

Characterization of Materials and Structures Using Raman Microscopy

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What is Raman Spectroscopy?

Raman spectroscopy detects characteristic molecular vibrations of (1) molecular gases, liquids, and solids and (2) crystalline lattices.

- The number of observed Raman bands is determined by molecule/crystal symmetry properties.
- Band intensities are determined by the magnitude of polarizability oscillations.

Credits

- Major contributors to the results presented here include:
 - Mr. Kartik Venkataraman
 - Dr. Jodi Reeves (SuperPower, Inc.)
 - Prof. Konrad Wu (SUNY, Old Westbury)
 - Dr. Albert Fischer
 - Dr. Dieter Gruen (ANL/MSD)
 - Dr. Dominic Lee (ORNL)
- The Raman microprobe instrument and the research on superconductors is supported by the Department of Energy, Office of Electric Transmission and Distribution, as part of a DoE program to develop electric power technology.

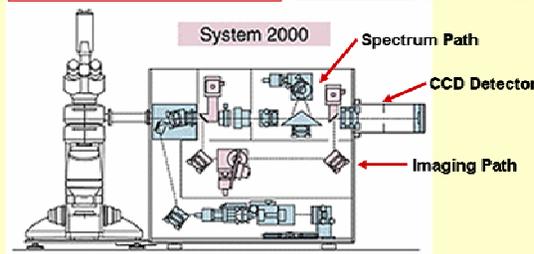
About Raman Microscopy Instrumentation

Raman microscopy and imaging Raman microscopy are becoming workhorse tools in the materials science field.

Raman microprobe instruments, like the one pictured to the right (the Renishaw System 2000, have the capability to collect both Raman spectra and Raman spatial images.

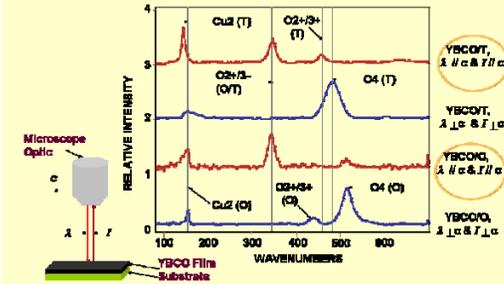
The functional features of a typical imaging Raman microprobe are illustrated in the sketch shown below:

- Raman spectra are excited by monochromatic laser radiation; the second order scattering is directed to a grating and the diffracted spectrum is captured with a CCD detector.
- Raman images are obtained by directing the scattered light from the sample through a band-pass filter array, which allows the CCD to be used as a camera.



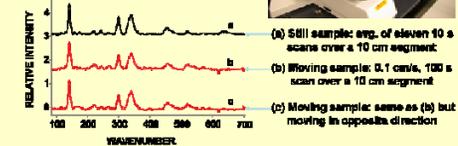
Raman scattering from ordered orthorhombic (O) and tetragonal (T) $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ (YBCO) crystals illustrate crystal orientation effects

• scattering intensity of each phonon is a function of incident laser direction (λ) and direction of observation of the Raman scattering (λ') with respect to the YBCO crystal axes



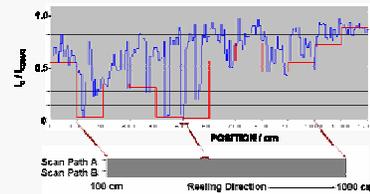
Raman examination of long-length conductor specimens

- easily adapted to reel-to-reel movement
- useful for studying fully processed and partially processed samples
- applicable to moving samples (requires dynamic focusing to accommodate vertical motion)

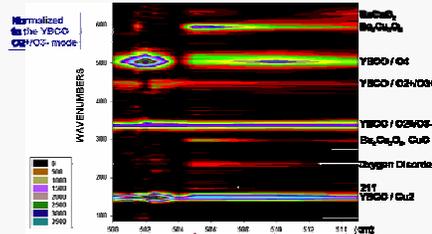


Reel-to-reel (R2R) Raman examination of a multi-meter coated conductor tape produced by SuperPower, Inc.

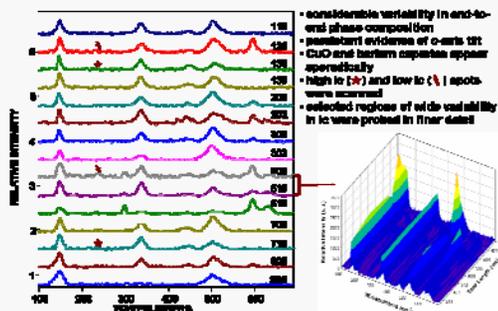
- Tape Embedment: MOCVD-YBCO (ca. 1 μm) / CuO_x / IBAD-Template / Ni-alloy
- Tactic: Obtain Raman scans of fully processed tape after its measurement
- Purpose: Compare/contrast Raman spectra from high I_c and low I_c regions



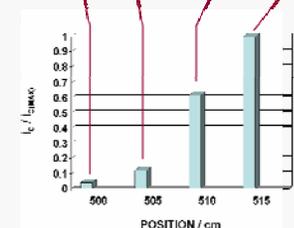
R2R Raman intensity map as a function of position on tape



Raman survey of YBCO tape in regions of high I_c and low I_c



- considerable variability in and-to-rod phase composition
- prominent evidence of c-axis CuO and CuO layers appear sporadically
- high I_c and low I_c spots were scanned
- selected regions of wide variability in I_c were probed in finer detail



SuperPower Inc.

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Diamond on silicon structures (samples from D.M. Gruen et al.)

