RAMAN-BASED DIAGNOSTIC APPROACHES TO THE CHARACTERIZATION OF COATED CONDUCTORS*

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- **Nondestructive interrogation procedures based on characteristic phonons**
- **A measurement method that is amenable to on-line diagnostics**
- **A method that gives a multiplicity of characterization information**
- **A method that gives information one doesn't readily get from other techniques**

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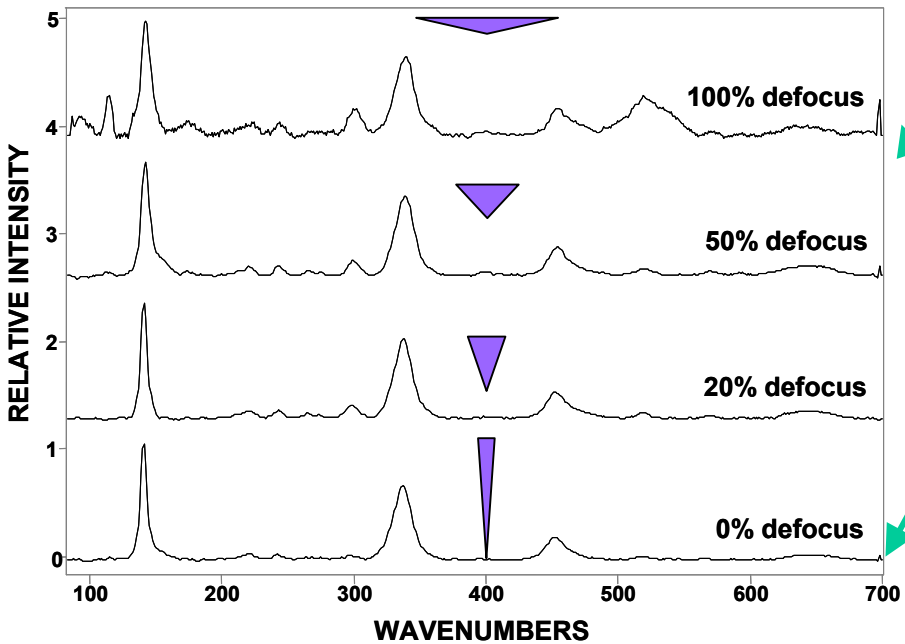
Raman Microscopy: What can it do? How can it be used?

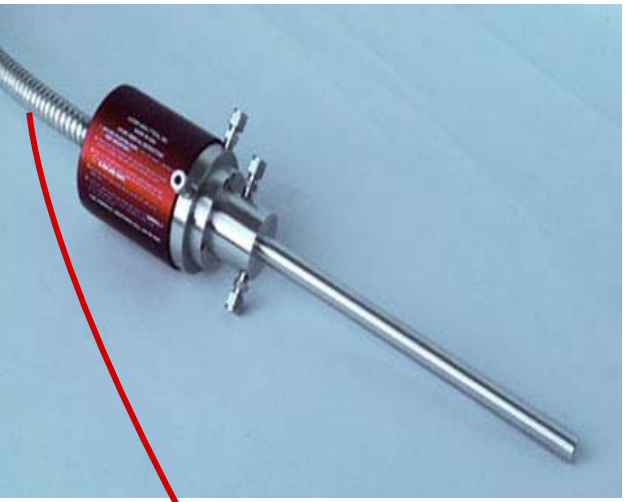
- phase identification:
  - O-YBCO $Y_2Ba_xCu_{2-x}O_5$
  - T-YBCO Ba-Cu-O
  - CuO, BaF_2, $BaCeO_3$
- phase separation: O(I)-, O(II)-, T'-, T-YBCO
- c-axis texture/tilt (e.g., a-axis grains)
- lattice disorder (cation, oxygen)
- reel-to-reel examinations

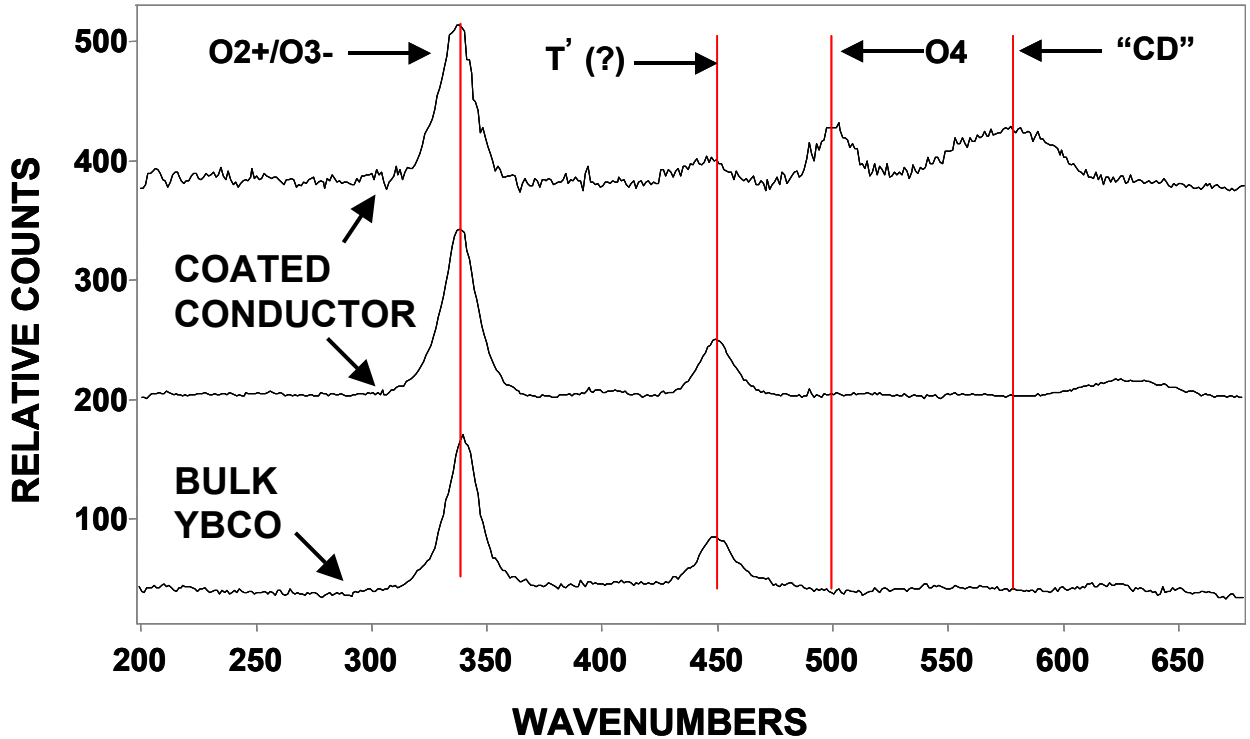


- spatial profiling of, e.g., impurities
- in-situ investigations vs. temperature, time, environment (inert, vac, chemical)
- on-line process monitoring

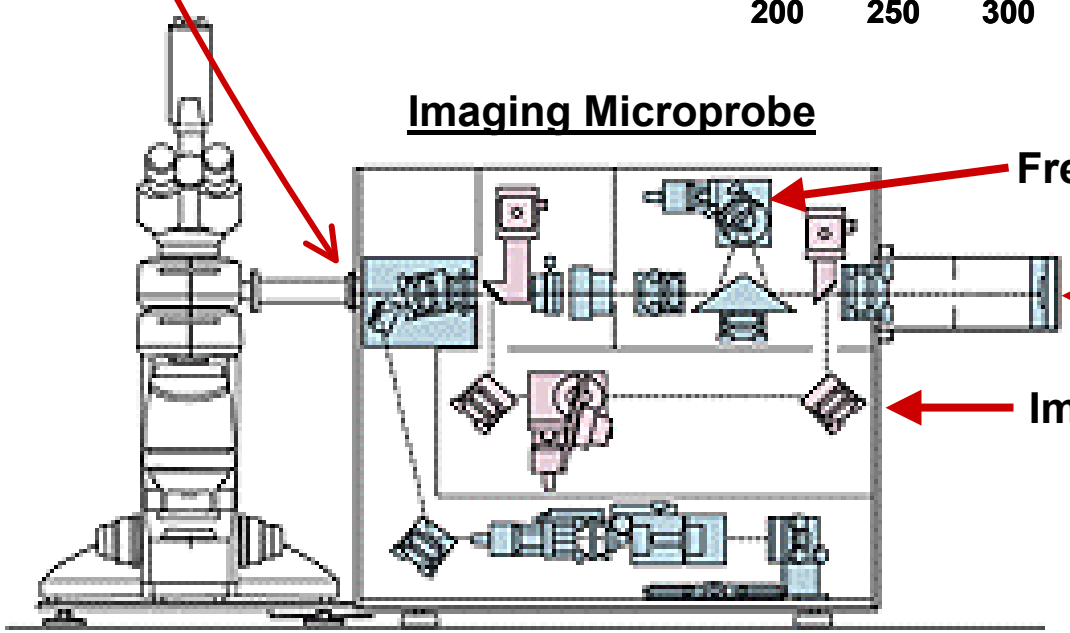
Raman Spectroscopy Using Microprobe and Fiber Optic Techniques

Fiber Optic Probe



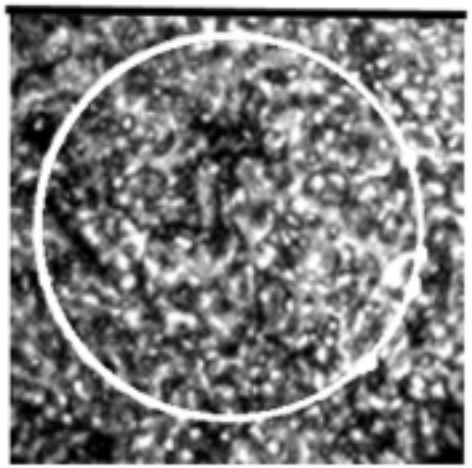


Imaging Microprobe



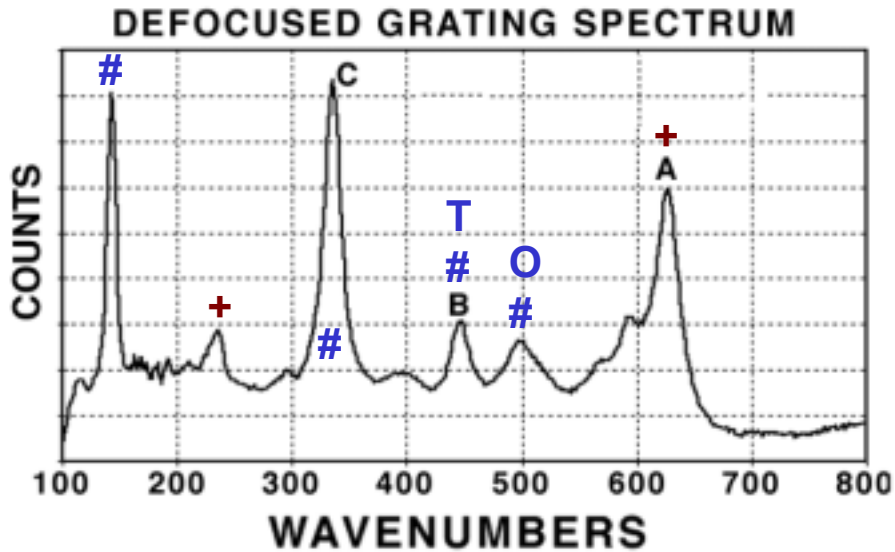
Raman Image of a YBCO/CeO_2/YSZ(sc) Specimen Showing an Array of ca. 1 μm $BaCuO_2$ Crystals on the Surface of Phase Separated YBCO

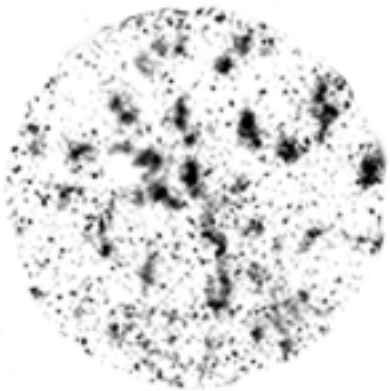
= YBCO + = $BaCuO_2$



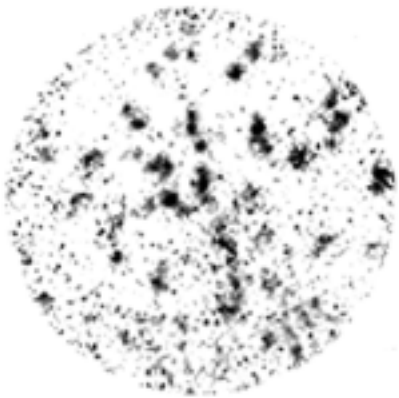
10 μm

WHITE LIGHT IMAGE

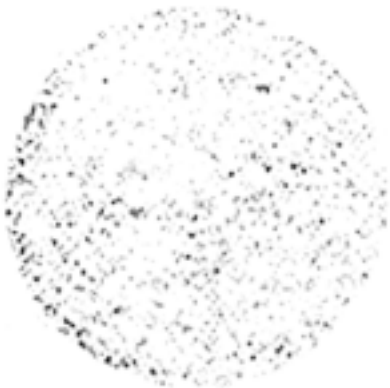




A(inv) – B(inv)



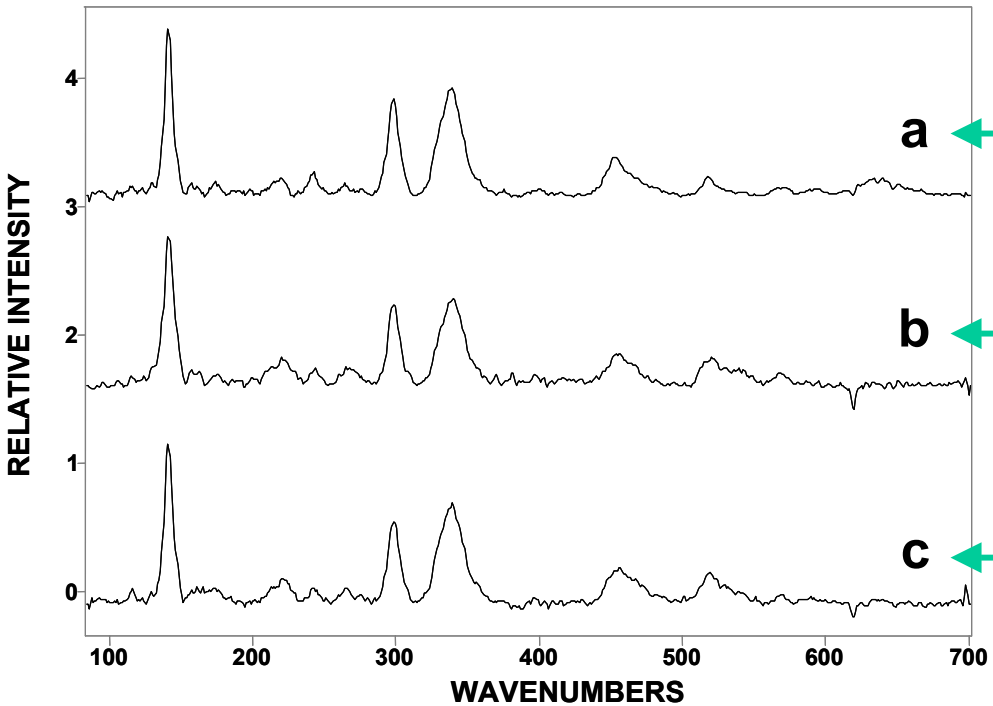
A(inv) – C(inv)



B(inv) – C(inv)

Using Raman Microscopy to Examine Long-Length Conductor Specimens

- easily adapted to reel-to-reel movement
- can be applied to moving samples (requires dynamic focusing to accommodate vertical motion)
- useful for studying quenched tapes and other types of partially processed samples

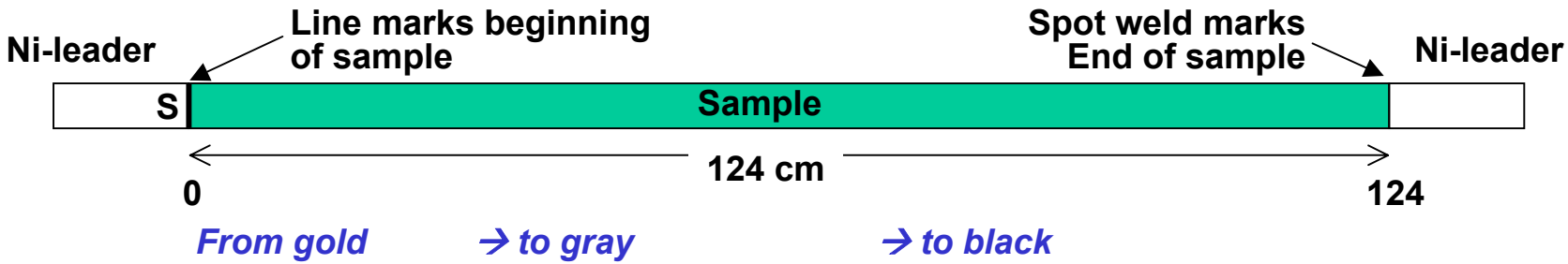


(a) Still sample: avg. of eleven 10 s scans over a 10 cm segment

(b) Moving sample: 0.1 cm/s, 100 s scan over a 10 cm segment (static grating mode)

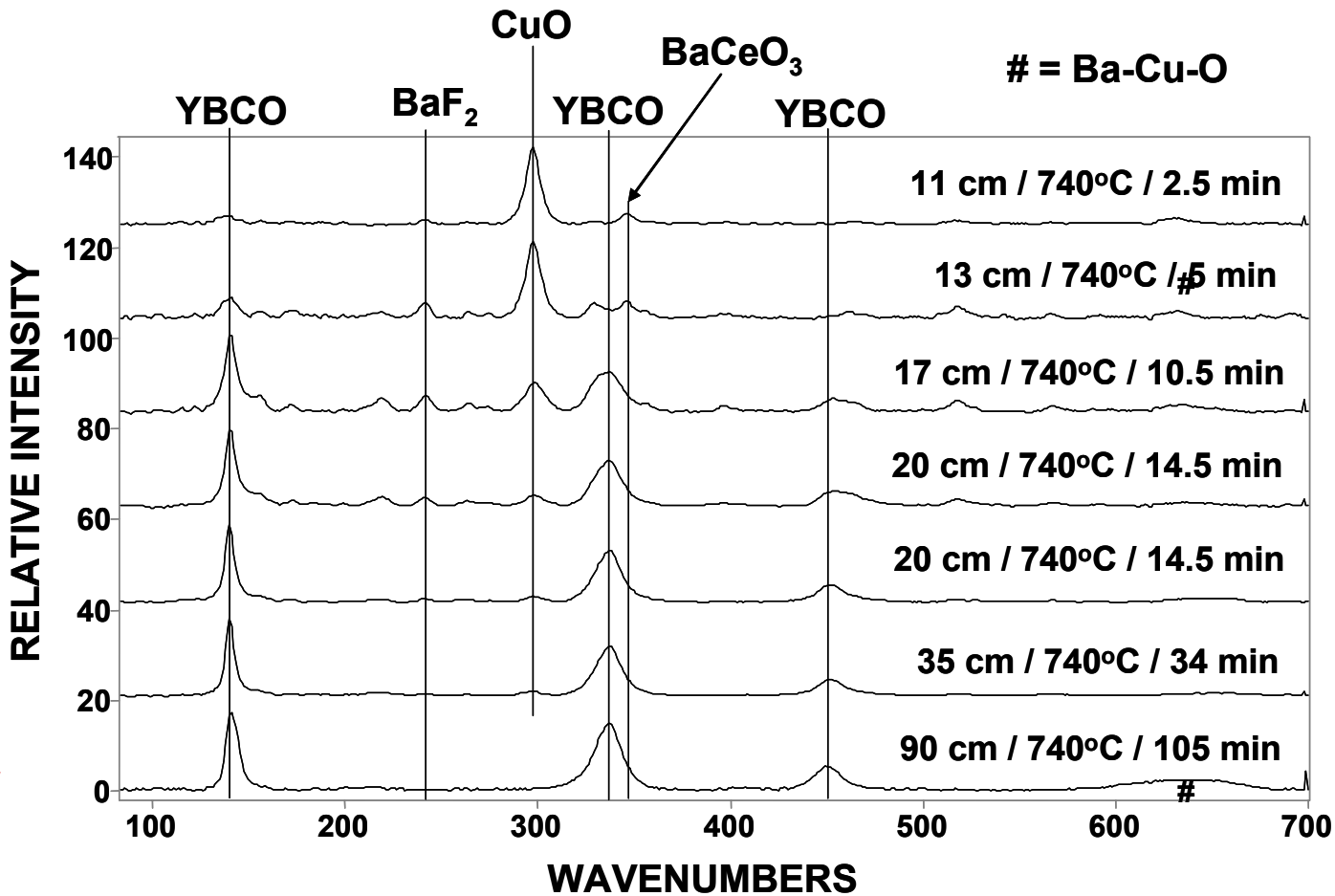
(c) Moving sample: same as (b) but moving in opposite direction

ORNL 0.28 μm BaF_2 Precursor Sample (D.F. Lee)



Reel-to-Reel Raman

- working on ORNL quenched tapes
- tracking phase evolution vs. time
- results complement and confirm ORNL R2R XRD data
- domains of lateral composition disparity



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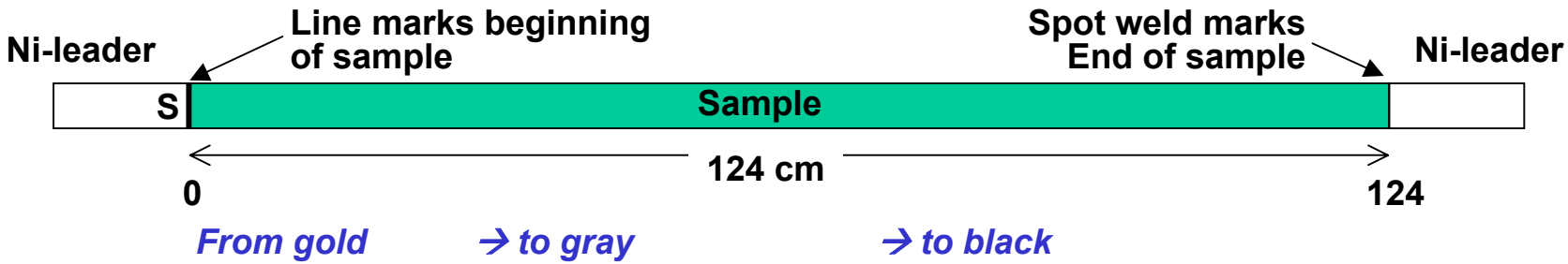
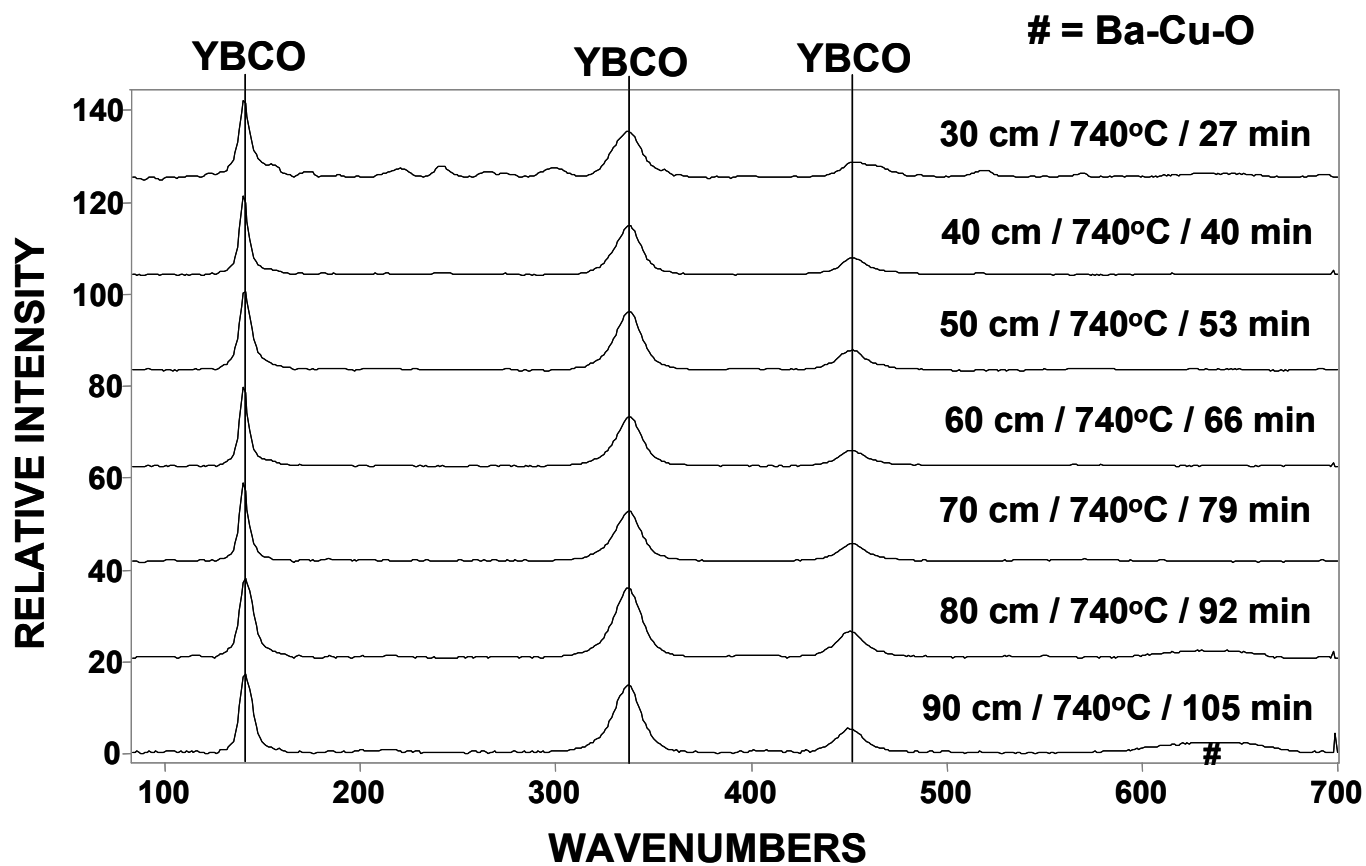
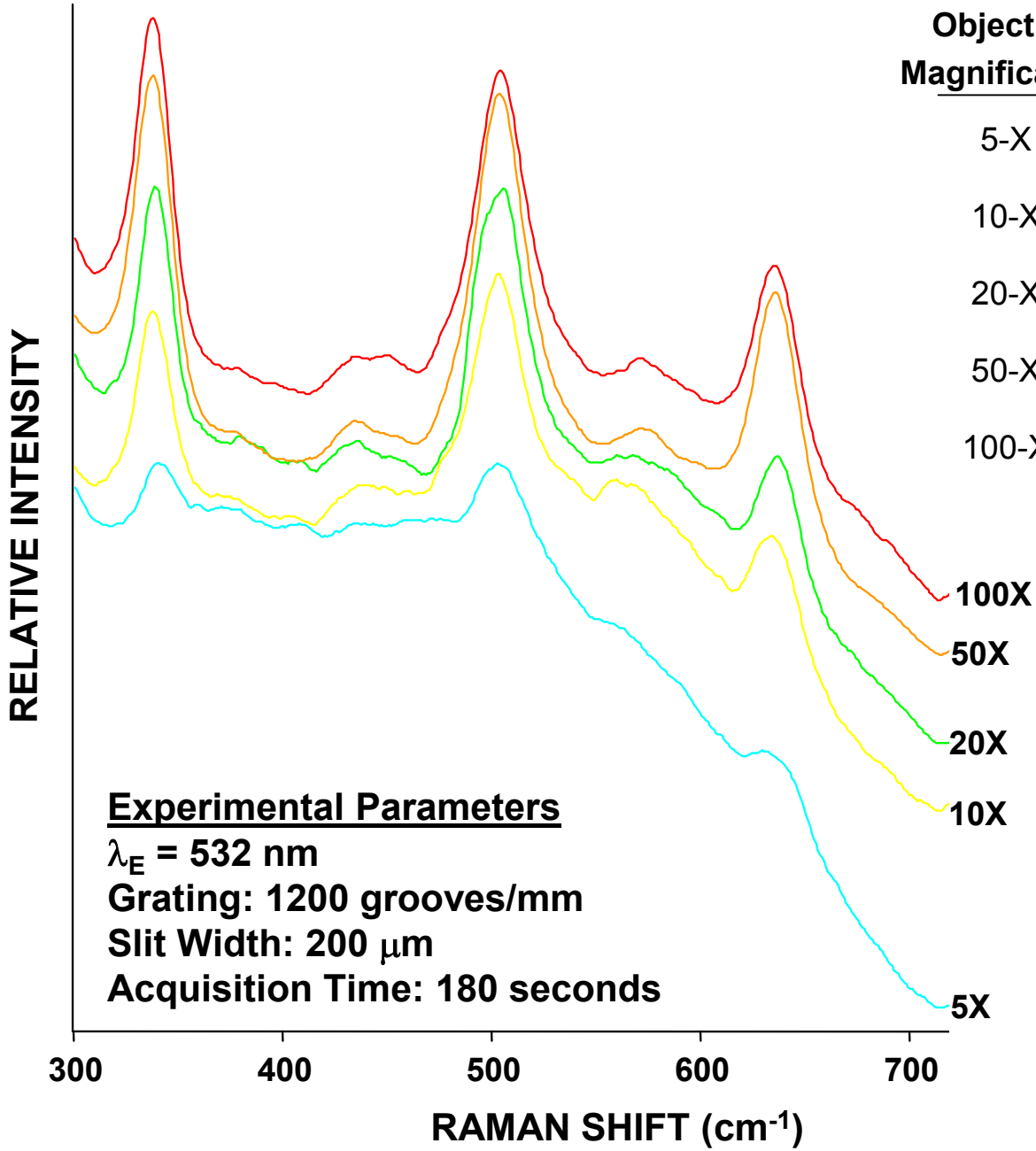


Reel-to-Reel Raman

- CuO forms from amorphous precursor
- $BaF_2 \rightarrow Y_2Ba_xCu_{2-x}O_5 \rightarrow$ T-YBCO
- Optimum time vs. precursor thickness
- Ba-Cu-O phases form after t_{OPT}



Raman Microprobe Working Distance Test



Objective Magnification	NA*	Working Distance (mm)
5-X	0.15	21.0
10-X	0.30	9.9
20-X	0.46	3.1
50-X	0.80	0.6
100-X	0.95	0.3

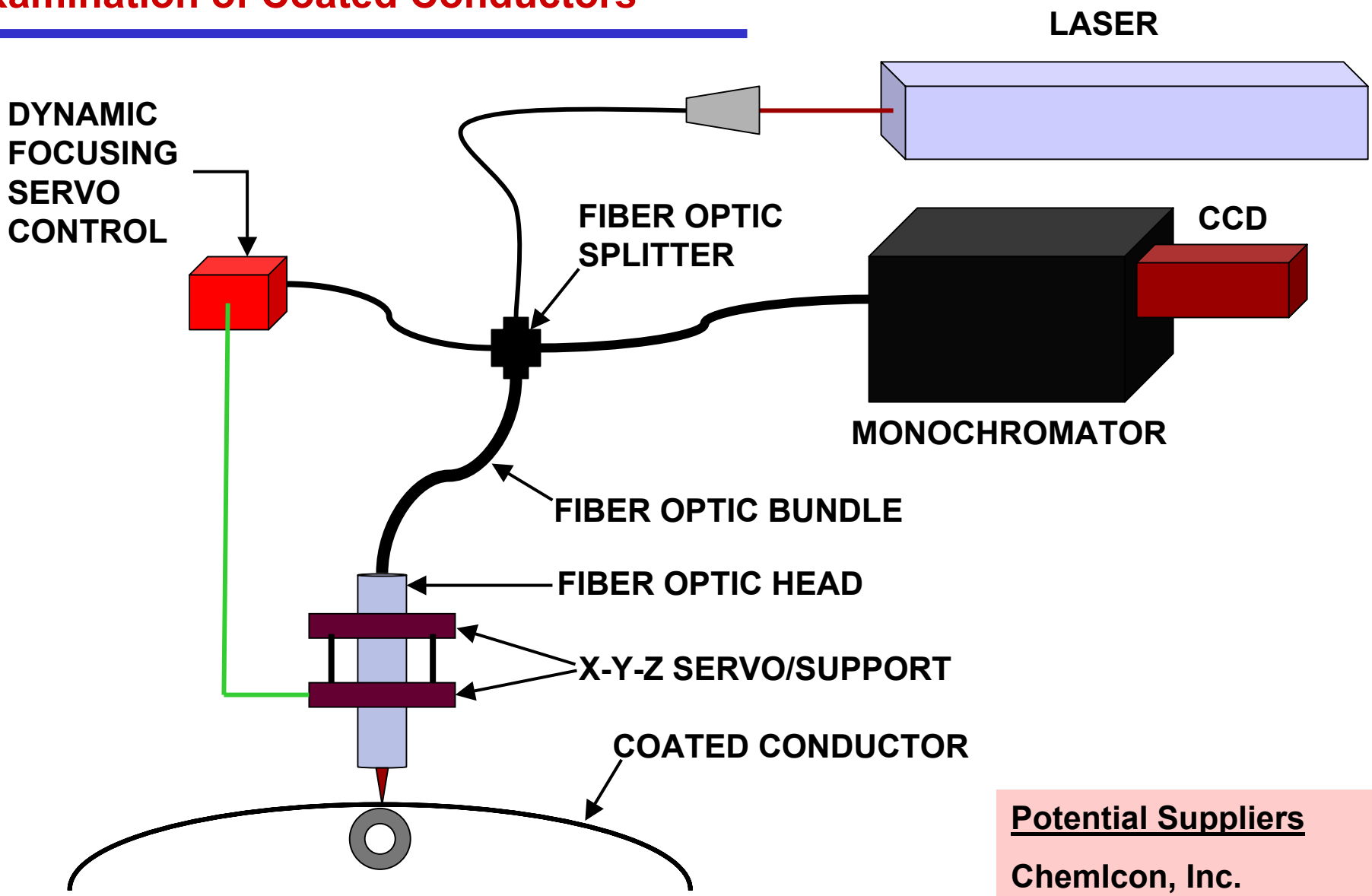
Notes:

(1) Test results courtesy of Matt Nelson, ChemIcon, Inc.

(2) Test sample is YBCO on CeO_2-buffered Hast. C

(3) Laser power increased from 200 mW at 100-X to 500 mW at 5-X

Reel-to-Reel Raman Probe for Continuous Examination of Coated Conductors



Potential Suppliers

ChemIcon, Inc.
Kaiser Optical Systems
Renishaw, Inc