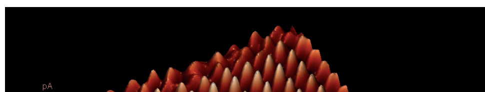
Interdisciplinary research at the nanometer scale: AFM+Confocal Raman+TERS

integration of SPM with confocal microscopy/ Raman scattering spectroscopy

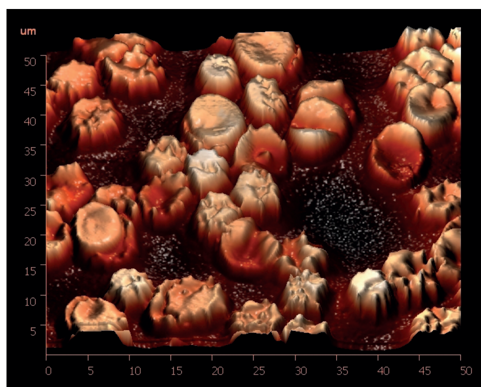
The newly created laboratory includes also an *NTEGRA Spectra* platform (NT-MDT), installed by the end of 2011. The equipment integrates the Atomic Force Microscope (AFM) and Raman Confocal Spectrometer *SOLAR TII*; it supports most of the existing AFM modes, providing comprehensive information about physical properties of the sample with nanometer scale resolution, whereas chemical composition can be simultaneously retrieved via confocal Raman spectroscopy. Measurements can be performed either through upright or inverted light excitation geometries. Complete Raman spectrum is recorded in each point of 2D / 3D scan with further powerful software analysis. The equipment is optimized for Tip Enhanced Raman Spectroscopy (TERS).

Owing to its multifunctionality, availability and simplicity, AFM has become one of the most prevailing tools for nanotechnology nowadays. It has a great advantage in that almost any sample can be imaged, be it very hard, such as the surface of a ceramic material, or a dispersion of metallic nanoparticles, or very soft, such as highly flexible polymers, human cells, or individual DNA molecules. An atomic force microscope allows us, for example, to get images showing the arrangement of individual atoms in a sample, or to see the structure of individual molecules.



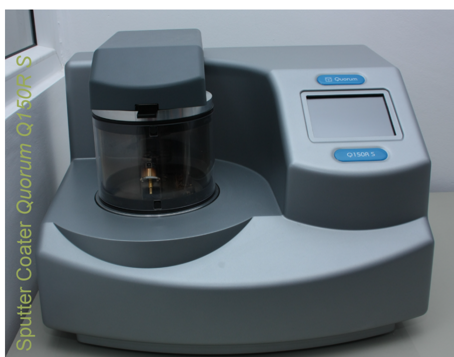
STM image of HOPG sample. Constant current mode. Scan size: 2.5 x 2.5 nm² Bias 0.1 V, FB 0.01. 80:20 Pt/Ir tip.

Besides its imaging capabilities, AFM has various spectroscopic modes by which other properties can be determined at nanometer scale. The strong enhancement of the electromagnetic field near nanometer scale metal asperities (nano-antennas) is at the origin of the TER spectra.



Tapping mode AFM height image of RBC measured with NSG03-A probe in air. Scan size 50 x 50 μm².

By using a specially modified AFM tip, Au/Ag coated (*Quorum 150R S*), the Raman signal strength is multiplied by a few orders of magnitude from a precisely scanned, localized spot on the surface several nanometers in diameter. To keep an optimal balance between maximum signal strength and the shortest penetration depth into the sample, the platform installed at INCDTIM was configured with three lasers, software selectable.



Sputter Coater Quorum Q150R S

Scanning Probe Microscopy Laboratory

NTEGRA Spectra platform combines a laser scanning confocal microscope and an AFM capable of both tip and sample scan modes

Configurations:

Upright for simultaneous AFM - Raman TERS imaging of opaque samples; objective 100x (NA0.7)

Inverted optimized for simultaneous AFM - Raman - TERS imaging of samples on transparent substrates; *Olympus IX71* microscope, high NA immersion objective (NA1.3)

Measurements in air, liquids, gaseous environments and vacuum up to 0.5 x 10^{-2} Torr

Quartz Crystal Microbalance, closed liquid and gas cell

Exchangeable scanners: 100x100x10 μm; 1x1x1 μm

Stand alone operation

Most of the existing AFM modes are available

Air and vacuum: contact; semi-contact; non-contact, Lateral Force Microscopy (LFM), Spreading Resistance Imaging (SRI), Force Modulation Microscopy (FMM), Piezoresponse Force Microscopy (PFM), Phase Imaging, Magnetic Force Microscopy (MFM), Electrostatic Force Microscopy (EFM), Scanning Capacitance Microscopy (SCM), Kelvin Probe Microscopy (SKM), AFM Spectroscopy, Adhesion Force Imaging, AFM Lithography (force and current); STM/STS

Liquids: contact, semi-contact, LFM, FMM, Phase Imaging, AFM Spectroscopy

Data acquisition and image processing: NOVA software

Raman spectrometer *SOLAR TII*

Lasers: 532 nm, 632.8 nm, 785 nm; 90 cm^{-1} Rayleigh filter
Spectral resolution: < 0.22 cm^{-1} (532 nm); < 0.1 cm^{-1} (785 nm);
Spatial resolution: < 200 nm (XY), 500 nm (Z)
4 gratings: 150, 600, 1800 ls/mm and Echelle (spectral resolution < 0.1 cm^{-1})

Detection: CCD camera

Vibration isolation: optical table *NEWPORT RS4000*

Sputter Coater *Quorum Q150R S*
Au/Ag targets