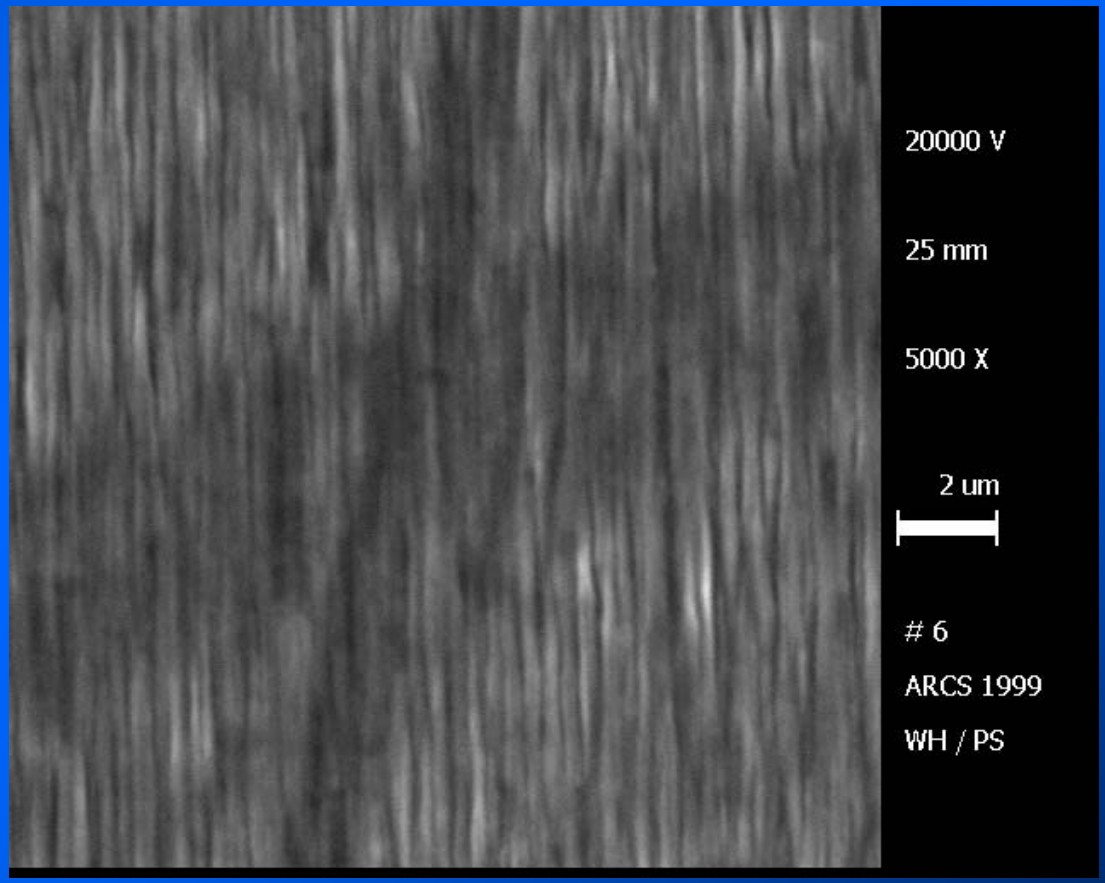
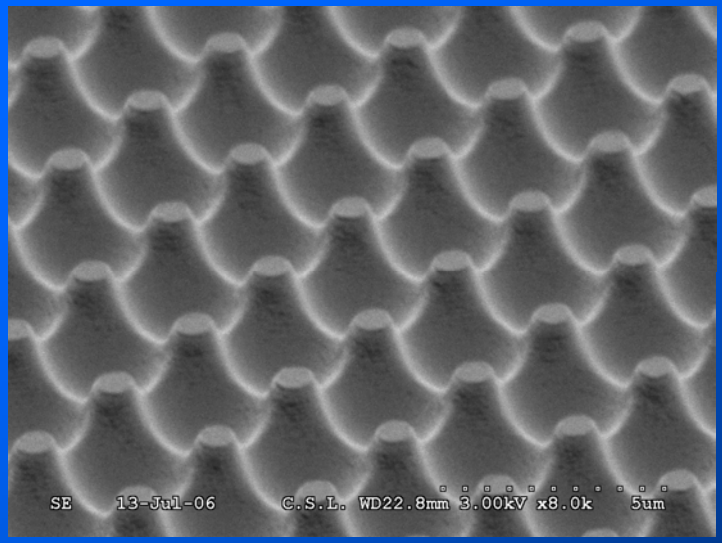
XMM - NGXF
at CSL

500eV Ar^+ → Au plating



Applications

- *Light trapping*
- *Selective absorption*
- *Photo-catalytic (self-cleaning surfaces)*
- *Photovoltaic (quantum dots solar cells)*
- *Surface wetting*
- *Diffusers/antireflective structure*



Currently on-going (ion-induced structures)

- ***Effective medium models for mesoscopic optical structures***
- ***Ion irradiation on SiC***
- ***Replication onto soft materials***

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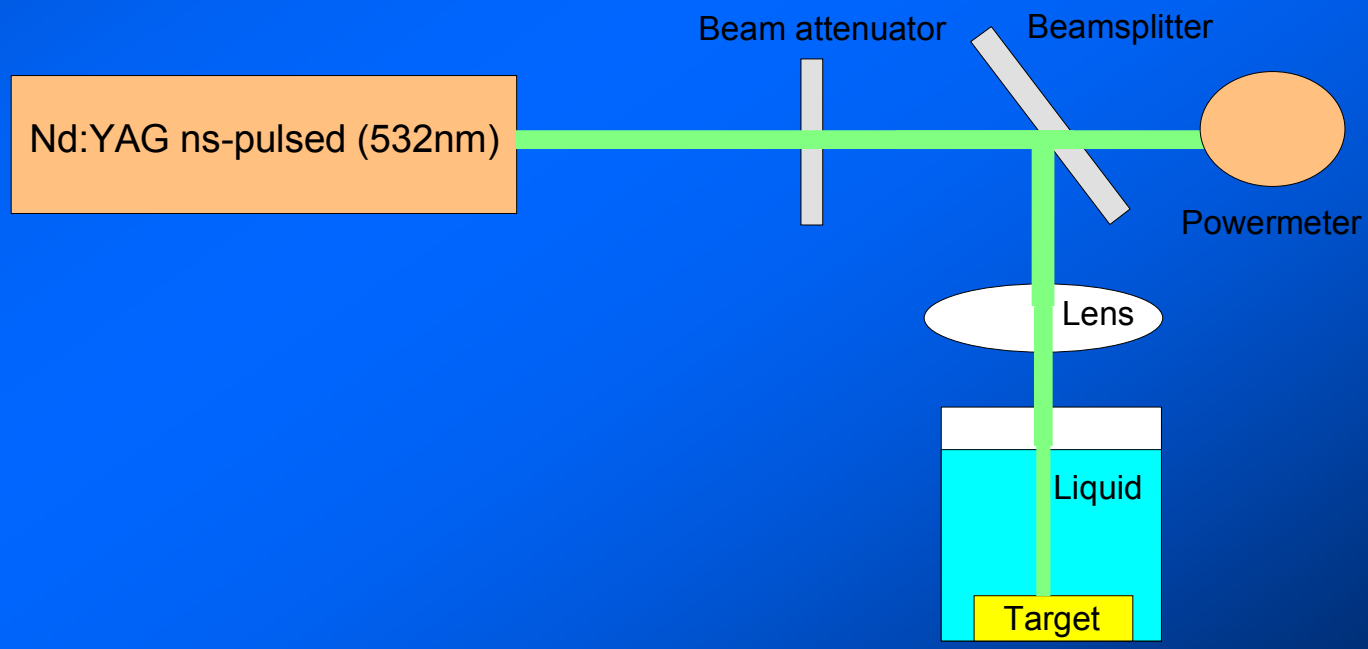
Laser ablation in liquids



Phenomenology

- Local spurious vaporization of the target and coalescence of the ejected particles. Convection contributes to the dispersion of aggregated particles in the liquid.

Process Parameters

- Energy density
- Laser wavelength
- Composition and viscosity of the liquid
- Structure of the target surface

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Nanoparticles production trials at CSL

- *Au*
- *Ag*
- *VO_2*
- *Si*
- *CdTe*

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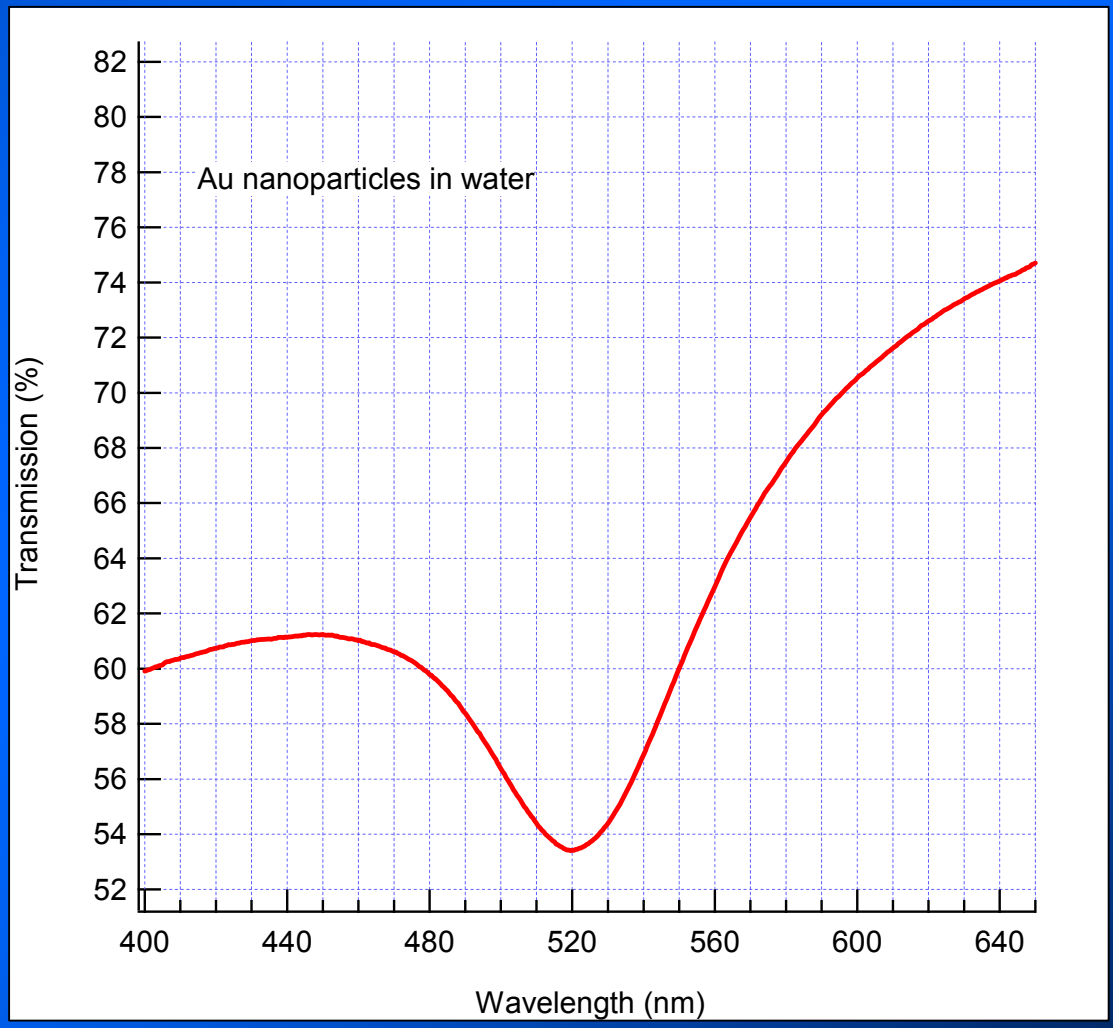
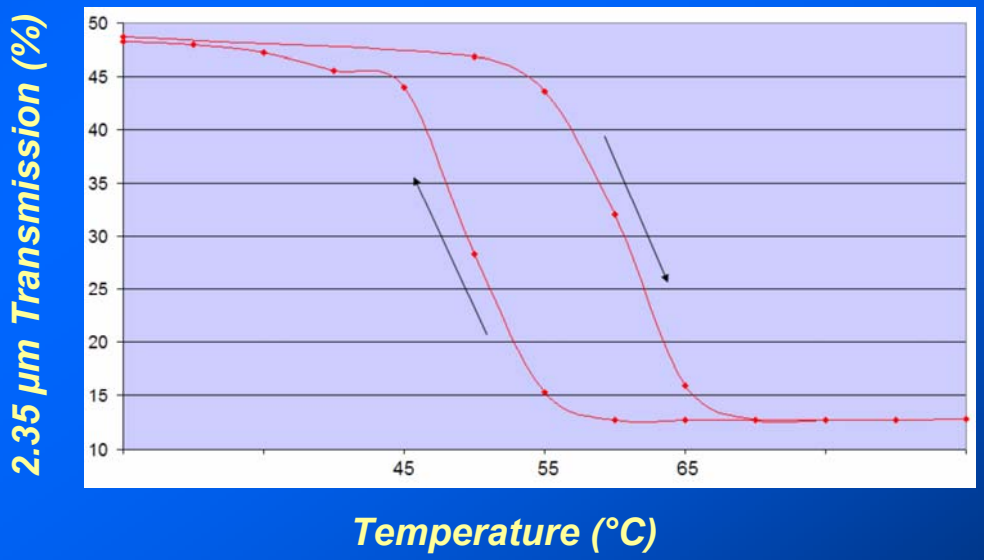
Au nanoparticles



Thermochromic VO_2

- MIT (metal-to-insulator transition)
- Monoclinic → tetragonal rutile
- Reflectivity and conductivity ↑
- Transition temperature (68°C for pure VO_2)



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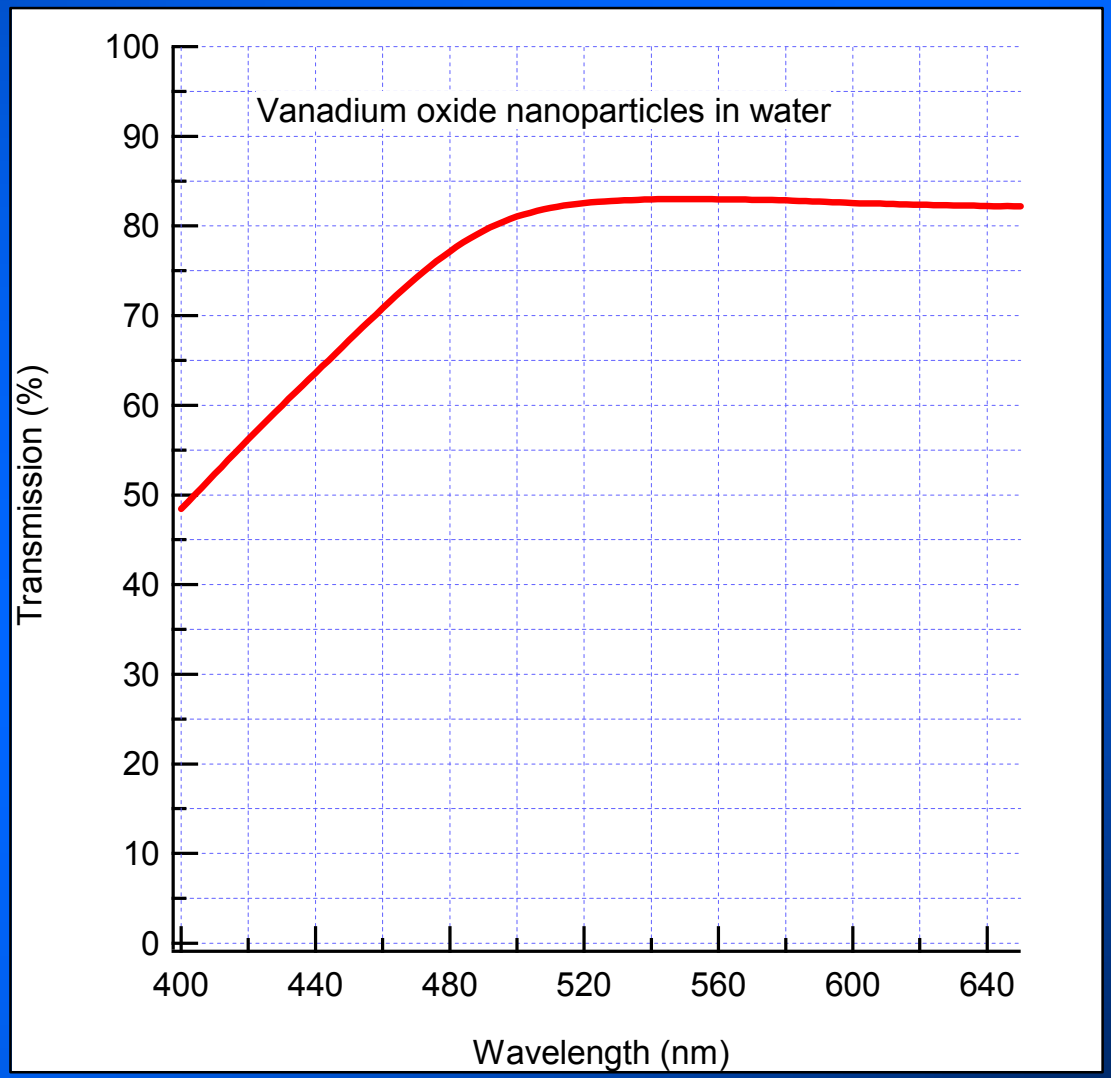
VO_2 nanoparticles



Currently on-going (nanoparticles)

- **Thermo-optical characterization of TC particles in liquids**
- **TC particles in polymer matrices (thin and thick films)**
- **CdTe nanoparticles production**

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