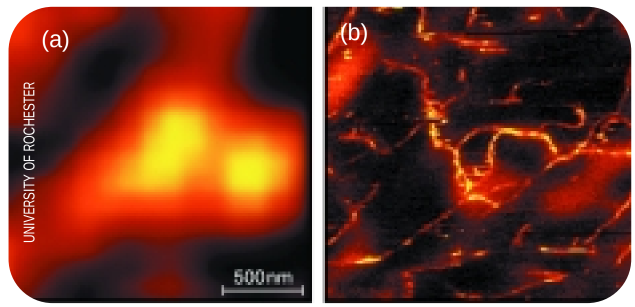
eye on technology

microscopy

near-field Raman microscopy images nanostructures

Constrained by fundamental limitations, light-imaging techniques have taken a backseat to scanning probe, optical tweezer, and electron microscope techniques for nanotechnology exploration—until now. In collaboration with Portland State University (Portland, OR) and Harvard University (Cambridge, MA), researchers at the University of Rochester (Rochester, NY) used a sharp silver tip as a probe to perform near-field Raman spectroscopy and imaging of single-walled carbon nanotubes (SWNTs) with 25-nm spatial resolution (see figure). Electrons at the probe tip are excited and interact with the vibrational atoms of the sample to produce a spectrum identifying the chemical composition of the material. “The method produces images with detailed chemical information of nanometer-sized objects,” says Lukas Novotny of the research group.

The group produced the 10- to 15-nm radius silver tip by electrochemical etching and focused-ion-beam milling. Based on an inverted optical microscope, the optical setup consists of a 30- to 100-mW, 633-nm laser beam reflected by a dichroic beam splitter and focused by a 1.4 numerical aperture objective onto a transparent sample containing isolated SWNTs. The silver tip is positioned near the focus of the beam and about a nanometer away from the sample surface. Using a spectrograph and a thermoelectrically cooled CCD detector, or a narrow bandpass filter,



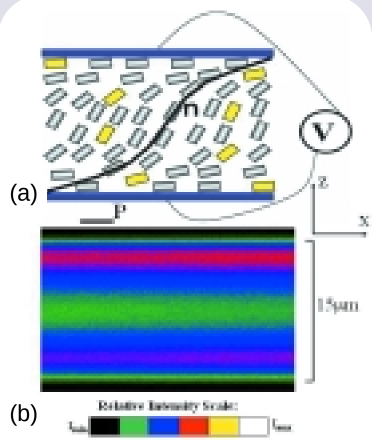
Images of carbon nanotubes on a glass substrate compare conventional microscope image (a) with near-field Raman technique (b).

instrumentation

liquid-crystal imaging goes 3-D

Typically, the molecular orientation of liquid crystals (LCs) is spatially complex and sensitive to external fields and molecular interactions. This sensitivity makes LCs ideally suited for applications such as sensors and low-power displays. However, until recently, indirect probing techniques could only obtain 2-D images of the average direction of molecular orientation (director field) in 3-D samples. Using a fluorescence confocal polarizing microscopy (FCPM) technique, researchers at Kent State University (Kent, OH) recently imaged edge dislocations in cholesteric LCs.

In order to make the instrument sensitive to orientational rather than concentration features in the test sample, the researchers supplemented the traditional fluorescence confocal microscopy method by probing the sample with linearly polarized light and by using a fluorescent dye composed of anisometric molecules that align in the LC host, preferably along the director field.



A vertical cross-section shows an LC cell undergoing the Frederiks transition under an applied electric field: the director field (*n*) describing the average orientation of LC molecules (a) and the FCPM texture visualizing this director field (b).

Determined by the angle between the transition dipole of the dye and the polarization of the probe beam, the measured fluorescence intensity pattern describes the director field’s spatial configuration as the dye aligns to the LC. “A typical LC can be scanned up to the depth of 10 to 30 µm with a resolution of 1 µm or so,” says Ivan Smalyukh of the research group.

The group is currently using the technique to probe director patterns in multi-component heterogeneous systems such as LC colloids, and plans on improving the image acquisition speed. The technique can be applied to a variety of orientationally ordered systems, and future applications will include high-tensile strength polymers, membranes, and colloids. —*Phillip Espinasse*