

Applications of Raman Microscopy to Nanoscience: Workshop Summary

A workshop on Applications of Raman Microscopy to Nanoscience was hosted by the Center for Nanoscale Materials (CNM) at Argonne National Laboratory, Argonne, Illinois, on October 22-23, 2010. The purpose of the workshop was to feature the recent scientific research of scientists and users from the five DOE-funded Nanoscale Science Research Centers (NSRCs) with respect to their Raman microscopy and spectroscopy capabilities. There were 80 registered attendees with 2 plenary speakers, 12 speakers representing the NSRCs, and 66 attendees representing 15 universities, 2 private companies, and 1 National Laboratory not affiliated with an NSRC. The workshop consisted of a full day of talks, an evening poster session, and a short course program. Regarding the latter, 25 people attended two 2-hour sessions consisting of hands-on demonstrations of the CNM's Raman microscope, an overview of Raman spectroscopy, and a tour of the CNM facilities. The oral presentations on Friday consisted of two plenary talks that covered both historical perspectives and recent results concerning surface-enhanced-Raman spectroscopy (Richard Van Duyne, Northwestern University) and graphene (Louis Brus, Columbia University). The rest of the presentations allowed each NSRC one hour. Generally, a brief description of their instrumentation and access was followed by scientific results from NSRC staff and users (the users generally did not have an NSRC affiliation).

Response from the attendees was overwhelmingly positive. Some examples of feedback are:

"The Raman Workshop was very worthwhile and well-organized."

"I really enjoyed the opportunity of listening to what academia is up to and learning what national labs are doing on nano research and Raman's roles in that area. The workshop was well organized and represented an excellent mix of the research focuses. Thanks to CNM for organizing the event. It's much appreciated."

"As an attendee, I want to express my deep gratefulness to the organizers and the CNM user office for putting together this very well-organized and informative workshop. The talks and posters presented were very enlightening and comprehensive. Participating in the workshop and the short course has made me more aware of the state-of-the-art instrumentation and capabilities of Raman spectroscopy in nanoscience. I am planning to adopt Raman spectroscopy into my future work so that I can obtain more information on the nanomaterials (e.g., carbon nanotubes, graphene) that I work on."

Some overall comments and observations:

- 1) Registration capacity was achieved quickly; the limit of 80 people was determined by the room size, and it also turned out to be a very manageable number of attendees for a 1-½ day workshop.
- 2) All of the NSRCs have a strong research component involving Raman microscopy. While there is some general overlap in basic capabilities, each Center also has some unique instrumentation. Awareness of the similarities and differences will allow users to

select the NSRC that best fits their needs. The general features at each NSRC is listed below:

- a. CFN – BNL
 - i. Confocal Raman microscope with AFM (633 nm, 532 nm)
 - ii. Tunable Raman spectroscopy
 - b. CINT – LANL/Sandia
 - i. Confocal Raman microscope (tunable from 345 nm to 1000 nm)
 - ii. Confocal Raman microscope (785, 532, 514, and 633 nm)
 - c. CNM – ANL
 - i. Confocal Raman microscope (633, 514, 442, 325 nm)
 - ii. Confocal Raman microscope/AFM/TERS (647, 532, 413 nm)
 - iii. Temperature controlled stage (-196 – 600C)
 - d. CNMS – ORNL
 - i. Confocal Raman microscope (785 and 633 nm)
 - ii. Tunable Raman (250 nm – 1600 nm) triple spectrograph
 - iii. High temperature cell
 - iv. Electrochemical cell
 - e. Molecular Foundry
 - i. Confocal Raman microscope
 - ii. Tip-enhanced Raman spectroscopy
 - iii. Temperature controlled stage
- 3) The use of Raman microscopy instrumentation has not been limited to simply taking Raman spectra -- a number of users also are taking advantage of extremely high detector sensitivity and computer-controlled mapping capability to perform confocal photoluminescence measurements. This shows the flexibility the user programs have in accommodating user-driven science.
- 4) A possible workshop related to nanophotonics was suggested as a follow-up to be hosted by one of the other NSRCs, perhaps in the Fall of 2011.

Sponsorship of refreshments during the poster session was provided by Renishaw Inc. The Argonne National Laboratory Chapter of Sigma Xi, The Scientific Research Society, provided lodging support for five graduate student conference attendees.