



*Advanced analysis techniques
for the development of
innovative materials and devices*

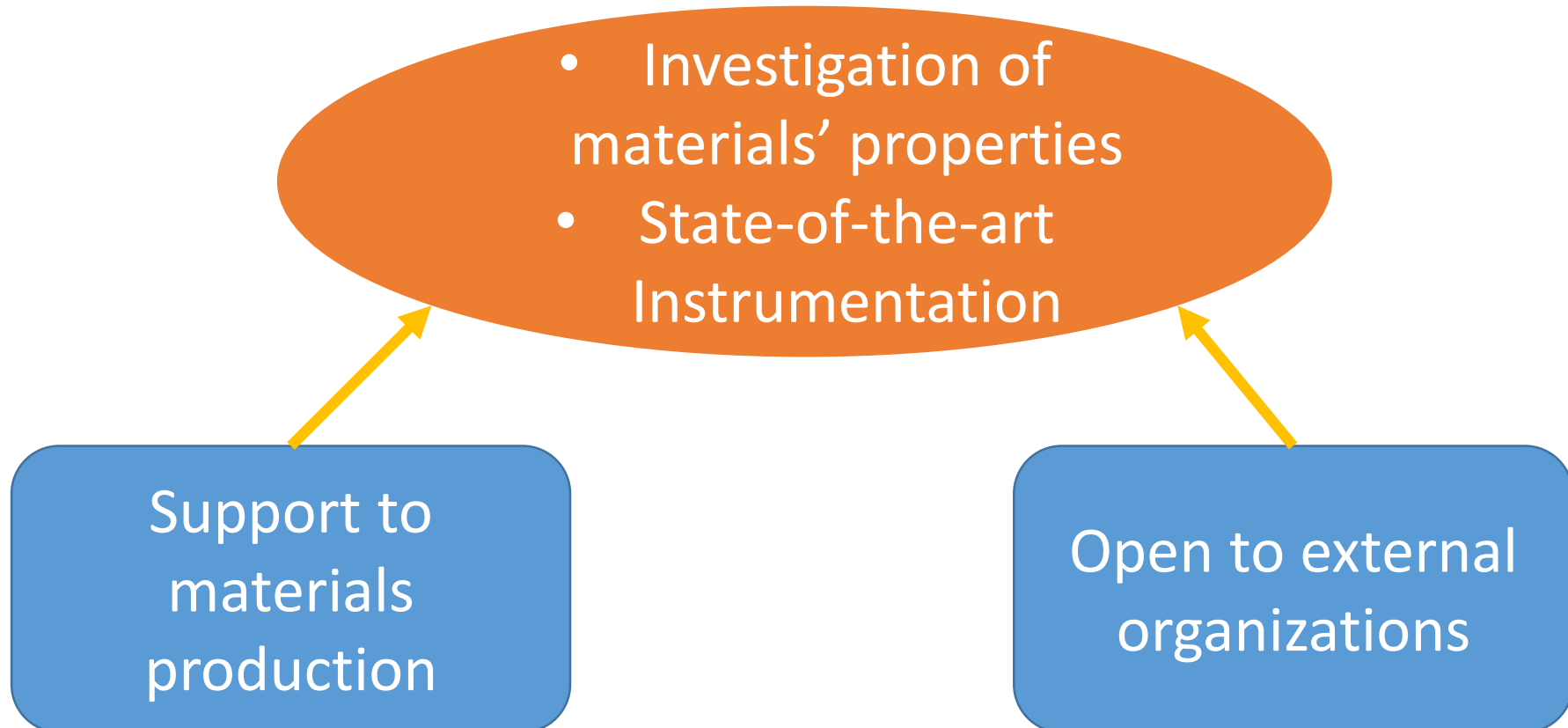


Daniele M. Trucchi
CNR-ISM

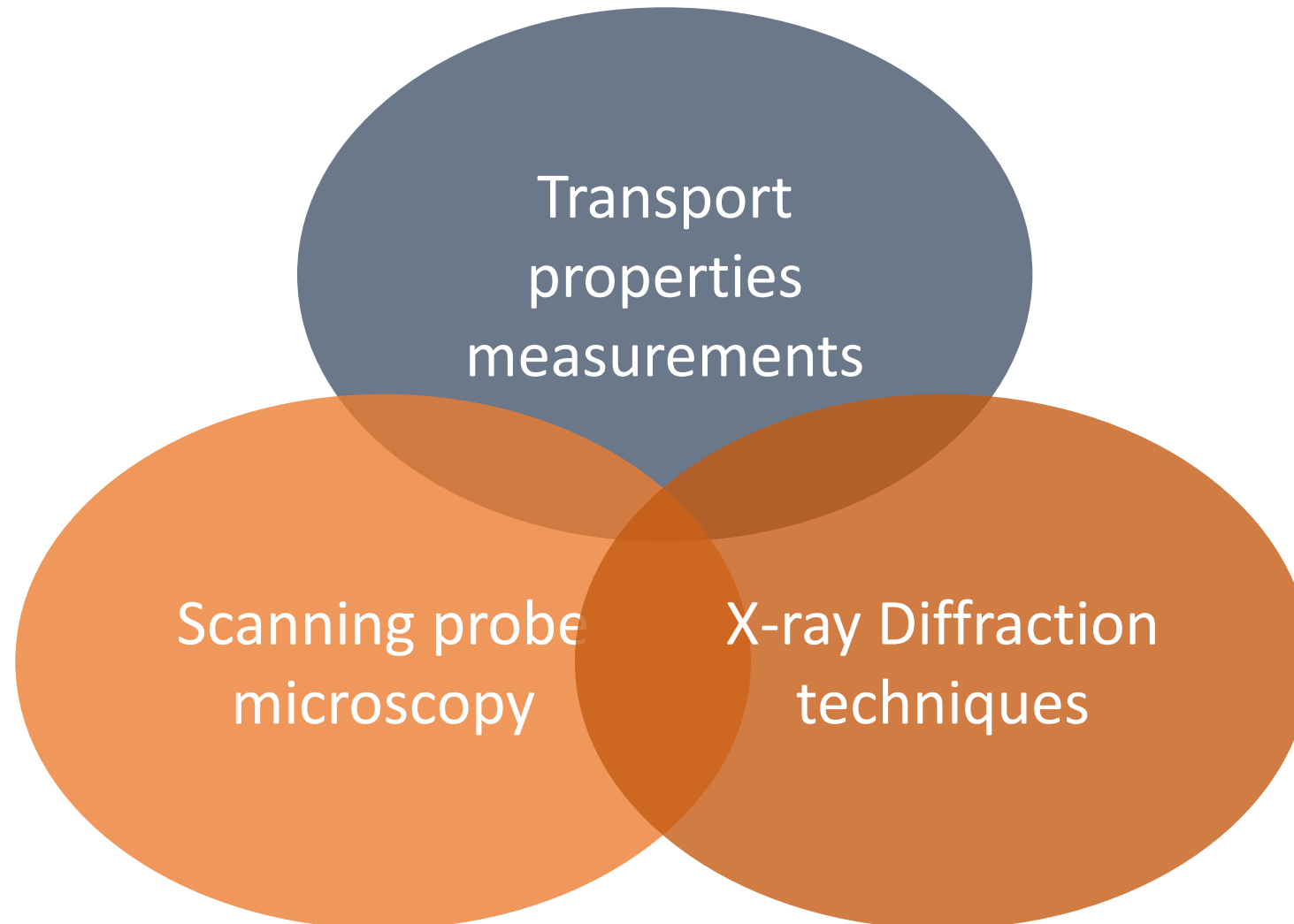


Mission of the Facility

- Supply of new materials
- Design, development, characterization of materials and devices



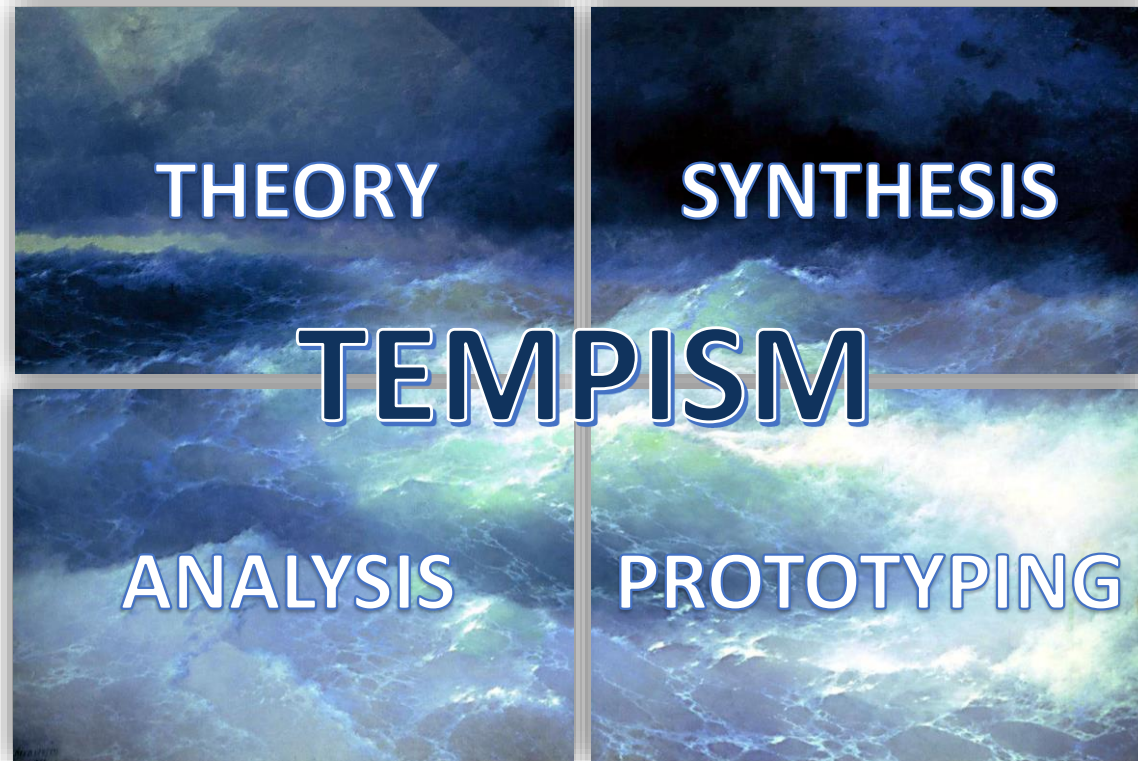
Instrumentation @ NanoMicroFAB



TEchnology Material Platform of CNR-ISM

Andrea Marini
CNR – ISM @ MLIB

THEORY

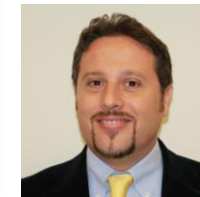


Antonio Santagata
CNR – ISM @ Tito Scalo

SYNTHESIS

Polina Sheverdyeva
CNR – ISM @ Trieste

ANALYSIS



Daniele M. Trucchi
CNR – ISM @ MLIB

PROTOTYPING

TEMPISM = about 150 instruments/services
(internally & externally available)



ANALYSIS



Energy dispersion
X-ray diffraction

Theoretical
modeling

Synchrotron
radiation
techniques

High temperature field
and thermionic
emission

Microscopy

Organic chemistry
synthesis

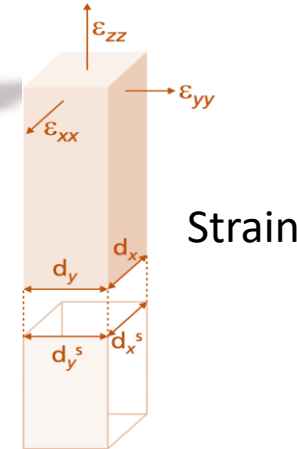
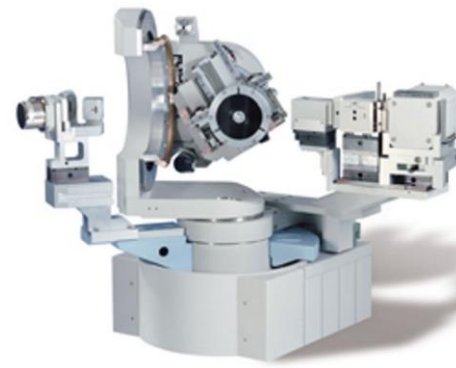
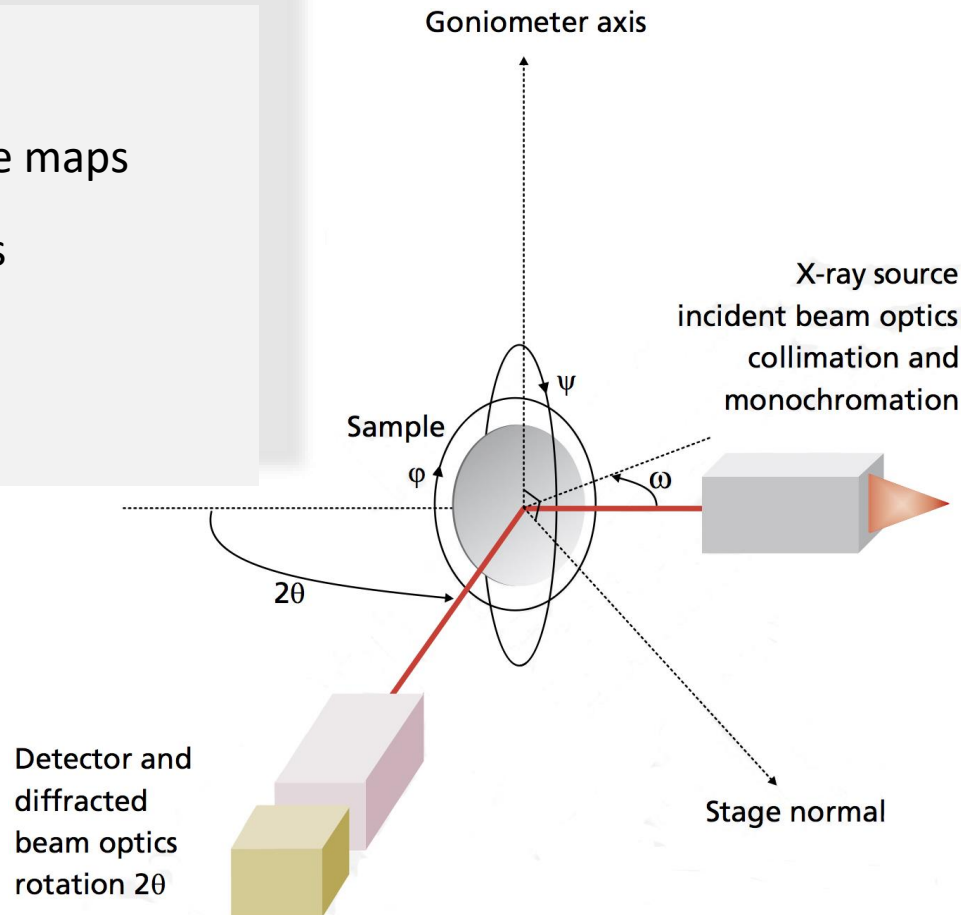
Preparation and
Investigation of
Nanostructured
Magnetic
Materials

Dielectric and
Elastic properties
of materials

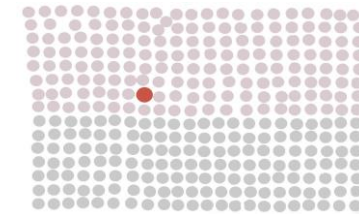
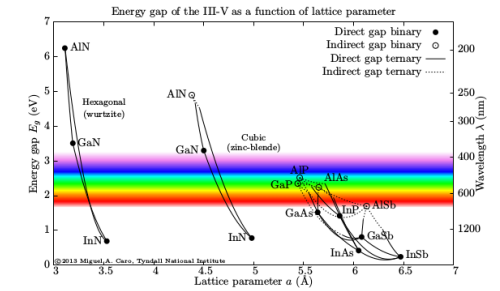
Ultra-fast optical
techniques

X-ray Diffraction

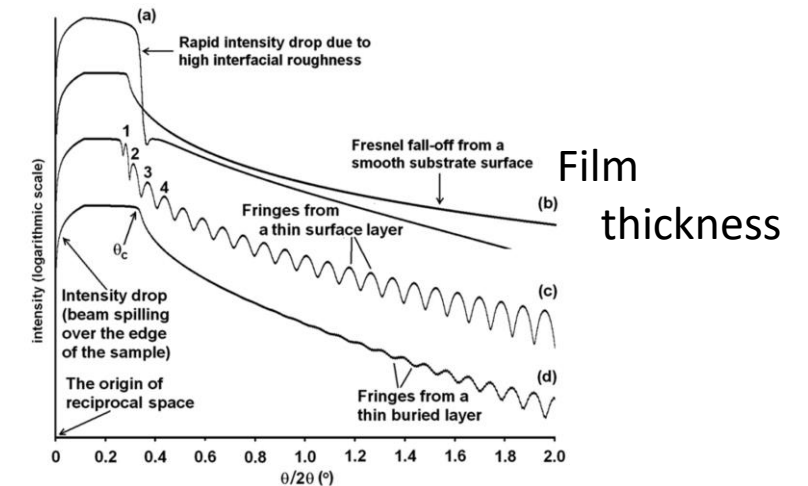
- ω - 2θ scans
- Reciprocal space maps
- ω Rocking curves
- X-ray reflectivity



Alloy composition



Defects

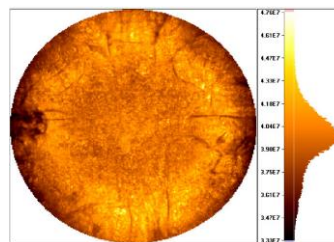
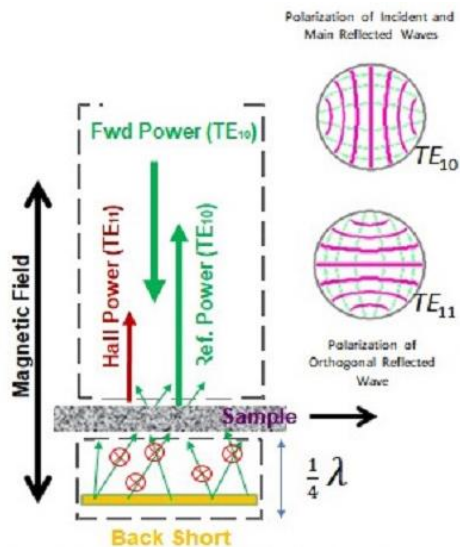


Transport properties

Contactless measurements

Non-destructive determination of carrier concentration and mobility

Electronic properties mapping up to 4" wafers



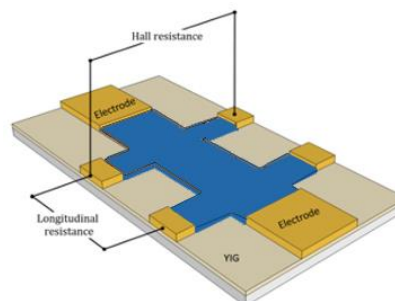
Magnetotransport

Hall mobility

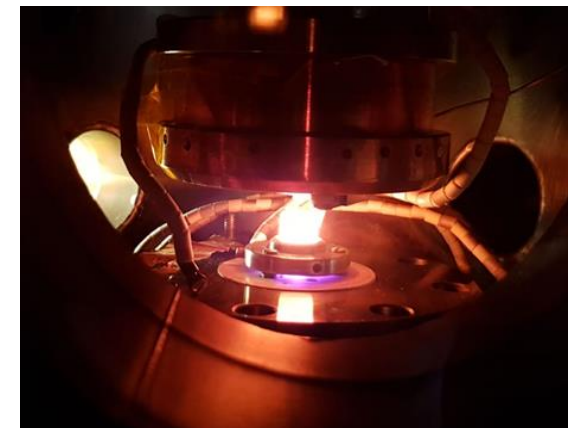
Material resistivity

Contact resistance

Measurements as a function of temperature



Transport & electron emission @ high temperature & high flux



VTEC

Vacuum & Temperature Electronic Characterization

UHV 10^{-9} Torr

- ✓ Thermionic Emission
 - ✓ Electrode distance down to $30 \pm 5 \text{ um}$
 - ✓ Mass spectrometry in situ
 - ✓ Rapid Thermal Annealing
- ✓ UHV Field Emission
- ✓ Photo-Thermionic Emission
- ✓ Photoconductivity (200-1300 nm)
- ✓ Total Photo Emission Yield (190 – 1150 nm)
- ✓ I-V and C-V curves
- ✓ Impedance Spectroscopy
- ✓ Four Point Probe

T up to 1800 °C

T from RT to 800 °C

Scanning Probe microscopy

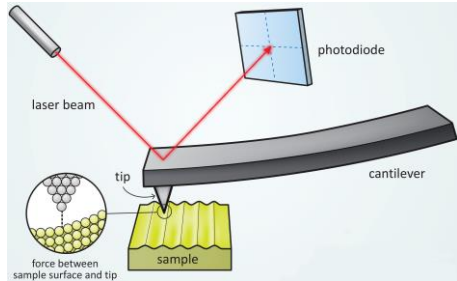
Atomic Force Microscopy

Surface structure morphology

Tribology properties of materials at the micro-scale

Reversed head geometry to couple fluorescence analysis with laser sources

Compatible with incubator for cellular analysis

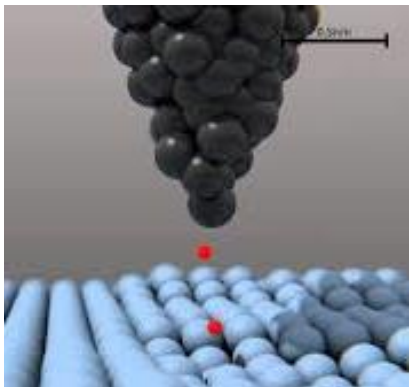


Scanning Tunneling Microscopy

Surface atomic structure

Electronic structure of surfaces and thin films

"In operando" electronic device investigations





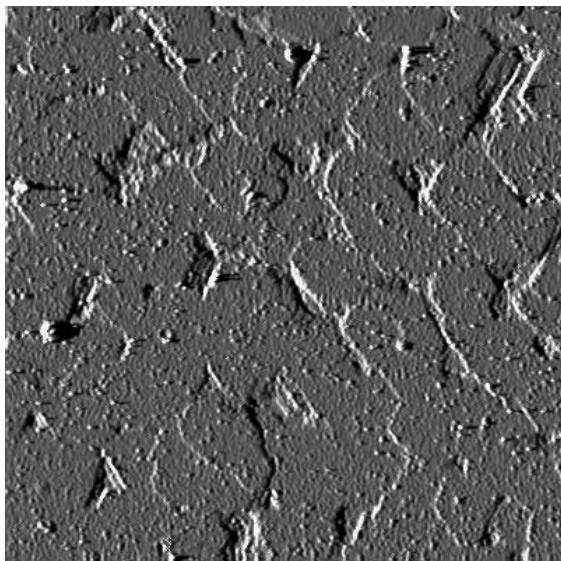
Example of materials' characterization @ the nanoscale

β -Si₃N₄/Si(111)

surface structure

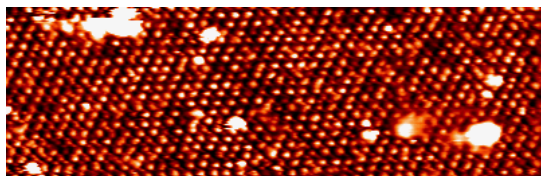
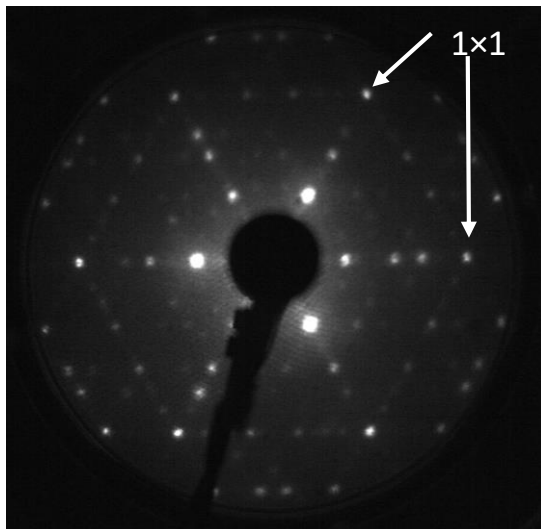
electronic structure

STM image 500x500 nm²



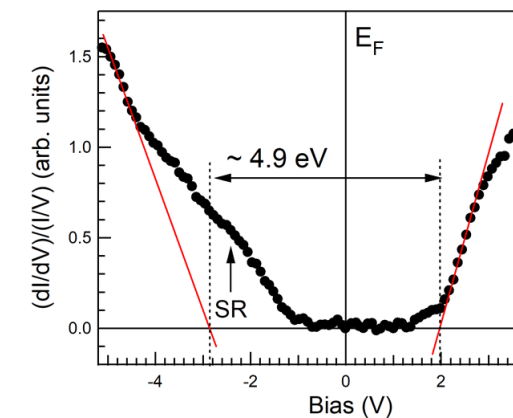
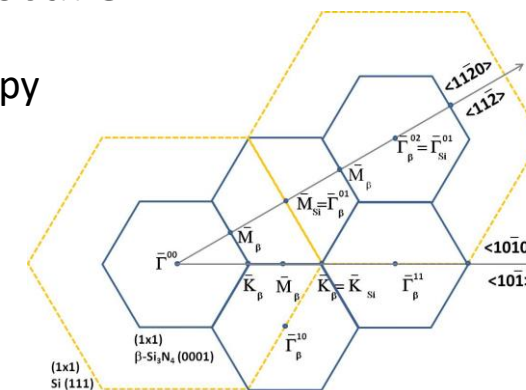
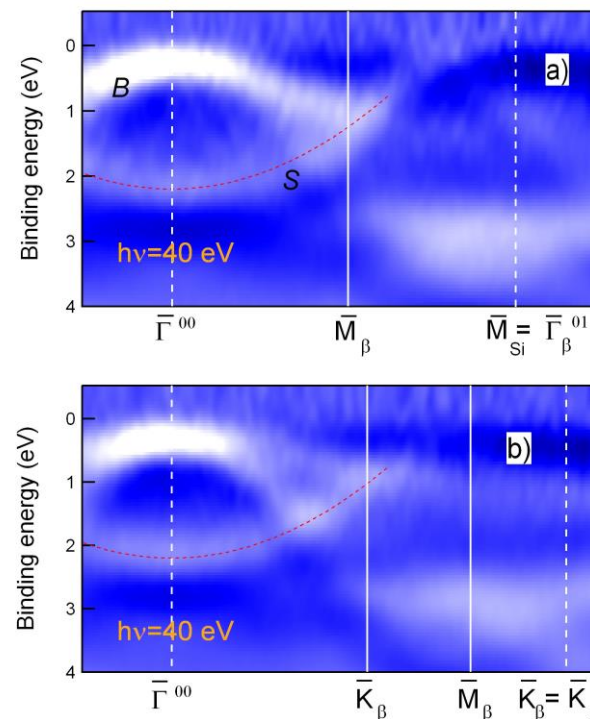
Roughness 0.503 nm
Grains average diameter ~100 nm

Electron diffraction



STM image
50x16 nm²

Angle resolved photoelectron spectroscopy



VUV beam line

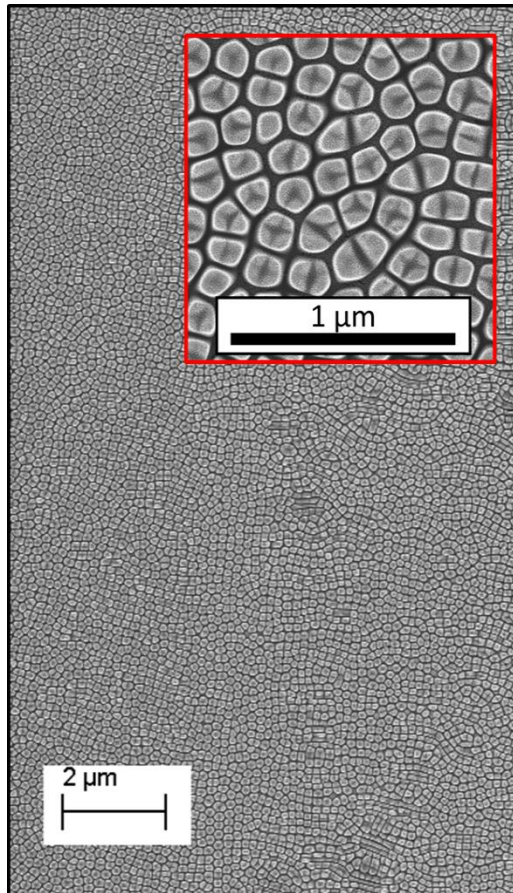
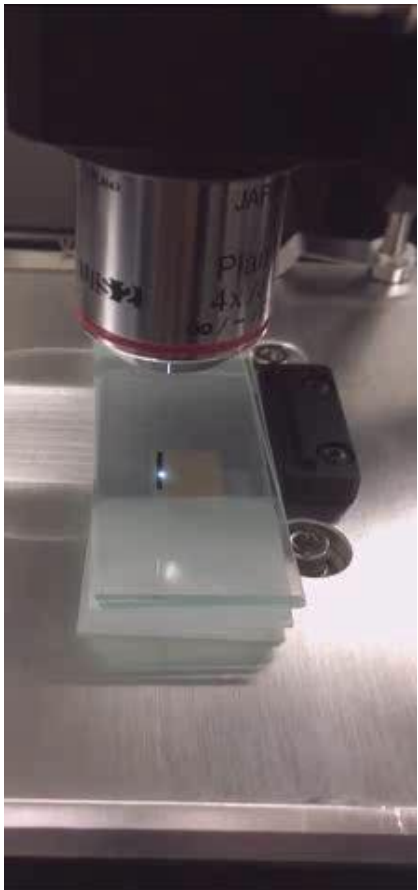
Elettra Sincrotrone Trieste

Scanning tunneling spectroscopy

Example of materials' characterization @ in temperature

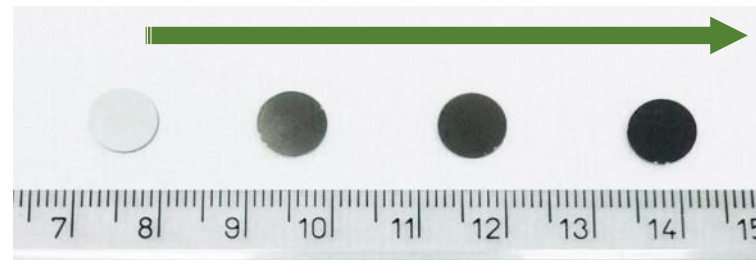
Black diamond for solar energy conversion

Fabrication

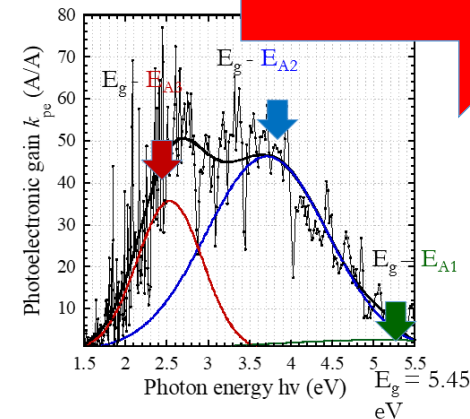
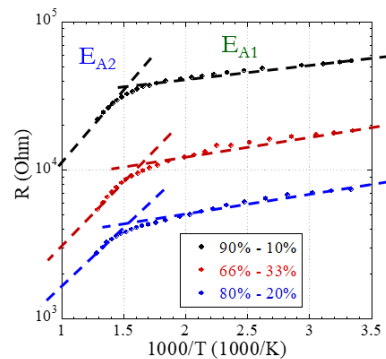
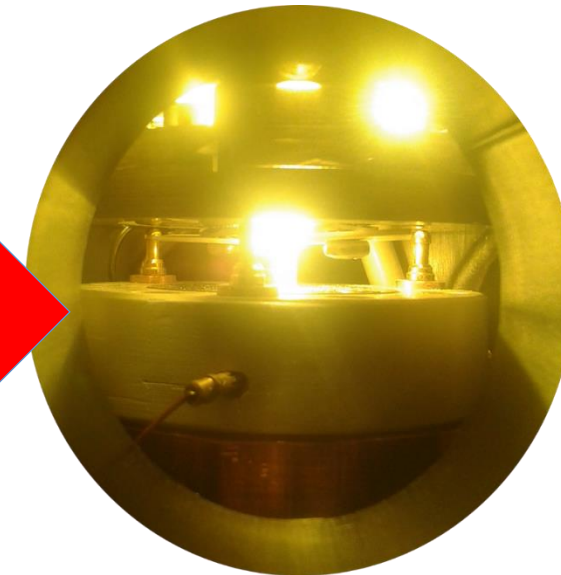


Photoelectronic
characterization in
temperature of the material

ACCUMULATED FLUENCE



Device characterization in
temperature and under
high radiation flux

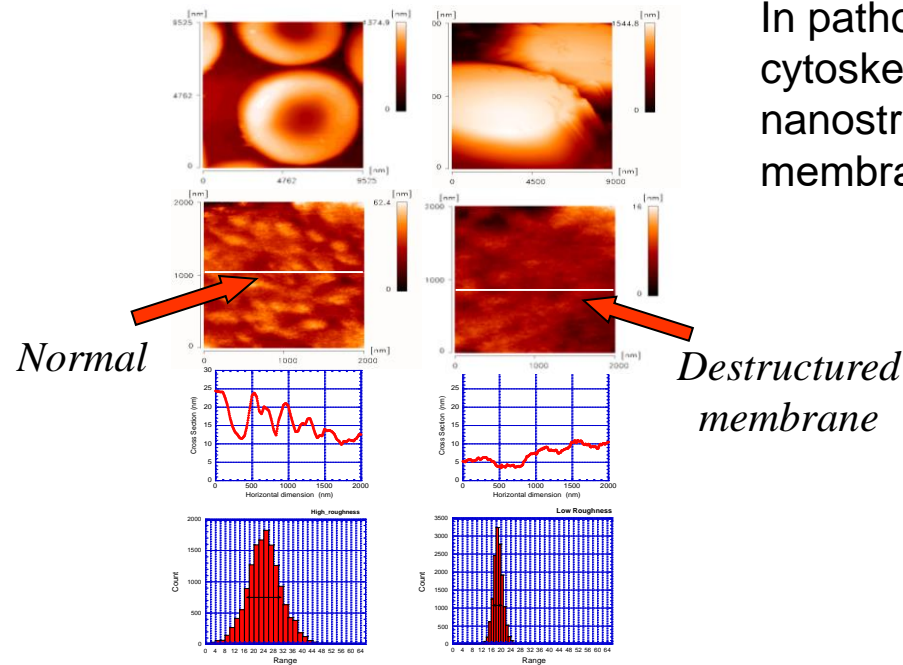




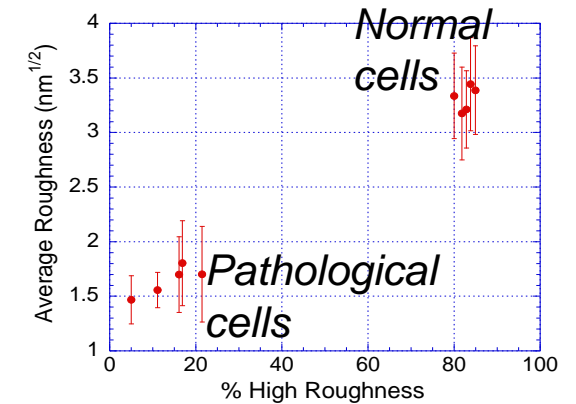
Not only materials...also bio applications

Nanoarrangement of the erythrocytes membrane and aging

A novel approach to study normal and pathological RBCs, has been developed. The method discriminates **normal** and cytoskeleton defective (**pathological**) erythrocytes according to the behaviour of the plasma membrane roughness



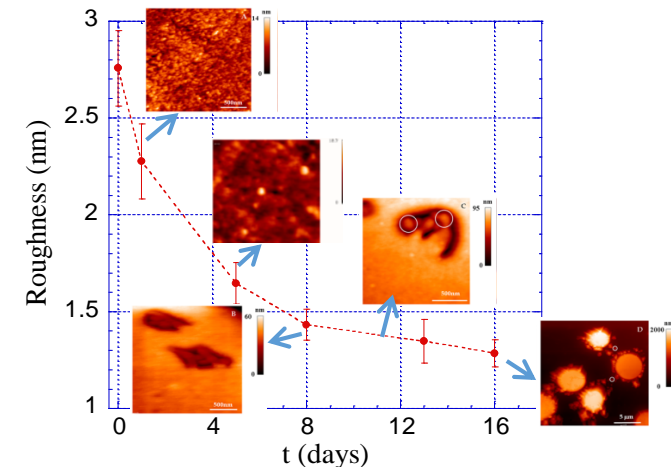
In pathologies related to cytoskeleton, the normal nanostructure of the membrane changes...



...and the average value of roughness strongly decreases

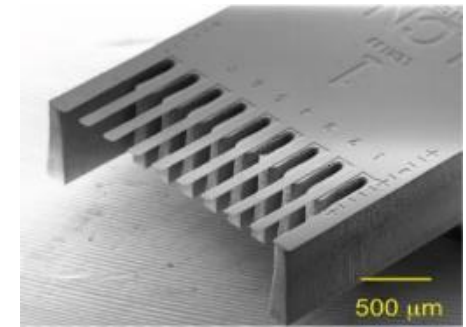
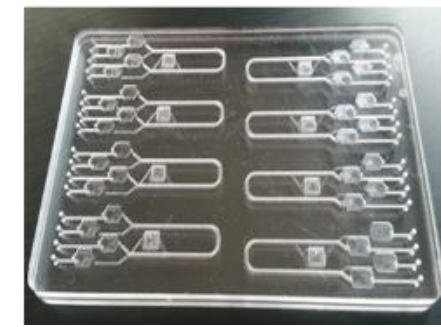
Application to study the **RBCs' aging**.

AFM data show that coupling the nanoscale imaging and quantitative morphometry can reveal the progression and reversibility of the cell aging.



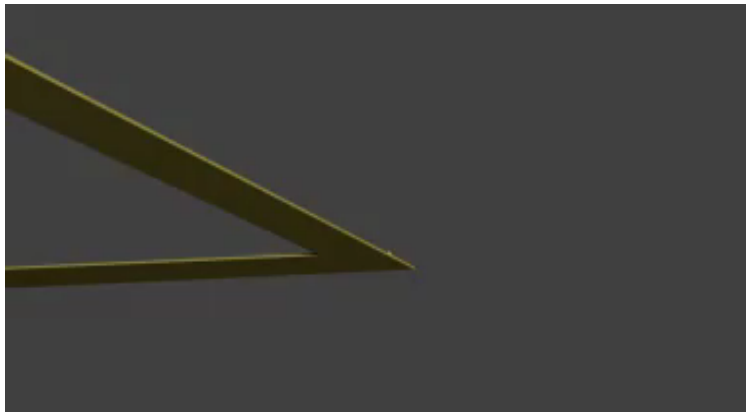
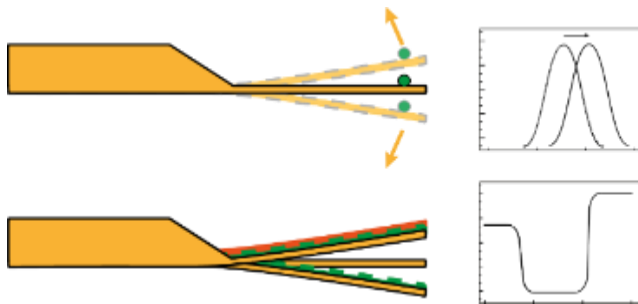


The cantilever without the AFM



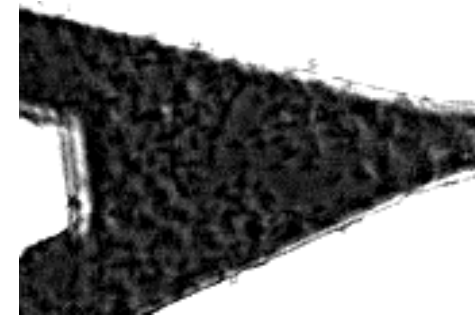
Cantilevers had been used as nano-mechanical oscillators as stand-alone sensors.

Nanomechanical oscillators



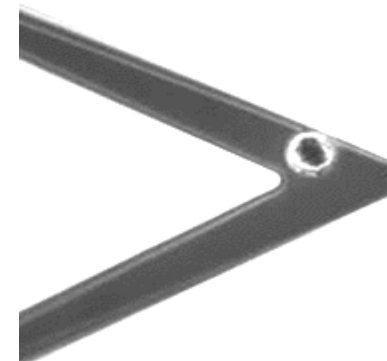
Combining the movement sensitivity of a cantilever with the nanomechanical sensor setup we developed a nano-scale motion sensor, determining the fingerprint of the metabolic activity of living systems: exploiting the connection between movement and life

Dinarelli et al., Meth. Mol. Biol., 2018

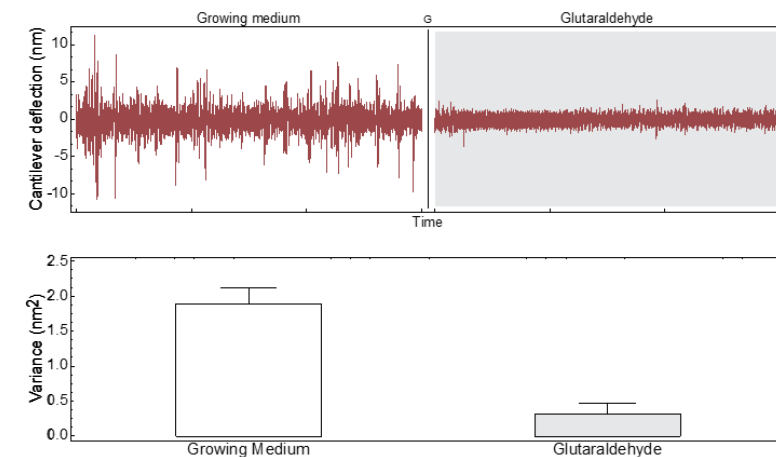


Longo et al., Nature Nanotechnology, 2013

Mouse osteoblasts studied with the nanomotion sensor and through optical microscopy



Aghaee et al., J. Mol. Recogn. 2013



Thank you for the attention



NANOMICROFAB
ADVANCED LAB

*Open Research Infrastructure to support companies
operating in the field of micro-nanoelectronics*

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