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Characterization and Quality Control of Second-Generation High Temperature Superconductors (2G HTS) for R&D and Manufacturing at SuperPower

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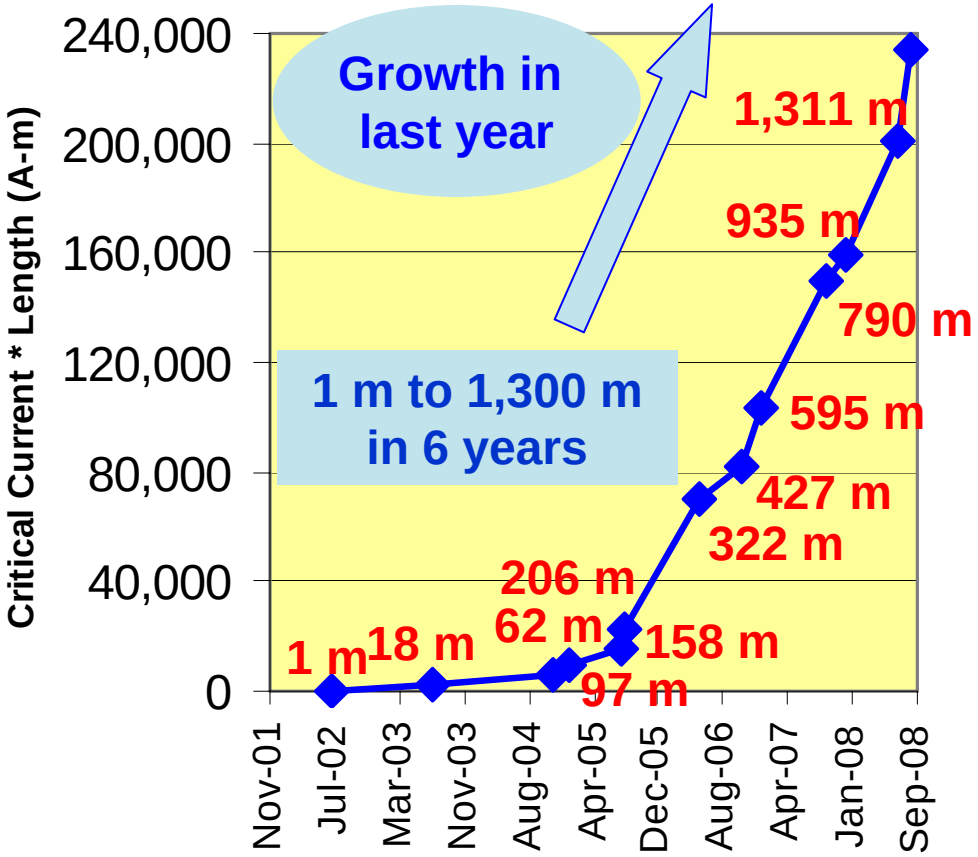
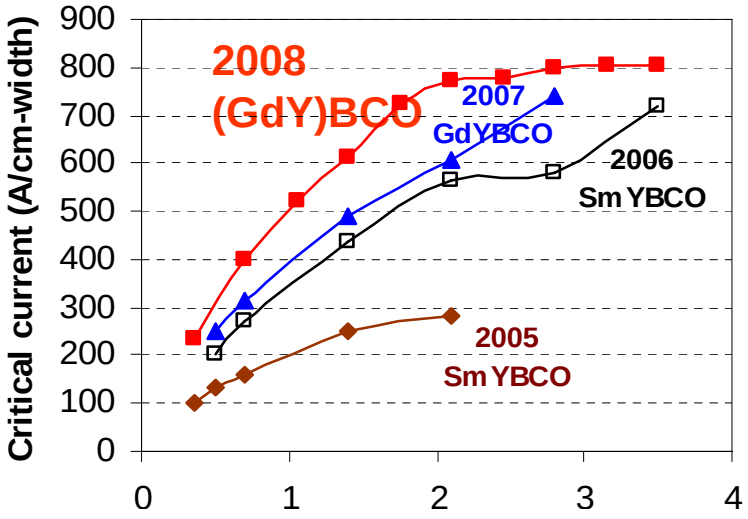
Outline

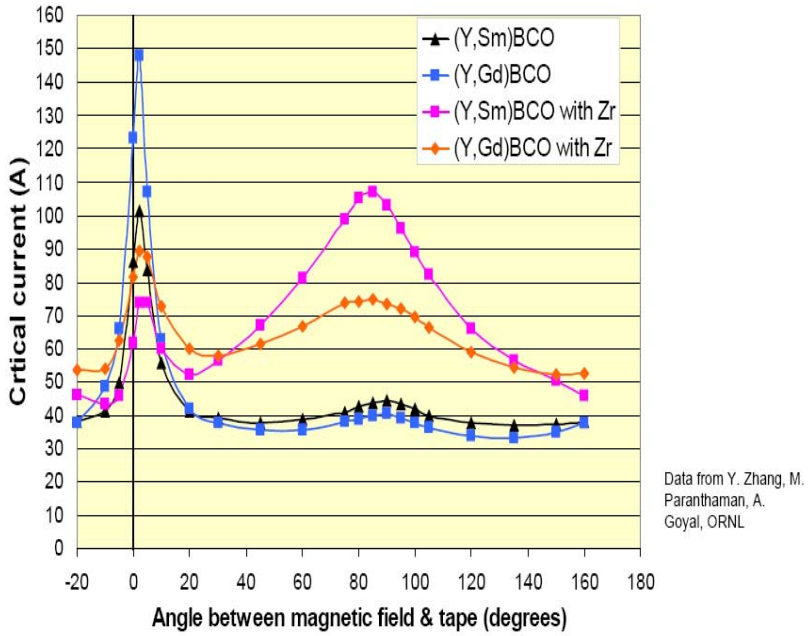
- Overview of SuperPower production process and quality control and characterization methods
- Examples of recent developments in characterization
  - Y_2O_3 / Al_2O_3 /Hastelloy structure
  - XRD control for BZO (BaZrO3) nanorods

Current status of 2G HTS production at SuperPower

Recent progress in long and short wires required characterization and QC support from initial to final production steps







Data from Y. Zhang, M. Paranthaman, A. Goyal, ORNL

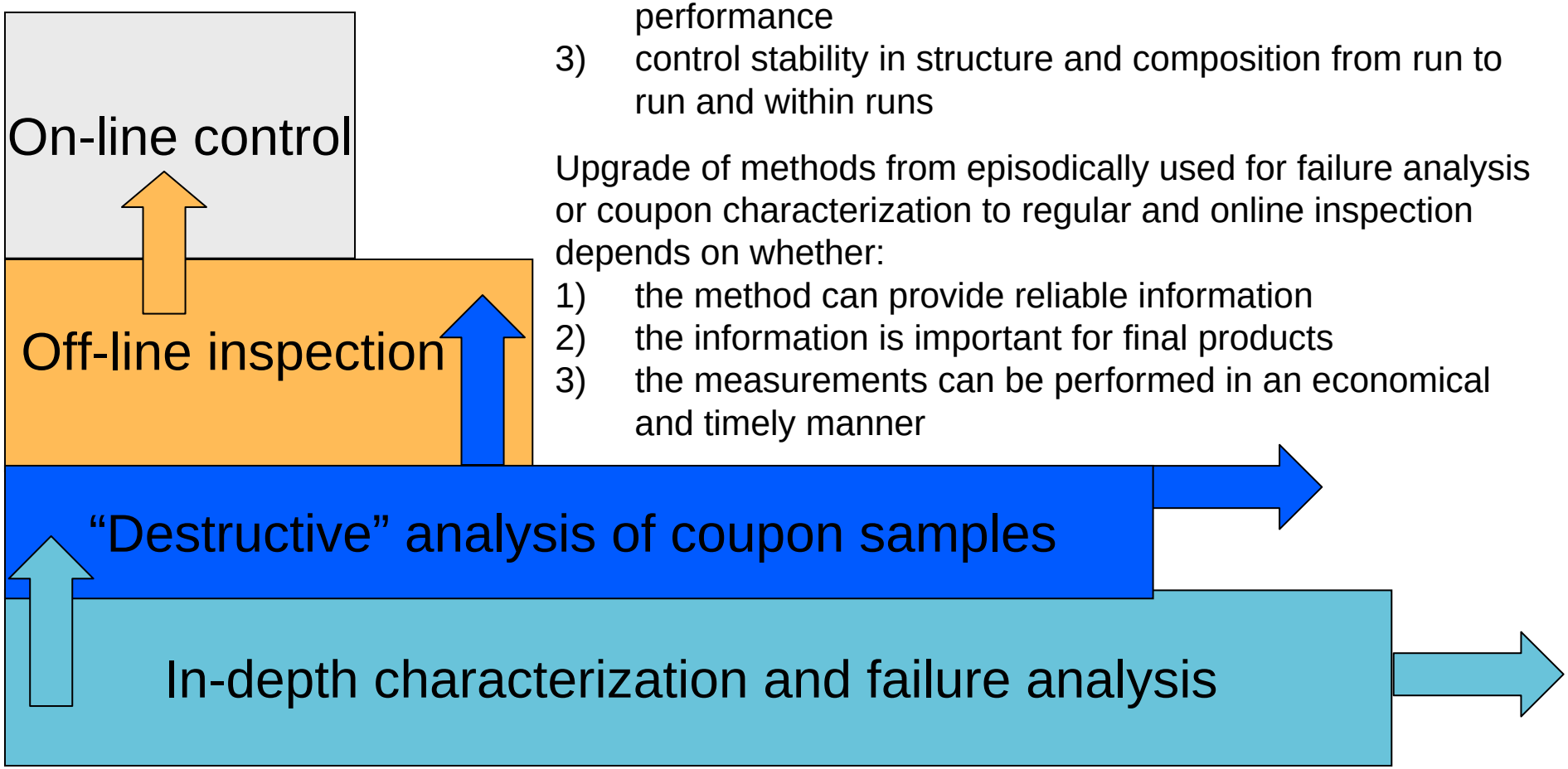
Structure and expansion of methods

Goals of characterization support:

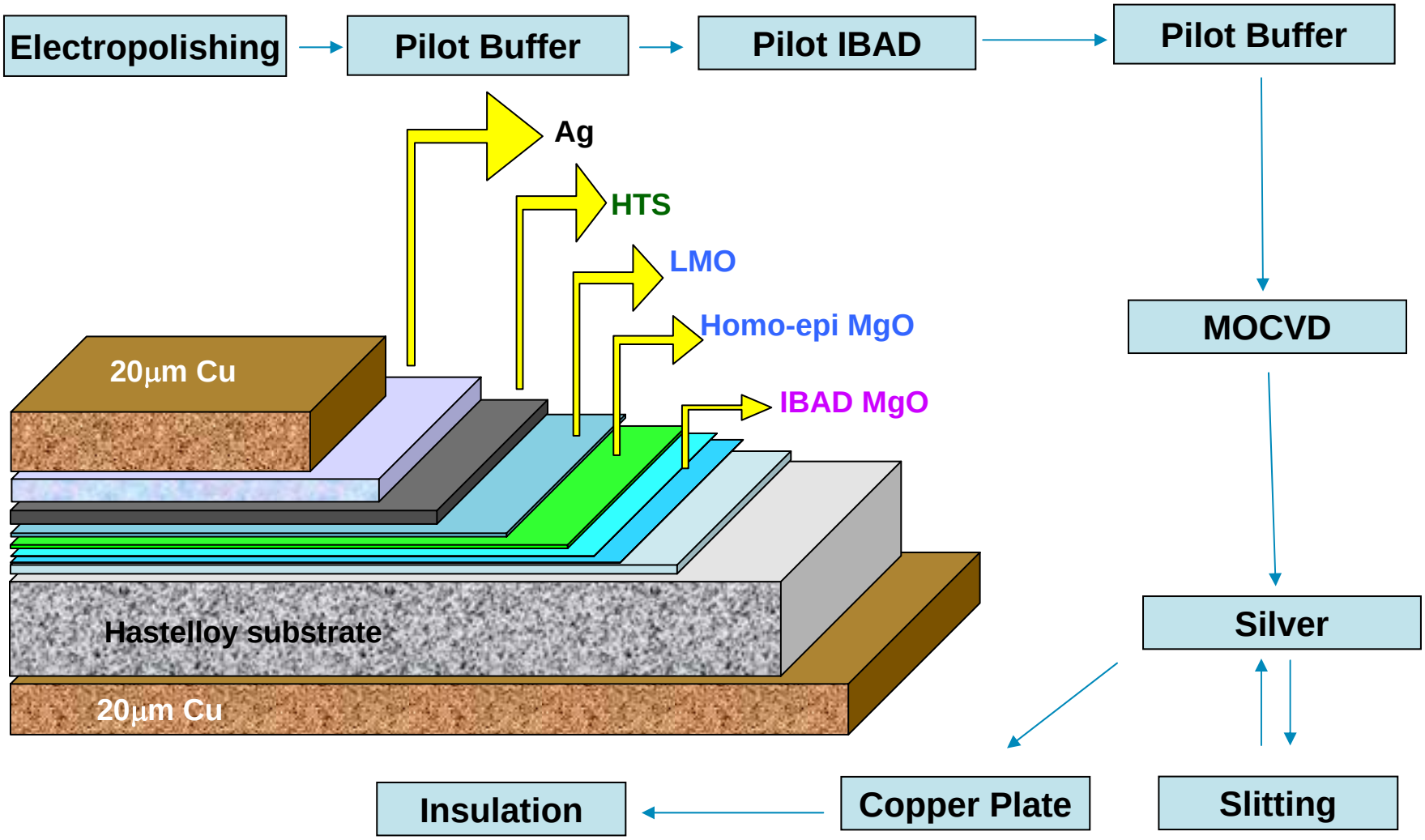
1) providing information about structure and composition of product on different processing steps
2) relate structure and composition with product performance
3) control stability in structure and composition from run to run and within runs

Upgrade of methods from episodically used for failure analysis or coupon characterization to regular and online inspection depends on whether:

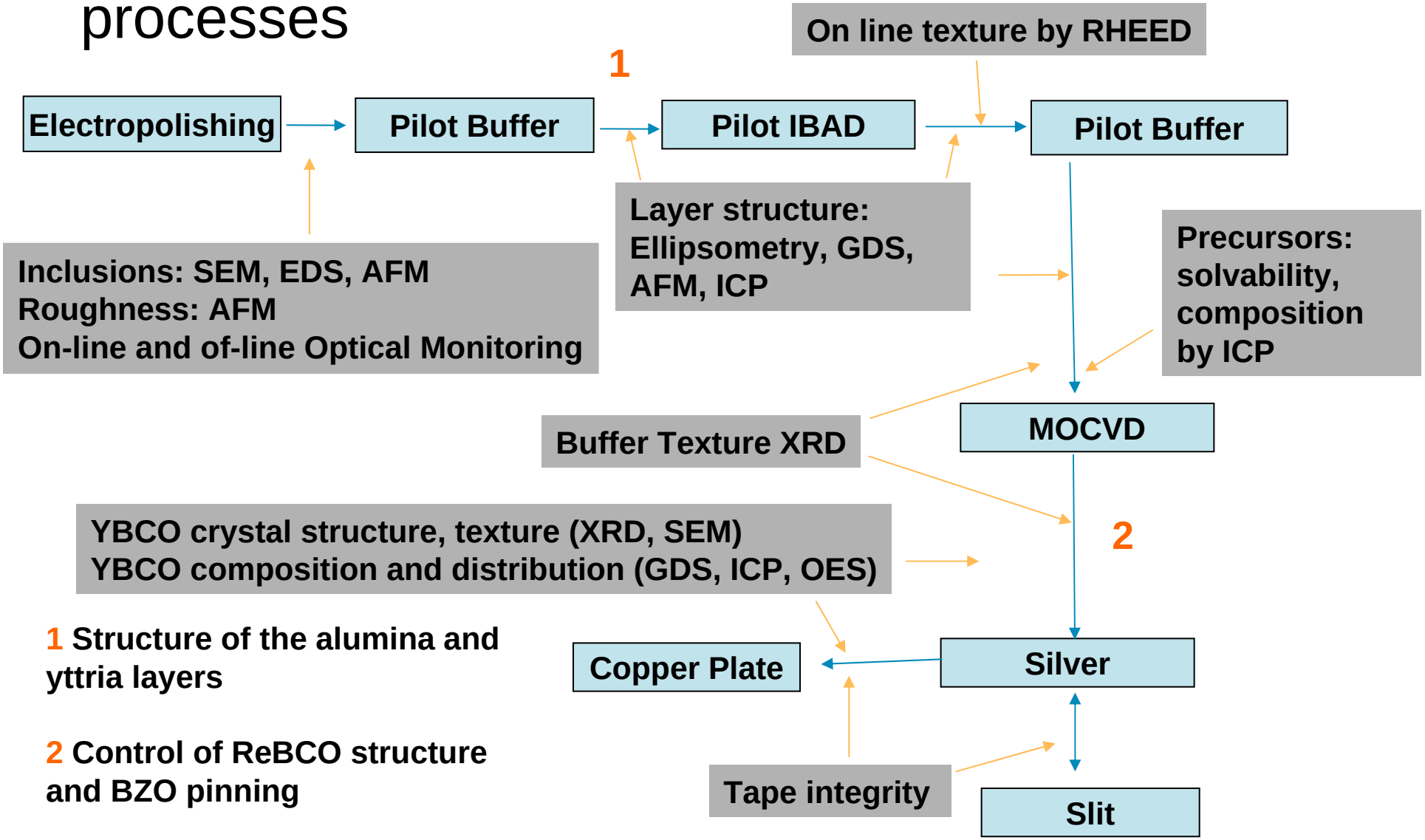
1) the method can provide reliable information
2) the information is important for final products
3) the measurements can be performed in an economical and timely manner



Structure and main processing steps



QC and characterization for manufacturing processes



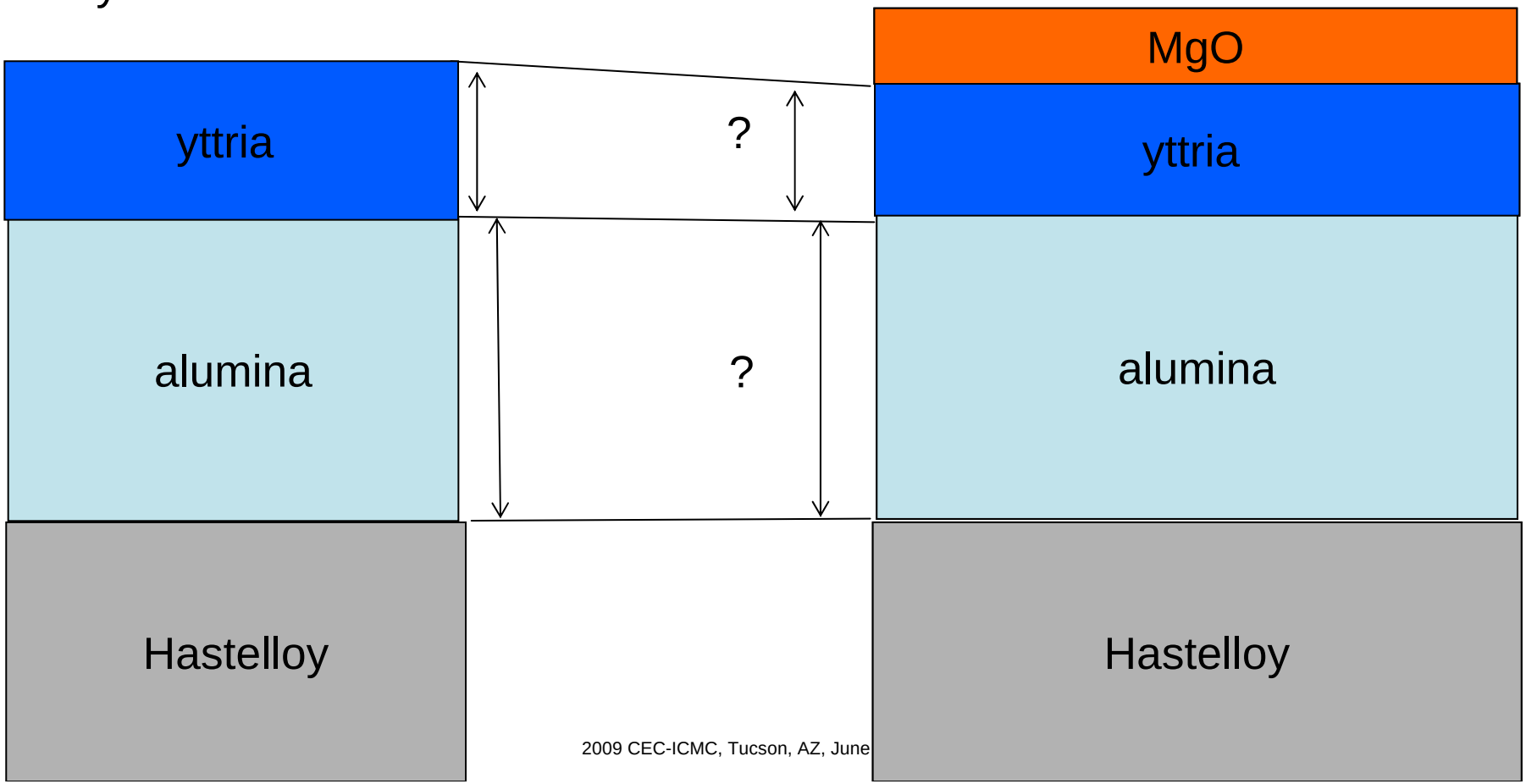
1 Structure of the alumina and yttria layers

2 Control of ReBCO structure and BZO pinning

IBAD MgO growth

What is the thickness of the alumina and yttria layers?

Does thickness of yttria and alumina layers change after IBAD MgO deposition?



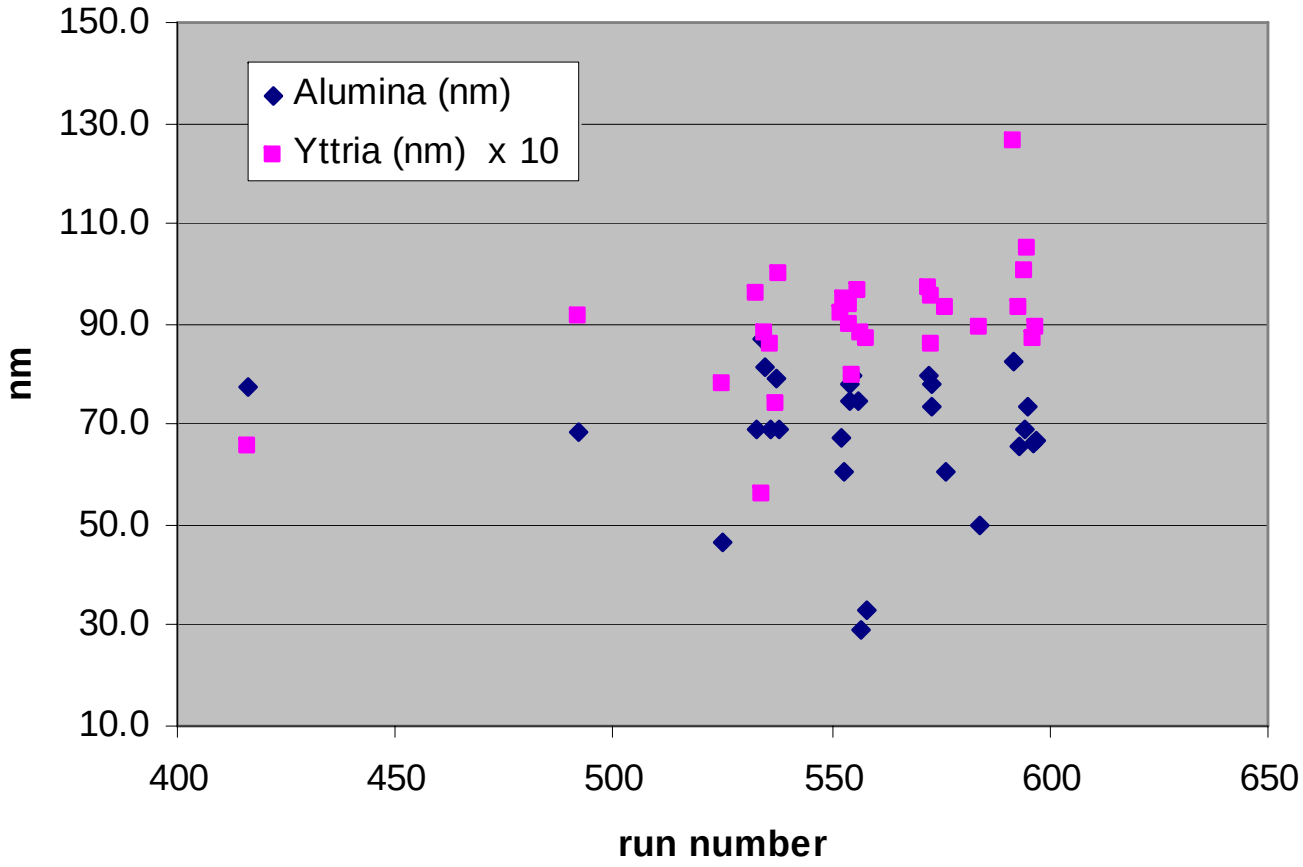
Ellipsometry and ICP OES

- Ellipsometry
  - Based on modeling, gives a unique solution only for simple structures
  - Provide information on optical properties and thickness
- ICP OES (inductively coupled plasma optical emission spectroscopy)
  - Direct method for precision measurements of concentrations in liquids
  - Provide direct measurements on the amount of solvable element on surface

Experimental procedures

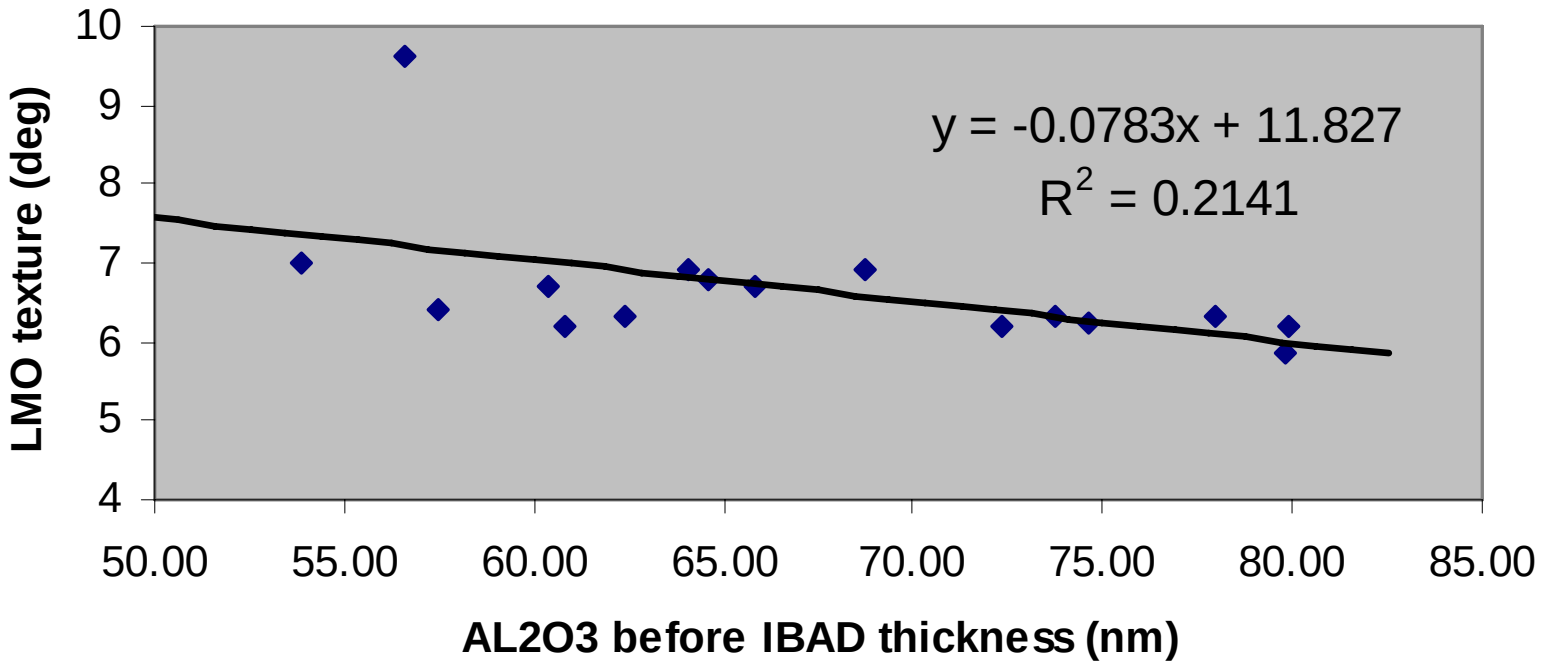
- A sample Y_2O_3 / Al_2O_3 / Hastelloy was measured as is, and after washing out yttria by diluted nitric acid, the Al_2O_3 / Hastelloy sample was easily measured with ellipsometry and this data was used for modeling of the structure
- The concentration of yttria in the acid was measured with ICP and Y_2O_3 thickness was calculated assuming material density as in perfect crystals

History of alumina and yttria deposition - process is stable over time



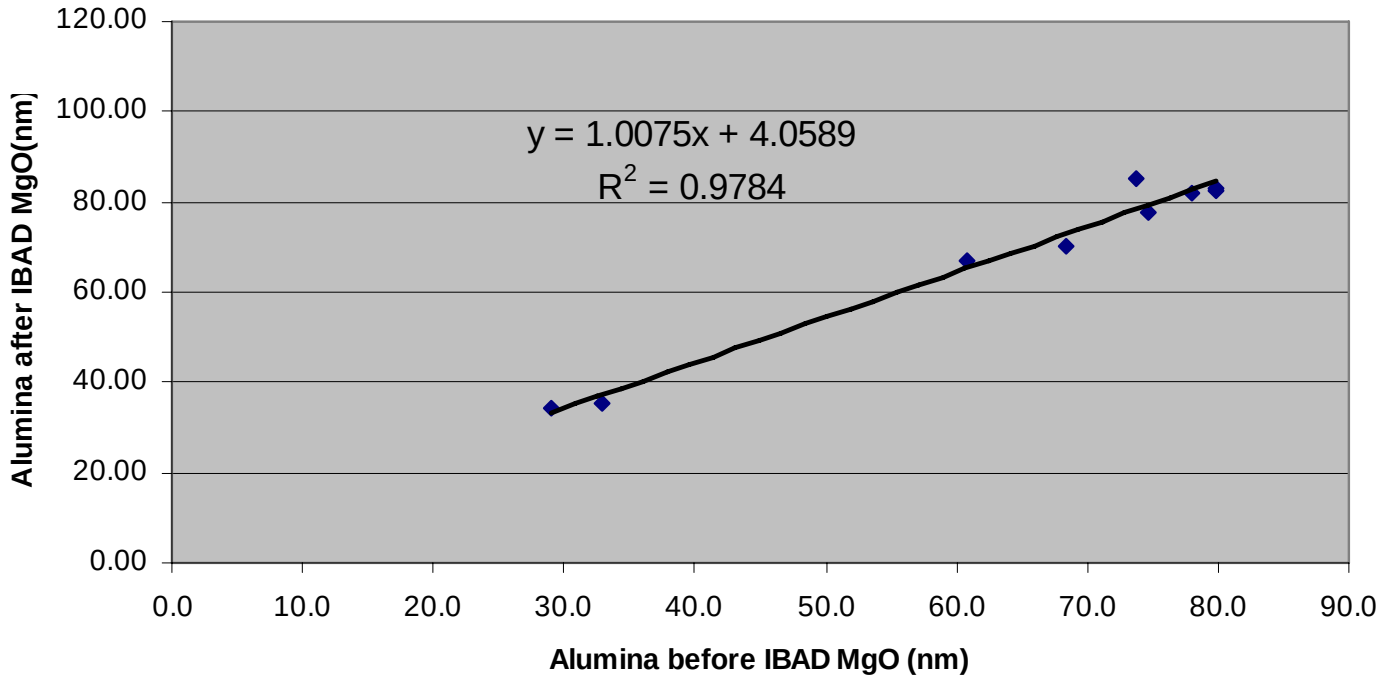
What is the importance?

Average texture for long tape improves with measured alumina thickness.

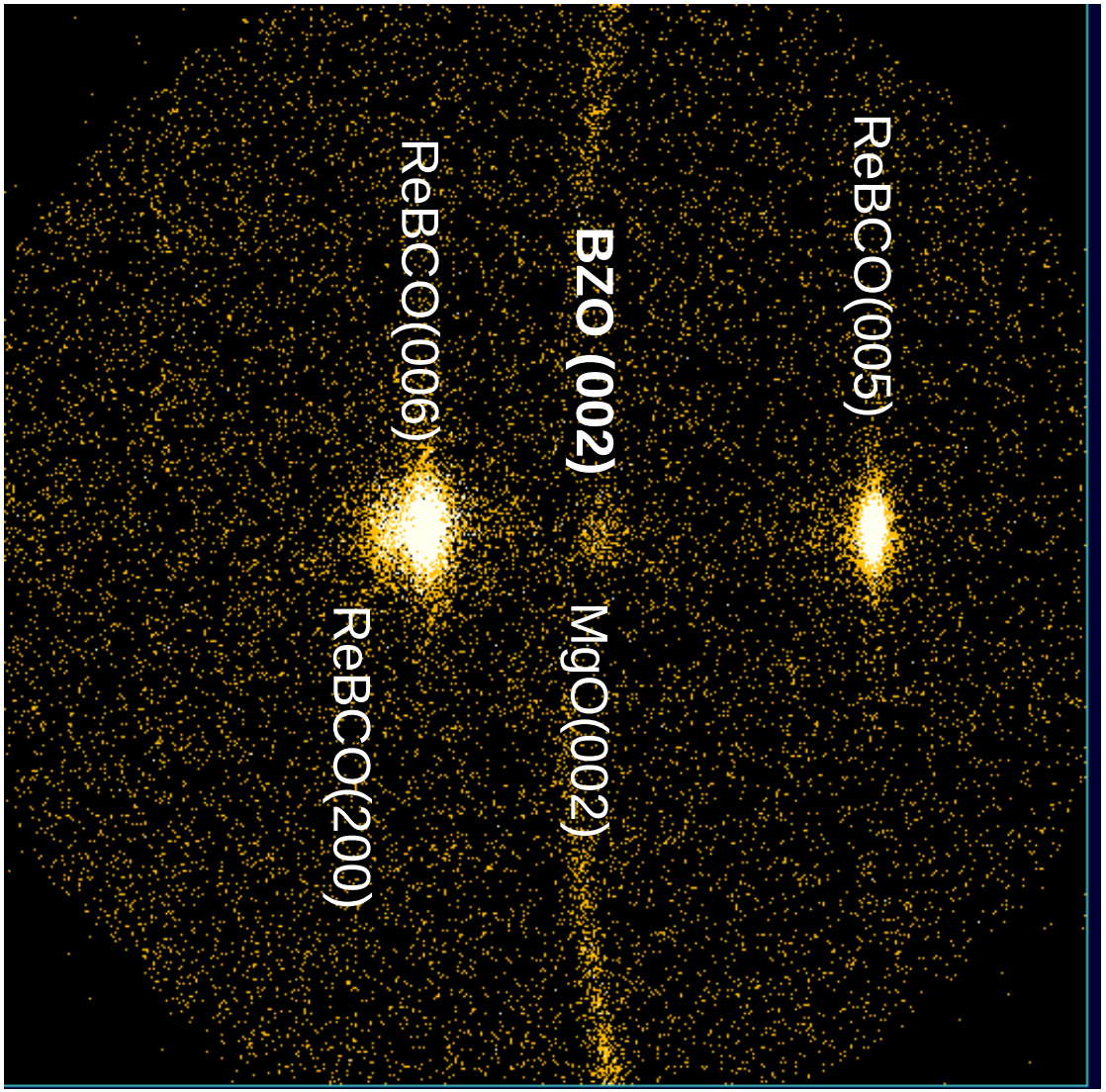


Influence of IBAD process on alumina and yttria layers

- IBAD MgO deposition leads to 3.1 +/- 1 nm *decrease* in yttria thickness and 4.1 nm *increase* in alumina thickness. Is yttria implanted into alumina?



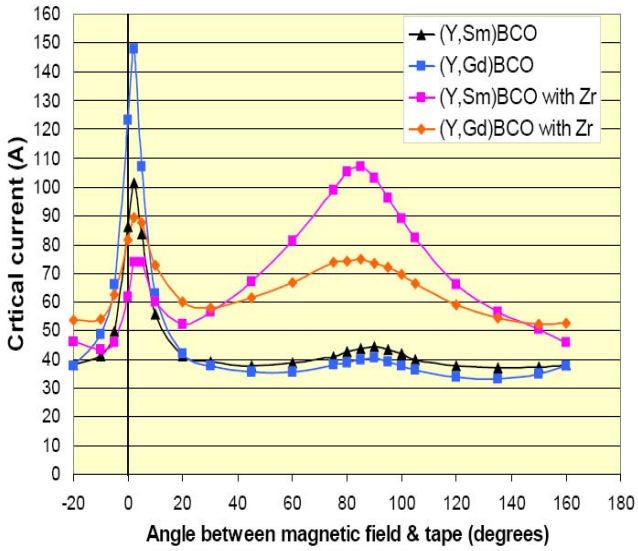
ReBCO control by XRD



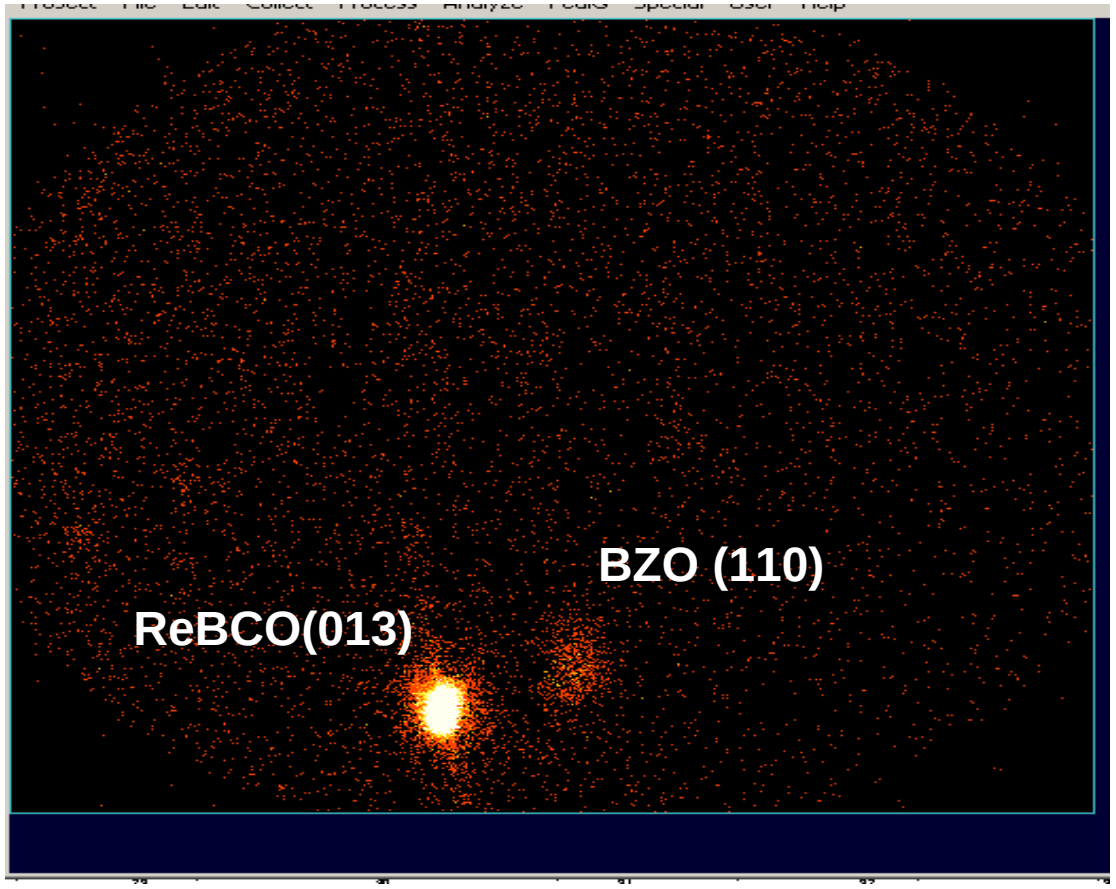
Quality of superconductor be predicted from:

- ReBCO (006) peak intensity
- ReBCO (200) peak
- Width of the peak in 2 Theta and chi scales

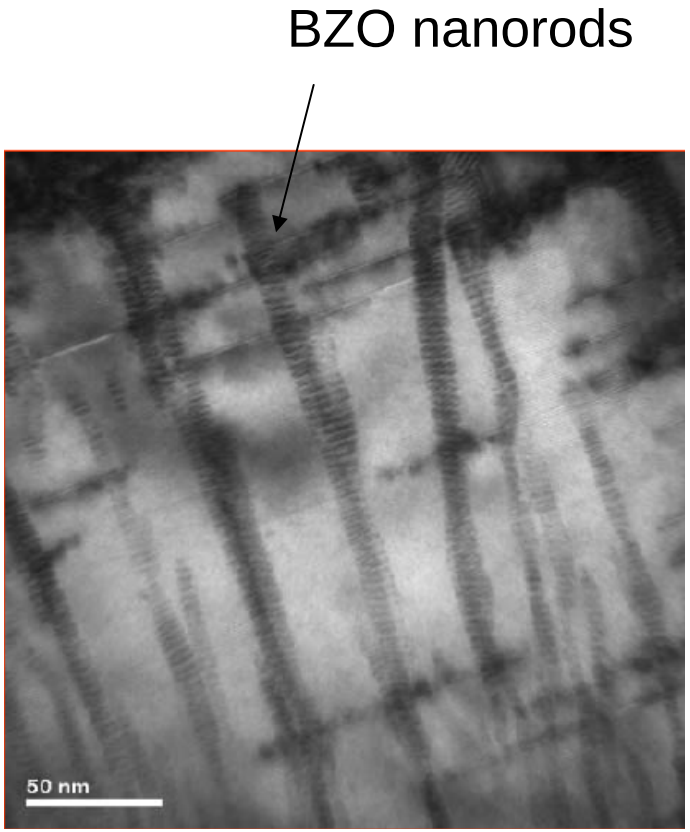
Can we perform the quick analysis for Zr doped samples?



Control for BZO doping for long tapes



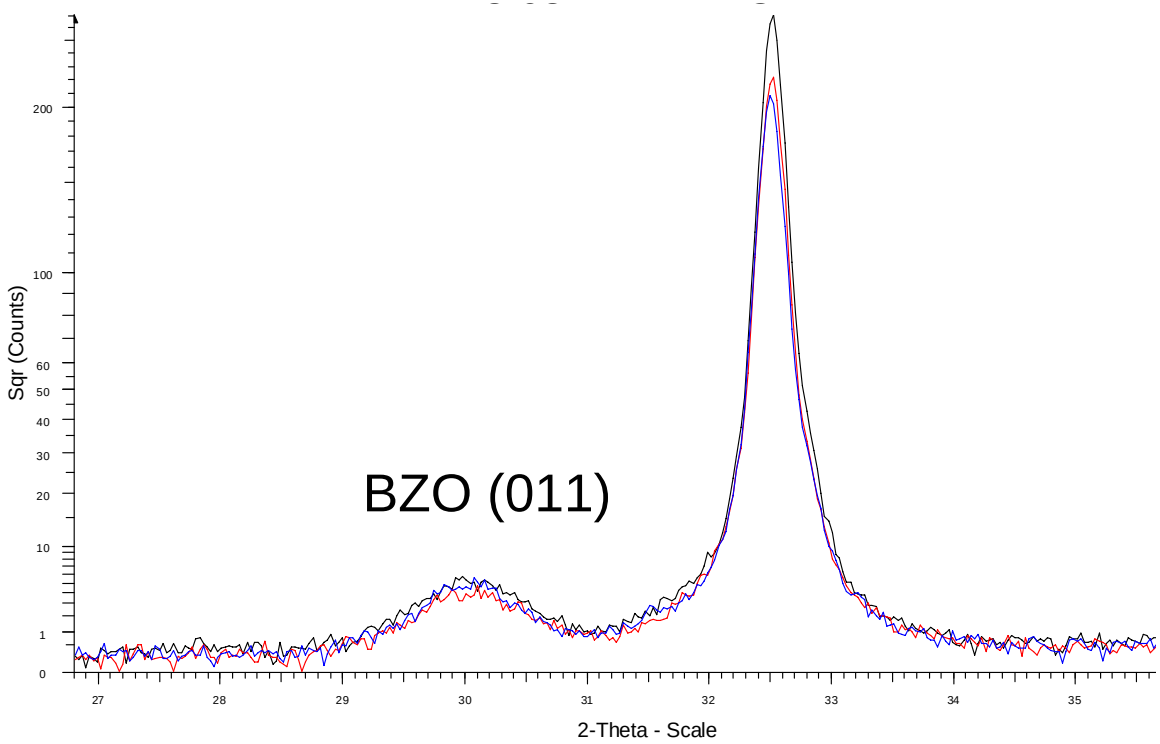
Accumulation time for XRD 160 sec.



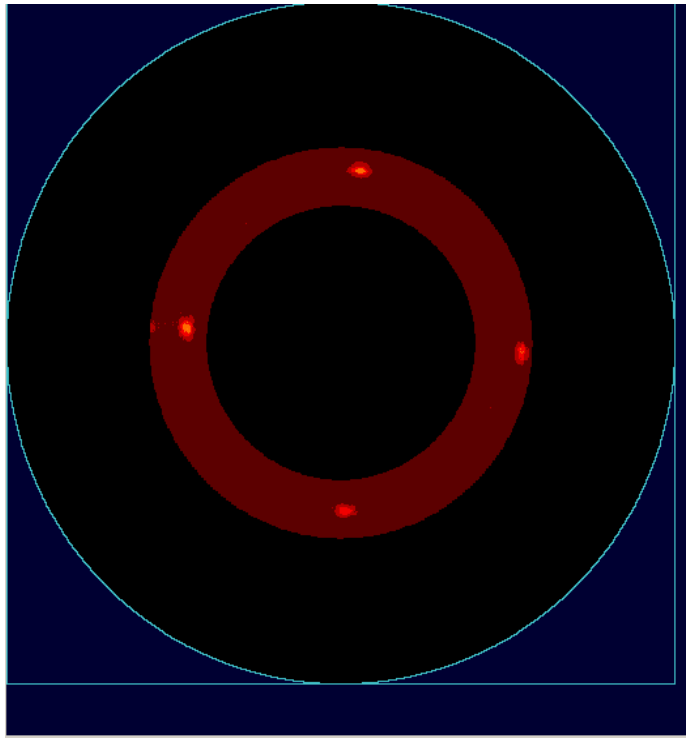
TEM by A. Goyal ORNL

2 Theta and polar figure for BZO (110) diffraction peak

ReBCO(103)



BZO (011)



Work on the correlations between XRD and in-field properties is in progress

Conclusions

- General structure and development of characterization support of 2G HTS production was discussed. The characterization support is covering all steps of the 2G HTS production

- Structure, process variations in time and changes in alumina and yttria layer structure during the IBAD process were measured for significant amount of production samples. Influence of variations of alumina thickness within processing window on LMO texture predicts the future improvement in the LMO texture with the increase in alumina thickness

- XRD measurements of BZO nanorods are established as routine test. The orientation of the nanorods planes and in-plane texture is measured

Acknowledgments

- This work was done with the support of all staff at SuperPower

- Further information available at: www.superpower-inc.com

- Please visit SuperPower at Booth Numbers 407 & 409