High-Throughput Processing of Long-Length IBAD MgO and Epi-Buffer Templates at SuperPower

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Objective: Extend helix tape handling system to all processes for long piece lengths & high throughput

Our use of in-situ processes allows us a choice between processing a wide tape or a narrow tape with helix tape handling.

We chose helix tape handling because of the immense advantages it provides and the demonstrated benefits of a multipass process.

- Much longer (>5 times) single piece lengths - important for wire customers who are already used to several 100 m to 1000 m of 1G
- Much shorter (>5 times) process times for the same piece length
- Less concern with uniformity across width (5 times narrower)
Pilot Production Equipment was upgraded in FY06 for high throughput processing of all layers

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<thead>
<tr>
<th></th>
<th>FY05 status</th>
<th>FY06 plan</th>
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<tbody>
<tr>
<td>IBAD</td>
<td>Helix tape handling</td>
<td>Transition to IBAD MgO in Pilot IBAD. Modify hardware accordingly.</td>
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<td>YSZ: 1 m/h</td>
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<tr>
<td>Buffer</td>
<td>n/a</td>
<td>New Pilot Buffer system with helix tape handling</td>
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<tr>
<td>Single tape: 5 m/h</td>
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<td>Retrofit with helix tape handling; Increase deposition zone length &amp; width</td>
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- Tremendous challenge to successfully implement modifications in three critical equipment simultaneously & then routinely produce 10,000 m of conductor for delivery to Albany Cable Project.
High-throughput IBAD MgO has been transitioned to Pilot IBAD system

Pilot IBAD system: Helix tape handling with a deposition zone length of 60 cm, 6 tape wraps. With IBAD YSZ, yielded ~ 1 m/h.

– With IBAD MgO would enable linear tape speeds > 100 m/h (or a throughput > 300 m/h of 4 mm wide tape)

IBAD MgO tapes up to 570 m long have been produced with a deposition zone of 42 cm & a speed of 65 m/h of 12 mm wide tape i.e. 195 m/h of 4 mm wide tape
Up to **570 m long single-piece** IBAD MgO tapes routinely processed in Pilot IBAD with good & uniform texture.

Uniform RHEED patterns obtained over process lengths up to 800 m.
Pilot Buffer System has been established for long-length, high-throughput buffer layers for IBAD MgO

- Two chambers for sequential deposition of 2 buffers (homo-epi MgO & LMO) on IBAD MgO
- Helix tape handling in both chambers, each with 12 tape wraps. Deposition zone length in each chamber = 0.3 m
- Spool boxes for 1 km single-piece lengths
550 m long tapes have been produced in Pilot Buffer system at linear speeds of 40 m/h

Using only 6 of the 12 tape tracks in helix tape handling in Pilot Buffer system, 40 m/h tape speed is routinely used to produce up to 550 m lengths of homo-epi MgO and LMO on IBAD MgO.

In-plane texture of LMO over 550 m produced at 40 m/h = 7.4°
Retuning of MOCVD process based on XRD data yielded high Ic over 300 m with excellent uniformity

Min Ic = 263 A = 219 A/cm over 322 m. Uniformity of 4.3% over 322 m.

World Record: 70,520 A-m!

YBCO thickness
1.2 μm

Composition
Y+Sm 1.21
Ba 1.64
Cu 3.14

Y+Sm 1.19
Ba 1.77
Cu 3.04

77 K, Ic measured every meter over entire tape width of 12 mm
Routine production of IBAD MgO now:
700 – 800 m per run

- Process length increased to ~ 770 m with two single-piece lengths
- Single piece lengths up to 570 m – limited by substrate

- 25 production runs yielding 14,660 m of 12 mm wide IBAD MgO tapes
  produced in the last 5.5 months – equivalent to 43,980 m of 4 mm wide tape
Routine production of Homo-epi MgO & LMO buffers now 500 – 600 m lengths per run

- Process length has been typically 400 – 500 m. Now 500 – 600 m
- No change in process parameters since the beginning of production!
- Single piece length up to 570 m – limited by substrate.

37 production runs yielding 12,520 m of 12 mm wide buffer tape equivalent to 37,560 m of 4 mm wide tape produced in the last 4 months
Summary

SuperPower has successfully transitioned from low-throughput IBAD (ion beam assisted deposition) YSZ technology to high-throughput IBAD MgO technology.

Pilot-scale IBAD system and pilot-scale epi-buffer deposition system have been established, each with the capability of producing single-piece lengths over 1000 m.

IBAD MgO buffer stack and their processes have been developed together with high throughput where each layer in the buffer stack is processed at 40m/h tape speed or higher during our Phase I scale-up. 700-800m IBAD MgO tape per run is routinely produced in pilot IBAD system with single piece tape length ~ 570m. 400-550m epi-buffer tape per run is routinely produced in pilot buffer system.

High-throughput IBAD MgO buffer gives better texture of YBa2Cu3O7 (YBCO) film compared with IBAD YSZ, and superior superconducting properties. World record critical current * length value of > 70,000A-m was obtained with the high throughput IBAD MgO buffers.