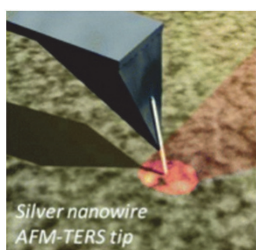
# Nanoscale Raman analysis of carbon materials using AFM-Raman microscopy

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

Schematic illustration

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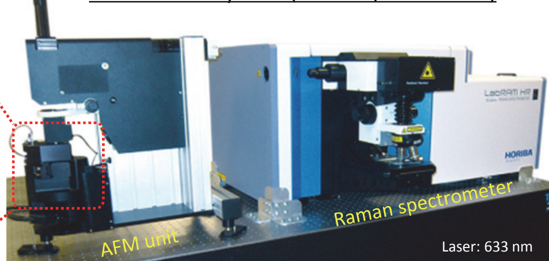
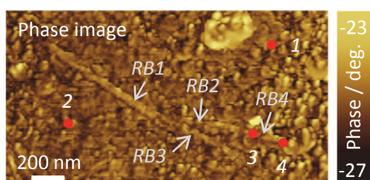
AFM-Raman system (AIST-NT/Horiba Inc.)




- ✓ 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.

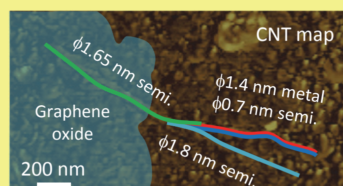
## Nanoscale analysis on CNTs

Sample: Carbon nanotube/Graphene oxide on gold substrate



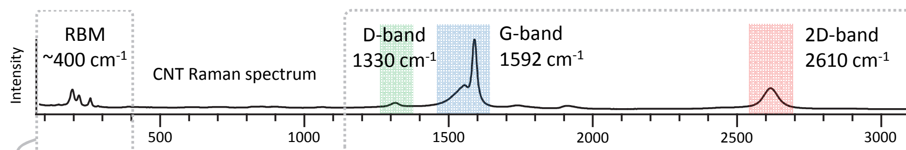

Reduced tip damage while AFM scan owing to cylindrical silver structure (cleavage of metal adlayer often occur with conventional TERS probes).

### Summary of analysis

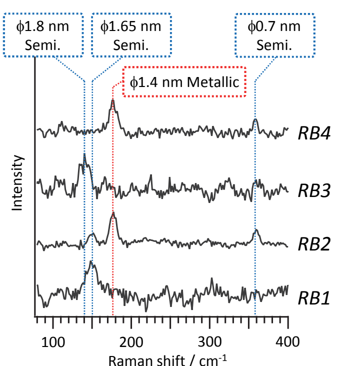



- ✓ GO sheet was found at left side in a scanned region.
- ✓ A semiconducting CNT (S-CNT) with ϕ1.65 nm was laid on the GO flake, connected with ϕ1.8 nm S-CNT and a bundle of ϕ0.7 nm S-CNT and ϕ1.4 nm metallic CNT (M-CNT).
- ✓ Point defects were observed on all measured CNTs, specifically at bend points 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.

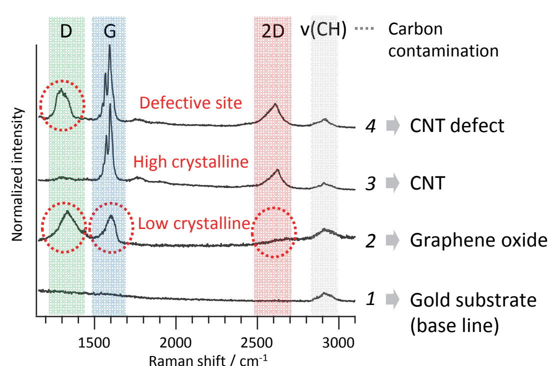
### Point spectrum analysis



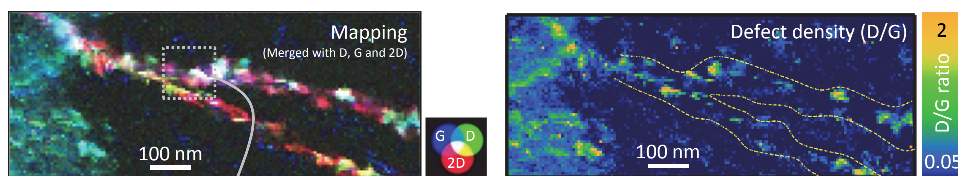

Diameter, Type(M/S)

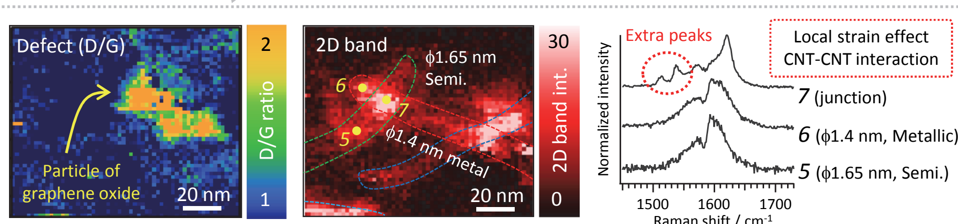



Point defect, crystallinity




### Mapping analysis



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