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Characterization of Carbon Nanomaterials with Confocal Raman-AFM

Fernando Vargas[1], Klaus Weishaupt[1], Ute Schmidt[1], Olaf Hollricher[1]

[1]*WITec GmbH. Hoervelsingerweg 6, D89081, Ulm, Germany*

email address corresponding author: fernando.vargas@witec.de

Carbon is known to exist in a number of allotropes which range from single crystalline diamond - the hardest of all known materials, to the soft, mainly amorphous graphite. The one-dimensional form of carbon, the carbon nanotubes [1,2] play an important role in modern material science due to their light weight, unique electrical and optical properties and mechanical strength. The recently discovered two-dimensional form of carbon, the graphene [3] gains more attention in the field of material science due to its functional properties and low production costs.

Although the diameter of single walled carbon nanotubes (SWCNT) is far below the optical resolution limit, its unique optical and spectroscopic properties are due to the one-dimensional confinement of electronic and phonon states, leading to resonant enhancement of the corresponding photophysical process. Characteristic for SWCNT are the radial breathing modes (RBM) providing information about the diameter of the tube. The G-band is used for diameter characterization, to distinguish between metallic and semiconducting SWCNT and to probe the charge transfer arising from doping a SWCNT. The G' band, characteristic for interlayer coupling in graphite, arises from phonon resonance in SWCNT. Graphene shows similar unique properties and is a perfect model system for Raman spectroscopy in a two-dimensional system [4].

Polarization dependent processes in carbon nanotubes can be studied using the imaging capabilities of the WITec Confocal Raman AFM (alpha300 AR). Fig. 1a shows a high resolution AFM image of carbon nanotubes spin coated on a Si-wafer. A large variety of individual carbon nanotubes are visible with lengths varying from several nanometer up to the micrometer length scale. By turning the microscope turret, the WITec AFM is transformed into a confocal Raman microscope. Fig. 1b shows the Raman spectral image recorded on the same sample area as Fig. 1a.

In Raman spectral imaging mode a complete Raman spectrum is recorded in every image pixel, leading to a 2D array of Raman spectra consisting of ten thousands spectra. The Raman spectral images are obtained after evaluation of characteristic features in the spectral array. Fig. 1b shows the distribution of the intensity of the Raman G band. Only nanotubes, which lay in the direction of excitation laser polarization, are visible in the image.

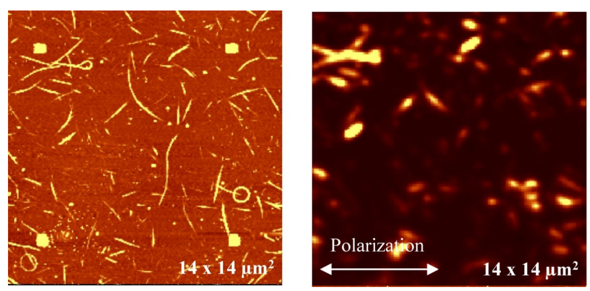

Fig. 1 *Carbon nanotubes imaged with high resolution AFM (left) and Raman spectral image of the same sample area (right).*

References

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