



Superconductivity for Electric Systems DOE 2005 Wire Development Workshop

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HTS Solutions for a New Dimension in Power



MOCVD Process for Coated Conductors

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MOCVD provides advantages of high throughput & single-piece lengths



For a low-cost conductor, high throughput is a major requirement.

Throughput =

Deposition Rate × Deposition zone length × Deposition zone width

Single-piece length =

Deposition Rate × Deposition zone length



Pilot MOCVD

Only MOCVD offers the advantage of high deposition rates (150 Angstroms/s) as well as long and wide deposition zone

Hours to produce 1 km of coated conductor

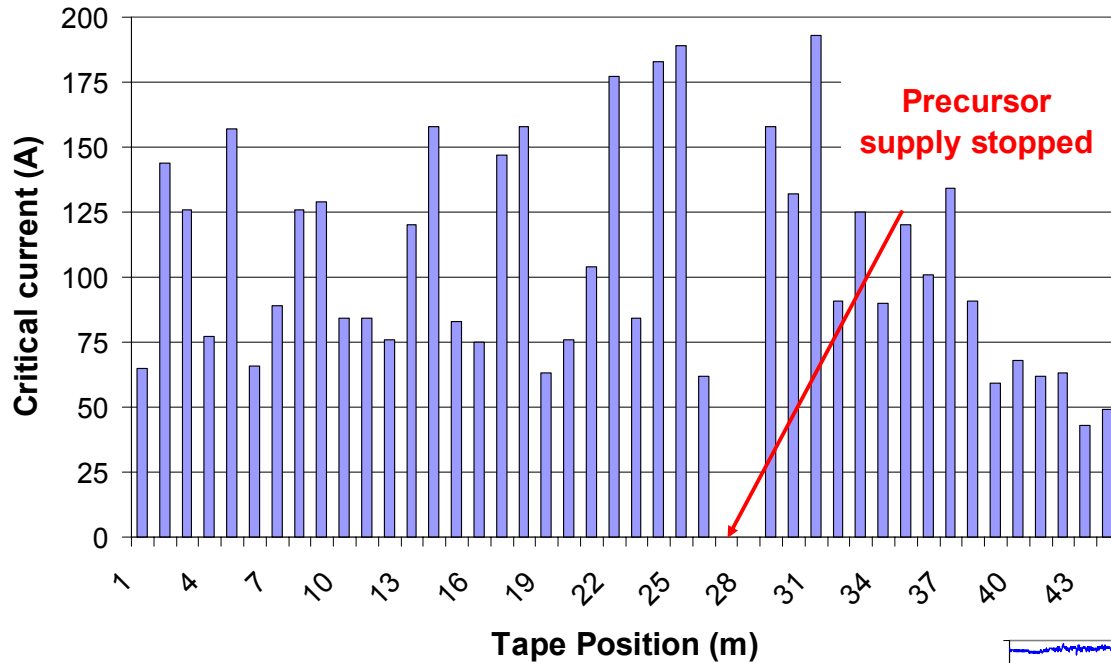
<i>1 micron thick HTS</i>	Deposition Zone	
Deposition Rate	1 m	10 m
150 Angstroms/s	18	2
1 Angstrom/s	2,778	278
10 Angstrom/s	278	28

Recent progress in MOCVD-based coated conductors at SuperPower



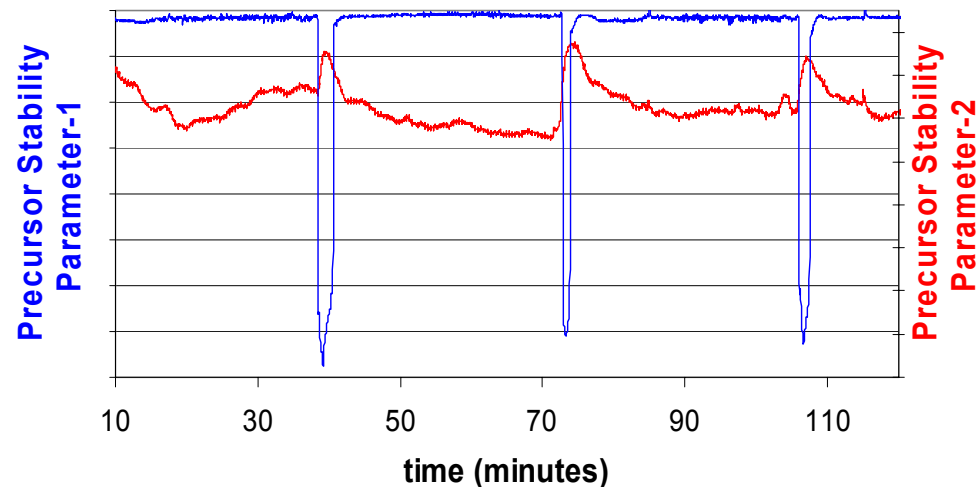
- Improved stability in precursor delivery
- High speed process
- Multi-pass technique
- High J_e & in-field performance

In July 2004, we reported that instability in precursor delivery limited long-lengths by MOCVD

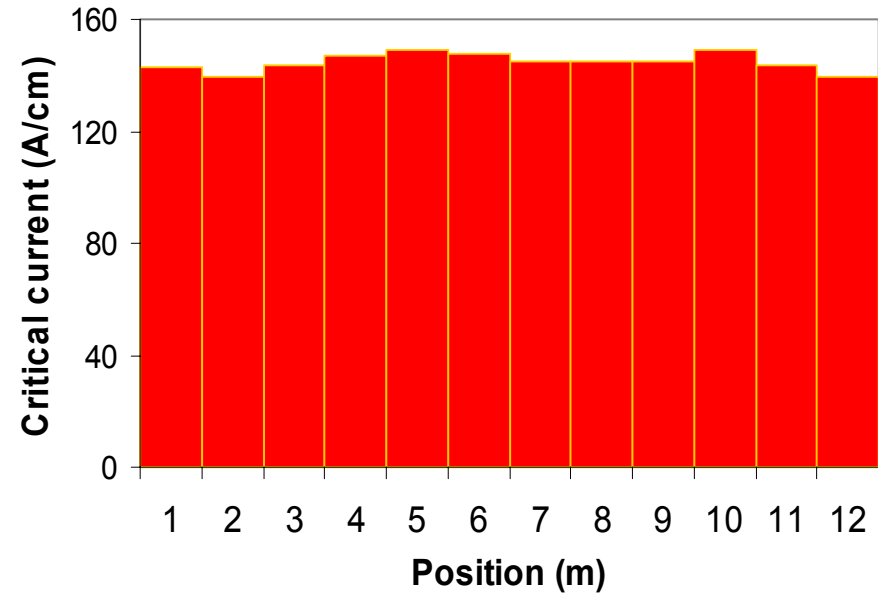
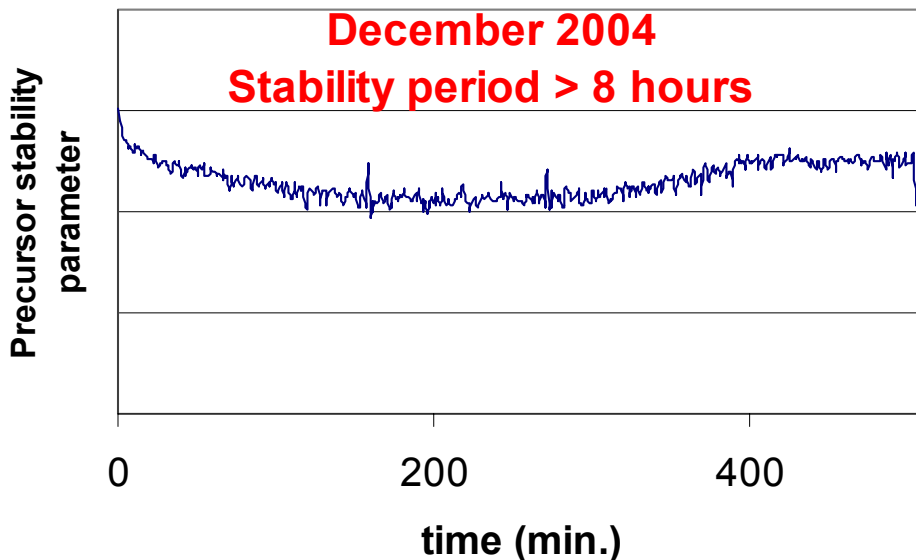
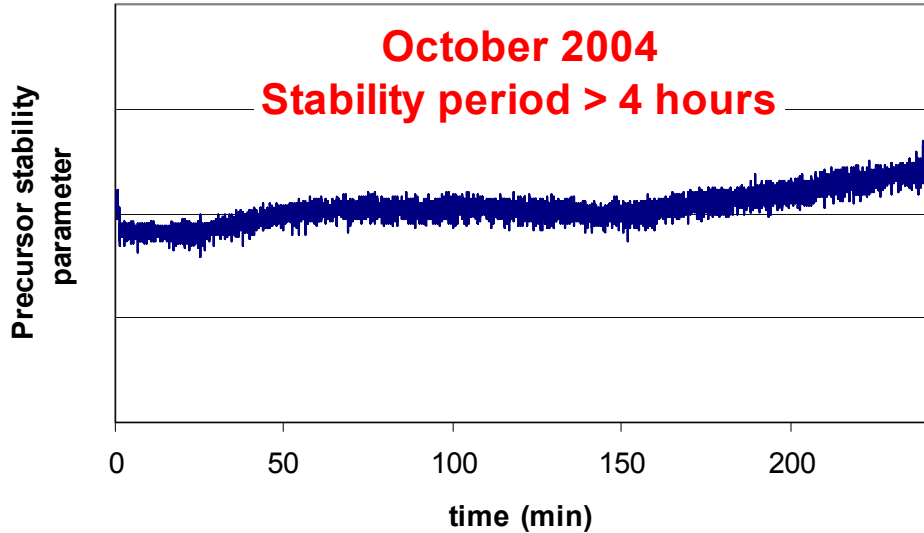


I_c ranged from 65 A - 193 A over 0 - 27 m & 30 - 43 m

On-line monitoring in the MOCVD system showed instability in precursor delivery in 40 minute intervals



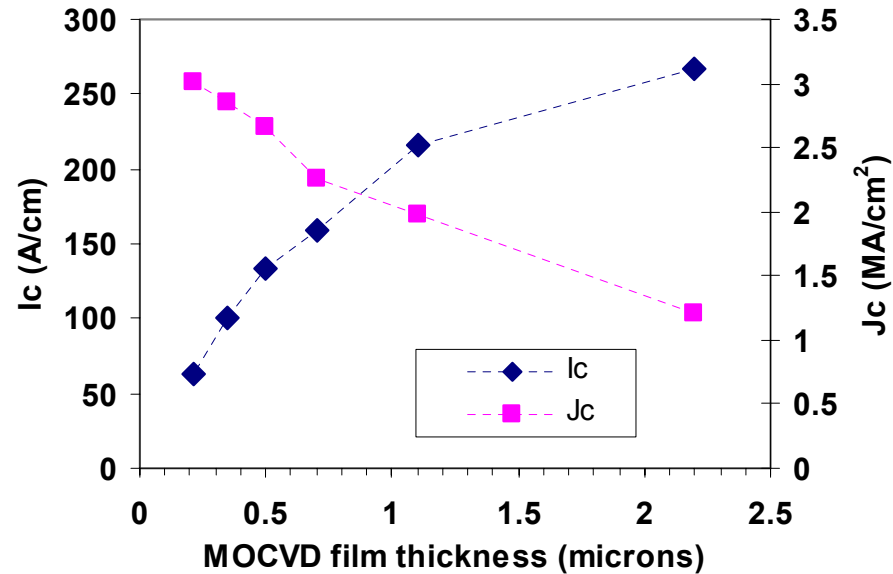
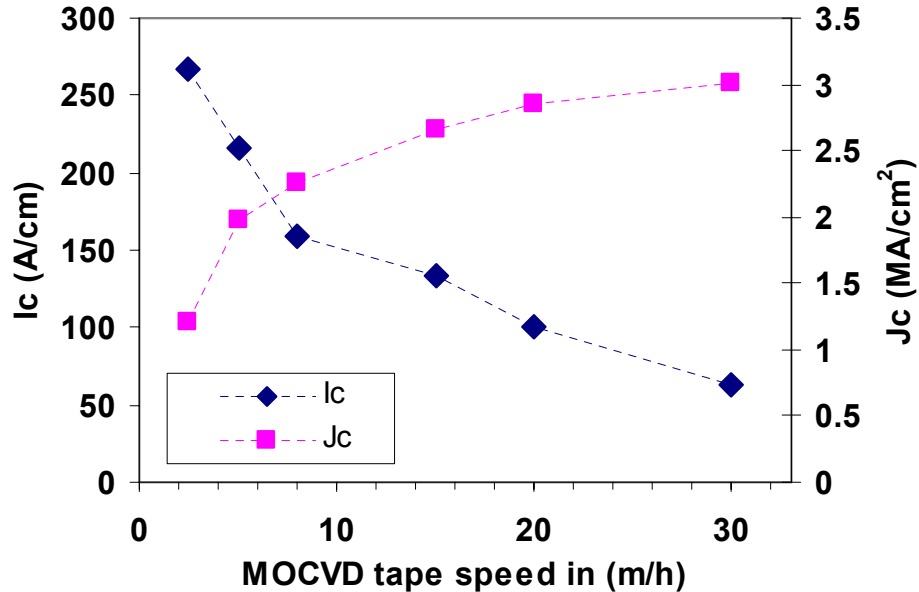
Stability of MOCVD precursor delivery was dramatically improved in the last 3 months



I_c over 12 m = 140 A/cm
Standard deviation = 2%

Excellent uniformity in I_c is achieved by improving the stability in precursor delivery

High deposition rates in MOCVD enable very high linear tape speeds even in a Research system



At a 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

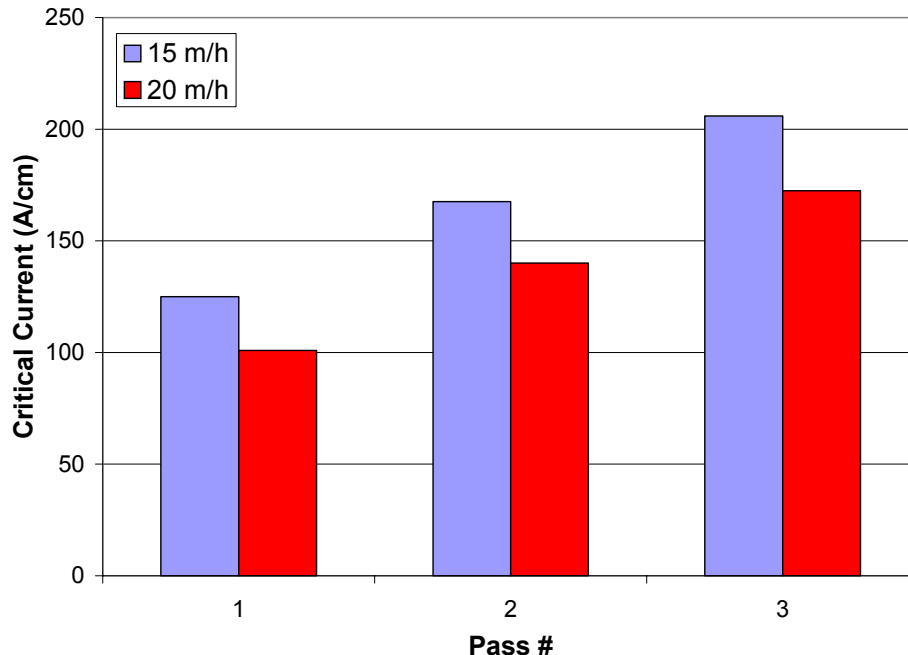
J_c ~ 2.8 MA/cm²

High speed, multipass Process was successfully developed for MOCVD



Multipass processes offer significant advantages for manufacturing

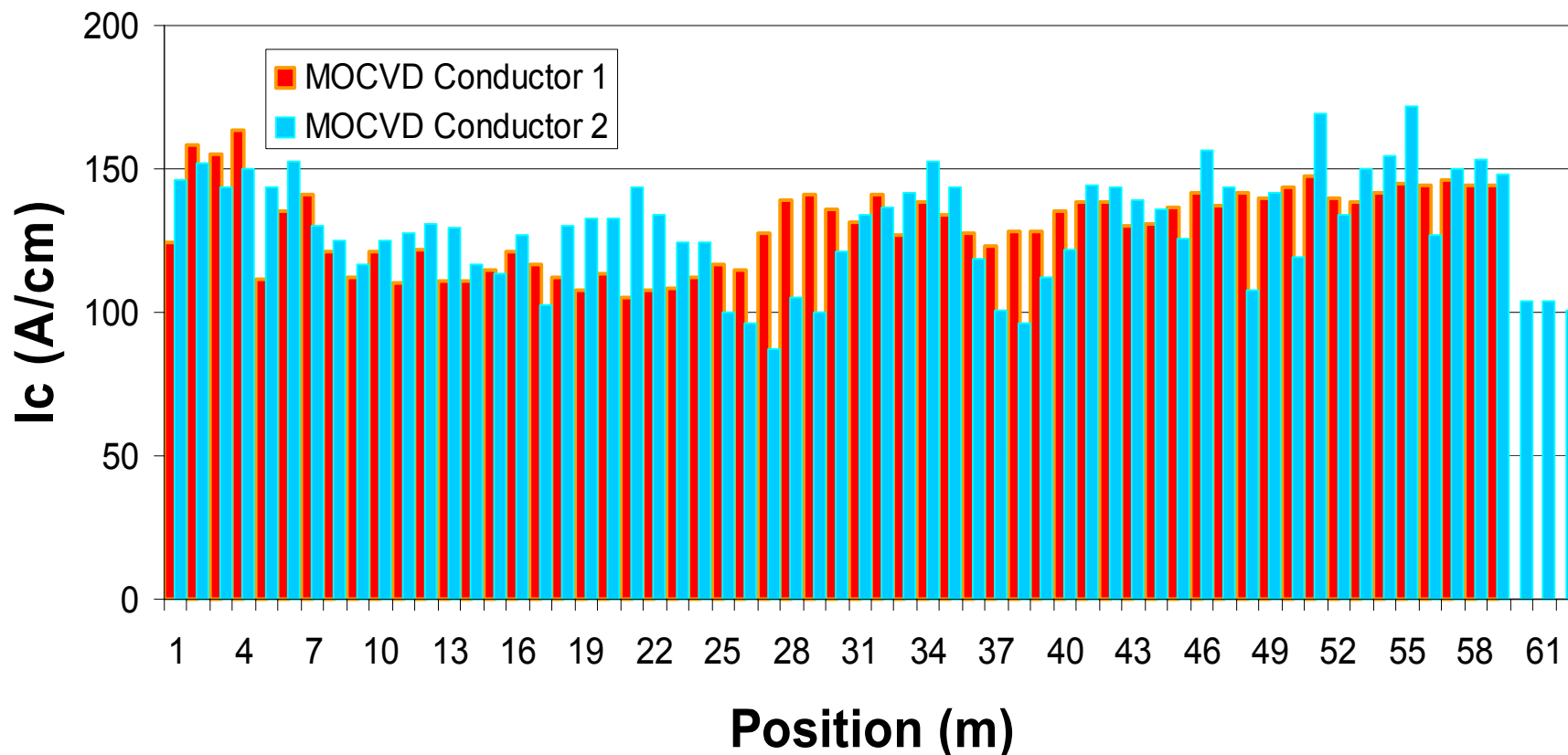
- Time for each pass is reduced by very high speed
- System maintenance can be done between each pass



- **200 A/cm achieved in 3 passes, each at 15 m/h**
 - This is about the same as the I_c achieved in a single pass at 5 m/h
- **175 A/cm achieved in 3 passes, each at 20 m/h**
 - This is about the same as the I_c expected in a single pass at 6.7 m/h (I_c interpolated between that achieved at 5 and 7.5 m/h)

Using a 3-pass process, 100 m tapes can be processed within 5 hours per pass even in a Research MOCVD system with only a 20 cm deposition zone

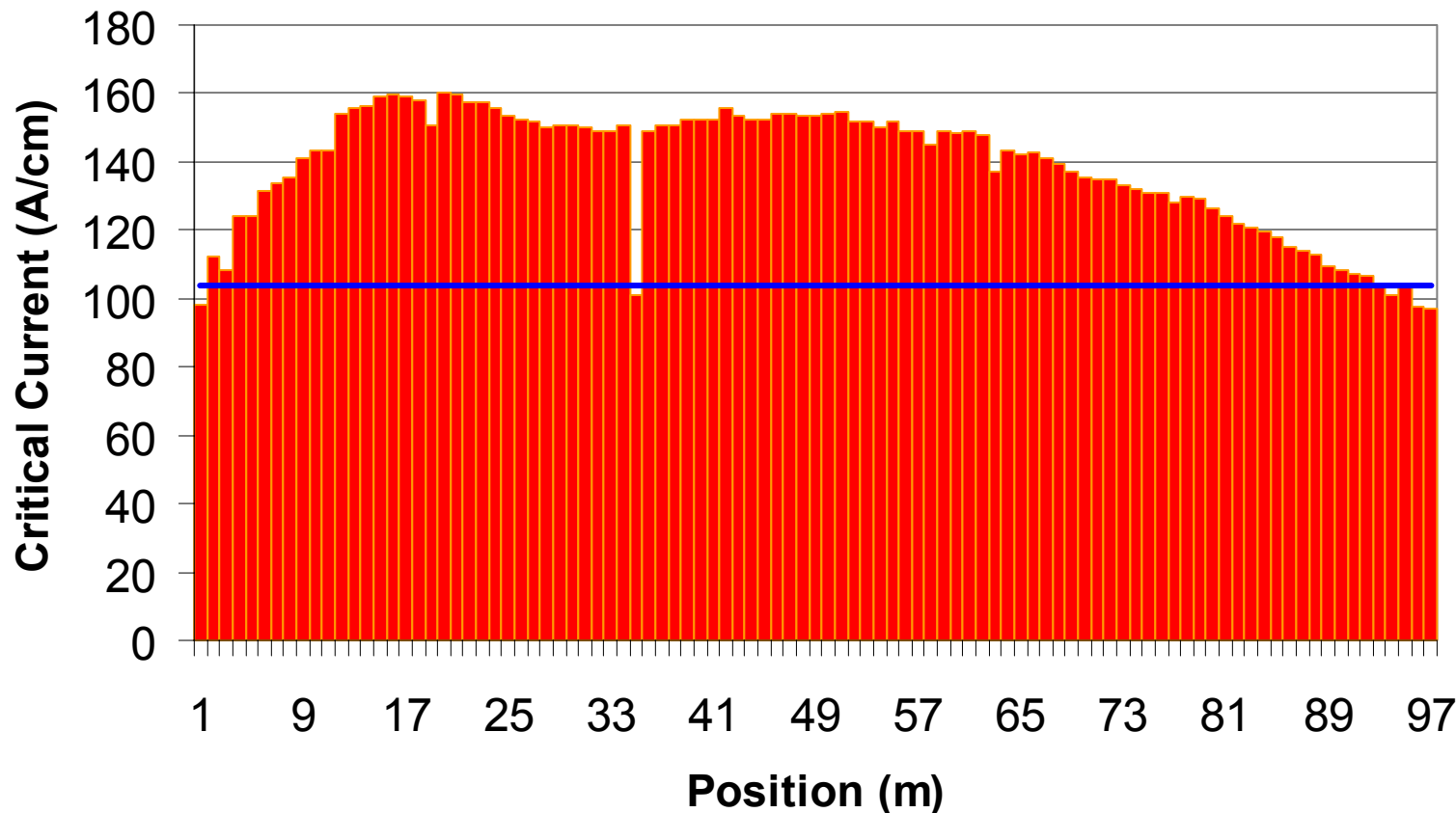
Improved stability in precursor delivery & multipass process enabled 60 m lengths



MOCVD Conductor 1: 100 A/cm over 62 m

MOCVD Conductor 2: 122 A/cm over 58 m

In Dec 2004, we crossed the 10,000 A-m milestone with MOCVD

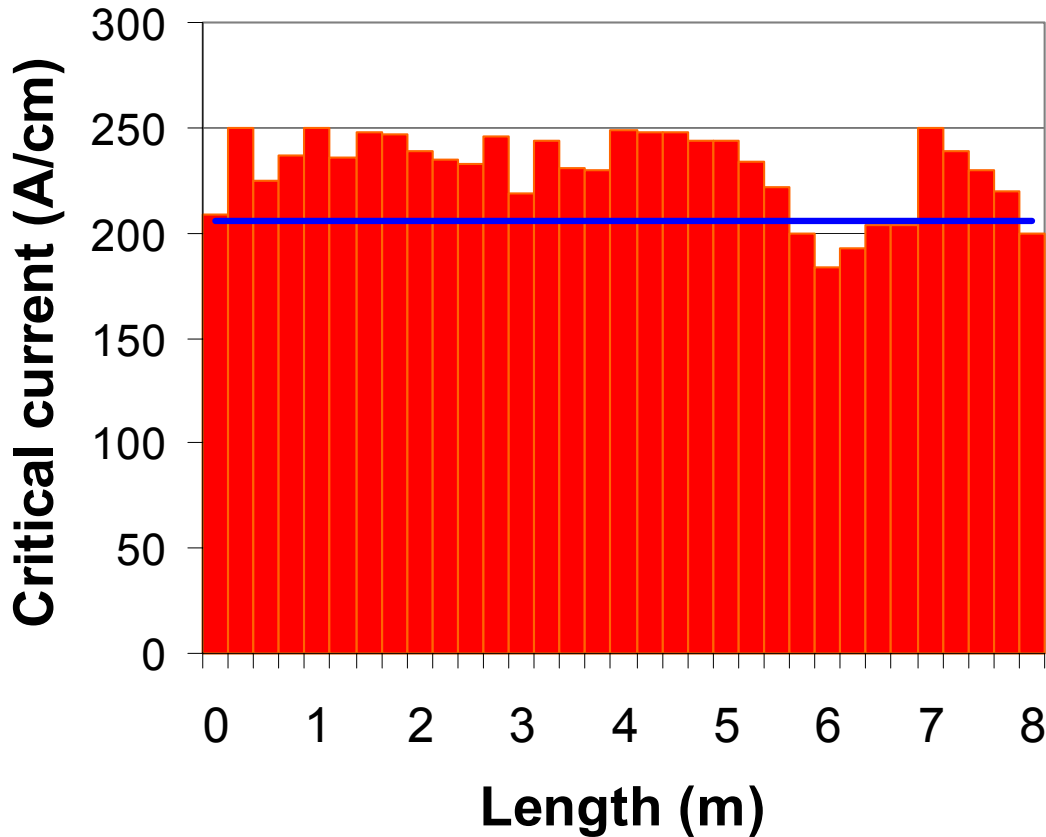


103.7 A/cm over 97 m = 10,050 A-m

5% uniformity over mid 50 m

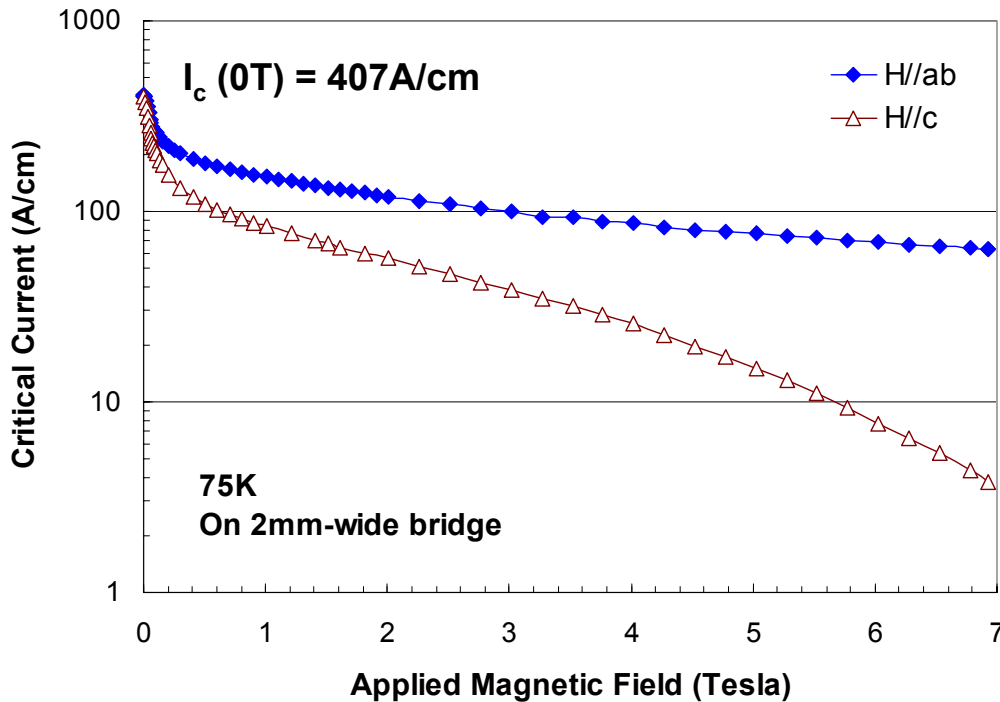
2% uniformity over mid 50 m except for 1 m segment

High currents achieved with MOCVD in R&D piece-lengths



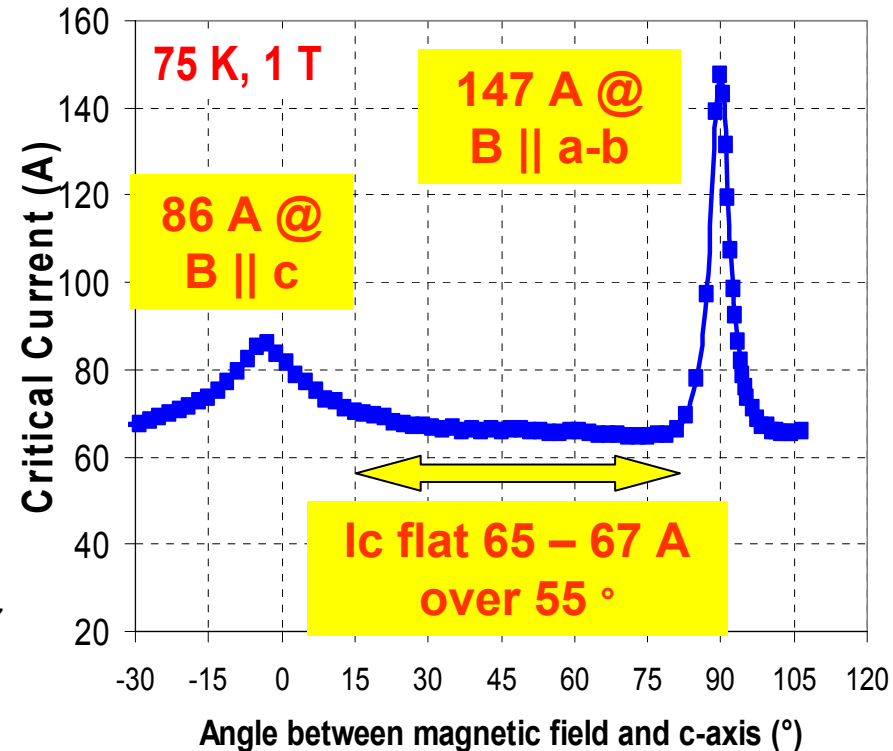
0.07 m	407 A/cm
1 m	265 A/cm
8.25 m	206 A/cm

Conductors with superior in-field performance by rare-earth (Sm) substitution in YBCO by MOCVD



$I_c @ 1 \text{ T} \sim 20\%$ of I_c at zero field

$I_c @ 3 \text{ T} \sim 10\%$ of I_c at zero field



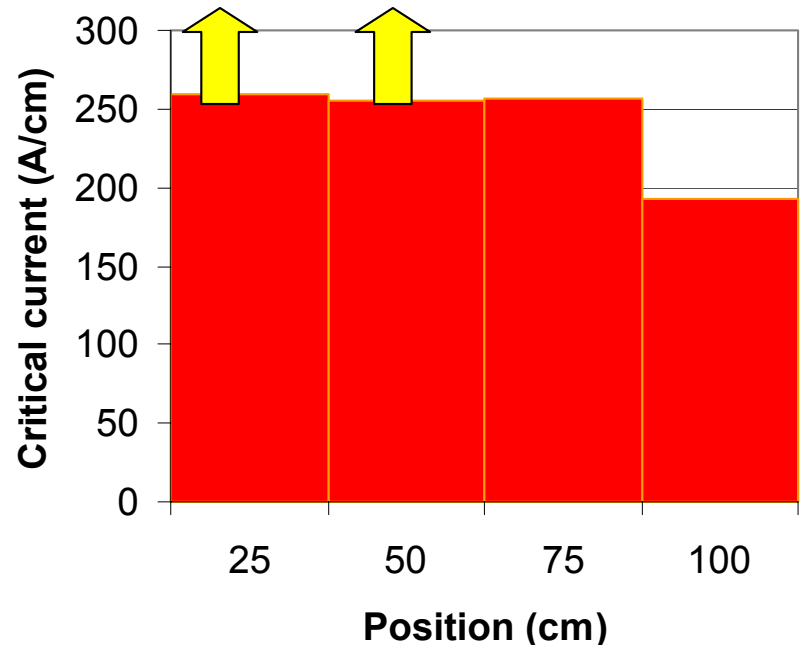
High critical currents achieved over entire range of magnetic field orientations with Sm-substituted YBCO

High engineering current densities achieved in field at 65 K : Selva's presentation, next session

We are combining high throughput processes: MOCVD on IBAD MgO on electropolished substrate



- Up to 60 m/h polishing speed demonstrated in our Production-scale Electropolishing facility
- Tape speeds of 10 m/h are used to fabricate IBAD MgO tapes with a texture of 6 - 7° even in a IBAD system with only 8 cm long deposition zone.
- **220 A/cm has been achieved in MOCVD YBCO on IBAD MgO on 50 micron substrate.**
 $J_e = 36 \text{ kA/cm}^2$
- July 2004 : 116 A over 1.86 m MOCVD on IBAD MgO - First demonstration of 100 A performance over meter+ lengths with IBAD MgO by any process other than PLD.



Jan. 2005 : $I_c > 193 \text{ A/cm}$ over 1 m MOCVD on IBAD MgO

Next Steps

Even higher currents with thicker films

Further improve in-field dependence by rare-earth substitution

Combine the above two with IBAD MgO based buffers on 50 micron thick substrates – highest J_e

100+ m MOCVD tapes with 10 m/h linear speed in every step