Coordinated Characterization of YBCO Coated Conductors Produced by Metal Organic Chemical Vapor Deposition (MOCVD)

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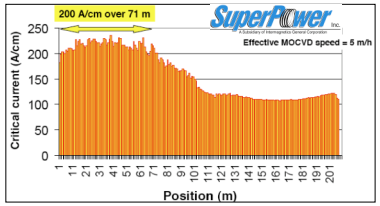
Motivation

SuperPower has made significant progress in the development of high performance YBCO coated conductors using Ion Beam Assisted Deposition (IBAD) templates and Metal-Organic Chemical Vapor Deposition (MOCVD).

Addressing non-uniformity over very long lengths (> 100 m) is a high priority to improve overall performance.

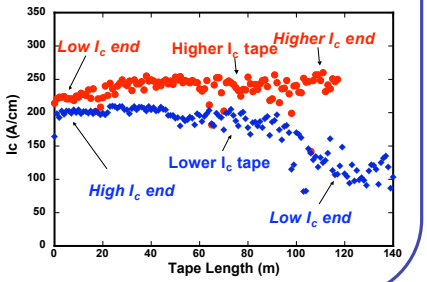


In this work, we **established the causes for variations in performance** from:
- **tape-to-tape** and
- **end-to-end**

Experiment

In order to identify the causes for non-uniform performance, we studied segments from two long-length tapes that exhibited differences in performance between each other and from end-to-end within each tape.

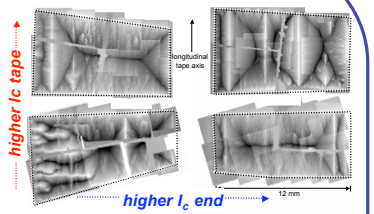
We used FIB-assisted SEM, TEM, Raman, and magneto-optical imaging to establish the basis for performance variations and to link that behavior to processing.



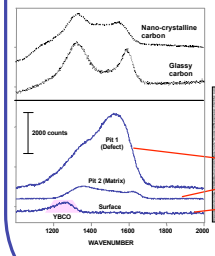
Global structure & the performance "ceiling"

Longitudinal defects revealed by MOI arise **from substrate defects**

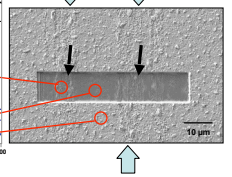
Not likely cause of performance variations:
- parallel to current flow
- ≈ same for all segments



- possible limit to overall performance

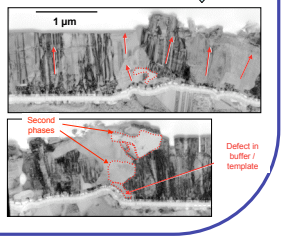


SEM reveals **imperfections at substrate level**; Raman reveals presence of **carbon**



SEM and Raman reveal a **high density of *misoriented* grains** associated with the defects

TEM reveals **misoriented YBCO** due to topography, loss of integrity of buffer/template

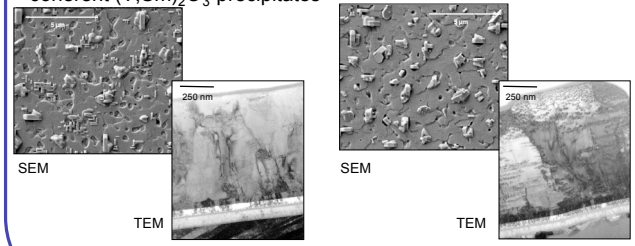


Microstructural basis for performance variations

Global changes in microstructure from **tape-to-tape**:

High Ic tape
- well-connected grains
- surface *a*-axis grains
- substrate reaction
- coherent $(Y,Sm)_2O_3$ precipitates

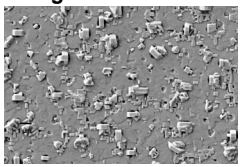
Low Ic tape
- tilted grains, visible boundaries
- few surface *a*-axis grains
- no substrate reaction



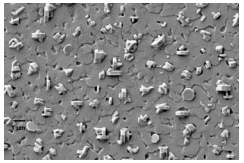
***Tape-to-tape differences** concluded to be due to deposition **temperature** based on microstructure*

Similar signatures in in microstructure from **end-to-end**:

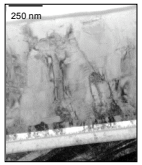
High Ic end



Low Ic end

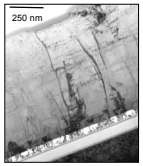


SEM



High Ic end: well-connected grains, surface *a*-axis grains, coherent $(Y,Sm)_2O_3$ precipitates

Low Ic end: tilted grains, visible boundaries, no precipitates



End-to-end variations also due to **temperature**

Conclusions

■ Our coordinated characterization provides a correlation between processing and behavior in SuperPower's conductors:

- microstructural evidence that differences in performance from **tape-to-tape** and from **end-to-end** are due to differences in **temperature**

- **global defect structure** revealed by MOI may limit highest performance; our characterization reveals that this defect structure **originates from imperfections at the substrate**
  - **surface topography**; **degraded integrity of buffer**, template layers; **influence of carbon**

A U. S. Department of Energy laboratory managed by The University of Chicago

This work was supported by the U.S. Department of Energy, Offices of Electricity Delivery and Energy Reliability and Basic Energy Sciences, under contract W-31-109-ENG-38.