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Scaling Up Substrate for Coated Conductors at SuperPower, Inc.

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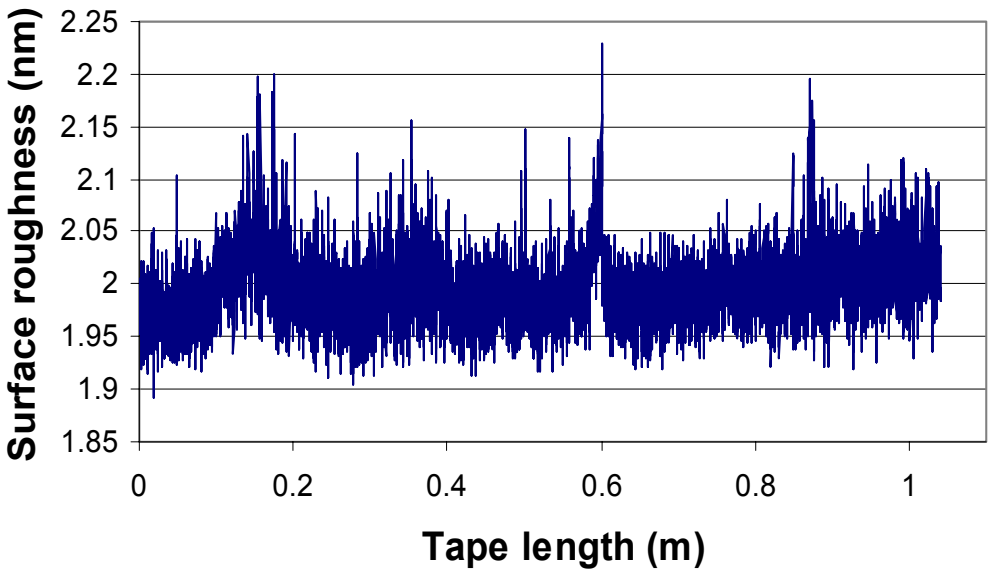
Objectives & Approaches

- **Objective: Scale up substrate fabrication to assist Coated Conductor processes to produce tape in piece-lengths greater than 1 km with uniform low surface roughness and good buffer texture**
- **Current Approaches: Reel-to-reel polishing, cleaning, IBAD buffer deposition**
- **Emphasis is on establishing**
  - **improved substrate manufacturing processes,**
  - **reel-to-reel on-line & off-line QC tools**
  - **equipment with increased yield for long length**

Issues affecting substrate quality

- **Surface roughness**
  - **Rough raw material, inclusions and precipitates**
  - **Mechanical grooves and grain boundaries**
  - **Particles generated in IBAD chamber**
- **Cleanliness**
  - **Residual polishing media and organic residues**
- **Adhesion**
  - **delamination at interface of buffer layer and metal tape**
- **Non-uniformity along tape length**
  - **Roughness and IBAD texture**
  - **Mechanical deformation and stress concentration**

Highly smooth metal substrates are being produced in reel-to-reel polishing facility

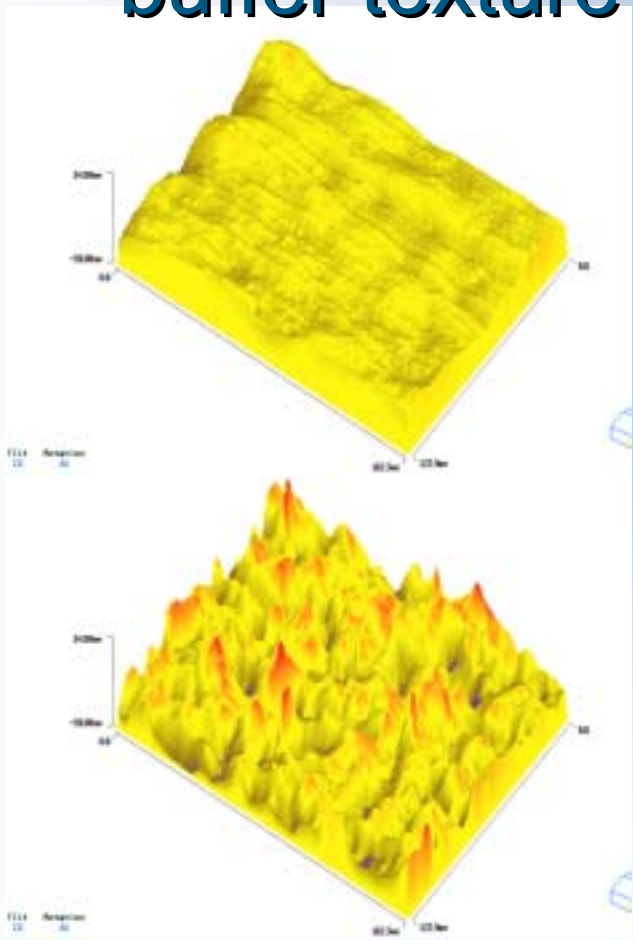


Av. roughness over 1 m = **2 nm**

Std. deviation over 1 m = **0.033 nm (1.6%)**

Tapes up to 100 m in single-piece lengths have been continuously polished.

Metal substrates surface roughness affect buffer texture and Ic of YBCO



Ra = 20 Å

Average Buffer Texture = 13.7°

Ic = 100A

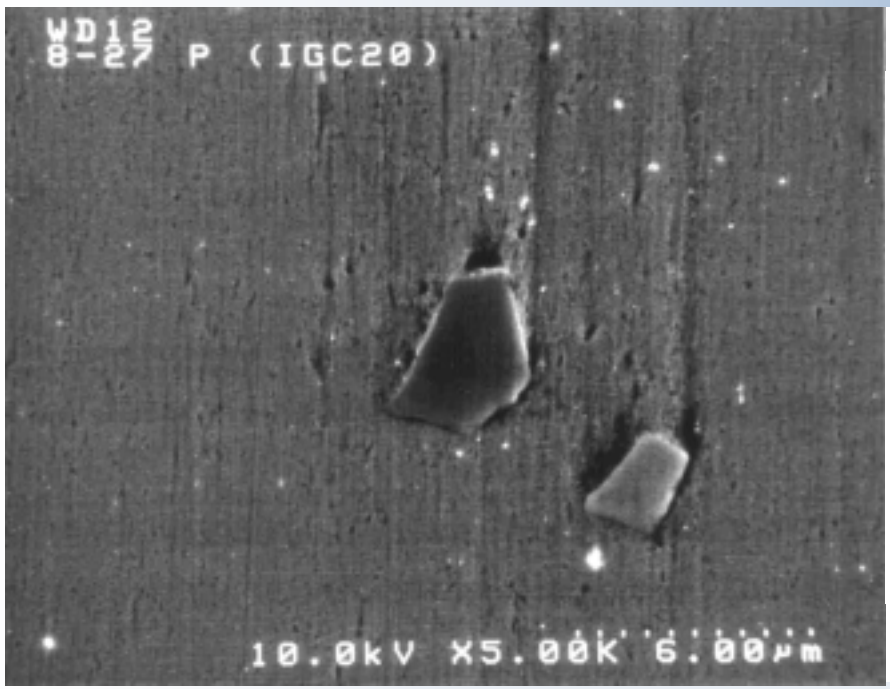
Ra = 50 Å

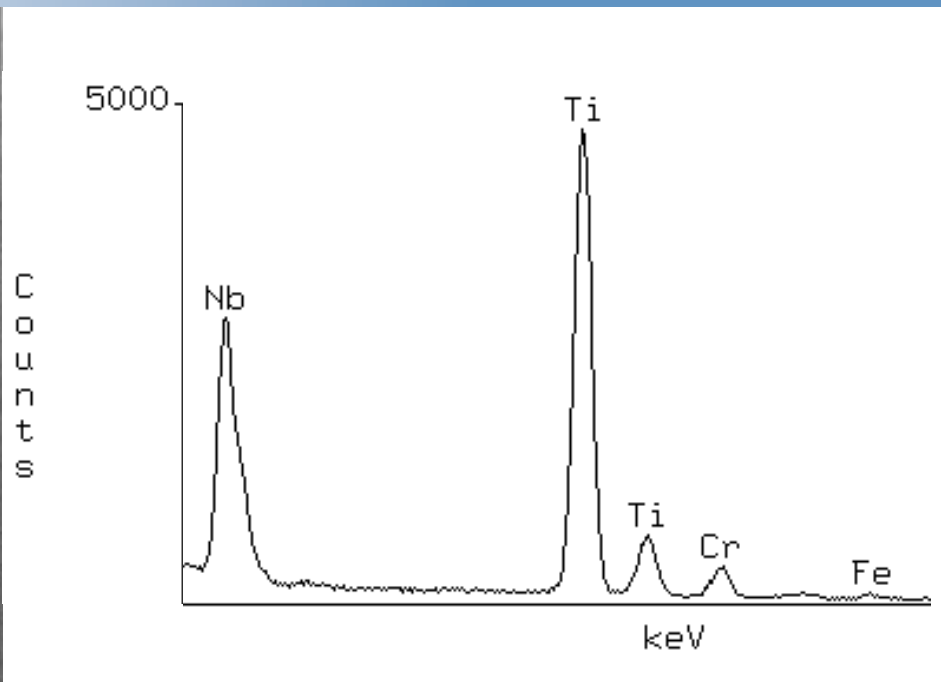
Average Buffer Texture = 15.4°

Ic = 61A

Buffer and YBCO process conditions are the same for the two sets of samples

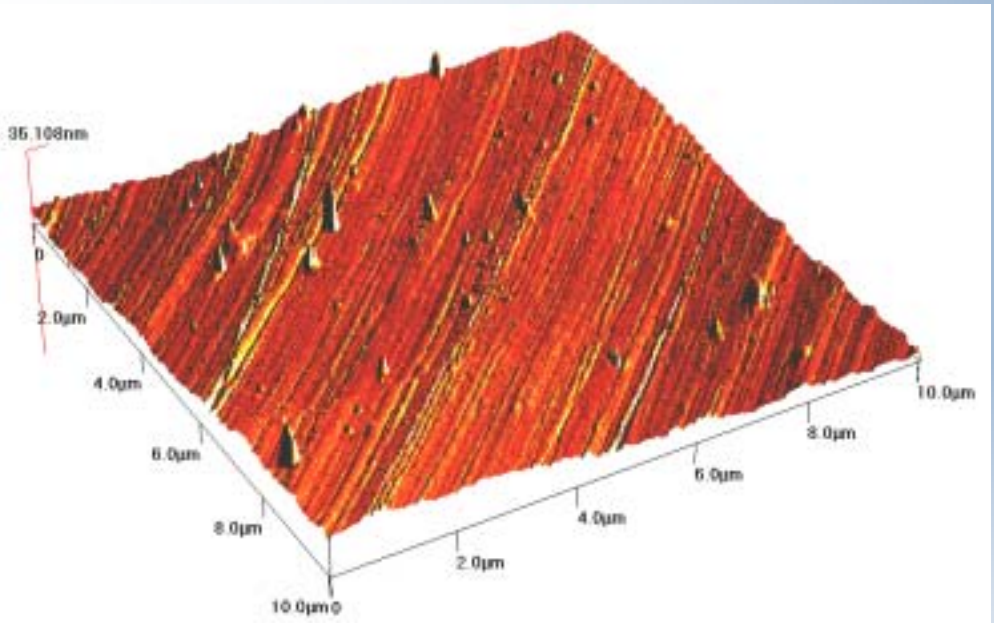
Hard precipitates in raw material

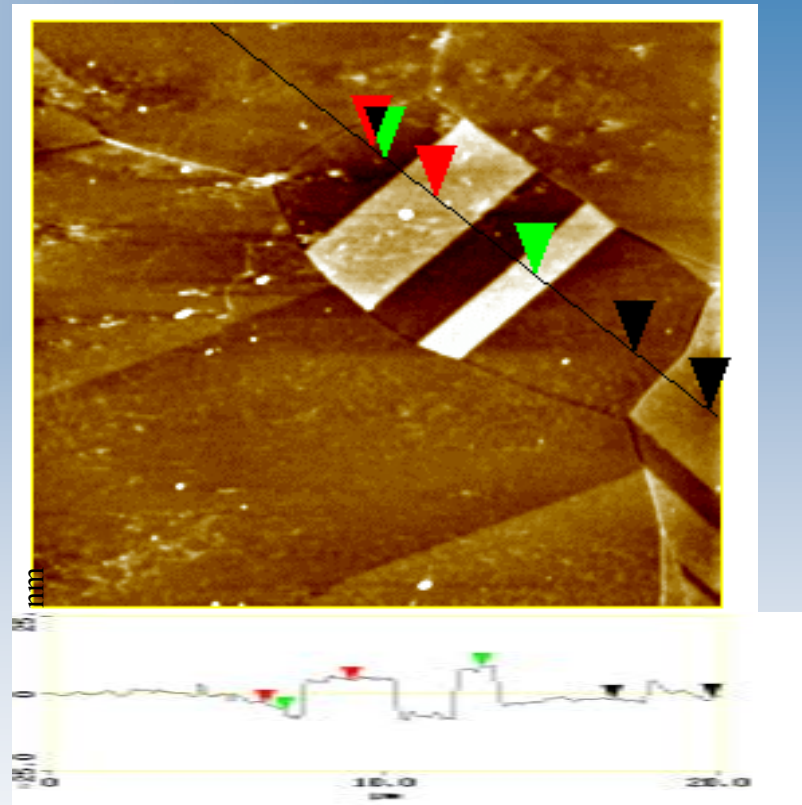




- **Hard Precipitates (Nb, Ti) in tape affect surface quality of polished substrate**

Grooves & Grain boundaries

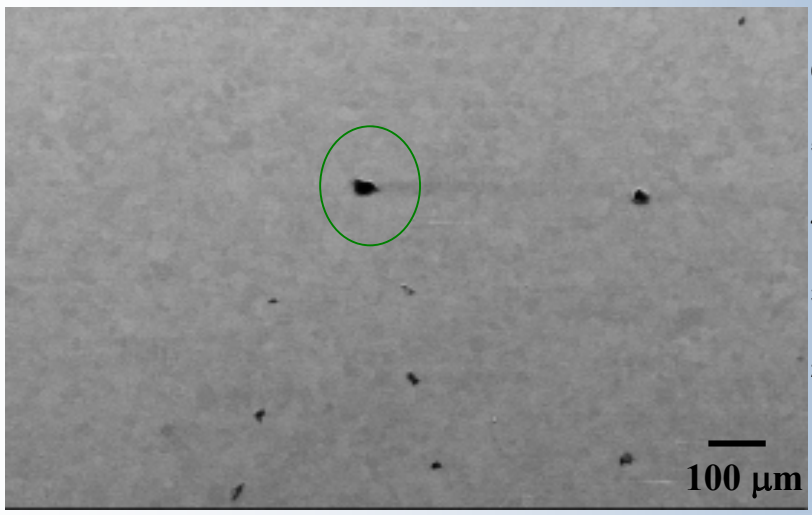


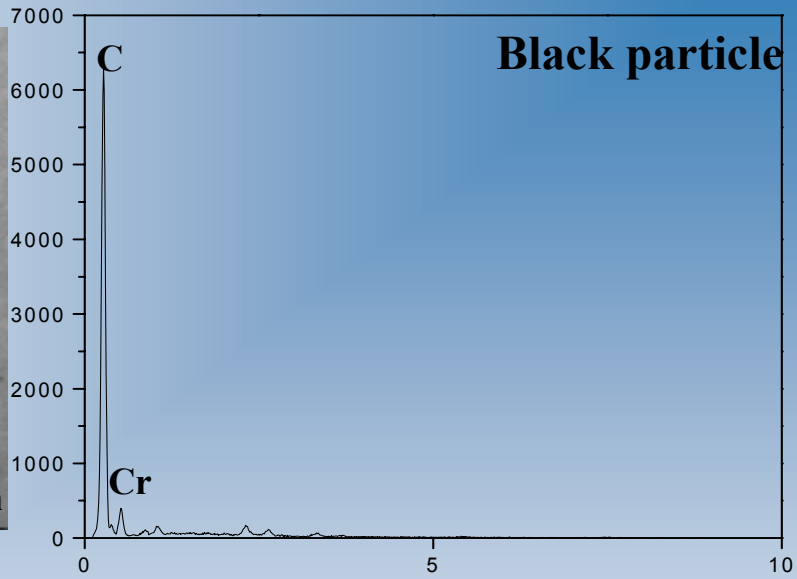


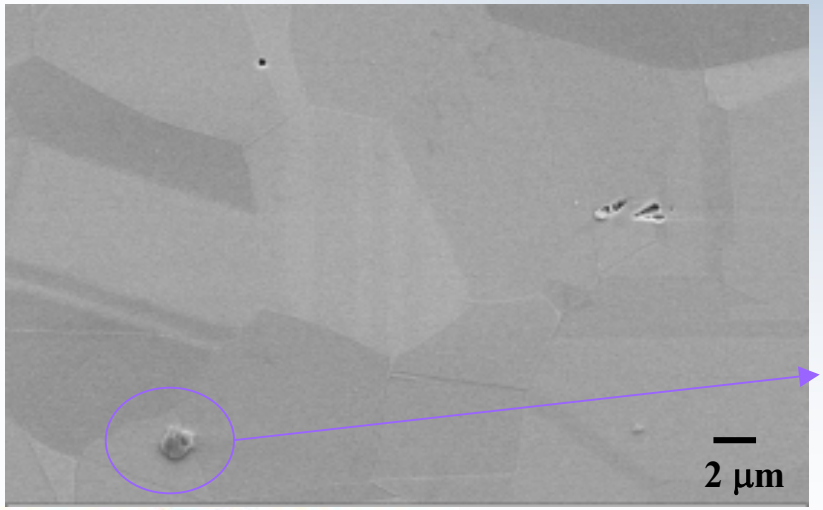
Grooves are ~100nm wide and 2-4nm deep

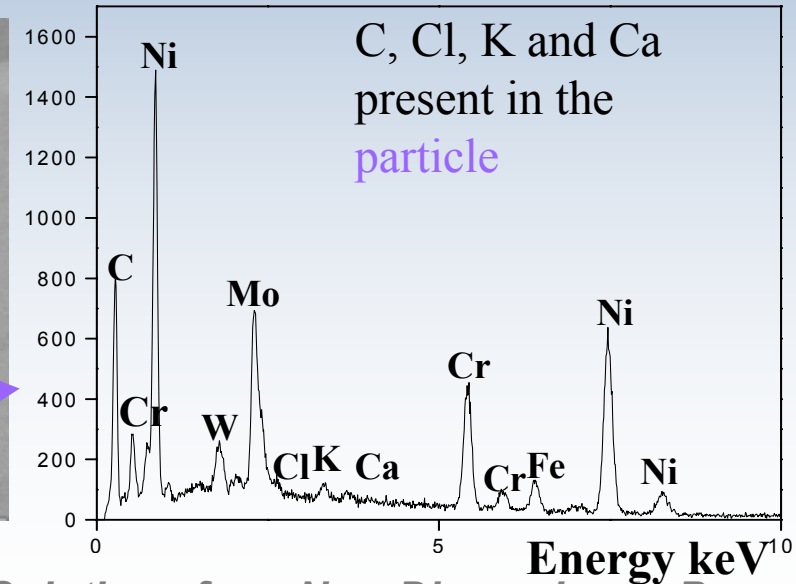
Vertical distance
7.57nm (twin 1)
14.3nm (twin 2)
0.3nm (grain boundary)

Contamination on polished metal surface

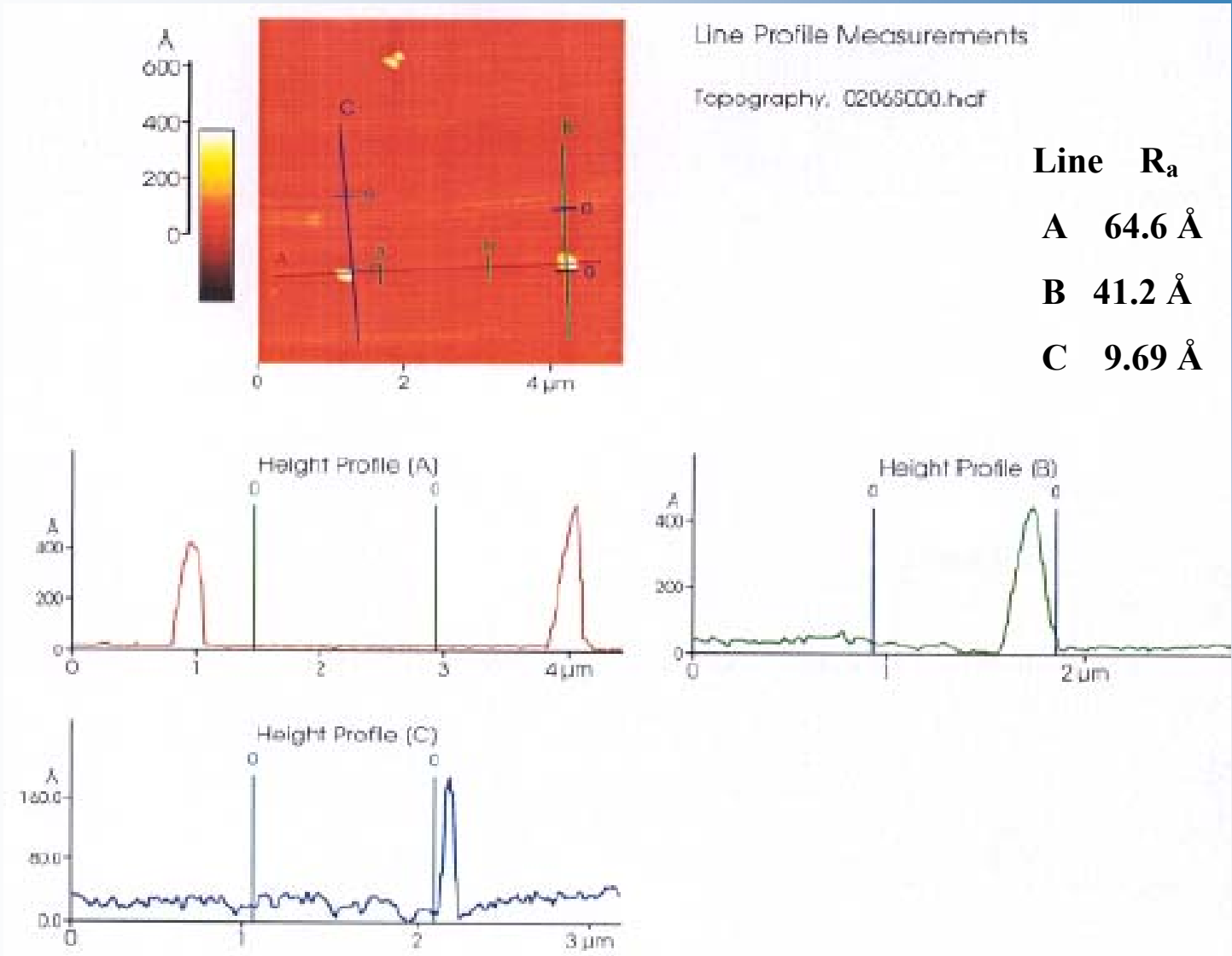




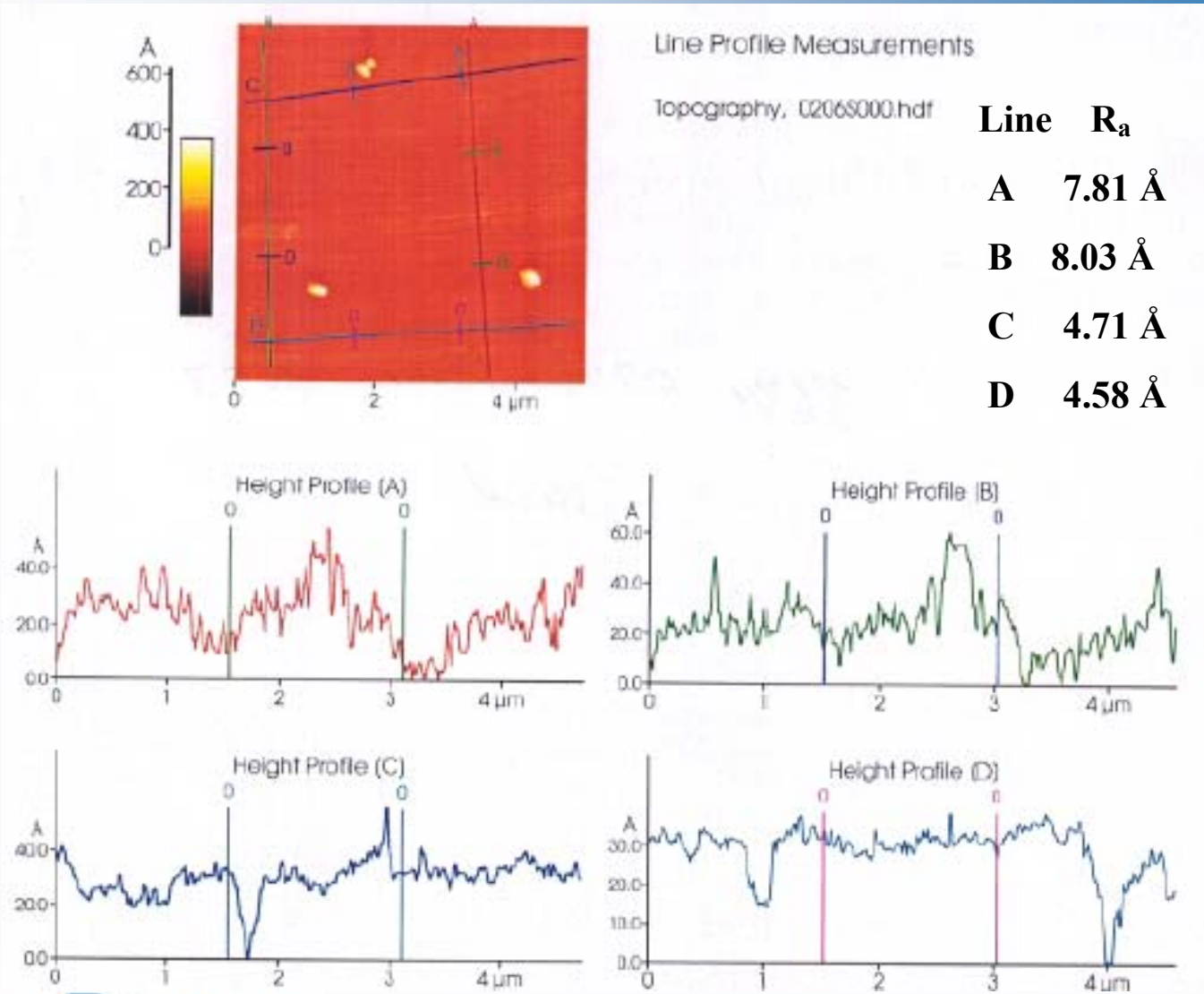




Substrate cleanliness is an issue

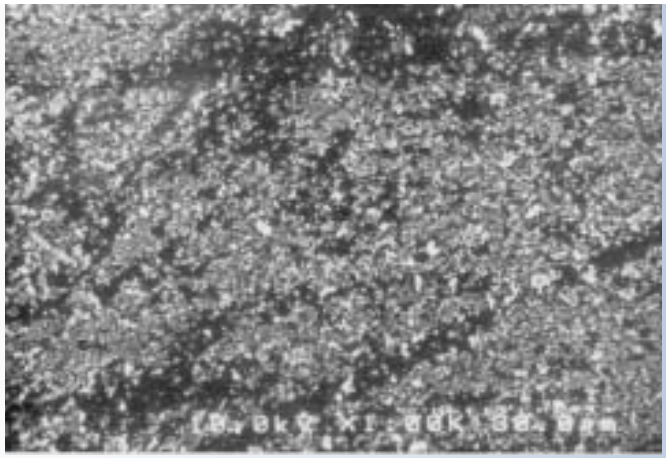


Effect of Residue on the Tape Roughness

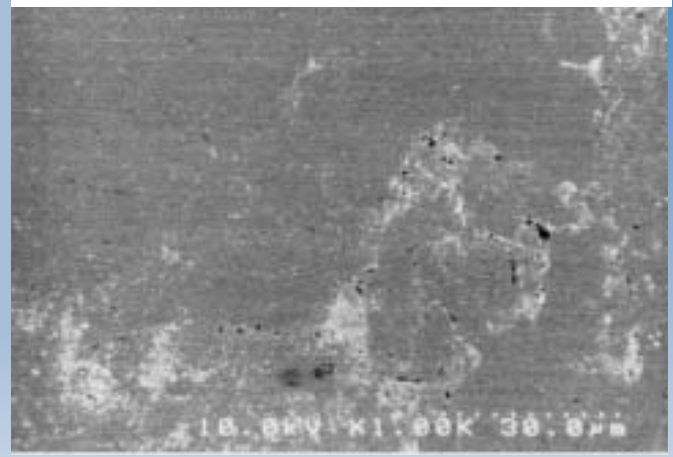


Substrate cleaning techniques developed to minimize surface contamination & defects

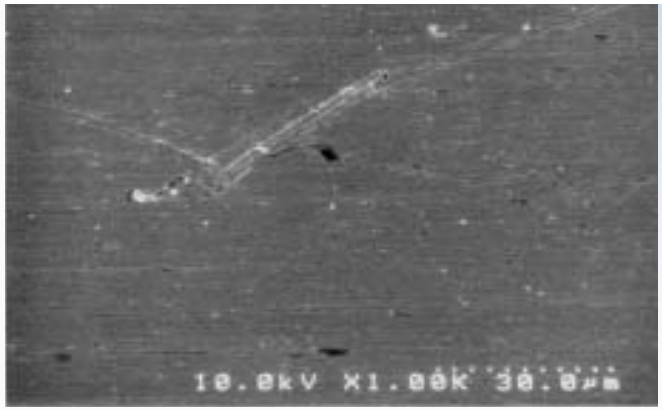
After Polishing



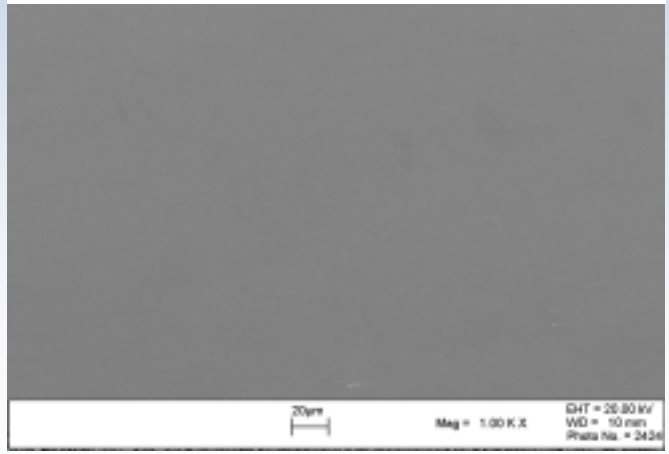
Ultrasonic Cleaning



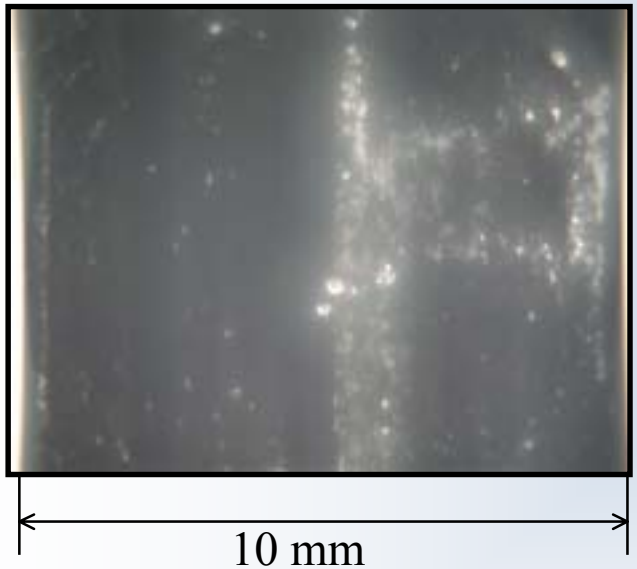
Chemical Cleaning

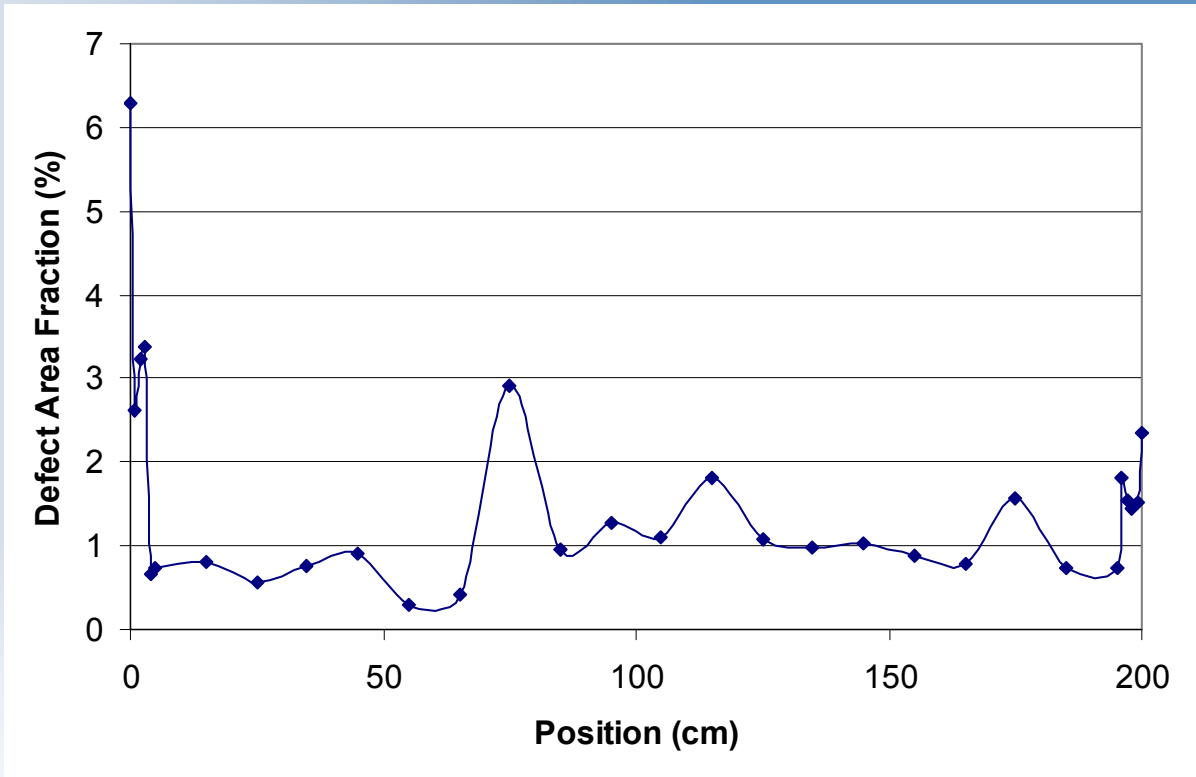


SuperPower Cleaning

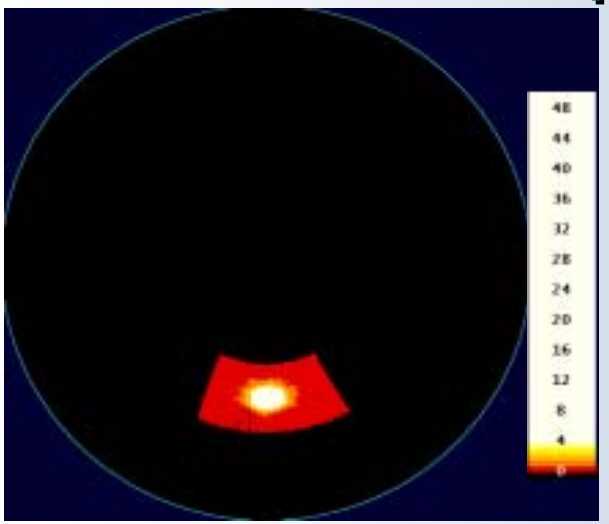


Quantitative defect analysis of meter-long tapes is routinely done

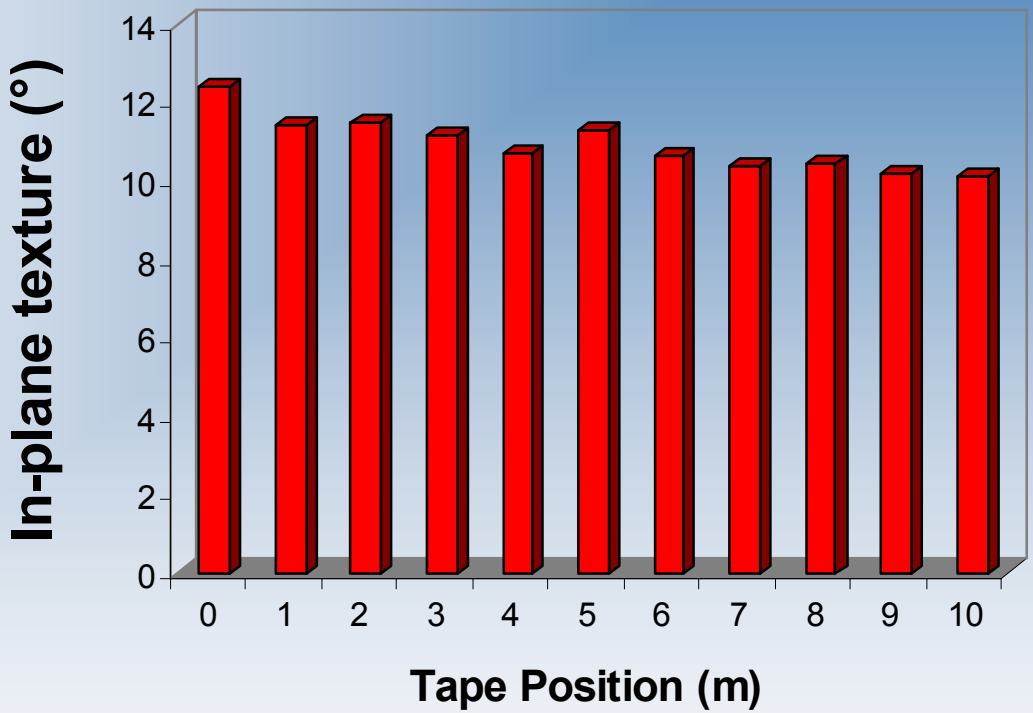




Uniform, well-textured 10 m IBAD tapes produced

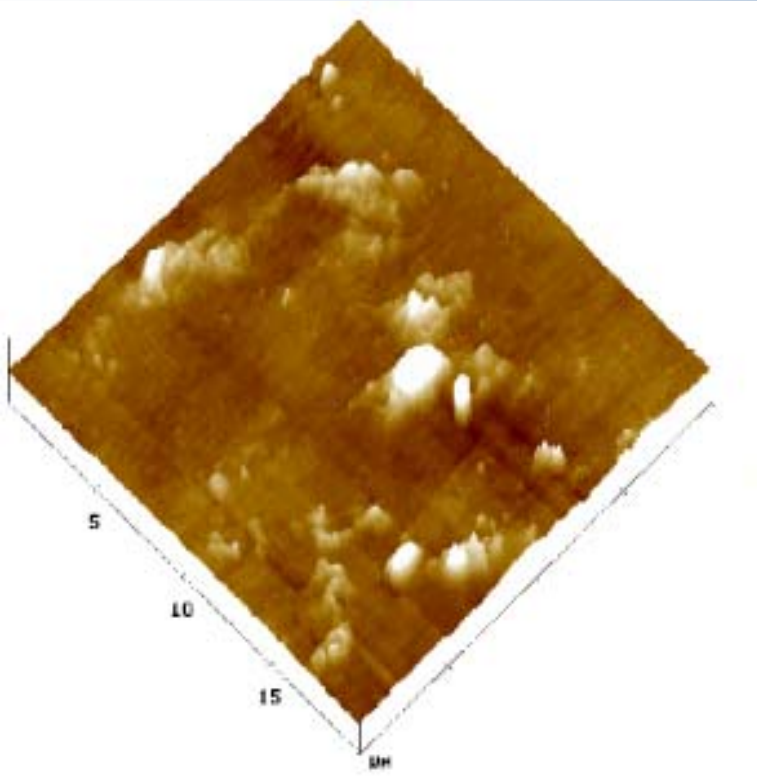


Direct in-plane texture measurement of long tapes using polefigures to calculate FWHM of (111) peaks

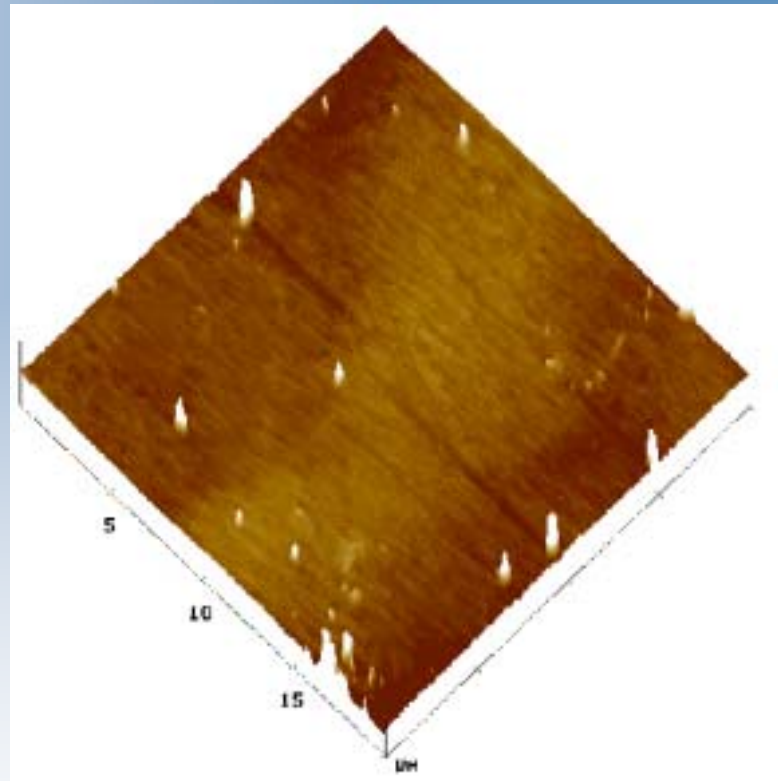


- **Average in-plane texture over 10 m** = 10.9°
- **Standard deviation = 0.7°**

Particulates found in buffer layers

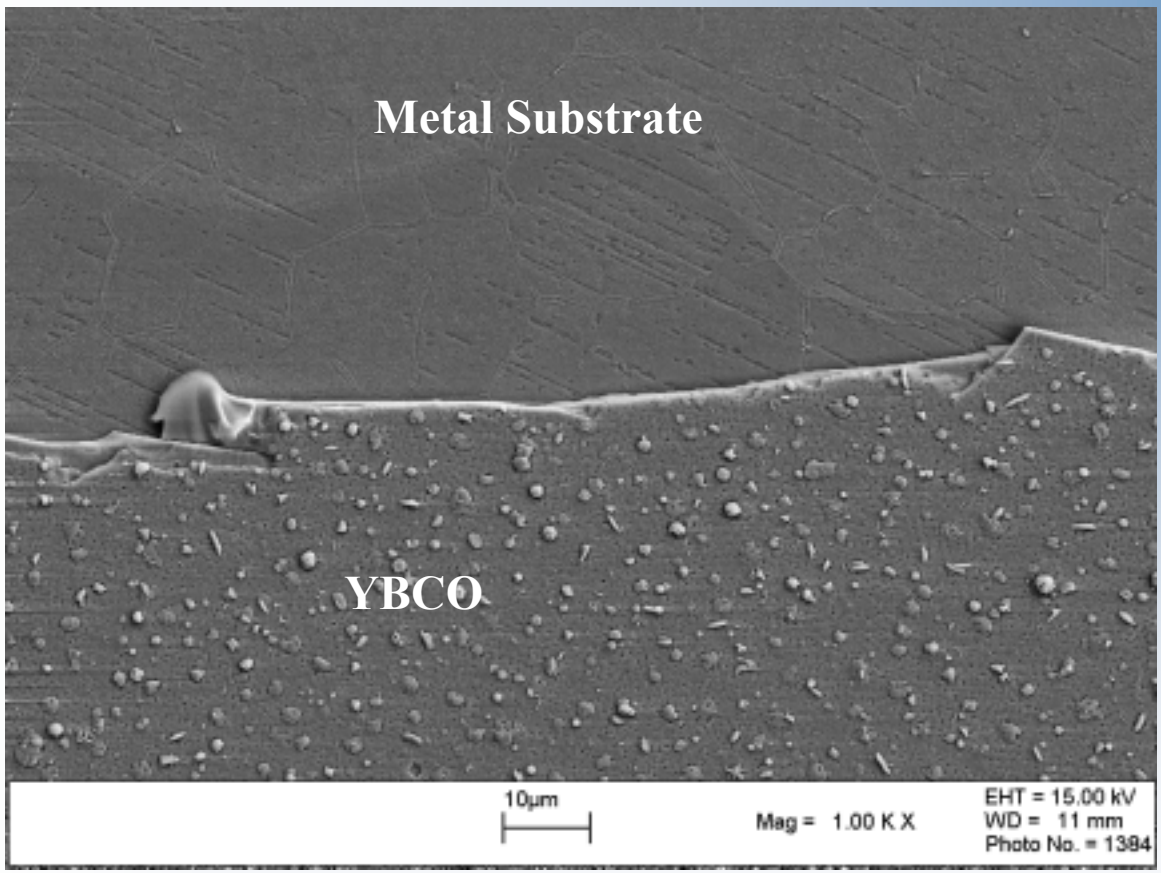


Average roughness = 12.7 nm



Average roughness = 4.6 nm

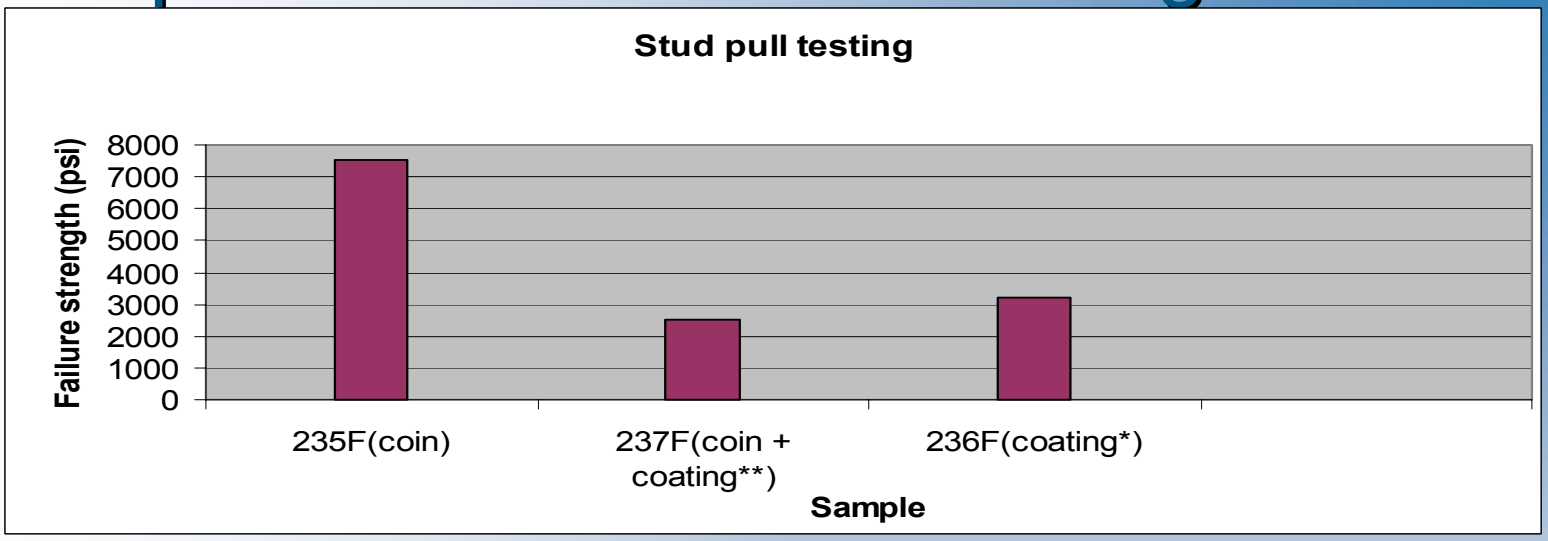
Delamination of buffer after YBCO deposition

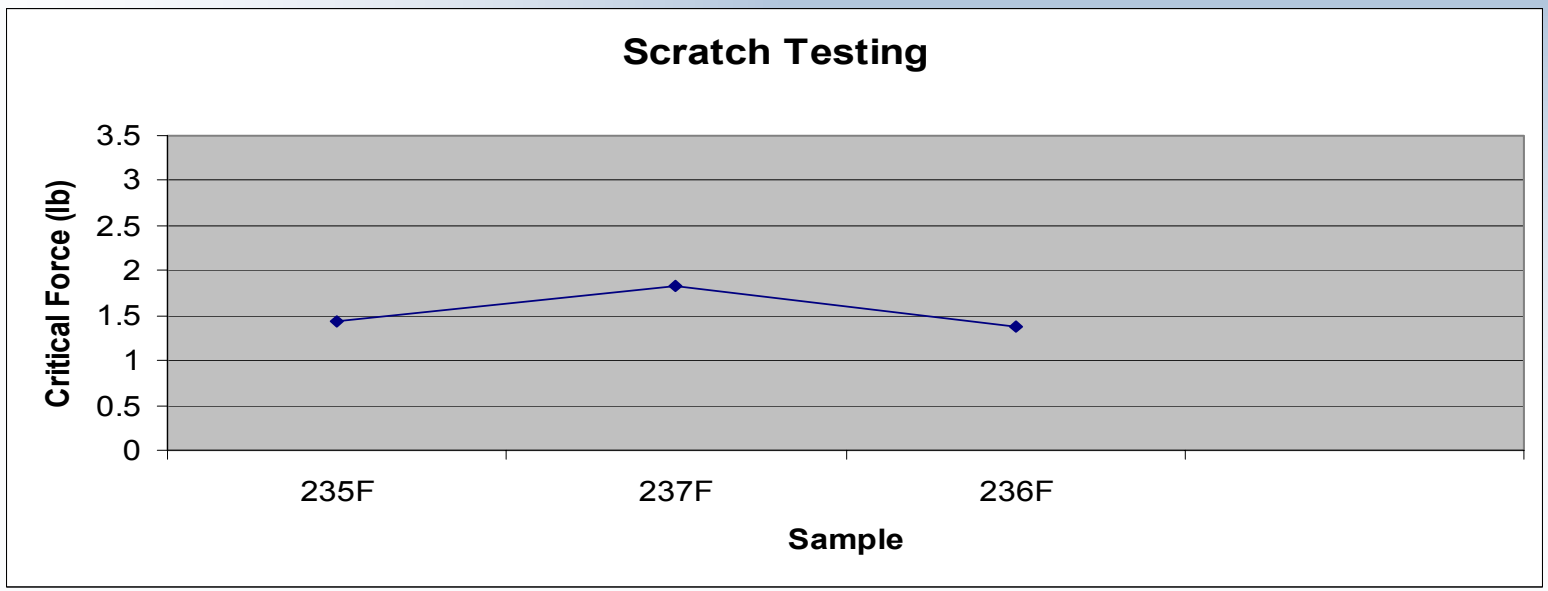


1 mm on each side delaminated.
Effective Ic/cm width = 127 A over 1 m

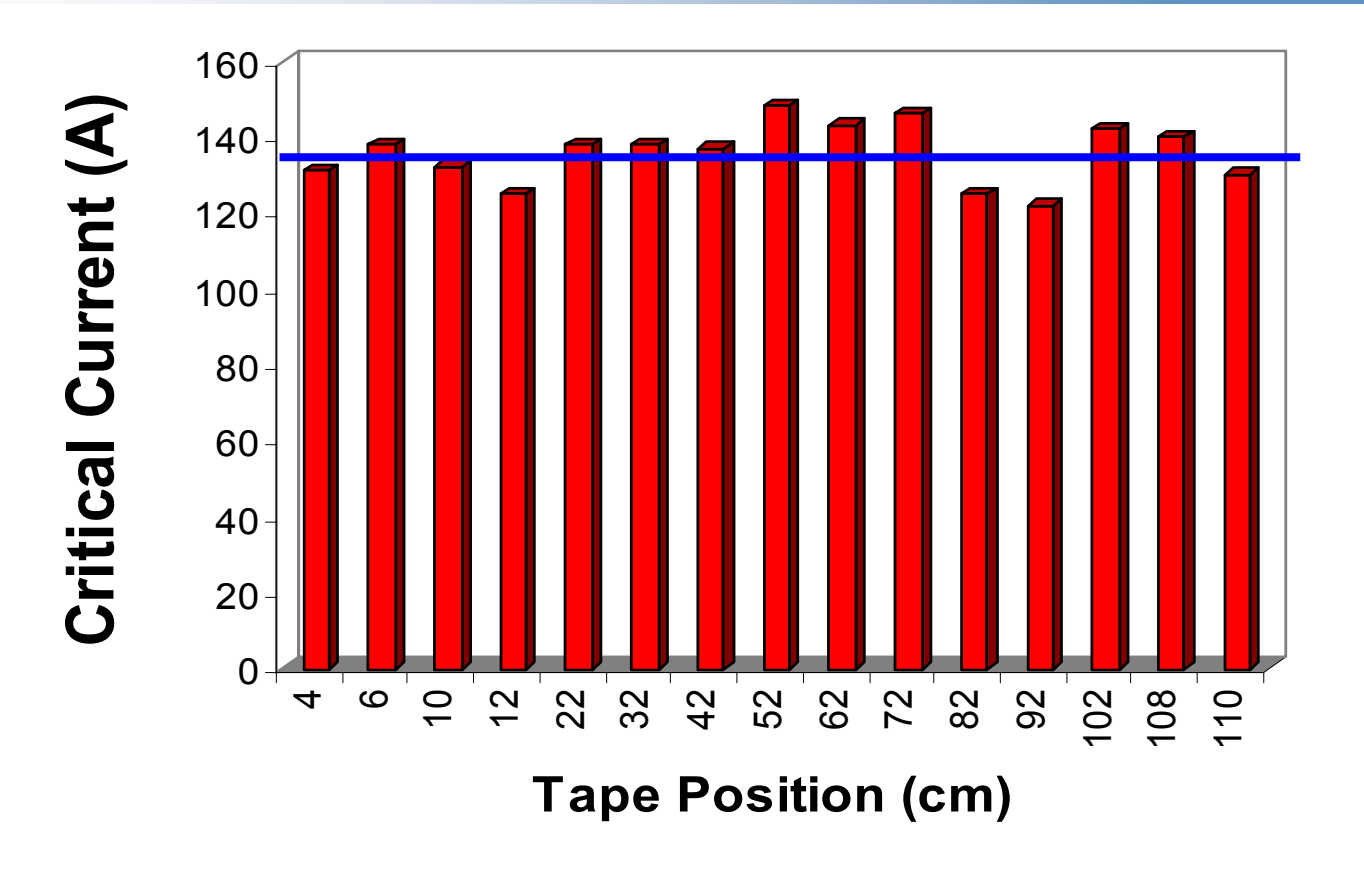
End-to-end Ic = 101 A over 1.24 m

Comparison of Adhesion Testing Methods





Elimination of delamination problem led to higher currents in meter-lengths



End-to-end Ic = **135 A over 1.1 m**