Diagnostic and analytical techniques for advanced materials and nanostructures

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Outline

- Glimpse on CNR Research Area - Roma 1 research infrastructure
- Ex situ characterization & diagnostic techniques
  - SEM-EDS
  - Auger & X-ray Photoelectron Spectroscopy
  - Combined use of SEM, EDS, XPS
  - Raman and IR Spectroscopy
  - SPM
  - Laser Scanning Spectroscopy
- Potential and perspectives

INSTITUTES

THEMATIC AREAS

- Environment
- Biology, Agriculture and Food Sciences
- Cultural Heritage
- Functional Materials
- Health and Wellbeing

The following Institutes are present in the AdR RM1 area:

- INSTITUTE OF AGRO-ENVIRONMENTAL AND FOREST BIOLOGY (IBAF)
- INSTITUTE OF AGRICULTURAL BIOLOGY AND BIOTECHNOLOGY (IBBA)
- INSTITUTE OF CELL BIOLOGY AND NEUROBIOLOGY (IBCN)
- INSTITUTE FOR THE CONSERVATION AND VALORIZATION OF CULTURAL HERITAGE (ICVBC)
- INSTITUTE OF CRYSTALLOGRAPHY (IC)
- INSTITUTE OF ENVIRONMENTAL GEOLOGY AND GEOENGINEERING (IGAG)
- INSTITUTE OF ATMOSPHERIC POLLUTION RESEARCH (IIA)
- INSTITUTE OF CHEMICAL METHODOLOGIES (IMC)
- INSTITUTE OF WATER RESEARCH INSTITUTE (IRSA)
- INSTITUTE FOR THE STUDY ON ANCIENT MEDITERRANEAN (ISMA)
- INSTITUTE OF STRUCTURE OF MATTER (ISM)
- INSTITUTE OF NANOSTRUCTURED MATERIALS (ISMN)
- INSTITUTE FOR TECHNOLOGIES APPLIED TO CULTURAL HERITAGE (ITABC)

MORE

To search type and hit enter

HIGHLIGHTS

RESTYLING DEL SITO DELL'AREA DI RICERCA DI ROMA 1 MONTELIBRETTI

8 Settembre 2017 RESTYLING DEL SITO DELL'AREA DI RICERCA DI ROMA 1 MONTELIBRETTI Grazie alle risorse interne all'Area di Ricerca […]

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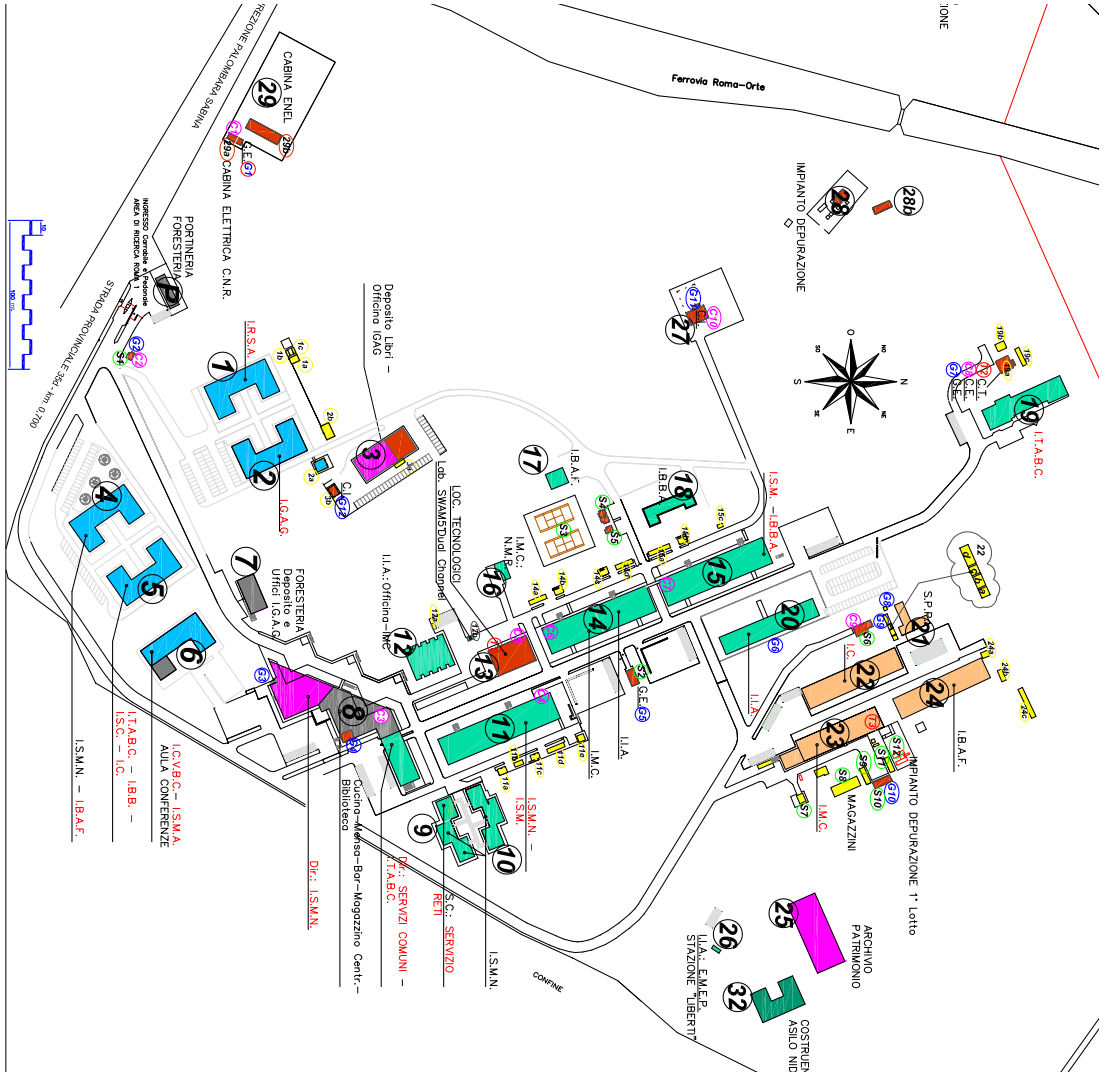
Area della Ricerca di Roma 1
Montelibretti

www.mlib.cnr.it

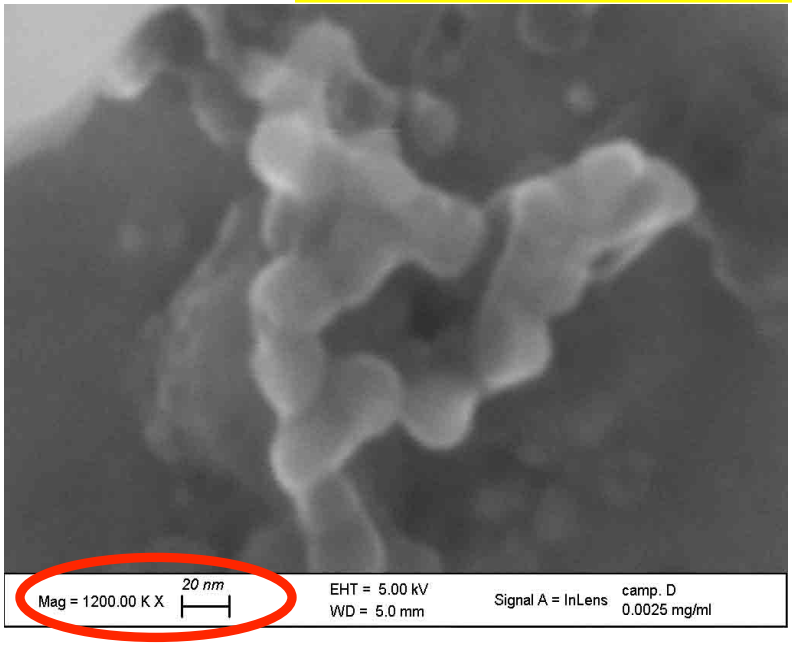
700 employees
37,000 sqm
technological infrastructure's area.



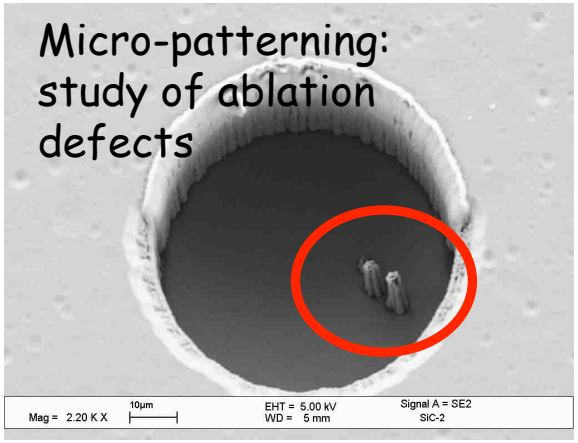
Scanning Electron Microscopy (SEM)

Due to its wide versatility, SEM is largely used to investigate the micro and nano-morphological-structural-chemical features and behaviour of a wide panorama of materials with a large industrial use or high technological interest.

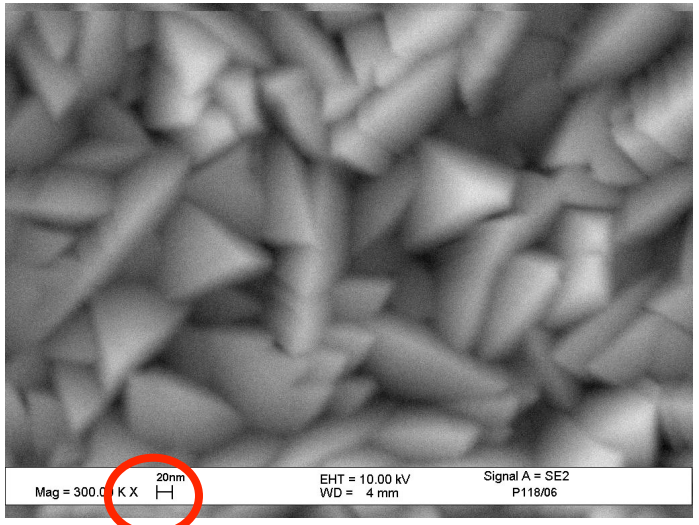
Morphological investigation of organic nanostructured materials: lipid nanoparticles for drug delivery (Bondì)

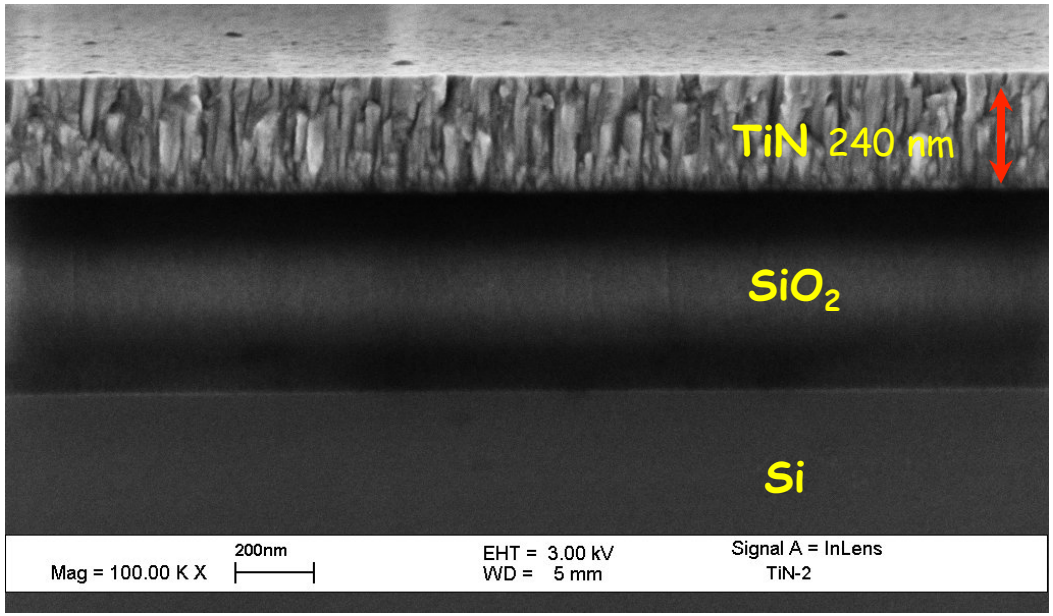


Process evaluation of microelectronic components production

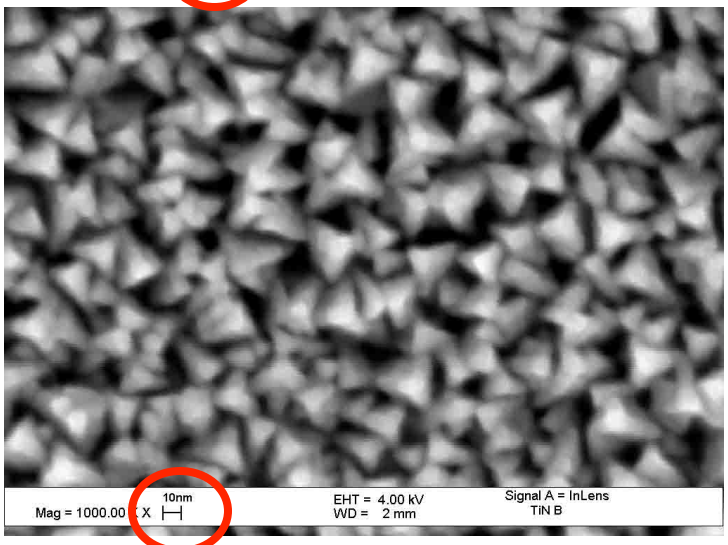


Optimisation of the ITO deposition parameters



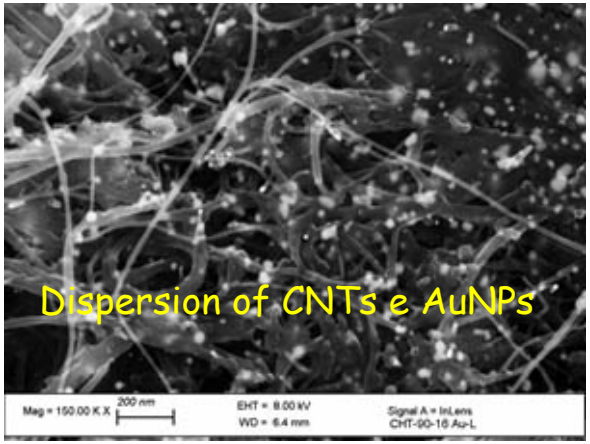


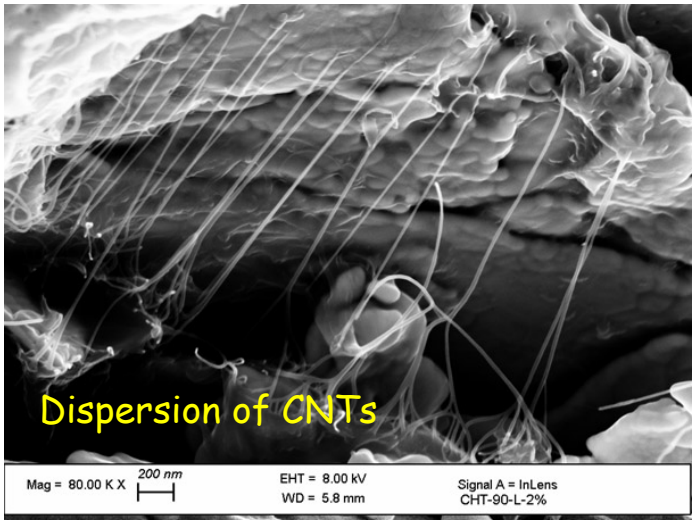
Structural and morphological study of thin films multi-layered structures for electronic devices

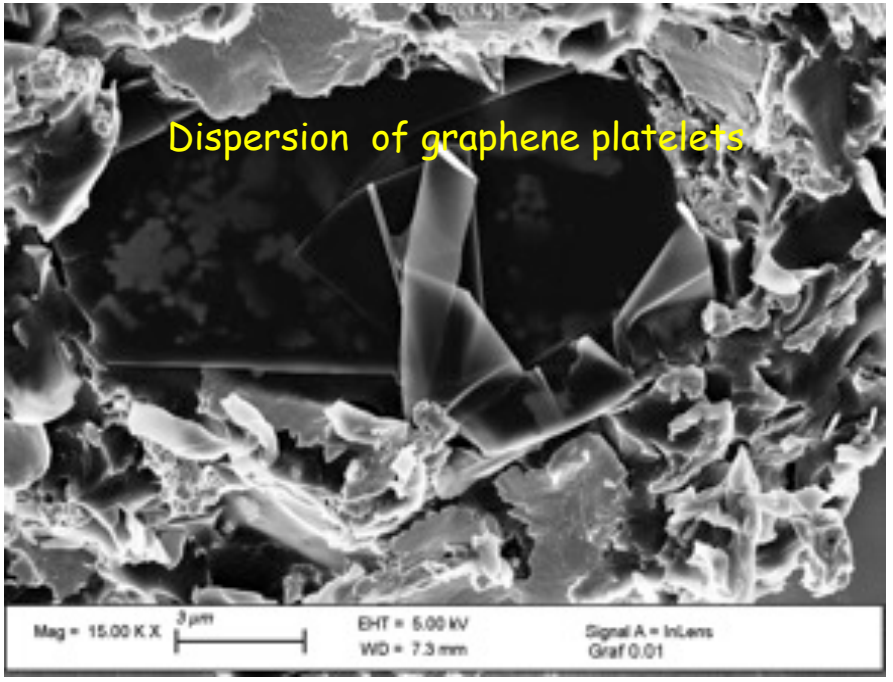


Investigation of the deposition processes of TiN protective films

Production and analysis of epoxy resins for the packaging of avionic system components







PON Ricerca e Competitività 2007-2013

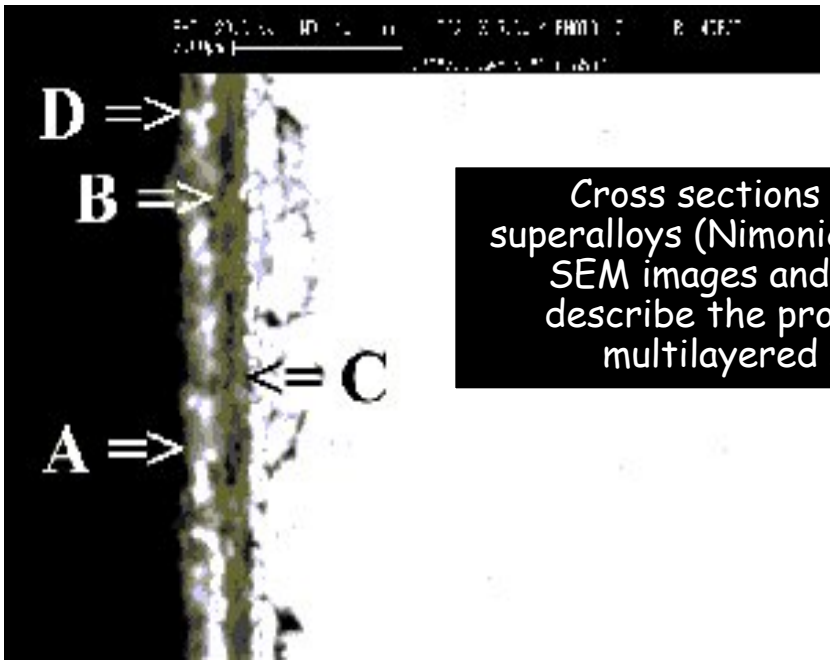
The morphological investigation has guided the synthesis and the dispersion procedures of nanostructures improving:

- the electrical conductivity of 1100 %;
- the thermal conductivity of 470 %.

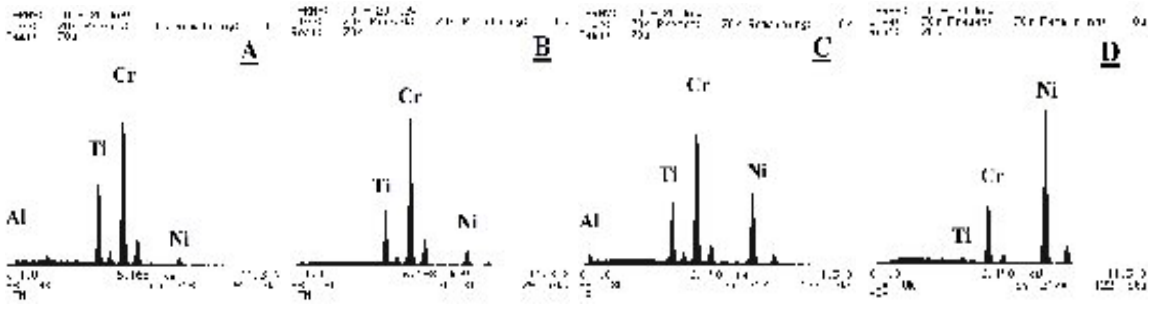
SEM-EDS morphological and chemical analysis

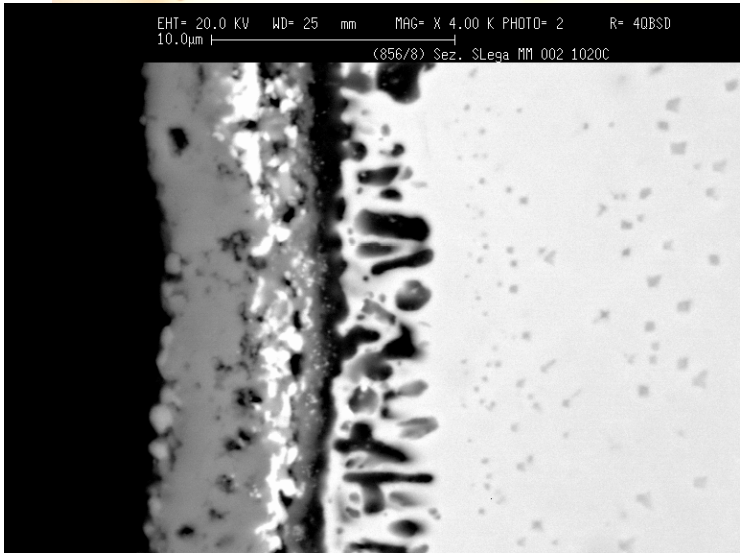
Failure analysis of jet engine turbine blades

Degradation mechanisms identified

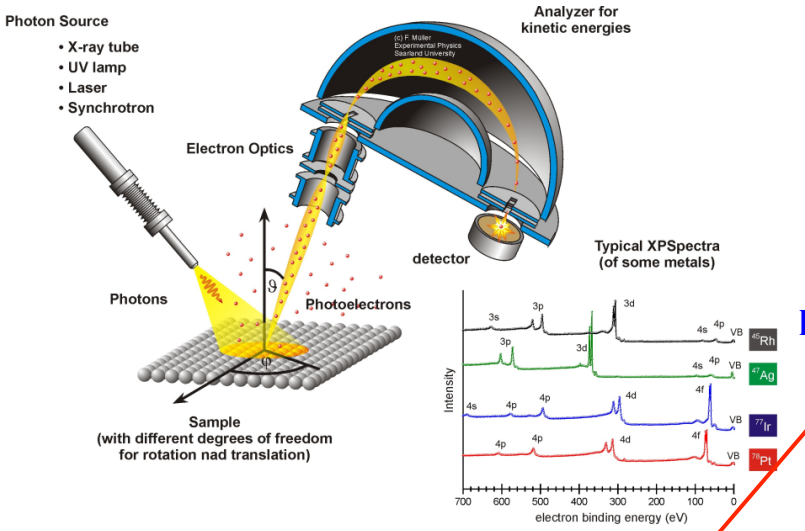


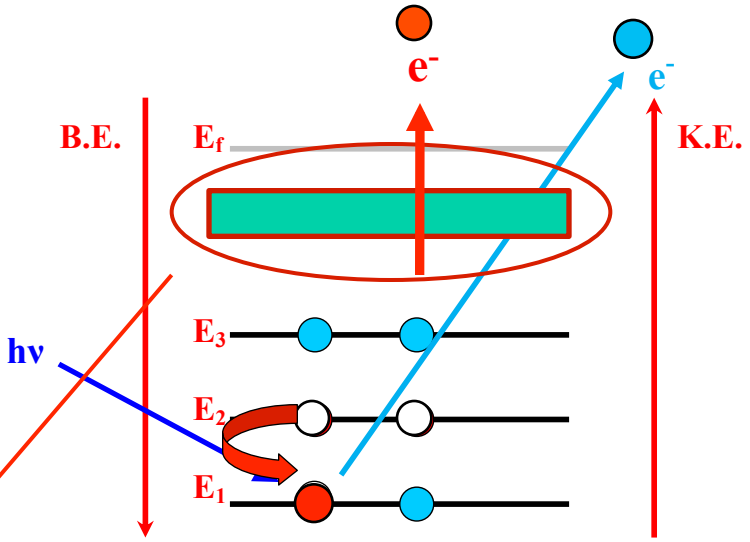
Cross sections of Ni-based superalloys (Nimonic 80 A, MM002). SEM images and EDS spectra describe the protective oxide multilayered structure.





Auger & X-ray Photoelectron Spectroscopy





CORE LEVEL SPECTRUM (XPS)

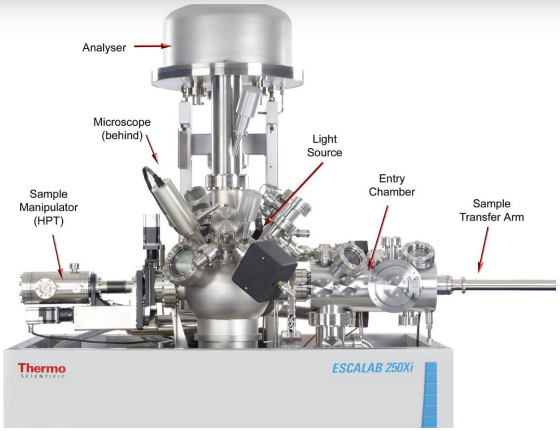
$$BE = h\nu - KE - \phi_{spec}$$

AUGER SPECTRUM (AES)

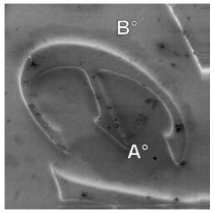
$$KE_{123} = KE_1 - KE_2 - KE^*_3$$

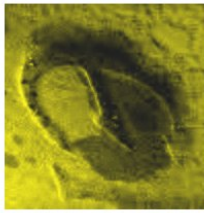
VB SPECTRUM

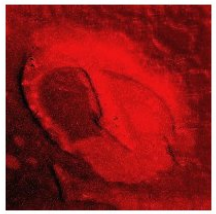
- **SURFACE CHEMICAL COMPOSITION (1-10 nm)**
- **CHEMICAL IMAGING**



➢ CHEMICAL IMAGING

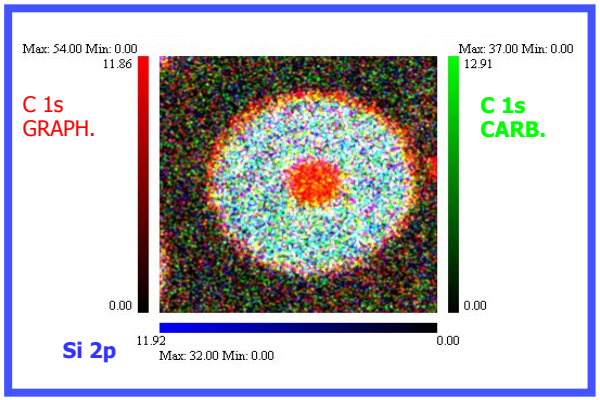




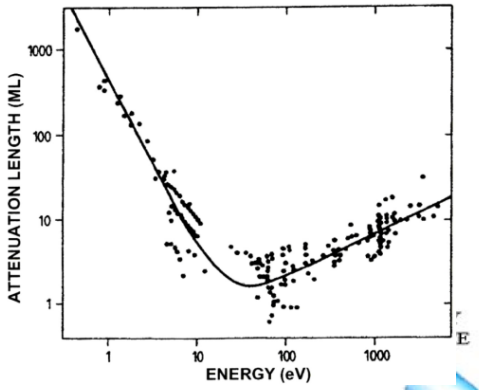


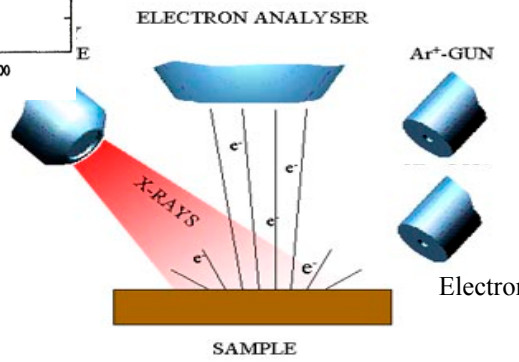
Au NOO image

Ag MNN image



➢ SURFACE CHEMICAL COMPOSITION (1-10 nm)

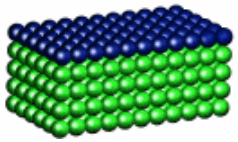


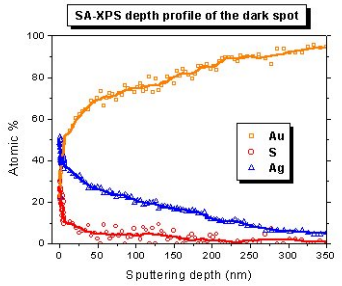


Electron-gun

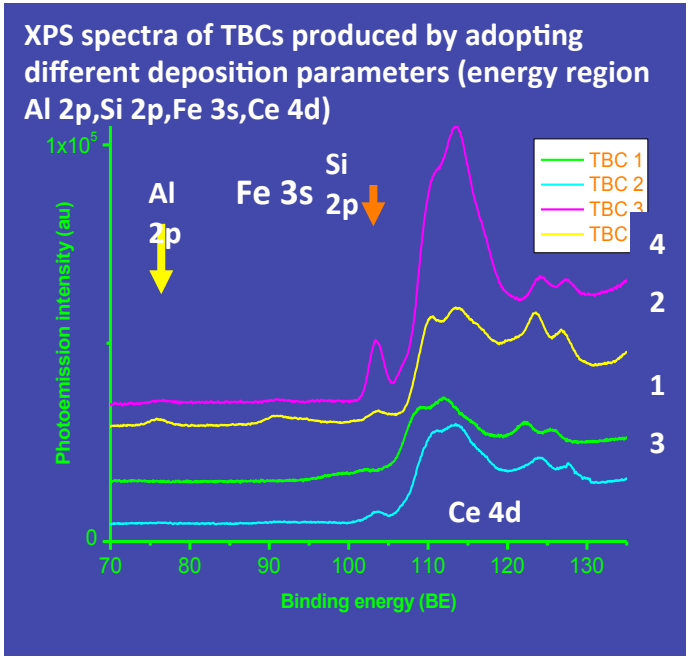
➢ ION SPUTTERING

Ar^+





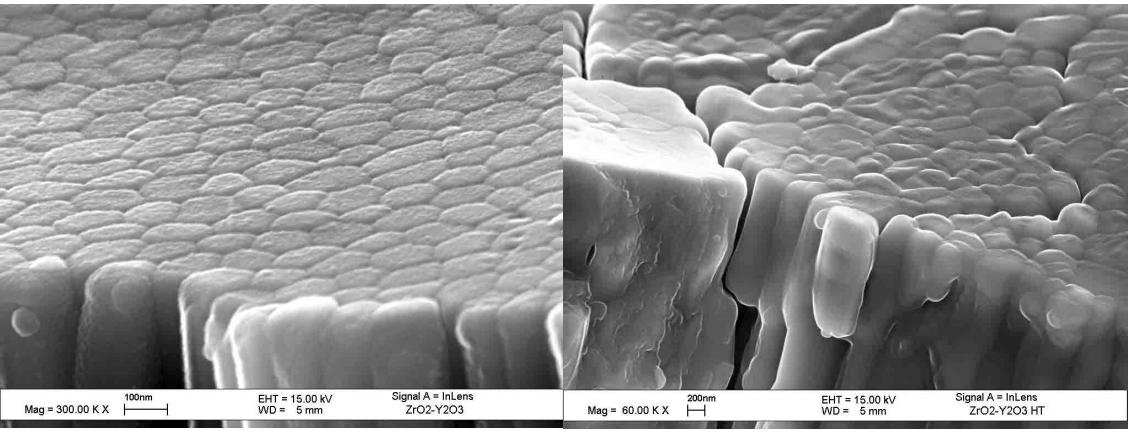
Coatings of turbine blades and combustion chamber in jet engines

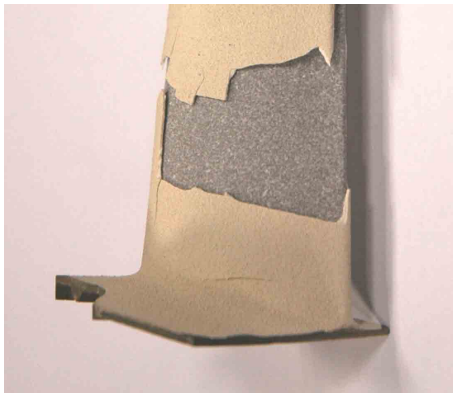


Combined XPS and SEM analysis allows:

- to optimise the production processes;
- to evaluate the durability and reliability
- to prevent catastrophic failure

TBC deposited on a jet engine turbine blade (25.5 wt% CeO_2-2.5 Y_2O_3 - ZrO_2) after a thermal cycling test. The coating fracture has been caused by impurities (Si, Al, Na) segregation phenomena inducing also a columnar growth.





μ-Raman spectroscopy

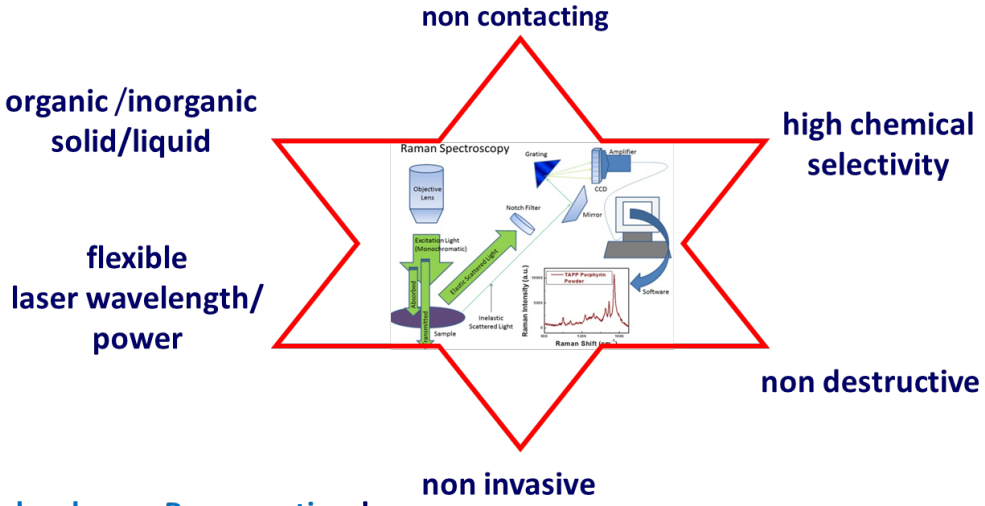
Renishaw 2000 μ-Raman with a Peltier cooled CCD camera in conjunction with a **Leica optical microscope** and laser excitation

Raman spectroscopy is a scattering technique based on the inelastic scattering of incident radiation through its interaction with vibrating molecules (Raman effect).

The vibration modes of a substance depend on:

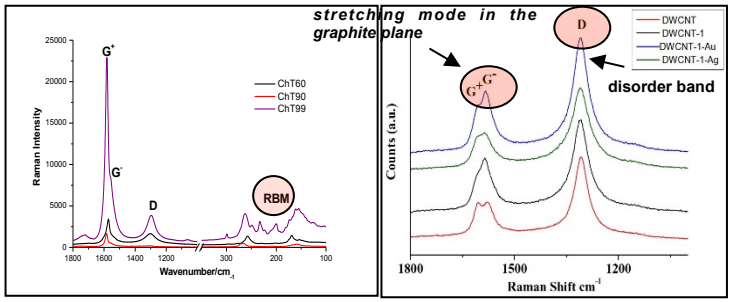
- mass of the atoms
- bonding forces
- symmetries of the molecules

Therefore, the Raman spectrum of a molecule corresponds to a "fingerprint" with which to identify it.



- **Not all** the **molecules** are **Raman actives**!
- The **fluorescence emission bands** can **cover** the Raman signal.
- Some compounds may suffer of a **thermal degradation** due to the laser irradiation.

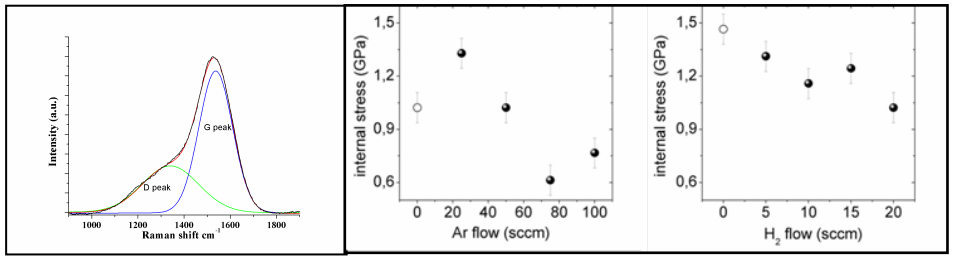
carbon nanotubes



G/D and **G^-/G^+** ratios are indicators of sample quality and conductivity of the sample

Radial Breathing Mode (RBM) is directly related to the diameter of nanotubes

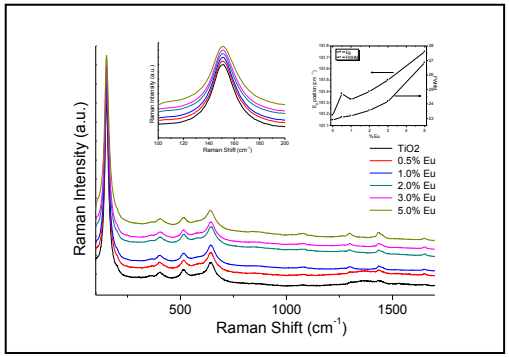
diamond like carbon DLC



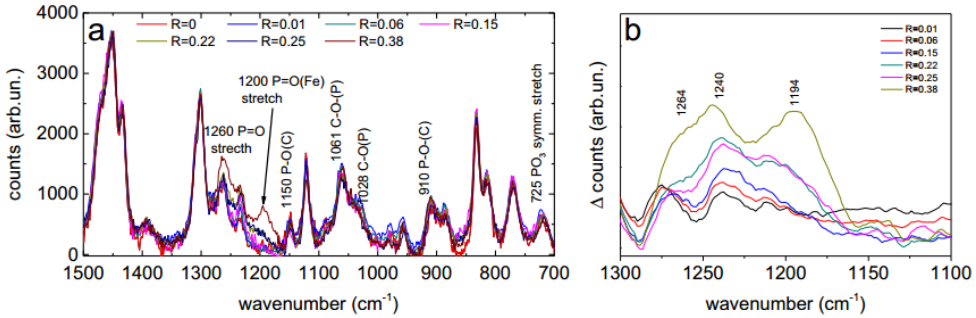
Evaluation of internal stress of a DLC film on a Si substrate:

$$\sigma = 2G\left(\frac{1+\upsilon}{1-\upsilon}\right)\cdot\left(\frac{\Delta\omega}{\omega_0}\right)$$

Eu-TiO2 NCs functionalized cotton



Molecular self assembly



ATR-FTIR spectroscopy for Cultural Heritage

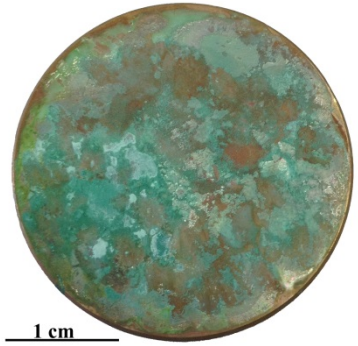
Investigation of the composition of degradation products on copper-based works of art.

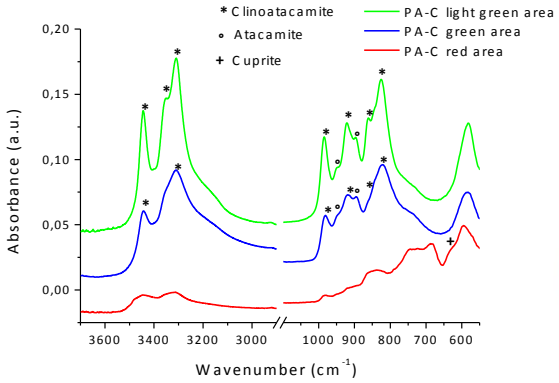
Analysis of patina composition:

- ✓ Identification of degradation products on copper-based alloys, as copper hydroxyclhorides and hydroxysulphates
- ✓ Distinguish degradation products polymorphs with different chemical reactivity (as clinoatacamite and atacamite)

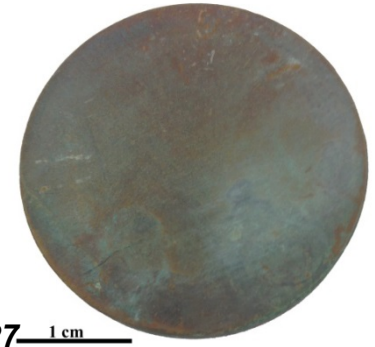
Adolfo Wildt

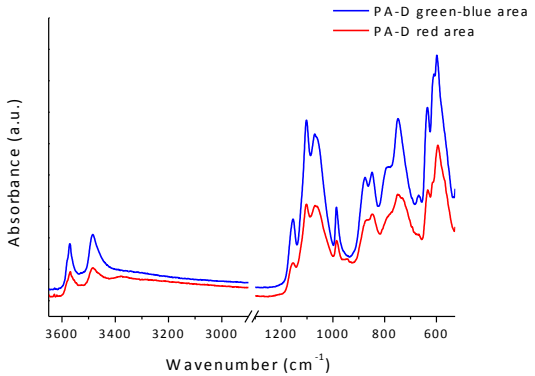
Copper hydroxyclhoride degradation products





Copper hydroxysulphate degradation products





G. Di Carlo et al., Applied Surface Science 421 (2017) 120–127

SPM

Topography

Magnetic properties

Mechanical properties

Mechanical properties of soft matter

Surface Friction

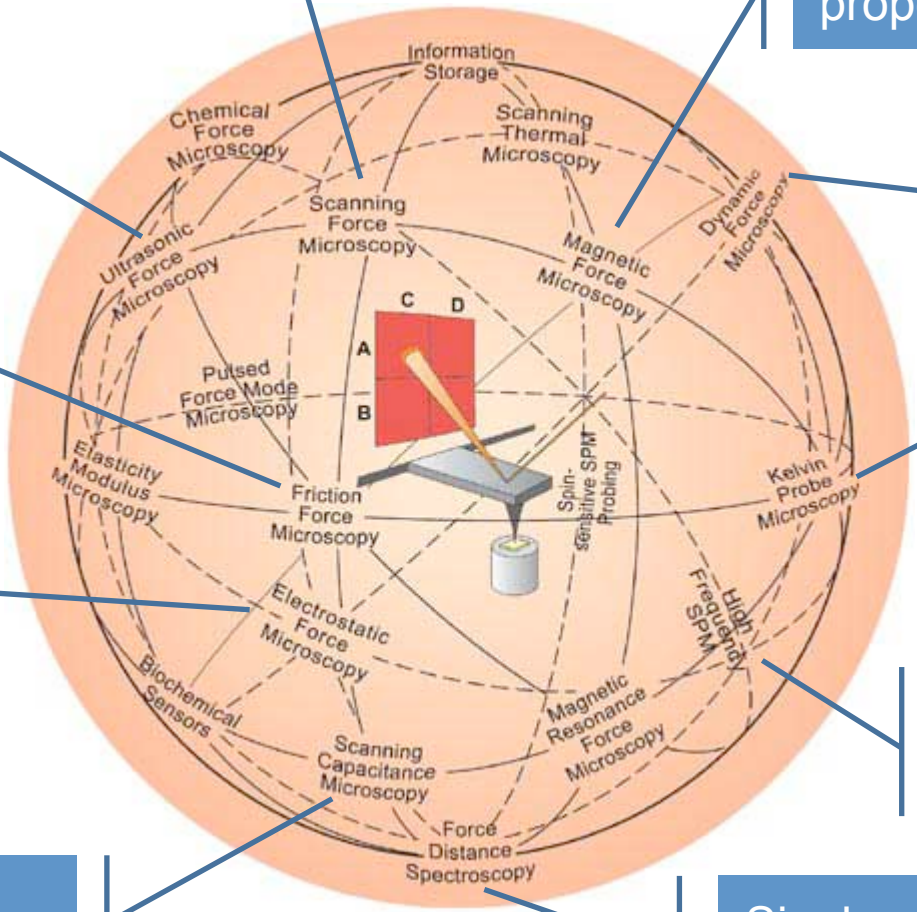
Surface potential

Electrical properties

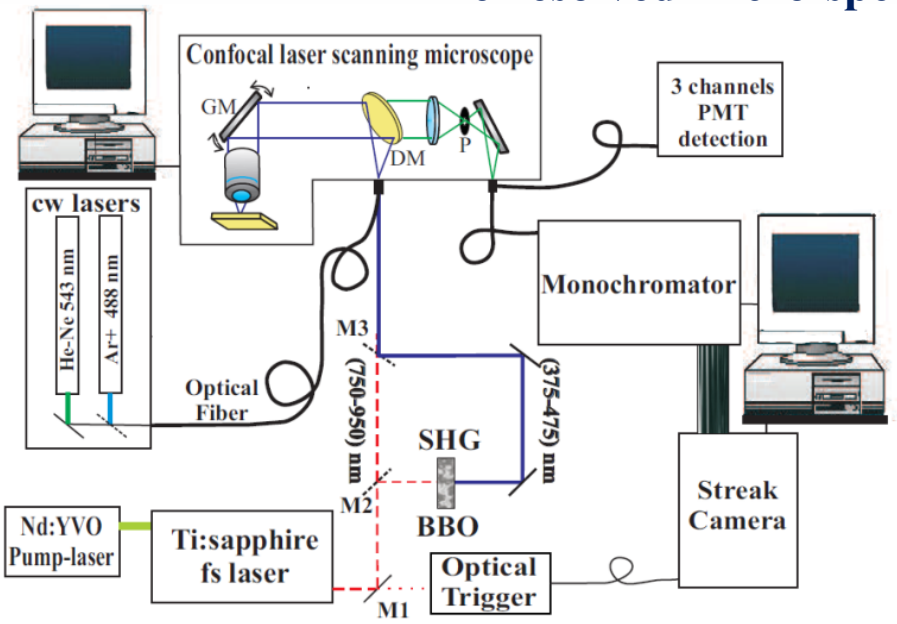
Mechanical properties

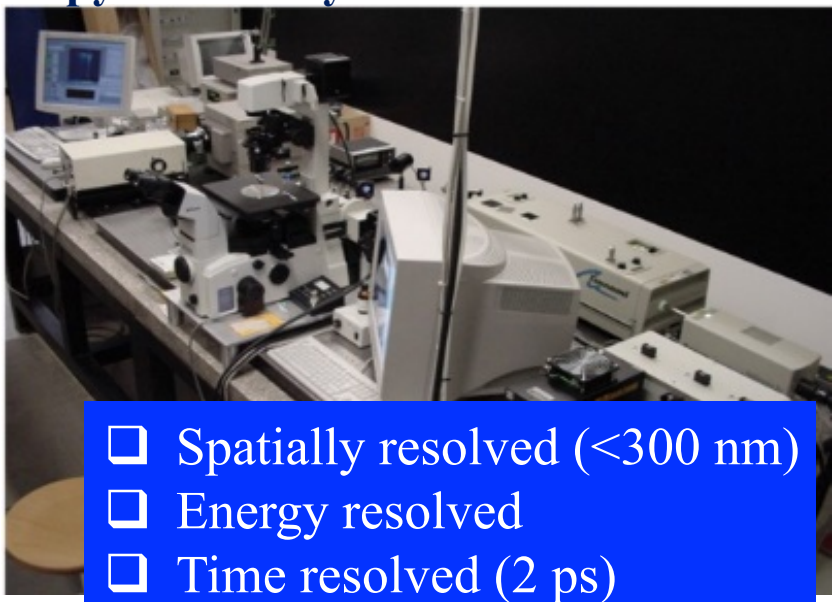
Electrical properties

Single molecules properties

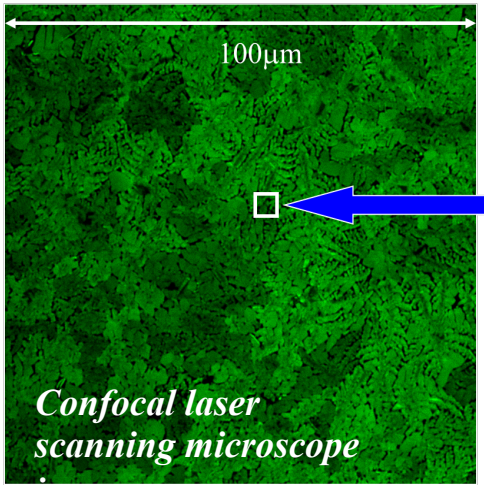


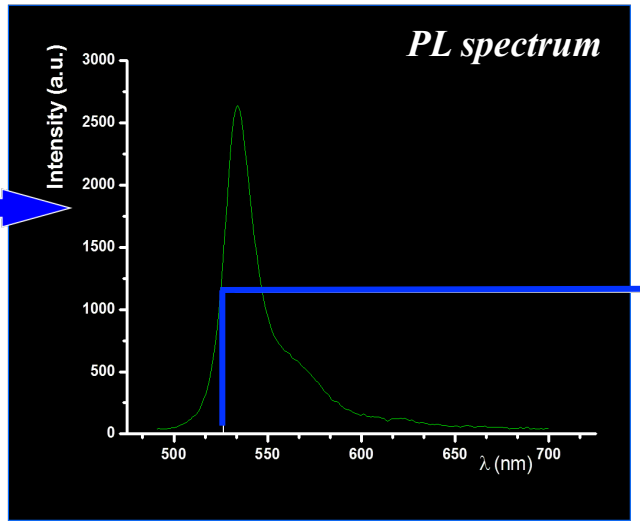
Time-resolved micro-spectroscopy laboratory

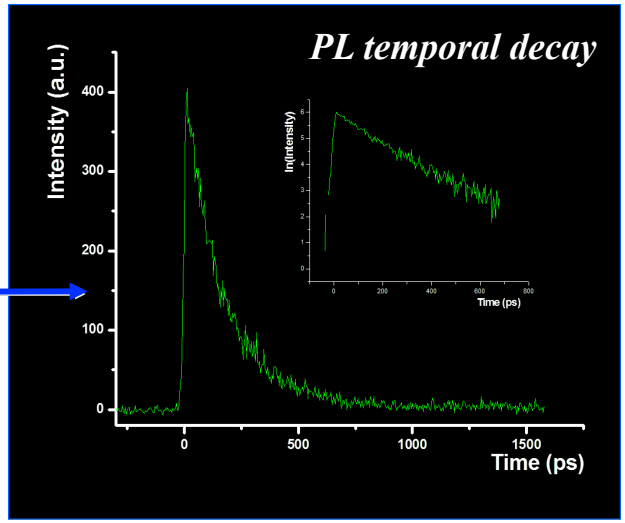




- Spatially resolved (<300 nm)
- Energy resolved
- Time resolved (2 ps)
- Temperature 450 – 4,2 K

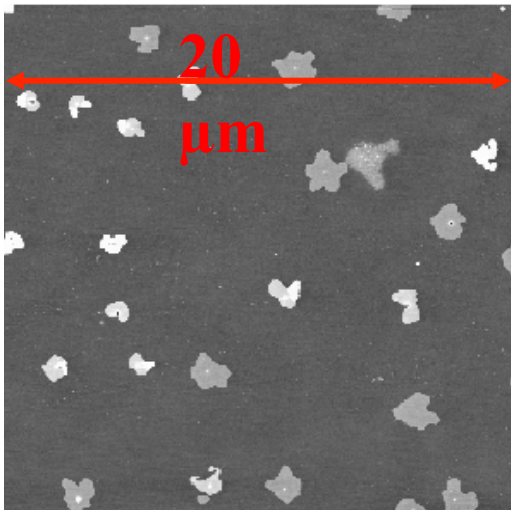




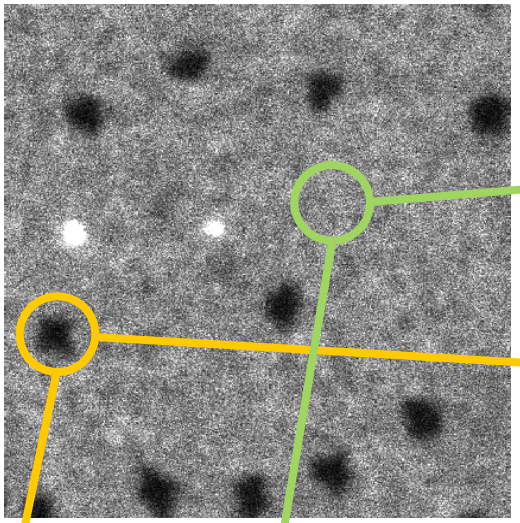


Correlation morphology-structure-function in composite systems

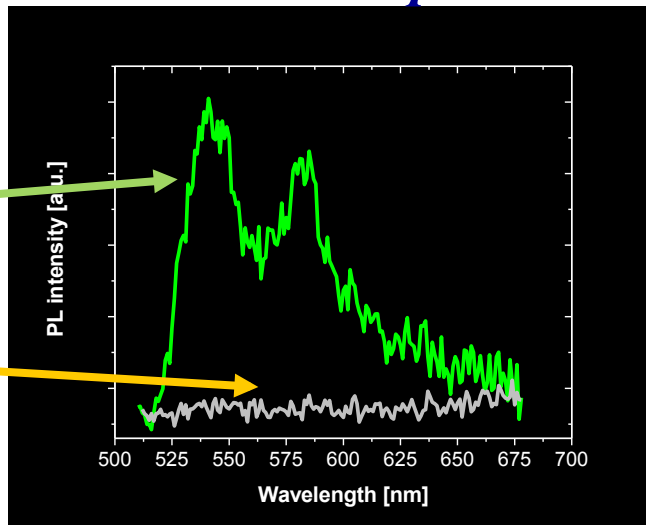
AFM

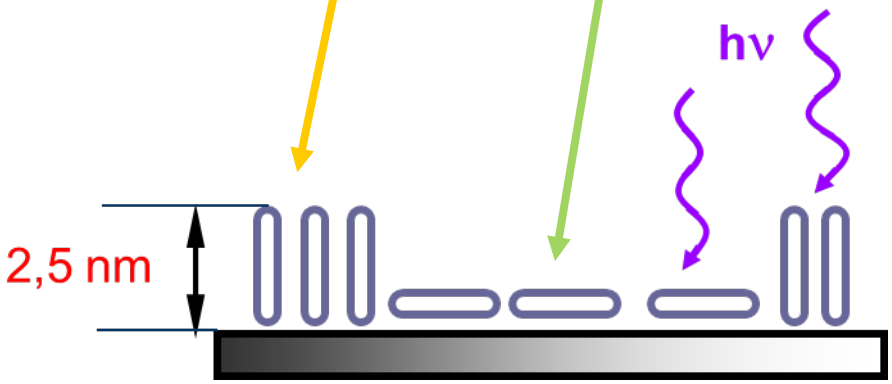


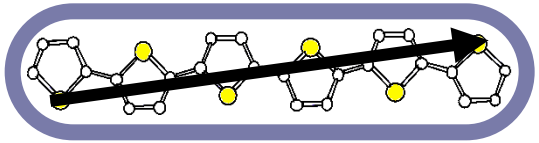
CLSM



Localized PL spectrum







Molecular orientation

Nature Materials, 4 (2005) 81

In summary

- The combination of different analysis techniques is essential for the development of ALM Technology
- SEM, XPS, XRD, SPM, RAMAN, FTIR, DTA-TG-DSC, LASER SPECTROSCOPY and OM, allows the thorough

- investigation of degradation phenomena (failure analysis) of structures and components
- optimization of production processes
- tailoring of the materials final properties

→ Aim at in-situ process monitoring and metrology

Acknowledgments

Electron & Optical Miscroscopy Lab
Ingo
Riccucci
Messina
Pascucci

Surface Analysis Lab
Kaciulis
Mezzi

PECVD – MOCVD Lab
Caschera
Toro
Federici

XRD Lab
Veroli

Raman Spectrocopy Lab
De Caro
Ruani

Laser Scanning Micro-Spectrocopy Lab
Toffanin
Bolognesi

FTIR Spectrocopy Lab
Di Carlo
Giuliani
Ingo

SPM Lab
Leo
Cerri
Padeletti
Valle
Brucale
Albonetti

Some of the projects @ISMN Mlib
MIUR-PON PANREX
EU-NANORESTART
EU-HERACLES
EU-MOSTOPHOS
Min Difesa – FABRICSAFE
EU-INNOVACONCRETE

Thank you!