SuperPower Inc.
A Subsidiary of Intermagnetics General Corporation

Quality Control Initiatives in Manufacturing Scale-up of Coated Conductors at SuperPower

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HTS Solutions for a New Dimension in Power

18th International Symposium on Superconductivity 2005 - ISS 2005 – Tsukuba, Japan

October 24-26, 2005

Outline

- **Characterization of Ic non uniformity in long MOCVD tapes**
- **Development of new quality control tools**
  - Automated optical tape inspection tool
  - Ex-situ XRD measurements
  - In-situ Raman spectroscopy
  - Off-line non contact critical current profiles
- **Manufacturing of 100m+ coated conductor**
  - Performance
  - QA/QC procedures

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Characterization of Ic non-uniformity in long MOCVD tapes

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MOCVD was chosen for its advantages of high throughput & high linear tape speed

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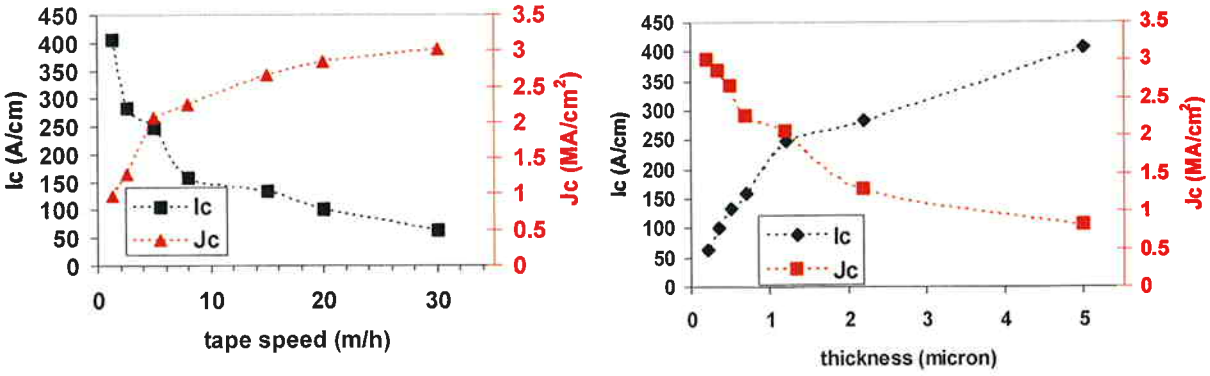
High deposition rates (120 Å/s) in MOCVD enable very high linear tape speeds



Even at a high linear tape speed of 20 m/h in our Research MOCVD system with a deposition zone of 20 cm, we achieved

I_c: 100 A/cm **J_c ~ 2.8 MA/cm²**

Pilot MOCVD system was installed for high throughput manufacturing of 100+ m tapes

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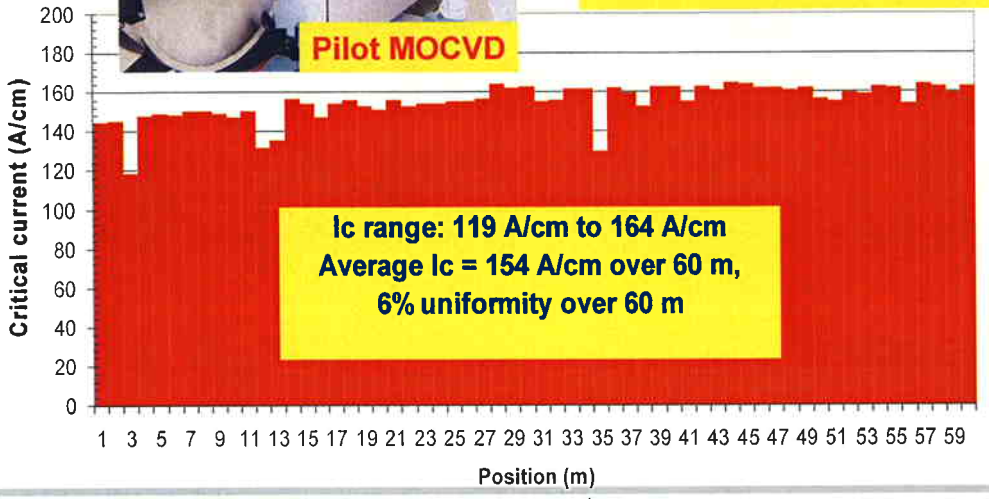
Pilot MOCVD

Spool boxes fit 2 km single piece lengths

Up to 1 m long deposition zone

7 cm wide deposition zone (for multiple wraps in a helix)



Ic range: 119 A/cm to 164 A/cm
Average Ic = 154 A/cm over 60 m,
6% uniformity over 60 m

An early 100 m tape in Pilot MOCVD showed variability in performance

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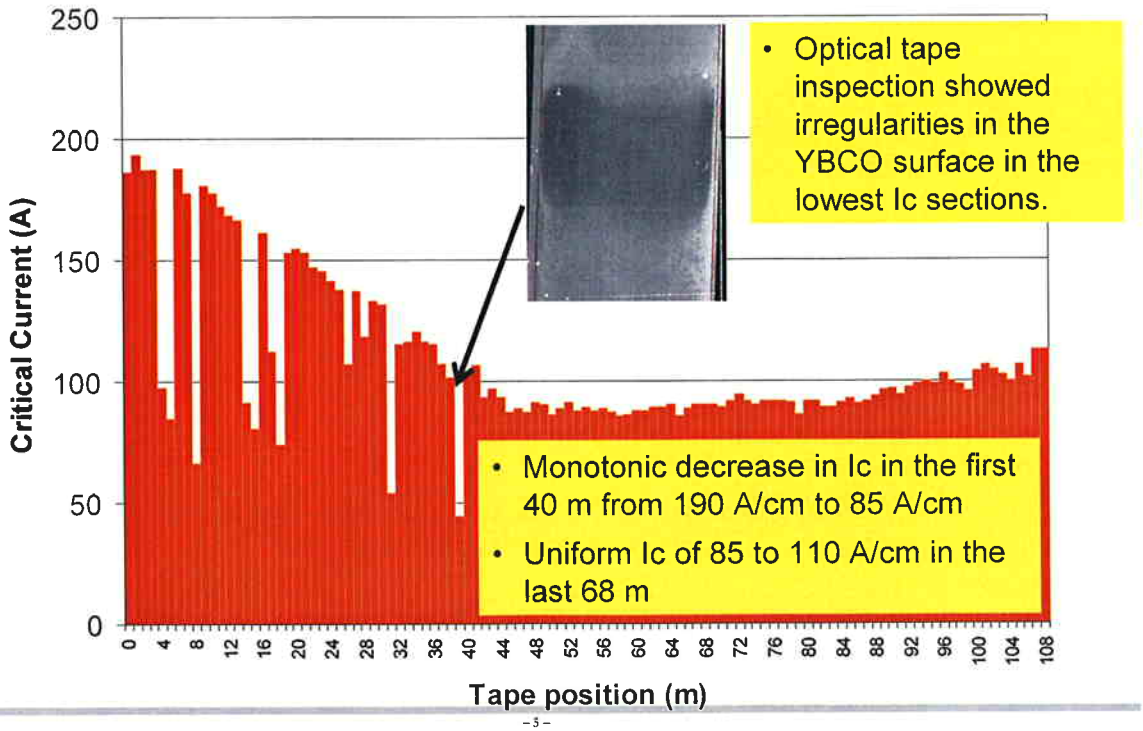

- Optical tape inspection showed irregularities in the YBCO surface in the lowest Ic sections.

- Monotonic decrease in Ic in the first 40 m from 190 A/cm to 85 A/cm
- Uniform Ic of 85 to 110 A/cm in the last 68 m

A microstructural correlation to the Ic profile over 108 m was identified.

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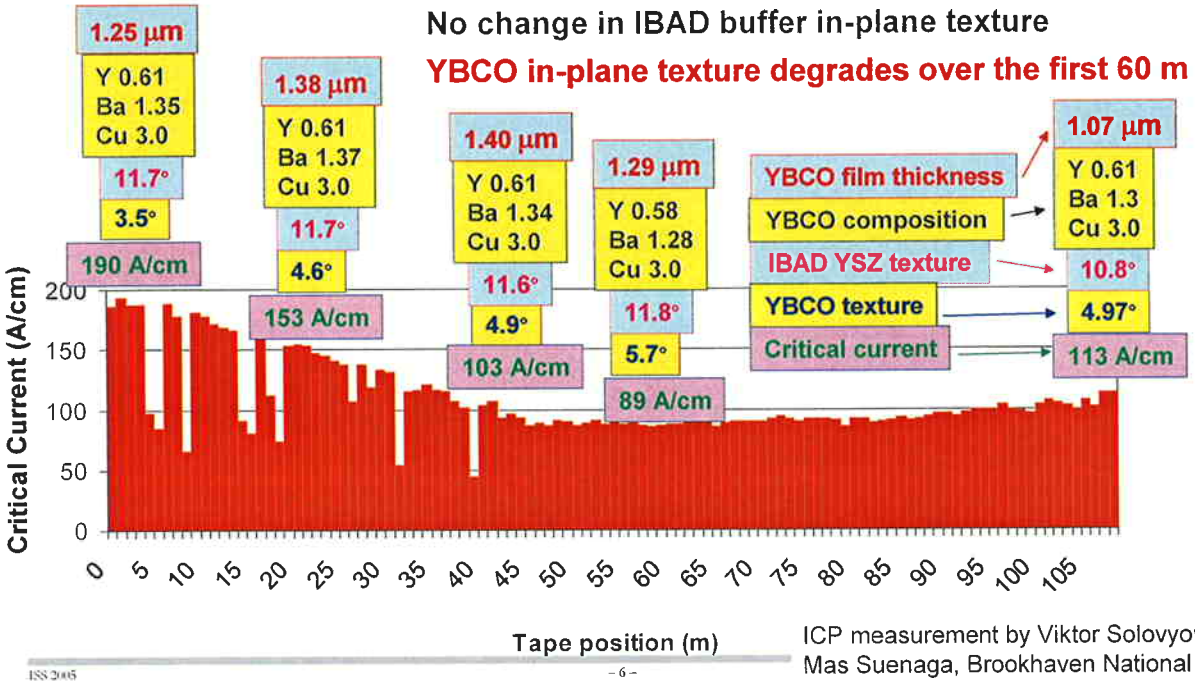
No change in YBCO film thickness

No change in YBCO film composition

No change in IBAD buffer in-plane texture

YBCO in-plane texture degrades over the first 60 m



ICP measurement by Viktor Solovyov & Mas Suenaga, Brookhaven National Lab

Raman spectra show a less intense peak (Y211 phase) in the highest Ic section.

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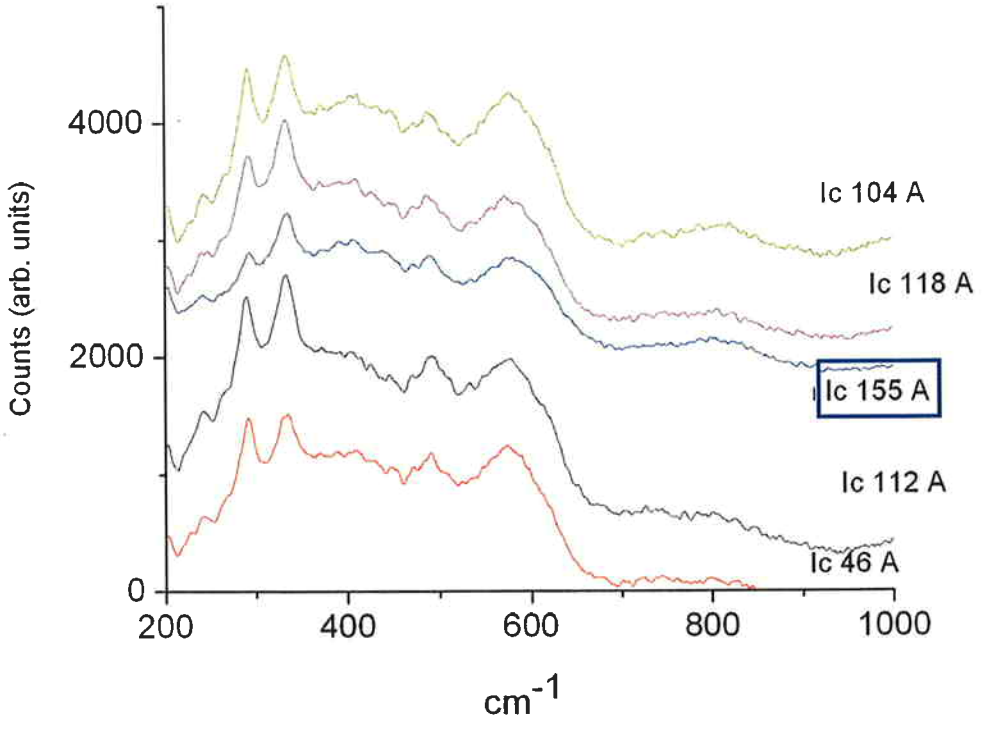
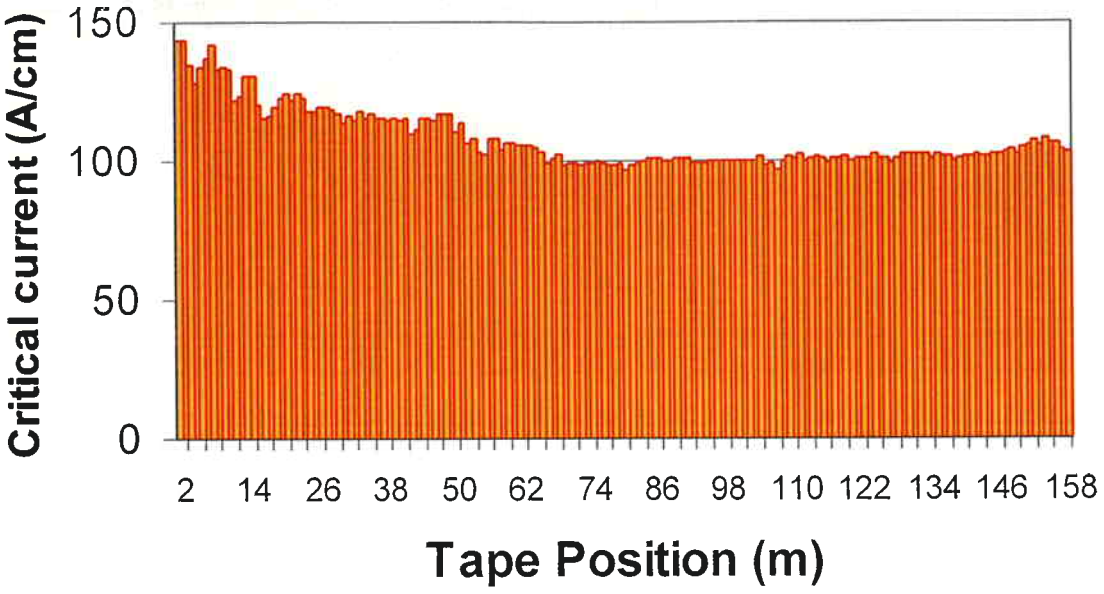


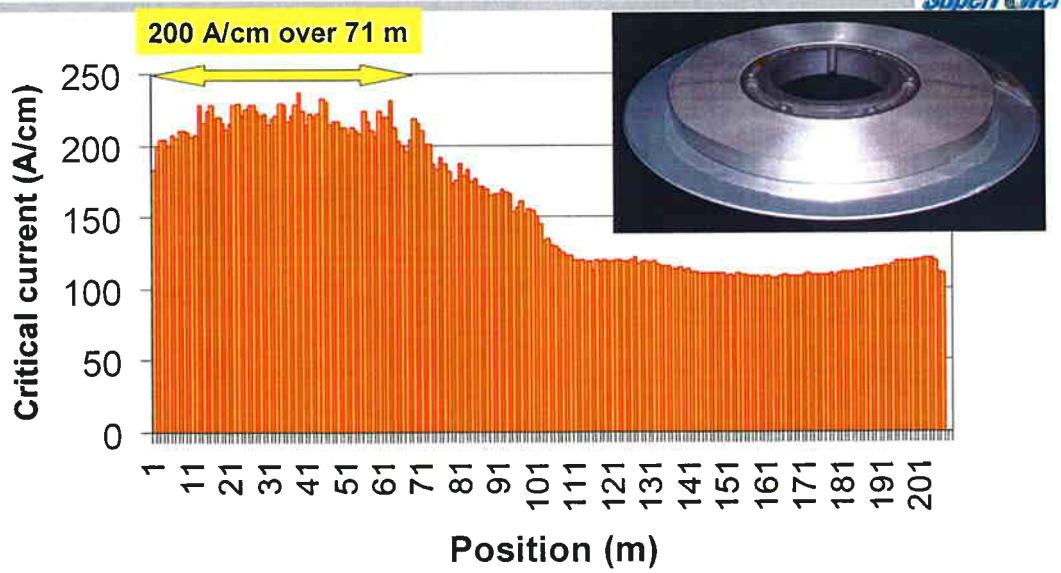
Multi-pass process successfully used to produce 158 m long tape by MOCVD with improved Ic uniformity



Ic ~ 100 A/cm over 158 m

Standard deviation = 2% over last 100 m

200 m long 2G conductor by MOCVD



Minimum Ic of 106.7 A/cm over 206.7 m (22,030 A-m)

71 m with Ic of 200 A/cm with standard deviation of 4.3%

Standard deviation of 4.3% over the last 100 m

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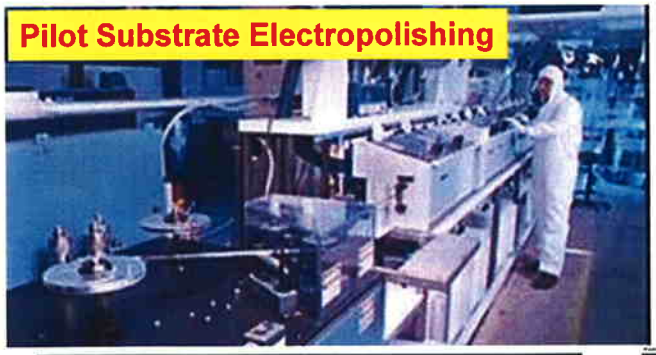
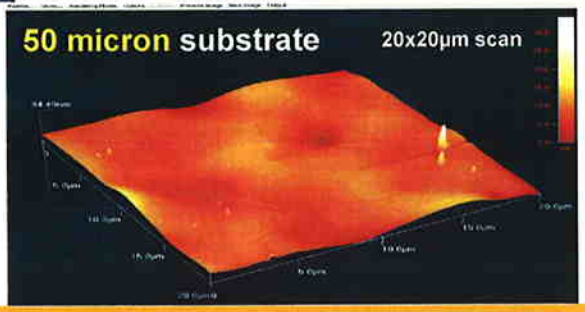
On-line roughness monitoring and off-line AFM measurements used as QA/QC for substrate polishing



	100 micron substrate	50 micron substrate
Lengths	150 m	300 m
Roughness	2.8 nm	1.9 nm
Slope	~ 3.3°	~ 7°
G.B. slope	< 1°	< 1°



Quality of electropolished 50 micron substrates meets even the stringent requirements of IBAD MgO

Reel-to-reel Nomarski microscopy & optical profilometry are used for substrate characterization

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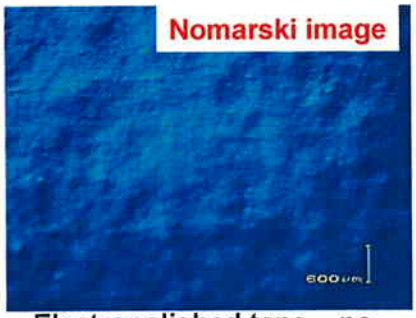
Electropolished tape – with grain boundaries



Electropolished tape – no grain boundaries

An automated optical tape inspection system is used for QC/QA between every process step.

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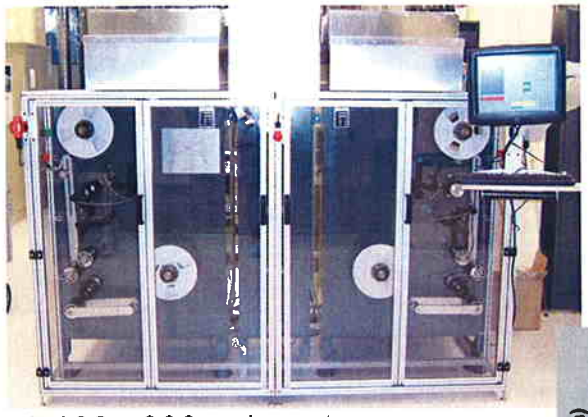
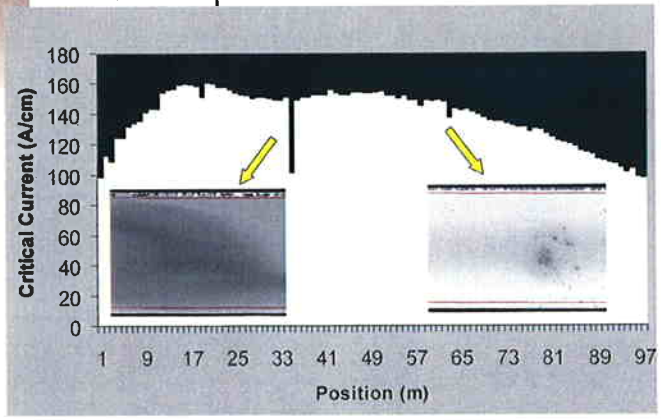
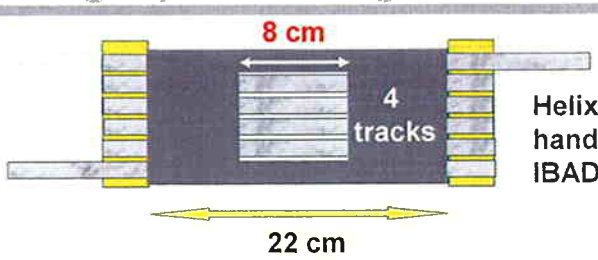


- 100 - 300 m long tapes inspected - as polished substrate, buffer, MOCVD YBCO
- Tape Inspection system was used to locate weak spots in the first 100 m MOCVD tape *before* Ic testing

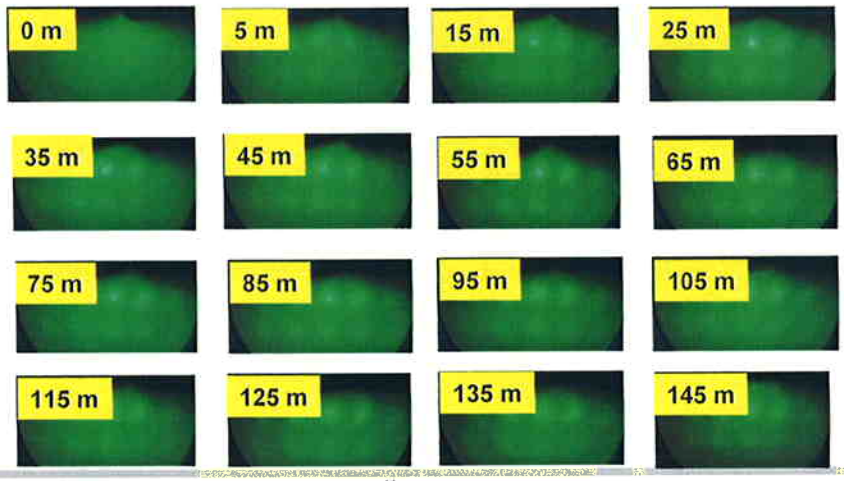
- Reel-to-reel tape drives for edge guided, tension control for over 2 km long tapes at a maximum speed of 450 m/h
- Camera system inspects tape at 90m/hr and correlates defect type to defect position



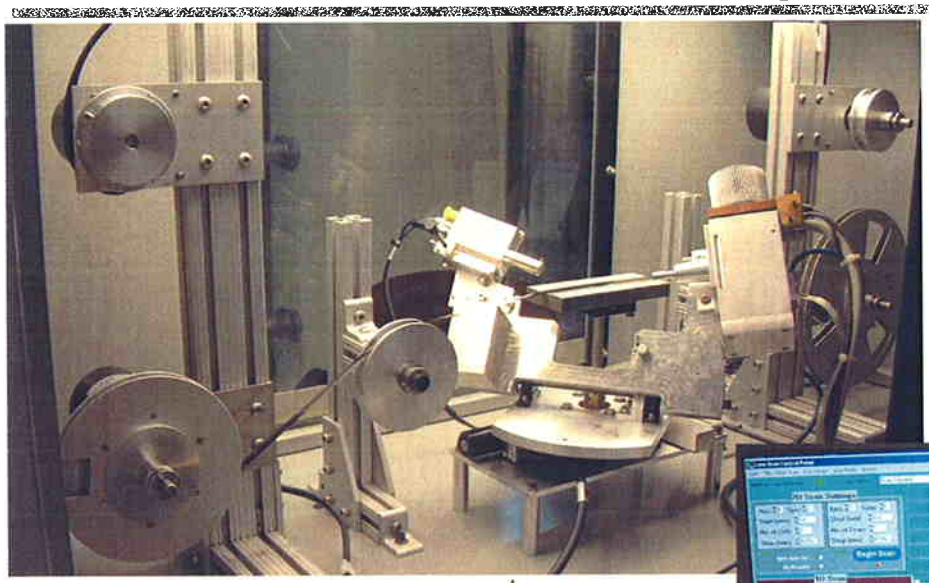
On-line RHEED qualifies the buffer surface texture during IBAD MgO processing



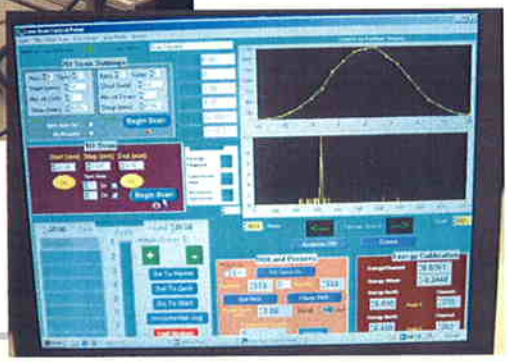
Helix tape handling in Proto IBAD system



High-speed, novel in-plane texture measurement system used for texture measurements on long IBAD tapes



- Acquisition time: 1 sec per point with detector averaging 5000cps
- Cycle time for complete pole figure = 35 seconds !



Upgrade to XRD system will allow rapid texture measurements of up to 1km of any material

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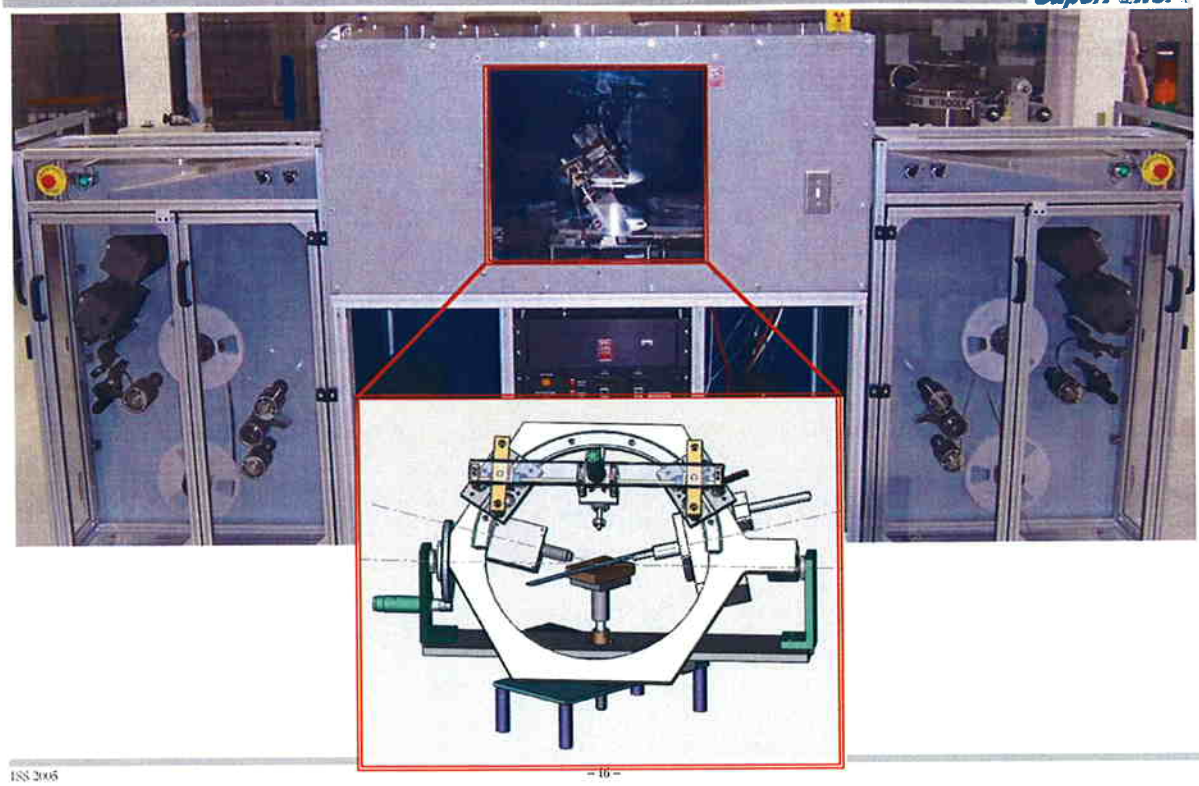

25 m MOCVD tape demonstrated with LMO buffered IBAD MgO: all buffers @ 10 m/h

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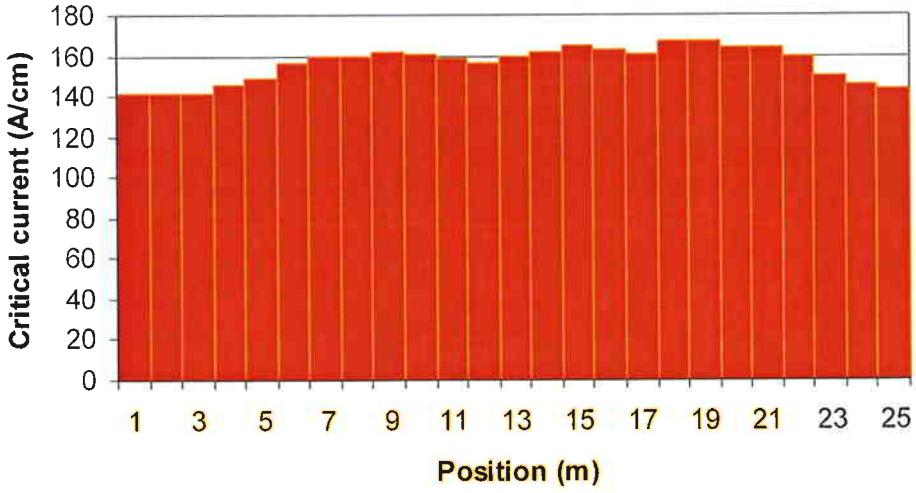

Long length performance: 142 A/cm over 25 m

Short length performance:

220 A/cm, 1.1 micron YBCO, Je = 40 kA/cm²

400 A/cm, 3.0 micron YBCO, Je = 71.4 kA/cm²