Nanoscale Raman analysis of carbon materials using AFM–Raman microscopy

AFM–Raman microscopy is a method which allows for both topographic and Raman imaging with nanometer resolution. Here its excellent resolving power on nanoscale structural analysis on carbon materials, e.g. carbon nanotubes and graphene oxides, is demonstrated using highly–stable ‘next generation’ AFM–Raman probes.

Principle of AFM-Raman (TERS) microscopy

A new design of AFM-Raman probes based on silver nanowires*
* Collaboration with Prof. Hiroshi Ujii at Hokkaido university
Resolution: down to ~20 nm
Applicability: nano-sized samples dispersed on a gold substrate, e.g. CNT, graphene, proteins, etc.

Nanoscale analysis on CNTs

Sample: Carbon nanotube/Graphene oxide on gold substrate

Reduced tip damage while AFM scan owing to cylindrical silver structure (cleavage of metal adlayer often occur with conventional TERS probes).

Summary of analysis

- GO sheet was found at left side in a scanned region.
- A semiconducting CNT (S-CNT) with δ1.65 nm was laid on the GO flake, connected with δ1.8 nm S-CNT and a bundle of δ0.7 nm S-CNT and δ1.4 nm metallic CNT (M-CNT).
- Point defects were observed on all measured CNTs, specifically at bend points and tube ends.
- Additional peaks on G-band were observed at a junction of M-CNT/S-CNT, which could be due to the presence of a local strain or intra-tube electronic interactions.

Point spectrum analysis

Intensity

RBM ~400 cm⁻¹ CNT Raman spectrum
D-band 1330 cm⁻¹ G-band 1592 cm⁻¹ 2D-band 2610 cm⁻¹

Diameter, Type(M/S)

Carbon contamination
4 ➤ CNT defect
3 ➤ CNT
2 ➤ Graphene oxide
1 ➤ Gold substrate (base line)

Point defect, crystallinity

Mapping analysis

Extra peaks
Local strain effect CNT-CNT interaction
7 (junction)
6 (δ1.4 nm, Metallic)
5 (δ1.65 nm, Semi.)
2 ➤ D/G ratio
6.05
3 ➤ 2D band
30
2 ➤ 2D band int.
30
1 ➤ D/G line
2
0 ➤ 100 nm...