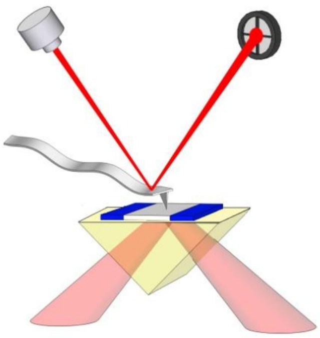
Nanoscale Chemical Spectroscopy with the Atomic Force Microscope

Juergen Schluetter[1], Craig B. Prater[2], Debra Cook[2], Roshan Shetty[2] and Kevin Kjoller[2]

[1] LOT-Oriel GmbH & Co. KG, Im Tiefen See 58, Darmstadt, 64293, Germany, schluetter@lot-oriel.de
[2] Anasys Instruments, 25 W. Anapamu Street Suite B, Santa Barbara, CA 93101, USA

The ability to unambiguously identify arbitrary material under the tip of an Atomic Force Microscope (AFM) has been identified as one of the "Holy Grails" of probe microscopy. While the AFM has the ability to measure a range of material properties including mechanical, electrical, magnetic and thermal, the technique has lacked the robust ability to characterize and identify unknown materials. Infrared spectroscopy is a benchmark technique routinely used in a broad range of sciences to characterize and identify materials on the basis of specific vibrational resonances of chemical bonds. Several AFM probe-based techniques have been used to beat the diffraction limit of conventional IR measurements, however, none of these techniques provide readily interpretable broadband IR spectroscopy with nanoscale resolution. We have successfully integrated the capabilities of AFM with IR spectroscopy to allow chemical characterization on the micro and nanoscale. The instrument employs a technique called photothermal induced resonance (PTIR) [1-3] that uses an AFM probe to measure the local thermal expansion from IR light incident upon a sample. This technique enables the ability to obtain a high quality IR spectrum at a selected point in an AFM image and/or automatically map spectra at an array of points on a sample to enable chemical mapping. In this presentation, we will share the details of the measurement technique including application examples on polymer multilayers and blends, along with measurements on plant cells.



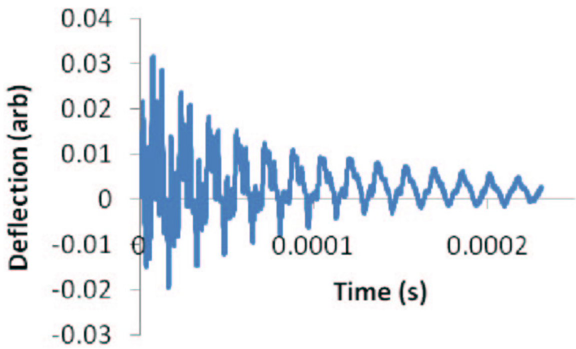


Figure 1. (L) Schematic diagram of PTIR technique for nanoscale IR spectroscopy. A pulse of infrared light from a tunable source is directed at a region on a sample. When the source is tuned to an absorption band of the sample, the absorbed radiation heats up the area, resulting in a rapid thermal expansion of the sample. This rapid thermal expansion excites resonant oscillation modes of the cantilever. (R) Example cantilever ringdown after excitation by sample IR absorption. The amplitude of this ringdown is proportional to the strength of IR absorption under the AFM tip. The PTIR technique also enables complementary and simultaneous mapping of mechanical properties through measurements of the ringdown resonant frequencies.

This work is supported in part by NIST-ATP-70NANB7H7025 and NSF-SBIR-0750512.

References

[1] A. Dazzi, R. Prazeres, E. Glotin and J. M. Ortega, Optics Letters **30**, 2388-2390 (2005).
[2] A. Dazzi, R. Prazeres, F. Glotin and J. M. Ortega, Ultramicroscopy **107**, 1194-1200 (2007).
[3]. A. Dazzi, R. Prazeres, F. Glotin, J. M. Ortega, M. Al-Sawaftah and M. de Frutos, Ultramicroscopy **108**, 635-641 (2008).