

Advances in Scale-up of 2G Conductor at SuperPower

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Program Objective

- The primary objective of the program is to **scale up high performance 2G conductors via high throughput process** technologies, namely IBAD MgO & MOCVD, to full-fledged manufacturing.

Key Metrics

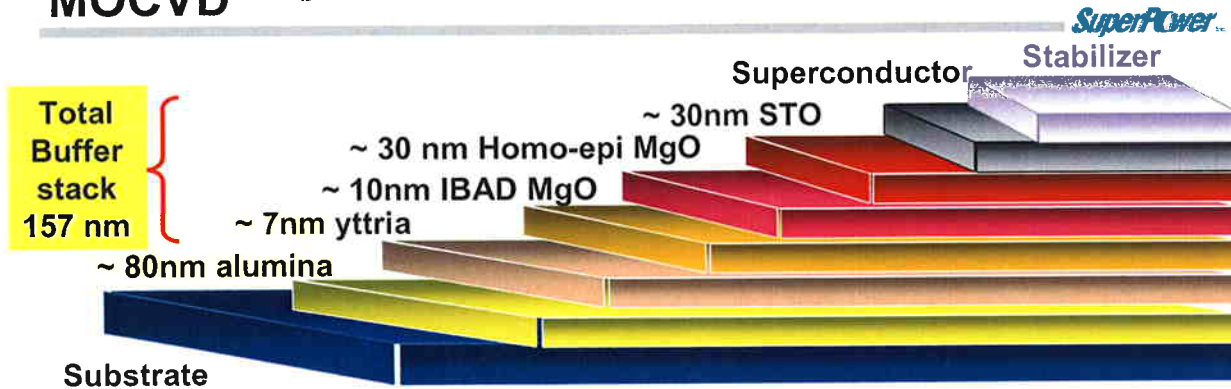
Scale-up:

- 100 m lengths of MOCVD-based conductor with I_c of 100 A/cm
- Scale up IBAD MgO & buffers to 100 m

High Throughput:

- Linear tape speed = 10 m/h of 12 mm wide conductor in every process step (equivalent to 30 m/h of 4 mm wide conductor)
 - Requires IBAD MgO-based buffers to be integrated with MOCVD
 - Requires high rate reactive sputtering of buffers on IBAD MgO

Major objective was to integrate IBAD MgO with MOCVD



- Alumina --- diffusion barrier
- Yttria - Nucleation layer
- IBAD MgO - Template layer
- Homo-epi MgO - Texture improvement layer
- STO - Lattice match cap layer

Concerns in integrating IBAD MgO w/MOCVD:

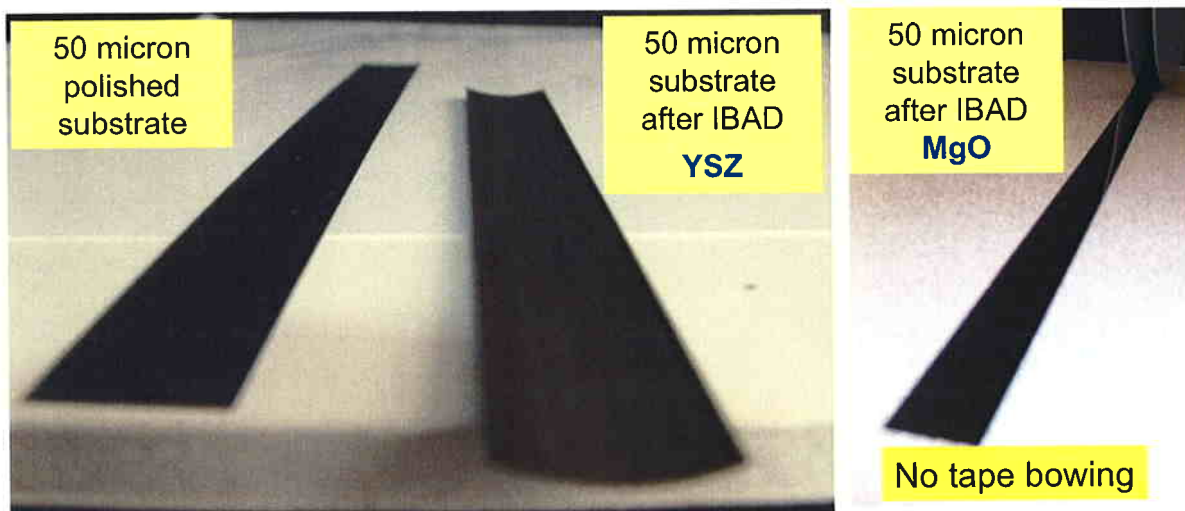
- LANL has developed this structure (materials, thickness) for PLD. Will it work for MOCVD?
- Can all buffers be deposited at high rates?
- More stringent requirement on substrate quality than with IBAD YSZ

Transitioning to MgO provided an additional advantage



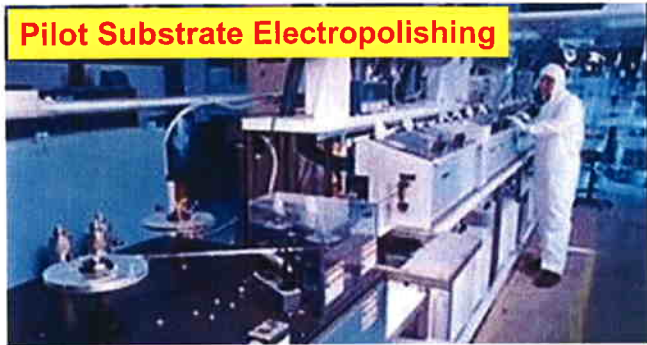
IBAD MgO provided the opportunity to use thin substrates (50 microns) for high J_e

Previously, 100 micron thick substrates were used for IBAD YSZ because of transverse tape bowing issue with 50 micron substrates

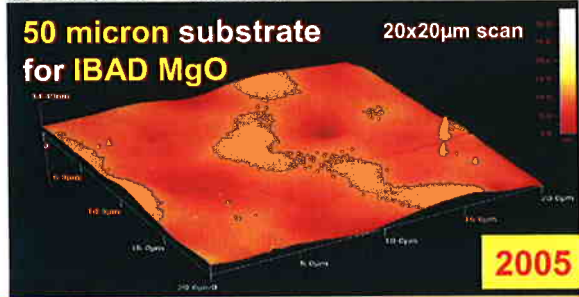
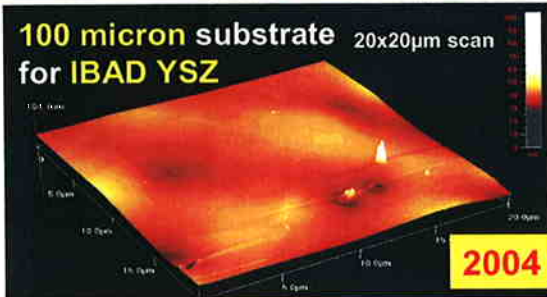


50 micron thick substrates electropolished for IBAD MgO in ~ 300 m single pieces, at 30 - 40 m/h

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	FY04: 100 micron substrate	FY05: 50 micron substrate
Lengths	150 m	300 m
Roughness	2.8 nm	1.9 nm
Slope	~ 3.3°	~ 7°
G.B. slope	< 1°	< 1°



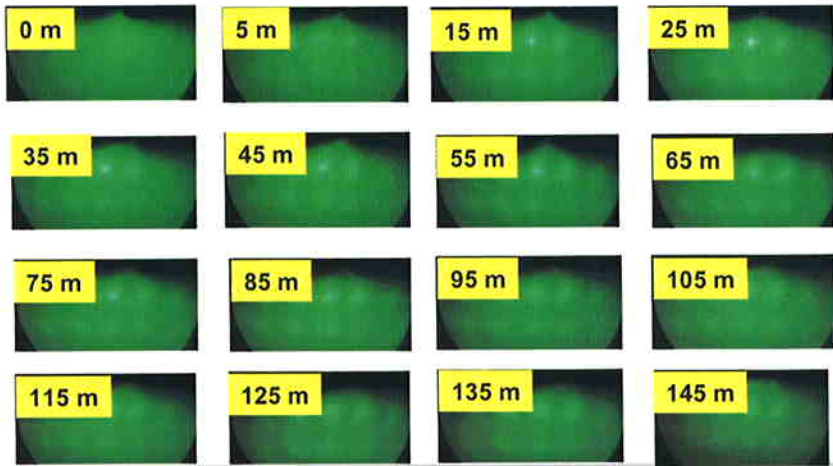
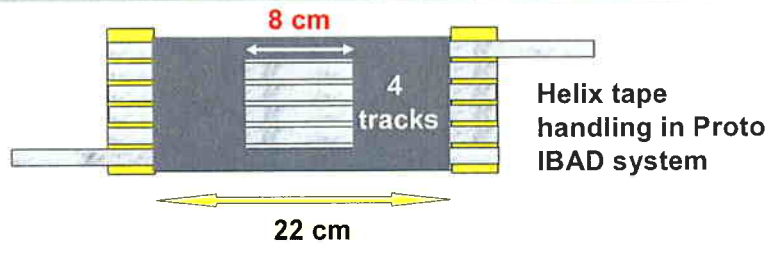
Quality of electropolished 50 micron substrates meets even the stringent requirements of IBAD MgO

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IBAD MgO is being routinely fabricated in 135 m lengths at 10 m/h even in a Prototype IBAD system

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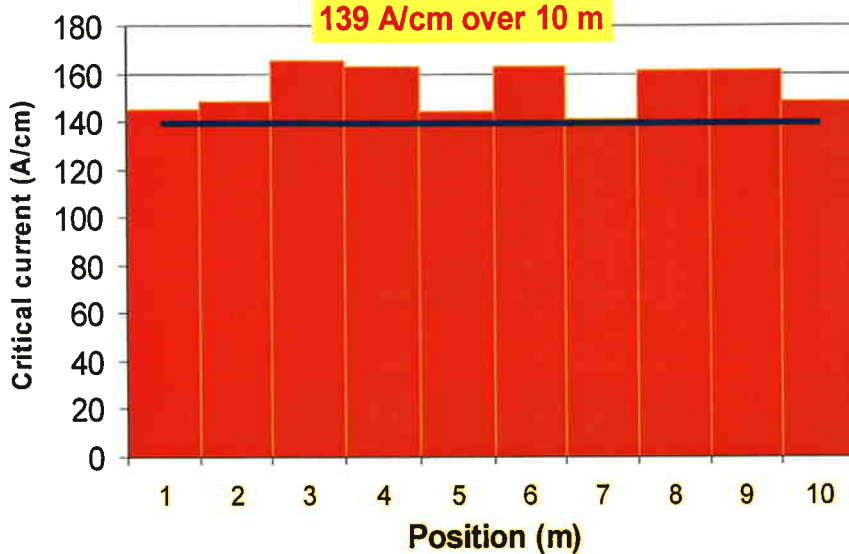
July 2004: One 40 m IBAD MgO produced at 10 m/h
July 2005: Twelve 135 m IBAD MgO tapes fabricated on 50 micron thick substrates at 10 m/h

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High I_c MOCVD tapes produced in 10 m lengths on RF-sputtered STO on reactively-sputtered MgO

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10m length MOCVD-YBCO conductor on RF-sputtered STO/reactively-sputtered MgO on 50 micron substrate.
End-to-end I_c^* = 139 A/cm. Standard deviation = 6%

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*YBCO film thickness = 1.1 microns

Need for an alternative to STO

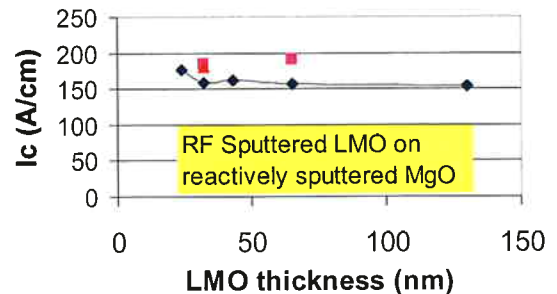
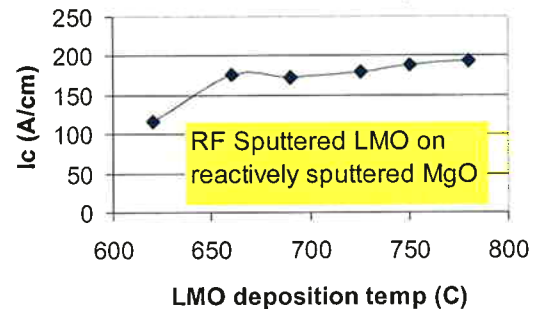
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Issues with STO:

- Sr-Ti targets are not available for high rate reactive sputtering
- High deposition temperatures (~ 850 C) are needed with RF sputtered STO on reactively sputtered MgO
- Deposition rate is limited. Processing speed for 10 m tape was 3.6 m/h

Advantages of LMO:

- Lower deposition temperature and larger temperature window than STO
- Higher deposition rate enables high speeds even with RF sputtering:
177 A/cm* with 24 nm LMO @ 10 m/h
- Higher I_c than STO (~ 40 A/cm higher) - Bonus!



*MOCVD films are 1.1 microns thick

LMO is an excellent alternative to STO especially in combination with MOCVD YBCO and reactively-sputtered MgO

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

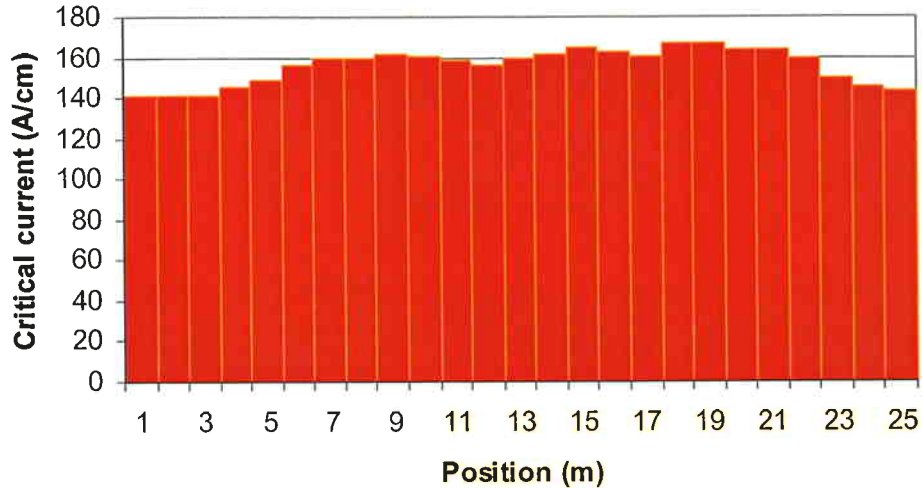
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IBAD MgO @ 10 m/h

RF-Sputtered LMO @ 10 m/h

Reactively-sputtered MgO @ 10 m/h

MOCVD @ 10 m/h × 2 passes



I_c^* of 142 A/cm over 25 m MOCVD tape with all high throughput buffers

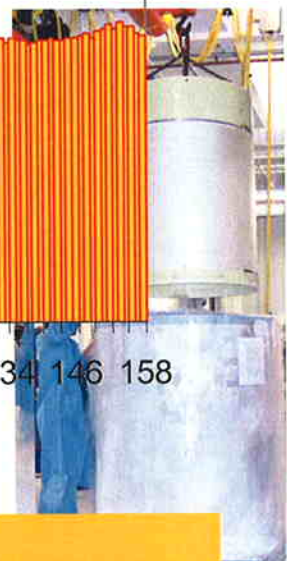
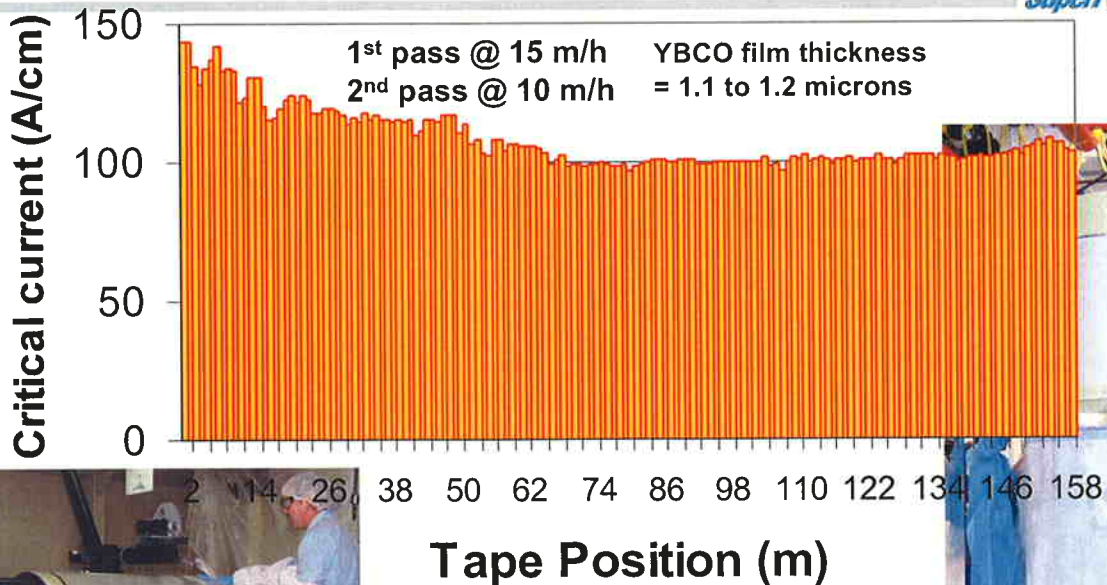
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*YBCO film thickness = 1.1 microns

MOCVD has been scaled up to 158 m with IBAD YSZ

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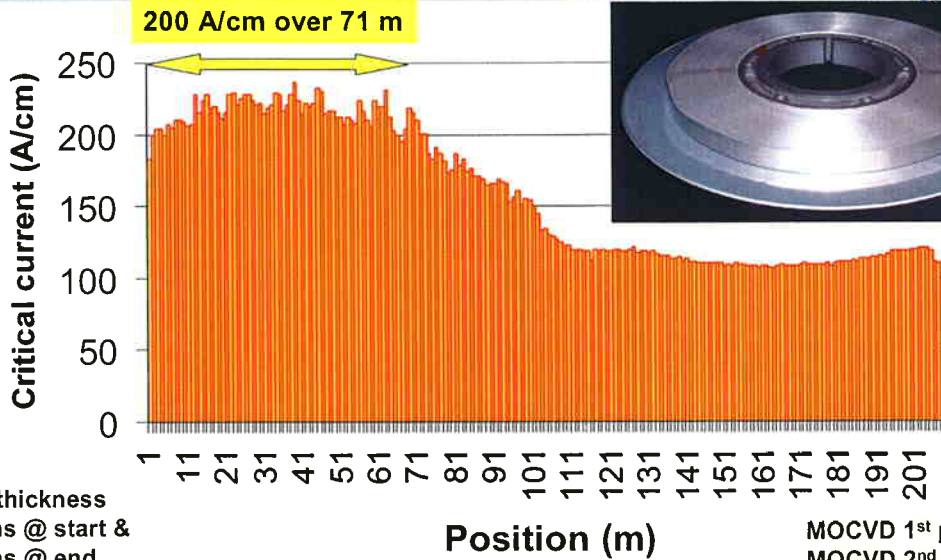
$I_c \sim 100$ A/cm over 158 m

Standard deviation = 2% over last 100 m

CBC-ICMC '06

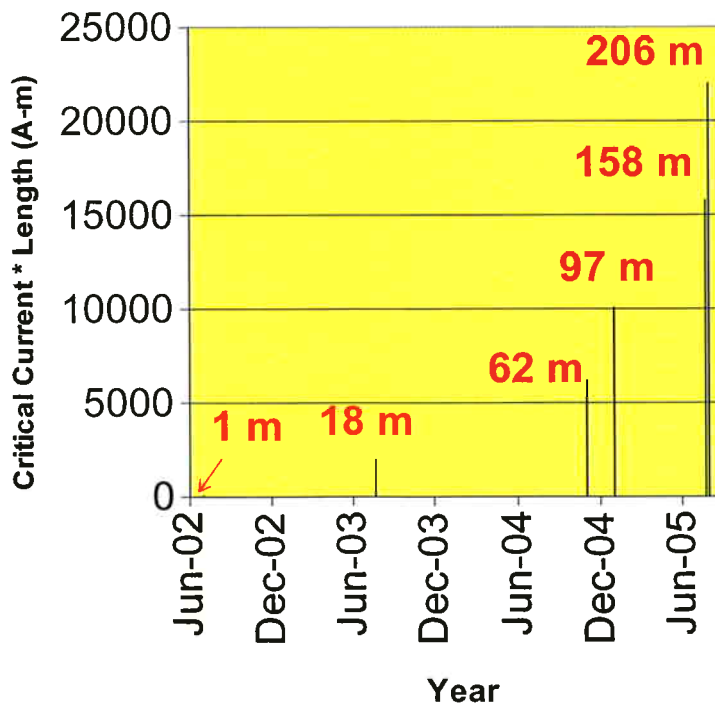
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200 m long 2G conductor by MOCVD



Minimum I_c of 106.7 A/cm over 206.7 m (22,030 A-m)
71 m with I_c of 200 A/cm with standard deviation of 4.3%
Standard deviation of 4.3% over the last 100 m

SuperPower progress in MOCVD scale-up



1 m to 206 m in 3 years

Summary

SuperPower™

- 50 micron substrates polished by electropolishing in **300 m lengths** at 30 - 40 m/h with surface quality suitable for IBAD MgO (compared to 150 m of 100 micron substrates last year)
- **Twelve 135 m long IBAD MgO tapes** fabricated with proto IBAD facility (compared to one 40 m tape last year).
- **LMO demonstrated as a better alternative to STO for IBAD MgO-MOCVD conductor** – lower deposition temperature, wider window, higher rate, higher current.
- **Demonstrated 142 A/cm over 25 m long MOCVD conductor with all-high throughput buffer** deposition with IBAD MgO i.e. both LMO & homo-epi MgO deposited at 10 m/h (compared to 118 A/cm over 1.8 m last year)
- 158 m conductor with 100 A/cm (15,800 A-m) (compared to 18 m with 118 A/cm last year). **First demonstration of 100 m conductors with any process other than PLD.** 100 m segment of conductor has uniformity of 2% (compared to > 10% in 10 m lengths last year)
- **206 m conductor with 107 A/cm (22,030 A-m).**
First 71 m of the tape has Ic of 200 A/cm with 4.3% uniformity.
Last 100 m of conductor has uniformity in Ic of 4.3%.