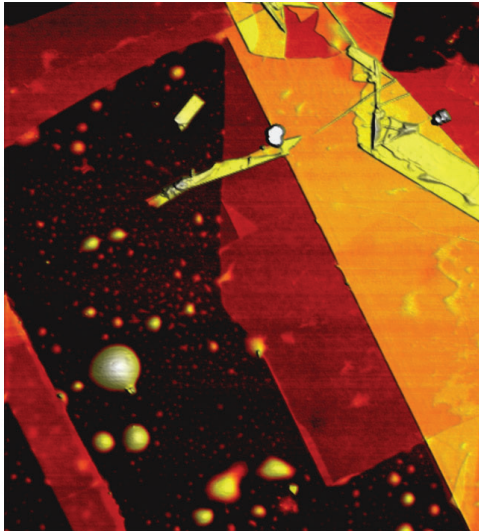
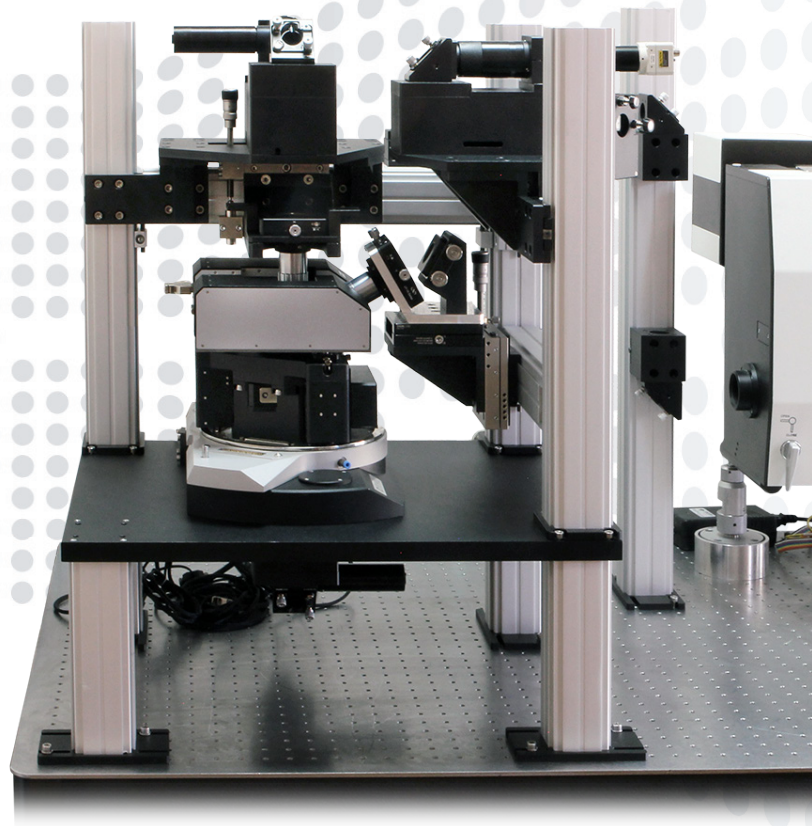


AFM - Raman - SNOM - TERS



Graphene flake on Si/SiO<sub>2</sub>, 2 x 2 μm



# NTEGRA SPECTRA II

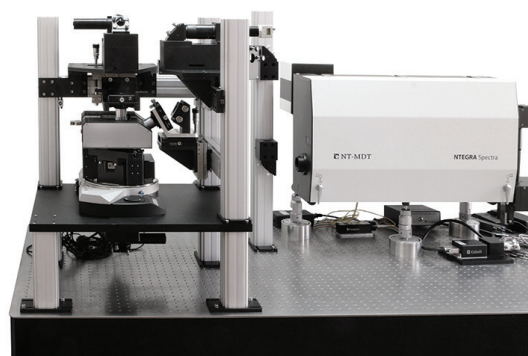
- High-performance versatile AFM
- Optical access from top, side and bottom optimized for Raman, TERS and SNOM
- Flexible optical design providing any combination of excitation/collection configurations
- Automated AFM laser, probe and photodiode alignment
- User-friendly change of wavelength of AFM registration system laser and photodiode
- Easy and user-friendly change of objectives

# NTEGRA Spectra II – automated AFM-Raman, SNOM and TERS system

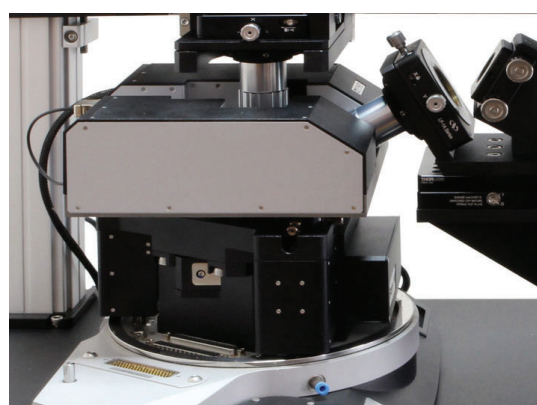
## OVERVIEW

Since 1998 NT-MDT has been successfully integrating AFM with optical microscopy and spectroscopy techniques. More than 30 basic and advanced AFM modes including HybriD Mode™ are supported providing extensive information about the sample surface physical properties. Integration of AFM with confocal Raman/fluorescence microscopy provide the widest range of additional information about the sample.

Simultaneously measured AFM and Raman maps of exactly the same sample area provide complementary information about sample physical properties (AFM) and chemical composition (Raman).



NTEGRA Spectra II



Full optical access from top, side and bottom

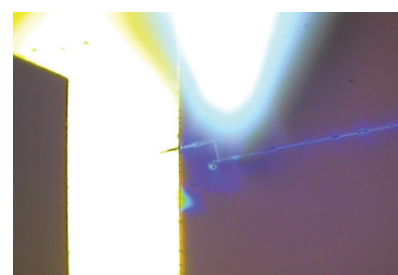
NTEGRA Spectra II with the help of Tip Enhanced Raman Scattering (TERS) allows carrying out spectroscopy/microscopy with nanometer scale resolution. Specially prepared AFM probes (nanoantennas) can be used for TERS to enhance and localize light at the nanometer scale area near the tip apex.

Such nanoantennas act as a “nano-source” of light giving possibility of optical imaging with resolution less than a diffraction limit (up to ~ 10 nm). Scanning near-field optical microscopy (SNOM) is another approach to obtain optical and spectroscopy images of optically active samples with resolution limited by probe aperture size (~ 100 nm).

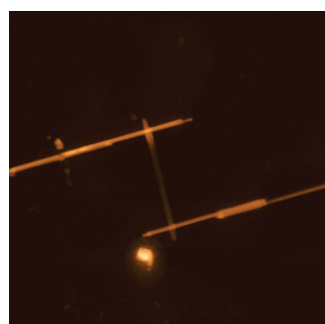
## CdS NANOWIRE

CdS nanowire was connected with metal electrode by conductive polymer nanowires. AFM probe is positioned on the structure with the help of viewing microscope. Thanks to the shape of the AFM probe laser can be positioned directly onto the tip apex.

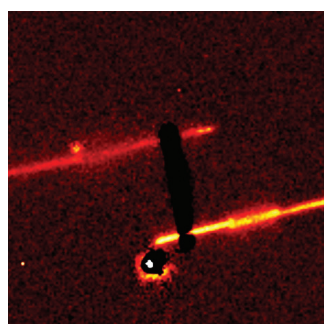
High resolution AFM images provide information about sample topography. Raman and luminescence maps taken from the same area show difference in nanowires chemical composition.



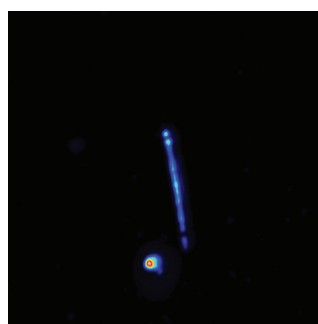
Optical viewing system image with approached AFM probe



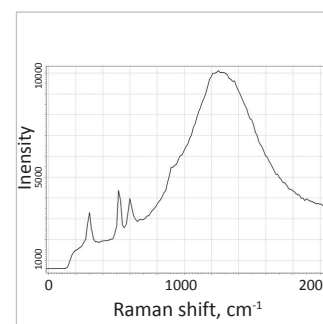
Topography



Raman map (conductive polymer nanowires)



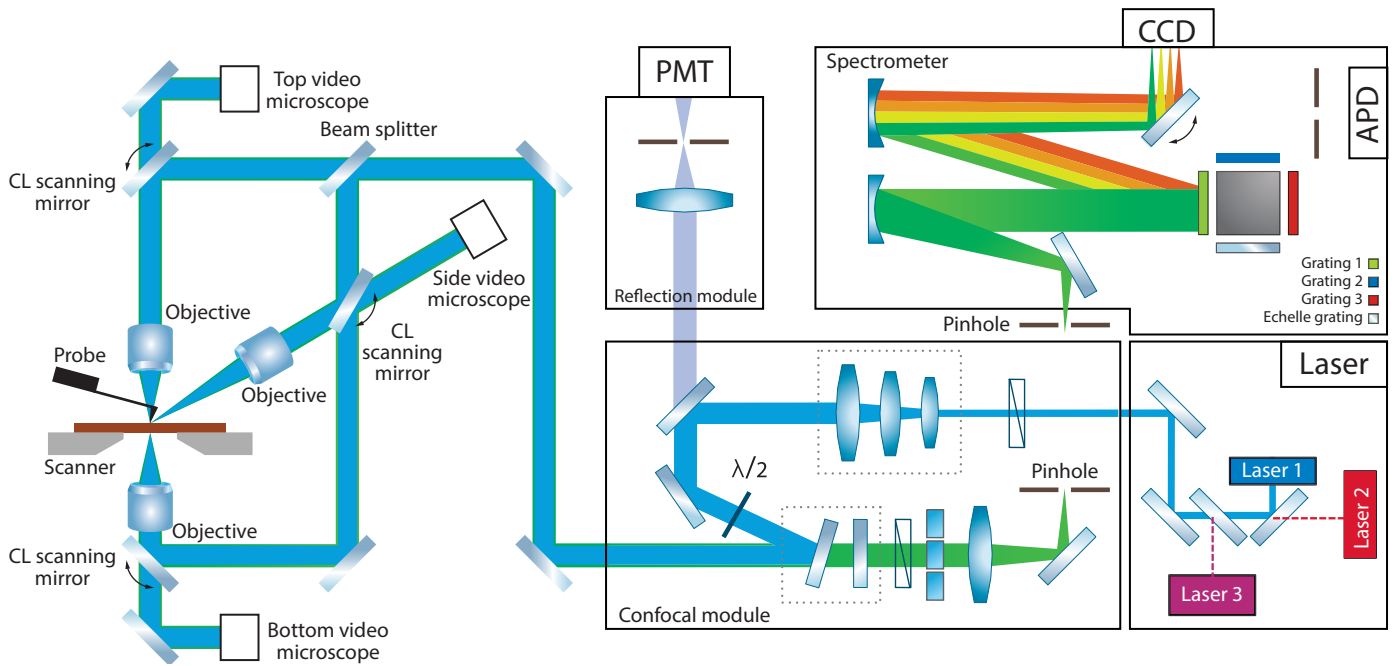
Photoluminescence (CdS)



Raman and PL spectrum of CdS nanowire

Sample courtesy: prof. R. Carpick, Penn State University. Scan size 20x20 μm

## OPTICAL SCHEME

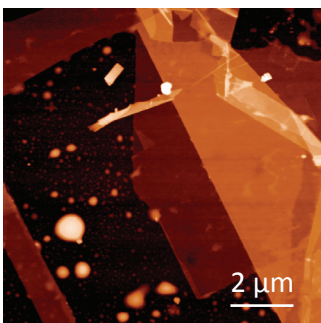


- Novel optical scheme consists of three independent channels of sample excitation: from top, side and bottom directions. Each channel is developed as independent module
- Sample excitation directions are easy to exchange between each other. Light collection could be done by excitation optical channel or by different one
- Open design provides great opportunities in system customization. Every particular channel allows to observe the sample by the objective with magnification factor up to 200 $\times$ , excite the sample by laser beam and scan by focused laser spot
- Excitation wavelength range is from 325 nm up to 1064 nm\*

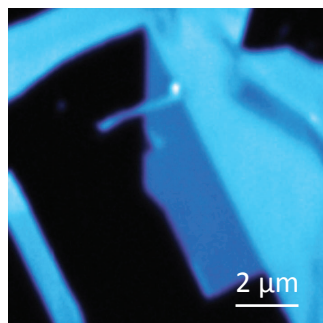
\*Compatibility with other wavelength upon request

- AFM registration laser system independent on Raman objective and this allows fast and easy exchange of objectives which are centered onto the same point on the surface
- Automated AFM laser, probe and photodiode alignment minimize customer routine operations
- User-friendly change of AFM registration system wavelength provides compatibility with any excitation or collection wavelength
- Stand-alone optical periscope allows to combine AFM-Raman system with virtually all Raman spectrometers available on the market upon customer request
- Spectrometer could be equipped with number of detectors: PMT, APD, CCD. Both Rayleigh optical image and Raman map could be obtained simultaneously

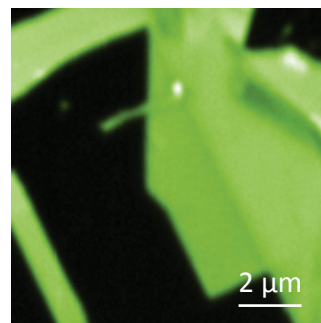
## GRAPHENE FLAKE ON Si/SiO<sub>2</sub>



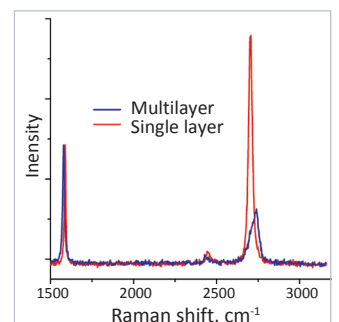
Topography



G band intensity



2D band intensity



Raman spectra



## SPECIFICATIONS

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### Confocal microscopy

Confocal Raman/fluorescence/Rayleigh imaging runs simultaneously with AFM

Diffraction limited spatial resolution: <200 nm in XY, <500 nm in Z (with immersion objective)

True confocality; motorized confocal pinhole for optimal signal and confocality

Continuously variable ND filter with the range 1 - 0.001 for precise change of laser power

Motorized variable beam expander/collimator: adjusts diameter and collimation of the laser beam individually for each laser and each objective used

Fully automated switching between different lasers - with a few mouse clicks

Full 3D (XYZ) confocal imaging with powerful image analysis

### AFM/STM integration with spectroscopy

High-performance low noise AFM: Z noise <0.1 nm (RMS in 10-1000 Hz bandwidth)

Easy-to-do exchange of registration system operational wavelength (670, 830, 1064 and 1300 nm). No interference between AFM laser and Raman spectroscopy

Automated AFM laser, probe and photodiode positioning and alignment

Objective-independent AFM registration system

XYZ closed-loop sample scanner 100x100x10  $\mu\text{m}$

Focus track feature: sample always stays in focus due to sample Z-feedback. High quality confocal images of very rough or inclined samples can be obtained

Exchangeable probe holders (AFM, STM, Tuning fork). All standard SPM imaging modes are supported (including KPFM, SRI, PFM, SCM) and combined with confocal Raman microscopy

A non-resonant oscillatory Hybrid Mode™ allowing direct and fast force detection for quantitative and high-resolution mapping of local sample properties

### Spectroscopy

Extremely high efficiency 520 mm length spectrometer with 4 motorized gratings

Visible, UV and IR spectral ranges available

Echelle grating with ultrahigh dispersion; spectral resolution: 0.007 nm (< 0.1  $\text{cm}^{-1}$ )

Up to 3 different detectors can be installed:

- TE cooled (down to -100 °C) CCD/EMCCD cameras
- APD in photon counting mode or FLIM detector
- PMT for fast confocal laser (Rayleigh) imaging

Flexible motorized polarization optics in excitation and detection channels, crosspolarized Raman measurements

Low wavenumber/THz Raman spectroscopy: <10  $\text{cm}^{-1}$  with Bragg volume filters

Hyperspectral imaging (recording complete Raman spectrum in every point of 1D, 2D or 3D confocal scan) with further software analysis

### Light delivery system

Optical access for top, bottom and side illumination at 30 degrees

Highest possible resolution optics is used simultaneously with AFM: up to 1.45 NA for Inverted, up to 0.7 NA for Upright, up to 0.7 NA for Side configurations

Exchangeable objectives with kinematic mounts: precision <2  $\mu\text{m}$

Dual scan: scan by sample AND scan by laser spot (for Hot Spot mapping in TERS)

Closed-loop scanning mirrors for precise laser spot positioning to the tip (important for SNOM, TERS): Upright, Inverted and Side configurations: 50x50  $\mu\text{m}$  with 100x objective

All SNOM signals are detected: laser intensity, fluorescence intensity, spectroscopy. All SNOM modes are supported: Transmission, Collection, Reflection, Scattering (s-SNOM)

All existing TERS geometries are available: illumination/collection from bottom, from top or from side