Imaging of Ultrathin Graphite with Confocal Raman Imaging

Thomas Dieing[1], Harald Fischer[1], Emelie Cederholm[2], Dag von Gegerfelt[3]

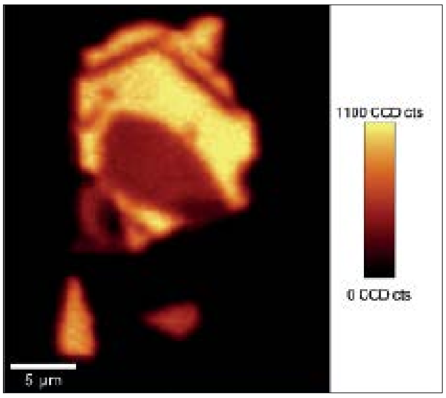

Fig. 1: Raman image of the ultrathin Graphite G-Band intensity.

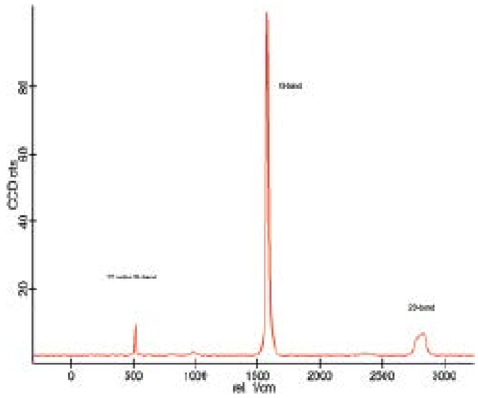

Fig. 2: Typical Raman spectrum of ultrathin Graphite.

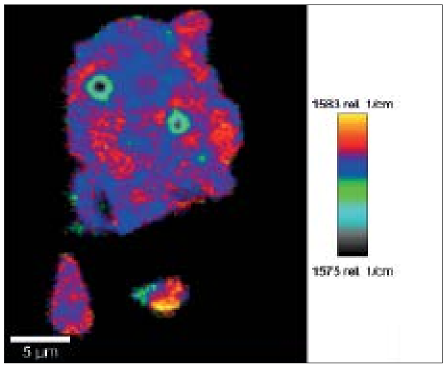

Fig. 3: Stress map obtained by peak shift analysis (lower wavenumbers: tensile stress; higher wavenumbers: compressive stress).

Ultrathin Graphite shows immense promise in many applications, e.g. transistors, sensors and optoelectronics. Flexible and adaptive analyzing methods can accelerate the progress in ultrathin Graphite R&D. Confocal Raman Microscopy is an effective tool for investigation of 2D material properties. This article will highlight Raman imaging as a technique for ultrathin Graphite analysis.

The Raman Effect

A Raman spectrum shows the energy shift of the excitation light as a result of inelastic scattering by the molecules in a sample. The laser light excites or annihilates vibrations of the molecular bonds within the material. Different molecular species consist of different atomic bonds, so each molecule can be easily identified by its unique Raman spectrum. As only molecular vibrations are involved, Raman spectroscopy is a nondestructive technique.

Confocal Raman Imaging

The confocal Raman Imaging technique combines Raman spectroscopy with a confocal microscope. Thus the spatial distribution of the chemical components within the sample can be detected and imaged. The relative amount of a specific component, stress and strain states, crystallinity, etc. can be further analyzed. High-resolution instruments acquire a complete Raman spectrum at every image pixel with a lateral resolution of ~200 nm. From the resulting "multi-spectrum file" an image of the distribution of different molecular species in the sample can be obtained. A confocal microscope also has an excellent depth resolution and features the generation of 3D Raman images and depth profiles. For excitation various laser sources can be attached to the microscope via an optical fiber. Choosing different wavelengths can be an effective means to suppress fluorescence effects, to increase the intensity of the Raman signal, or to achieve a greater penetration depth. With new solid state lasers even UV excitation has become easy and practical.

Raman Imaging of Ultrathin Graphite

In the following study a confocal Raman Microscope (WITec, alpha300 R) equipped with a 355nm solid-state laser (Cobolt Zouk 10mW), was used for analyzing an exfoliated multilayered ultrathin Graphite flake deposited on patterned silicon.

The maintenance-free laser operates at a stable single frequency (linewidth < 1 MHz, drift < 2 pm over 8 hours, spectral purity >60 dB).

A Raman image as shown in figure 1 was recorded by evaluating the integral intensity of the characteristic G-Band (fig. 2) which can be considered a measure for the material concentration/thickness. In a second step, the peak shift of the G-Band was evaluated and displayed as an image. Raman peak shift analysis is widely used to determine the material stress (compressive & tensile) distribution in a sample. In the resulting stress distribution map (fig. 3) two remarkable circular structures can be observed indicating strong tensile strain regions which might serve as an indication for material defects in the ultrathin Graphite layers or underneath.

Summary

Combining confocal microscopy with Raman spectroscopy provides an effective analysis method for ultrathin Graphite research applications. It was demonstrated that multilayered ultrathin Graphite can be easily excited in the UV regime for Raman images showing the material distribution as well as the stress fields induced by potential defects.

Affiliations
[1]WITec GmbH
[2]Cobolt AB
[3]Von Gegerfelt Photonics GmbH

Contact
Emelie Cederholm
Cobolt AB
Solna, Sweden
info@cobolt.se
www.cobolt.se