

Near-field spectroscopy of individual single-walled carbon nanotubes

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Spectroscopic methods with high spatial resolution are essential for understanding the physical and chemical properties of nanoscale materials including biological proteins, quantum structures and nanocomposite materials. Optical techniques are of special interest because the energy of light quanta is in the range of electronic and vibrational transitions. Advances in near-field optics open up new means to overcome the diffraction limit and extend the range of optical measurements to the length scales of most nanosystems.

Recently, a near-field optical technique based on local field enhancement has been demonstrated which allows to perform spectroscopic measurements with 20 nm spatial resolution [1,2]. The method makes use of the strongly enhanced electric field close to a sharp metal tip under laser illumination. In this approach the metal tip is held a few nanometers above the sample surface so that a highly localized interaction between the enhanced field and the sample is achieved. Raster scanning the sample then allows for simultaneous optical and topographic imaging.

Single-walled carbon nanotubes (SWCNTs) have been the focus of intense interest due to a large variety of potential nanotechnological applications. We demonstrate near-field Raman and fluorescence imaging of the same individual single-walled carbon nanotube and show that a spatial resolution of less than 20 nm can be achieved.

The high-resolution capability and chemical specificity of the presented method is used to study local variations in the optical spectra of SWCNTs caused by structural defects which would be hidden in farfield measurements. The technique has great potential for becoming a routine tool for the chemical analysis of surfaces at high spatial resolution.

[1] E. J. Sánchez et. al, Phys. Rev. Lett. **82**, 4014 (1999).

[2] A. Hartschuh et. al, Phys. Rev. Lett. **90**, 095503 (2003).