

Recent Advance in Cost-effective Chemical Solution Derived ReBaCuO Coated Conductors

C. B. Cai, M. Yu, Y. Q. Guo

**Shanghai Key Laboratory for High Temperature
Superconductors, Shanghai University, China**

Shanghai Creative Superconductor Technologies Co. Ltd.

cbcai@shu.edu.cn



Outline

1、 Technology Routes Applied in SHU & Spin-off Company

2、 Improvement on Textured Buffer and HTS processing

3、 State of the Art for Typical MOD Tapes in Shanghai

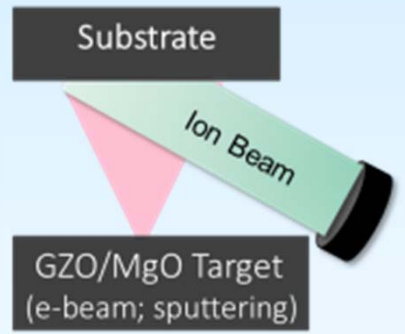
HTS Coated Conductors

@Shanghai University & Spinning-off Company, SCSC

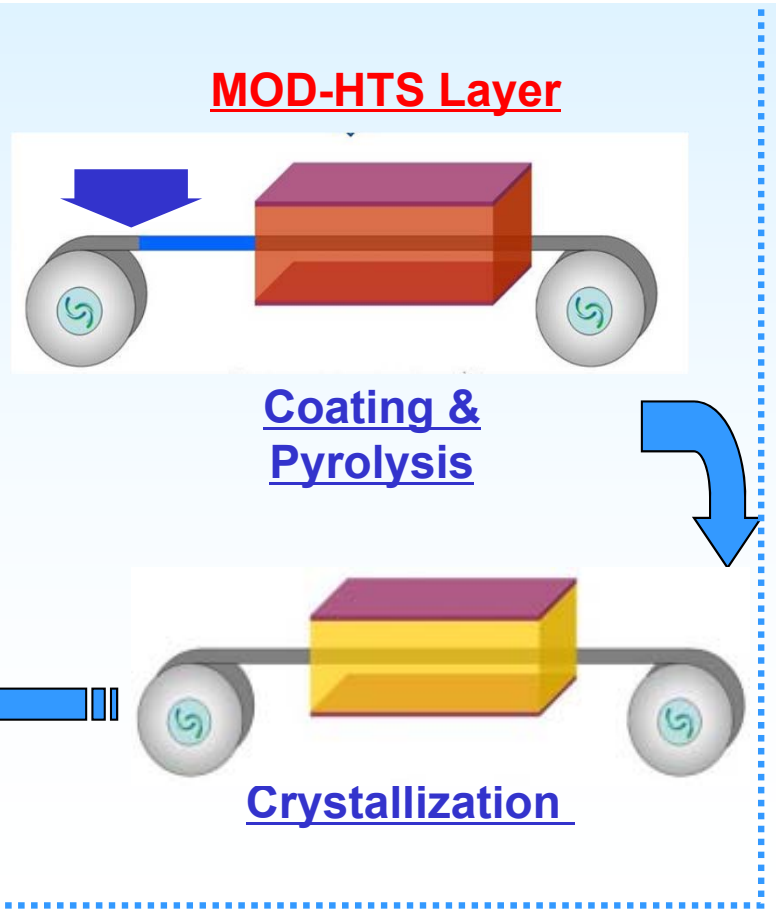
- ◆ Textured Oxide Buffers on Textured or Untextured Tape via RABiTS or IBAD
- ◆ Epitaxial HTS Films on Textured Oxide Buffer via MOD



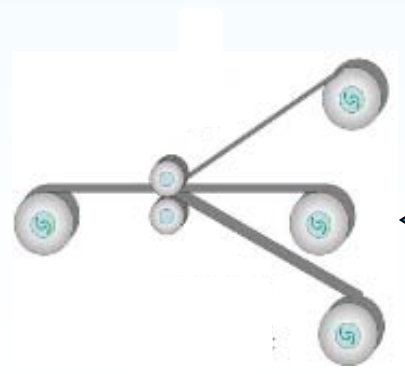
or



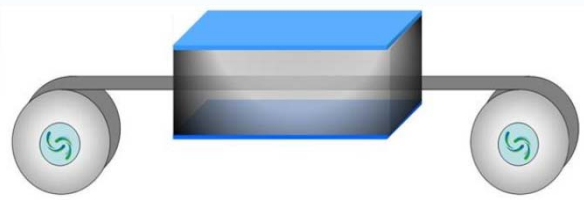
上海创意超导科技有限公司
Shanghai Creative Supercond. Technol. Co. Ltd



Oxide Buffer on Textured or Untextured



Slitting & Package



Protection

Cost-effective MOD Technology Developed at Shanghai Uni. & Production Line at Shanghai Creative Supercond. Technol. Co. Ltd.(SCSC)

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● Electropolish of Substrate



● Sputtering Buffer



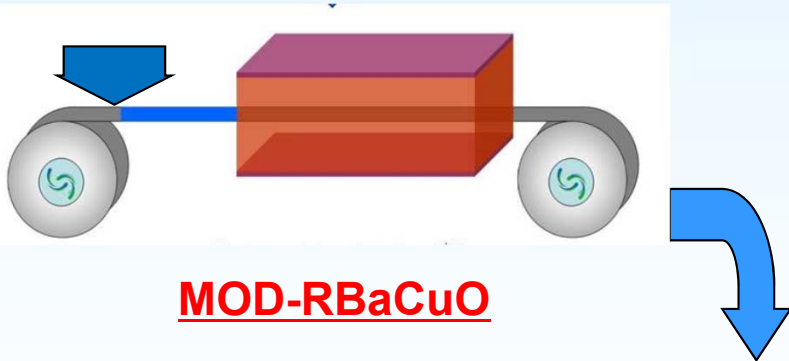
● MOD HTS Layer



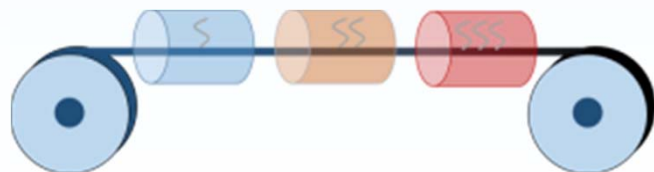
● Lamination



Coating and Low-temperature Pyrolysis



MOD-RBaCuO



High-temperature Crystallization

- **Cost-effective MOD**
 - Non-vacuum, low cost tools
 - Easy and accurate to modify composition
 - 100% utilization of precursor solution
 - Readily scale up for wide-web process
 - “Dirty” films, but helpful for pinning
- **Independently developed pilot lines**
 - Smart control system
 - In-situ quality inspection

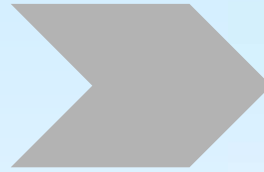
Reel-to-Reel Production Line Spinning off from Shanghai University



For buffer layers



Spin-off



Industry-level Sputtering Production Line

NSFC、MOST-863/973 Project



STCSM-Key Project



Shanghai Municipal Key Project



For HTS layers



Spin-off



Industry-level MOD Production Line

Research Level R2R MOD System

Outline

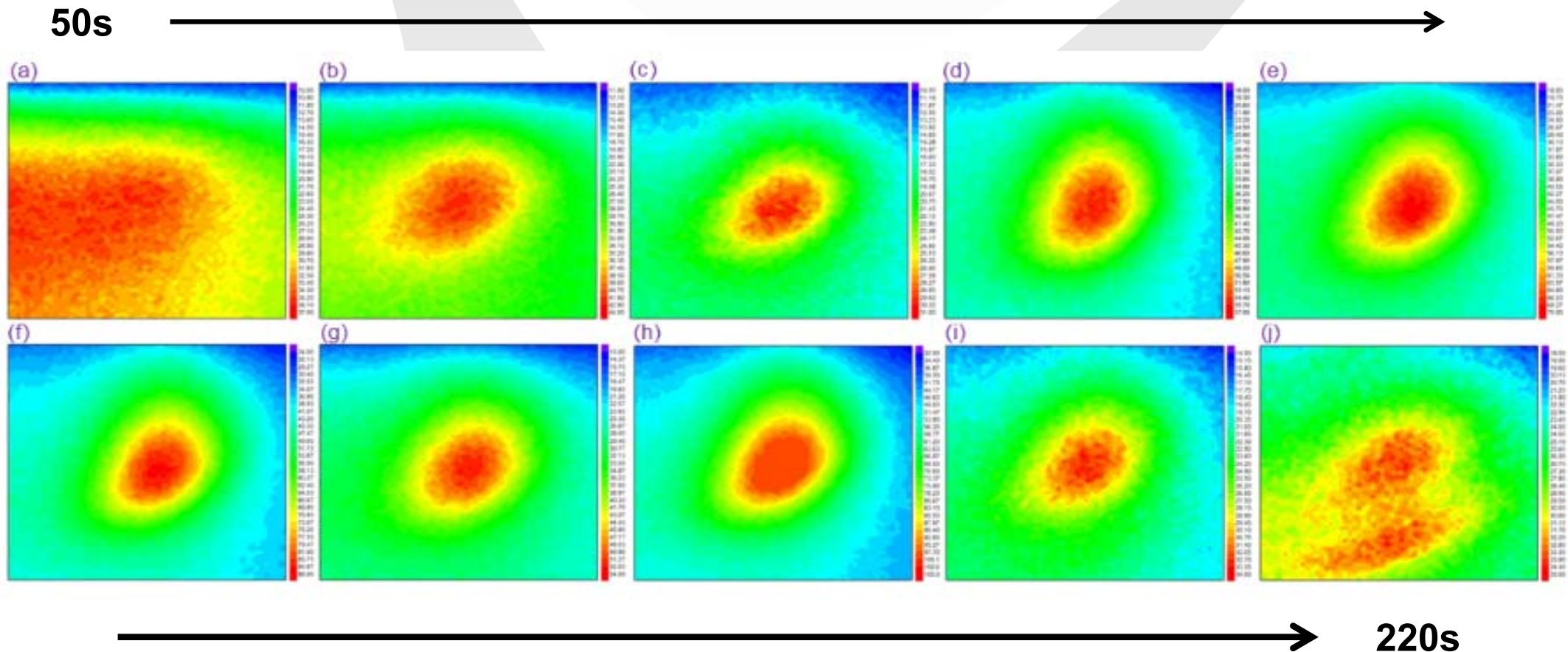
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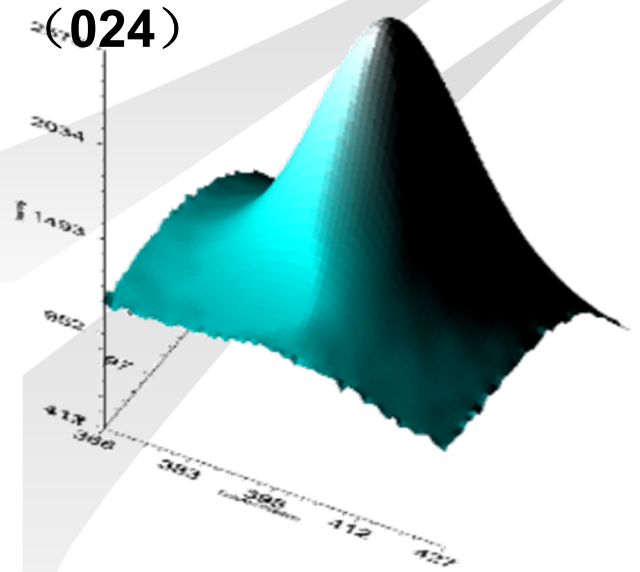
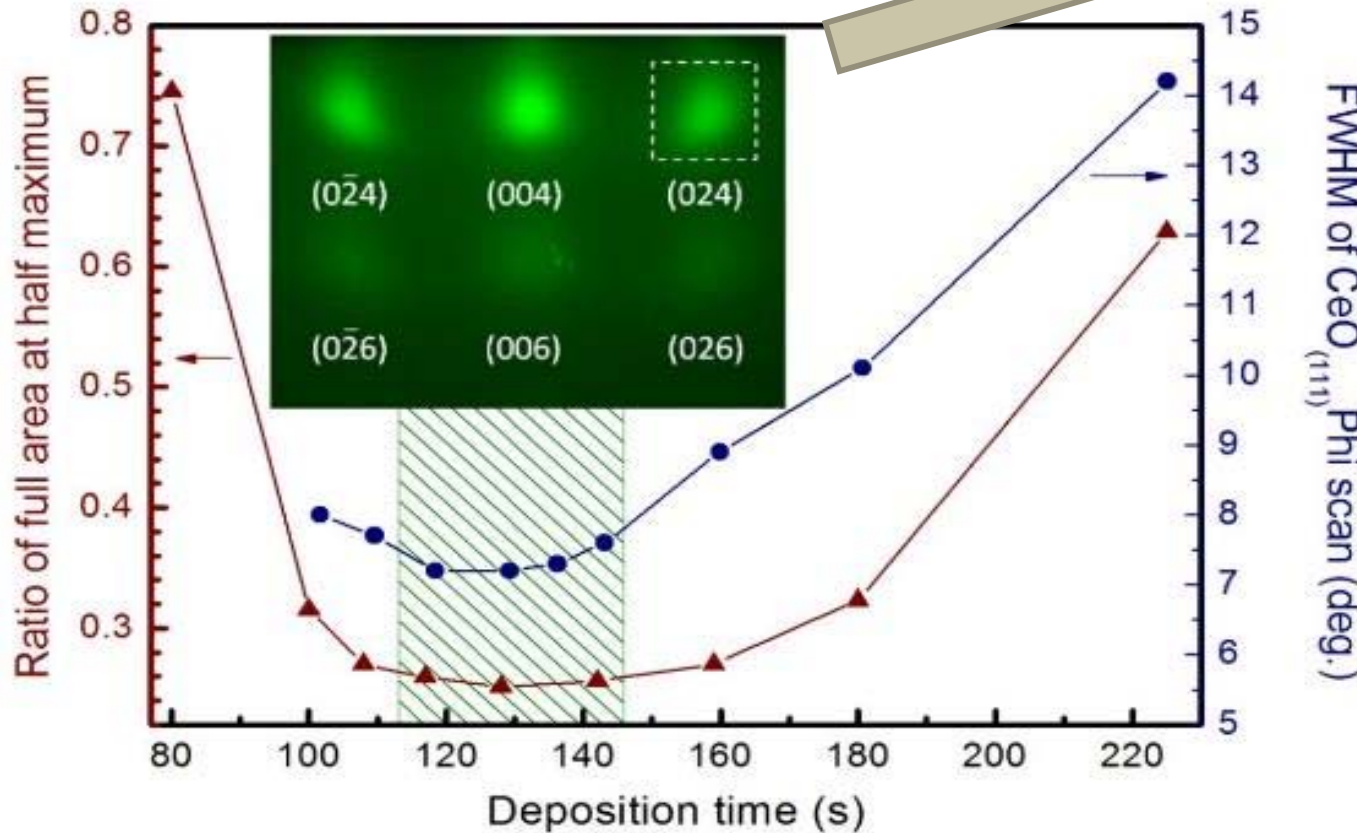
On-line RHEED Observation for Texture Evolution of Oxide Buffer on Untextured Tape

- ◆ Peak intensity of RHEED pattern for using PVD tools
- ◆ Increasing intensity at proper time windows



Evaluation Method Developed for Texture of Oxide Buffer

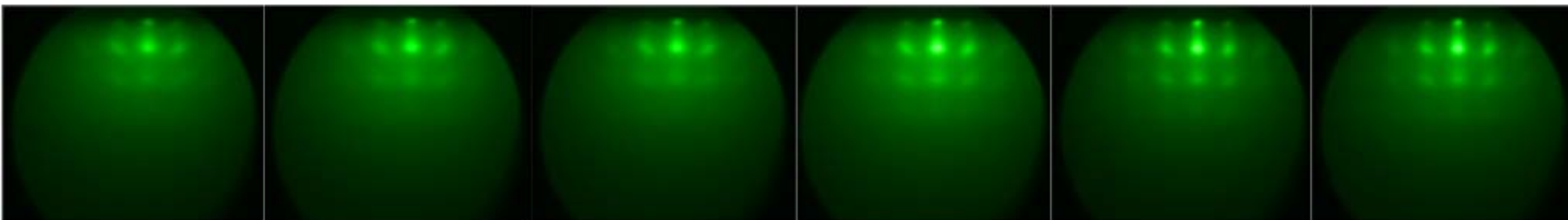
- Direct comparison of time dependence of In-situ RHEED pattern and ex-situ x-ray Phi scanning



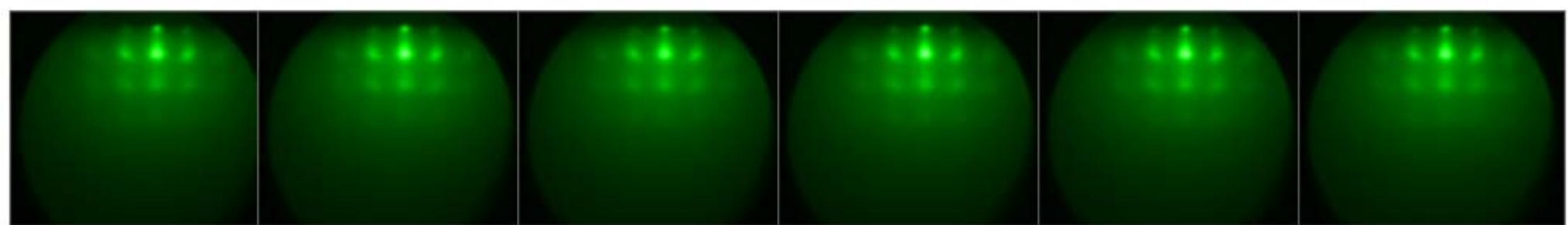
- Characteristic Method Developed For in-situ Check of Texture

On-line Check for Texture of Kilometer's Oxide Buffer on Untextured Metallic Tapes

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10m 50m 100m 9 200m 300m 400m



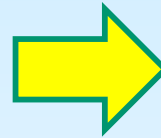
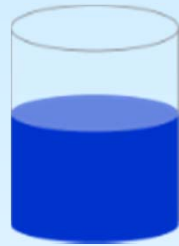
500m 600m 700m 800m 900m 1050m

RHEED observation for texture for 1050 meter tape

Industrial Process for MOD-RBaCuO Coated Conductors¹⁰



Solution Preparation



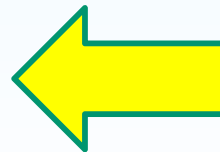
Coating + Low temperature Pyrolysis



High-temperature Crystallization



Oxygenation





◆ To increase the production rate

➤ Shorter Pyrolysis Time:

Low-fluorine (ISTEC/AMSC/Tsinghua/...); TFA-Anhydride(ICMAB);

Additions such as DEA/TEA (SNL/SHU...) /PEG(ICMAB, Tsinghua...)

➤ Less Crystallization Time:

Low ambient pressure(SNL/AMSC...); Fast gas flow

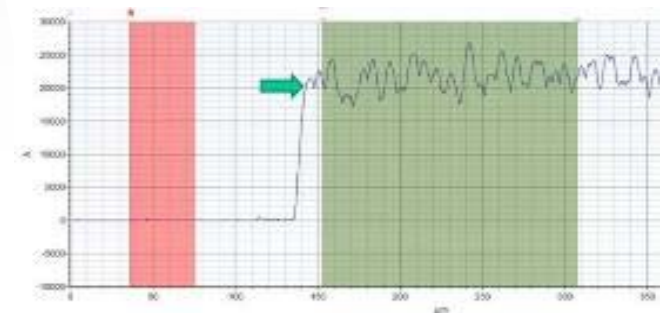
1.4-2.1 μm YBCO by single MOD coating developed in Shanghai University

◆ To improve performance

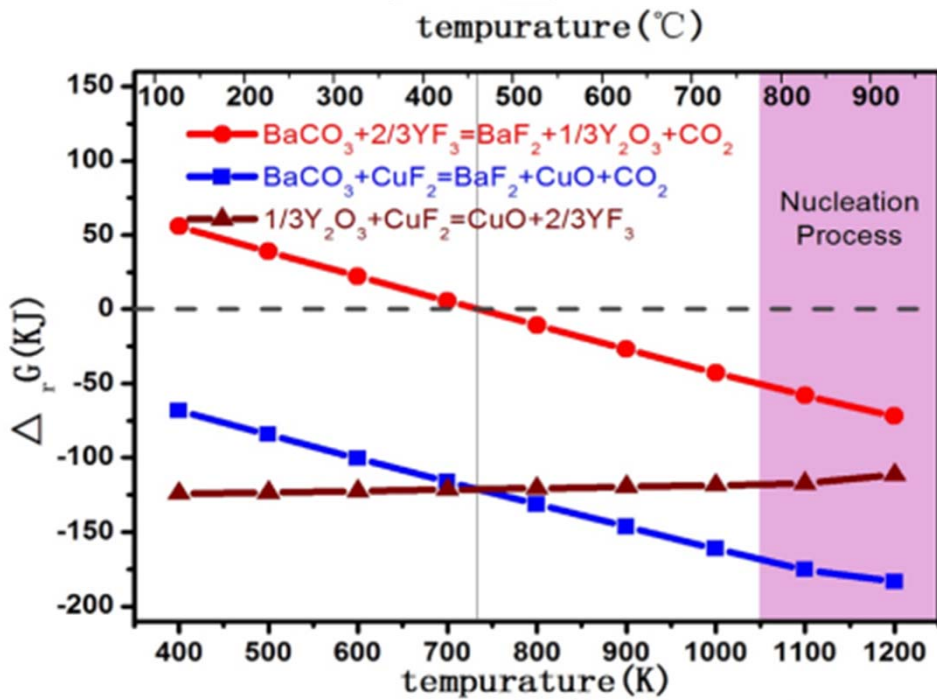
➤ Increased thickness of YBCO layer

➤ Enhanced flux pinning via doping

➤ Improved morphology via doping



Dramatic Reduction For Pyrolysis Time of MOD

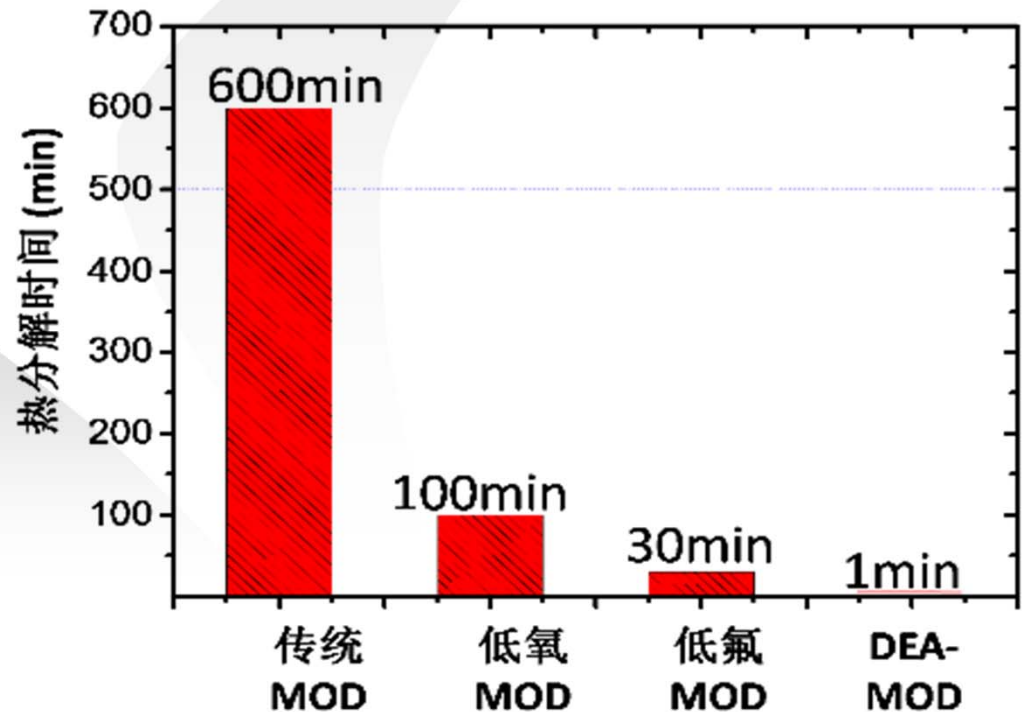


$\Delta G < 0$, Possible reaction

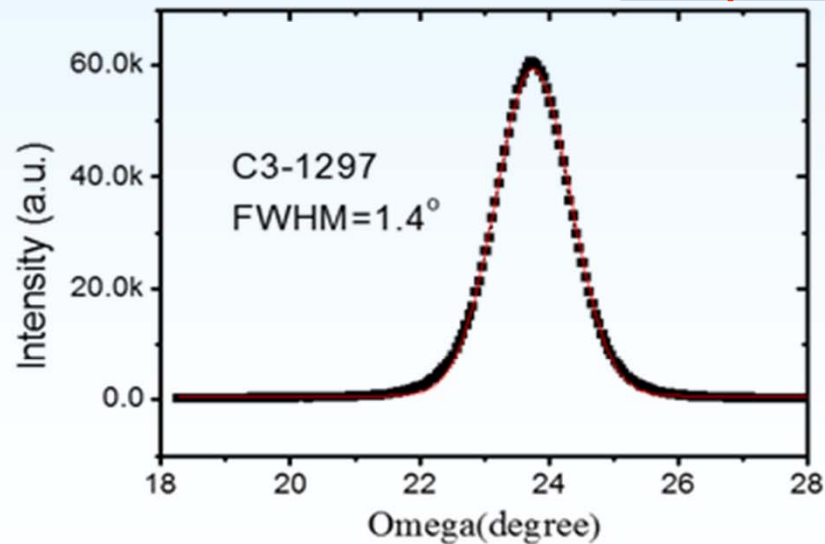
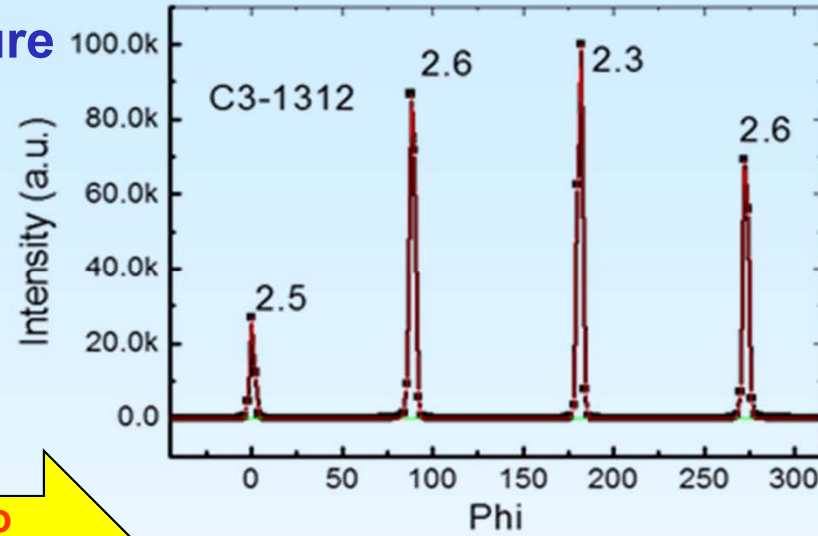
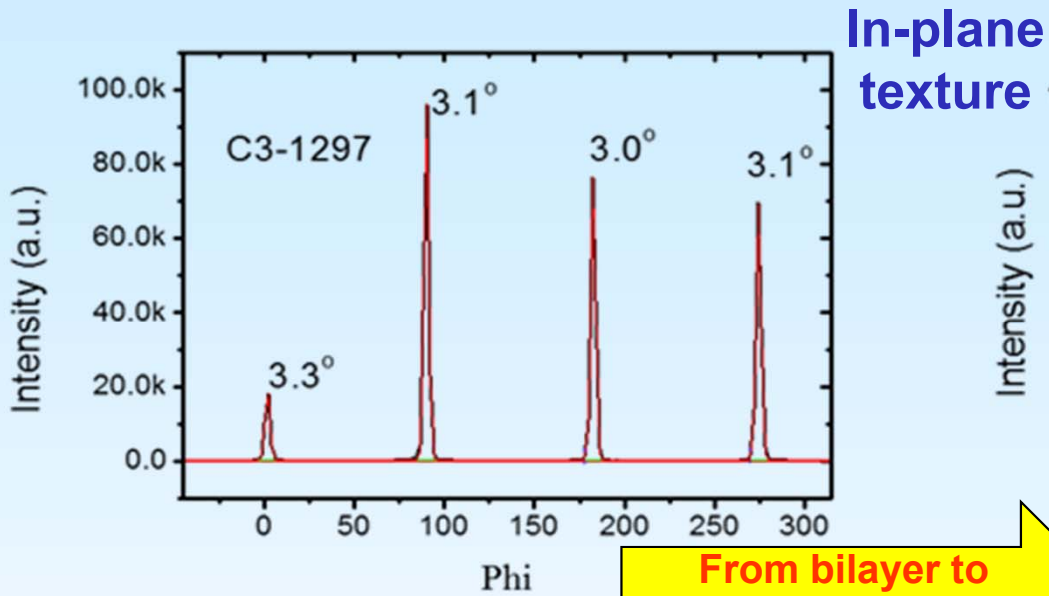
$\Delta G = 0$, Balanced reaction

$\Delta G > 0$, Impossible reaction

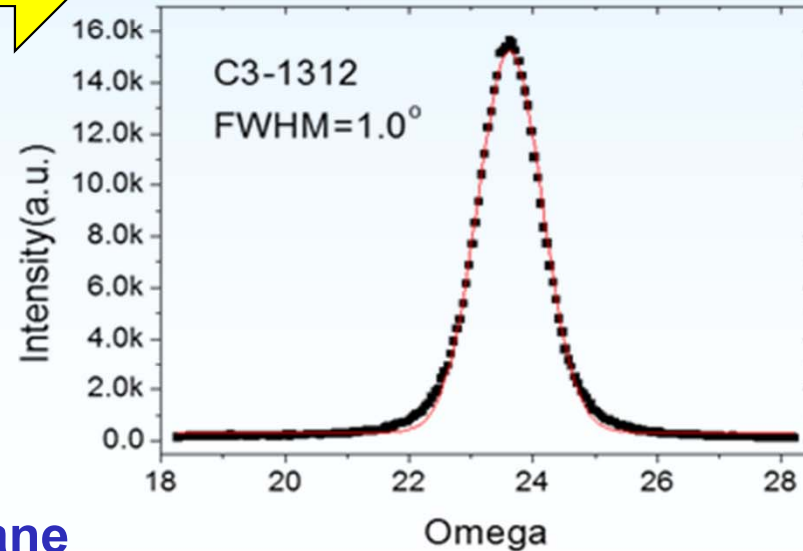
$$\Delta G_T^\theta = \sum v \Delta G_{f,T}^\theta(\text{products}) - \sum v \Delta G_{f,T}^\theta(\text{reactants})$$



- ◆ Pyrolysis time reduced to be as short as one minute using extremely low F-content solutions
- ◆ Smooth and dense films obtained at a pyrolysis rate as high as 25 K/min



Out-plane texture



HTS Bilayer (1.0~1.1 μm thick)

HTS Trilayer (1.4~1.6 μm thick)

Most other groups

$$\Delta\phi \sim 4^\circ$$

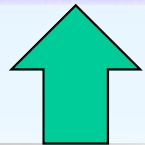
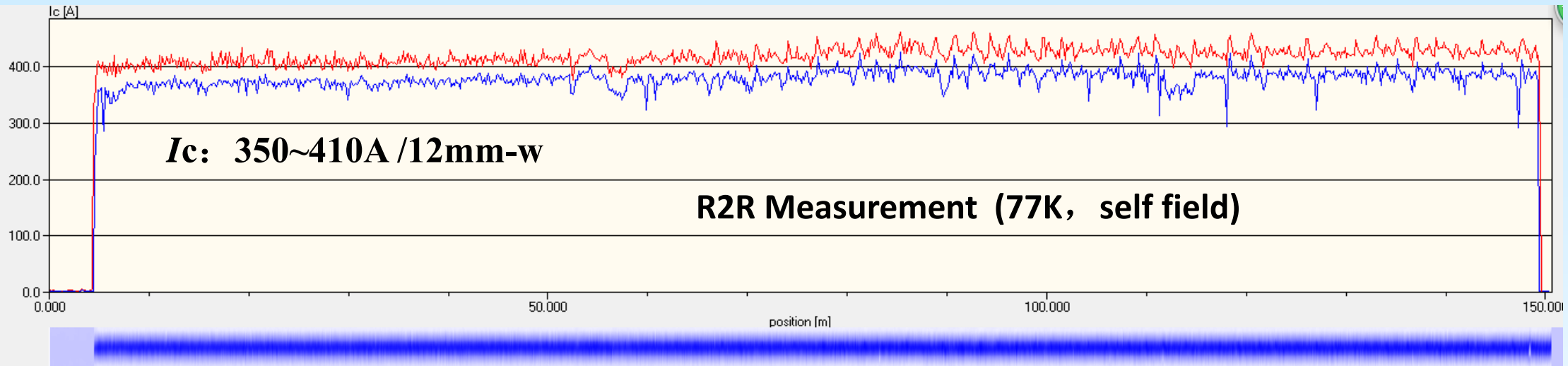
$$\Delta\omega \sim 2^\circ$$

Outline

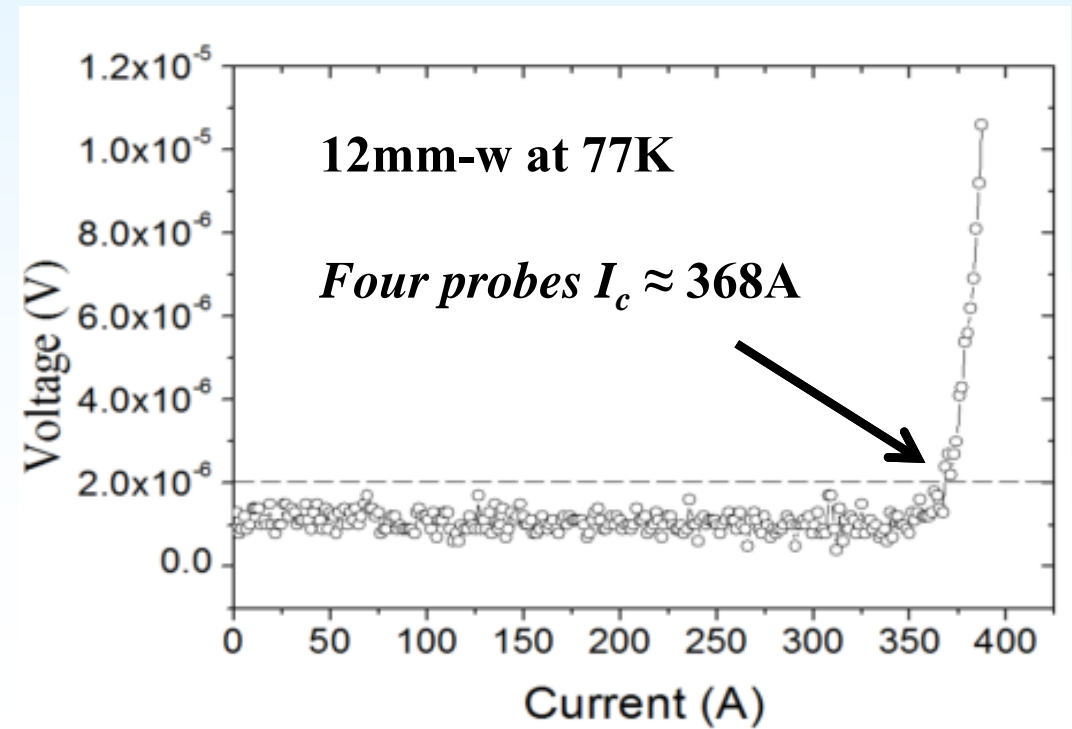
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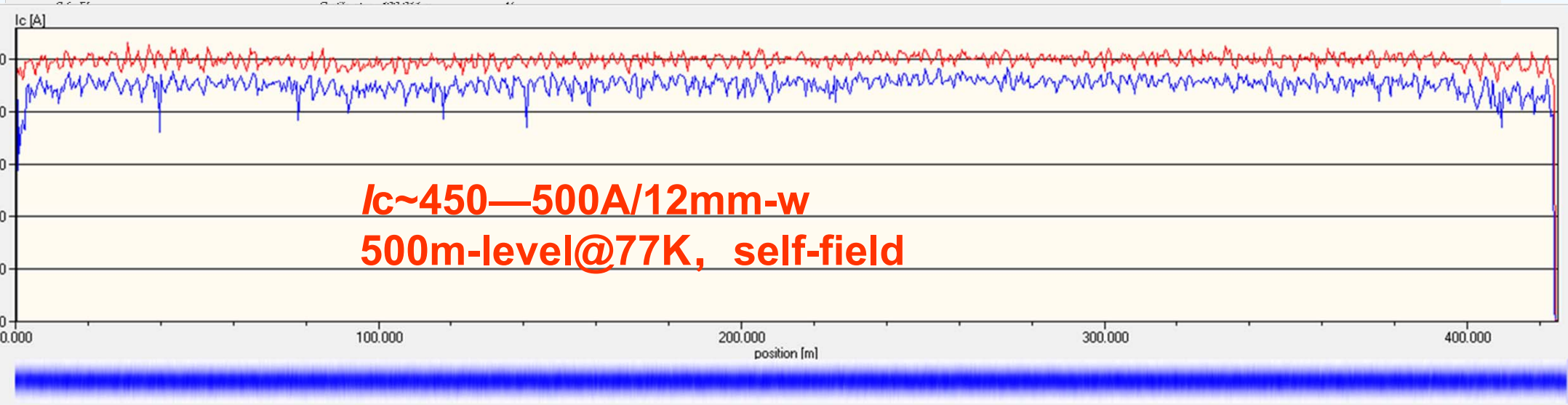
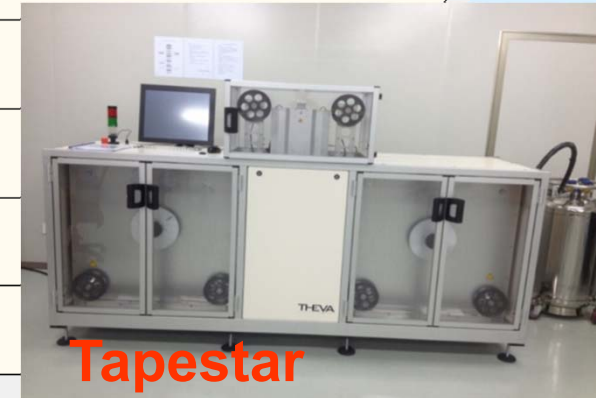


Tested by THEVA TapeStar

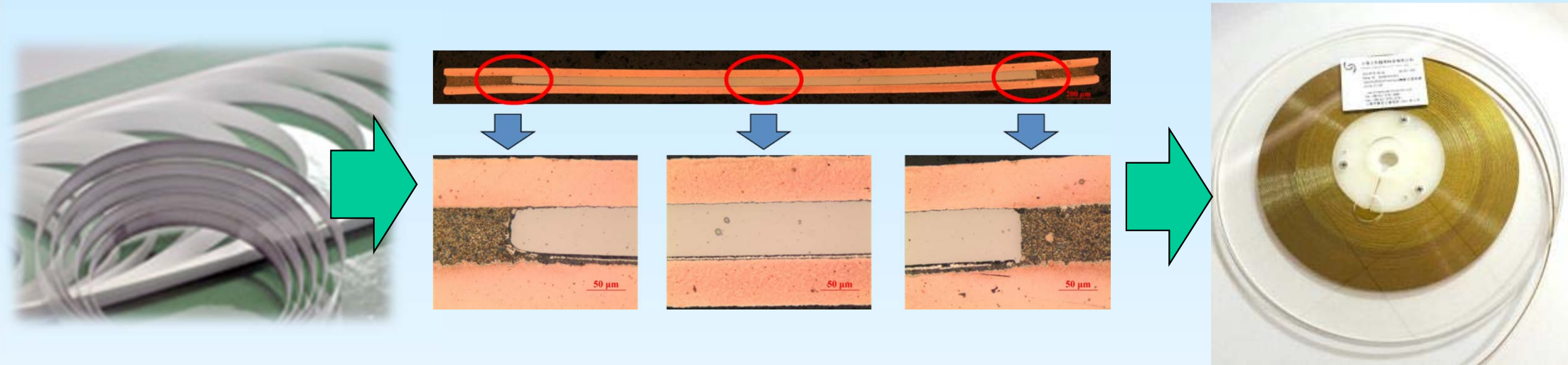


Critical Current for Modified MOD-HTS Tapes at SCSC

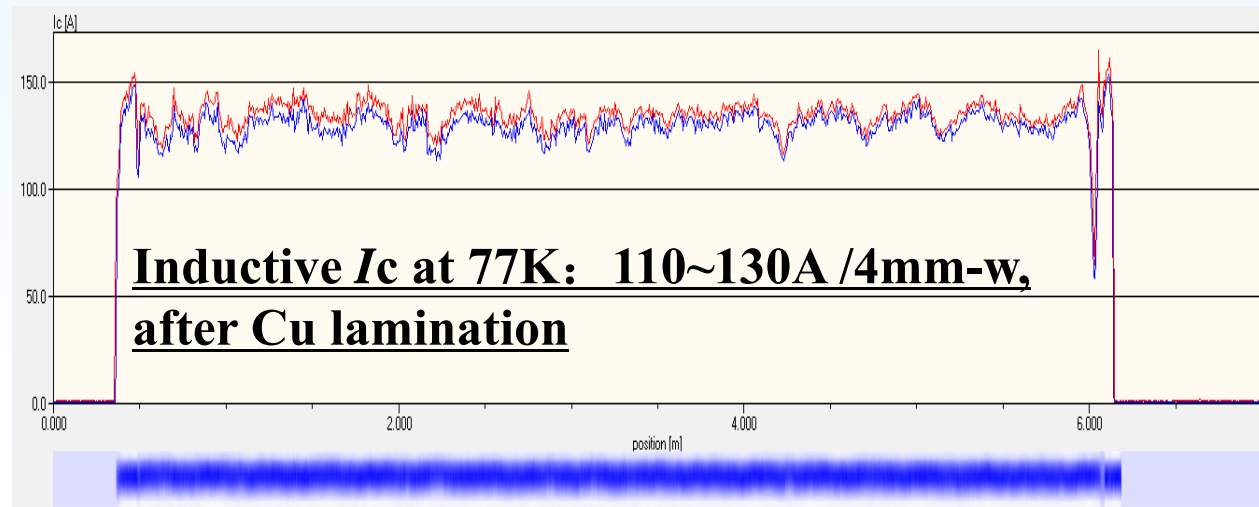
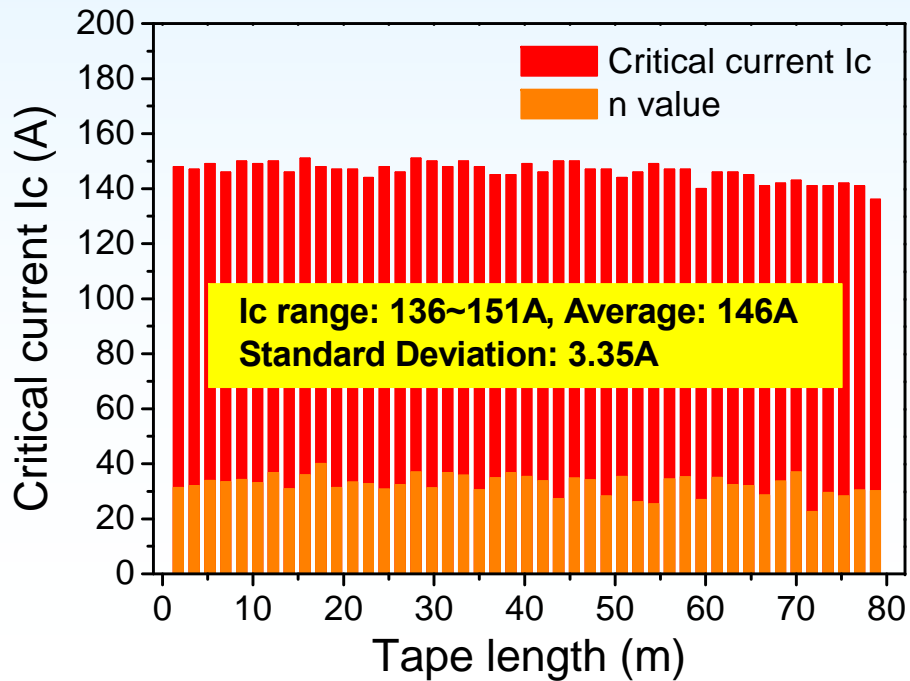
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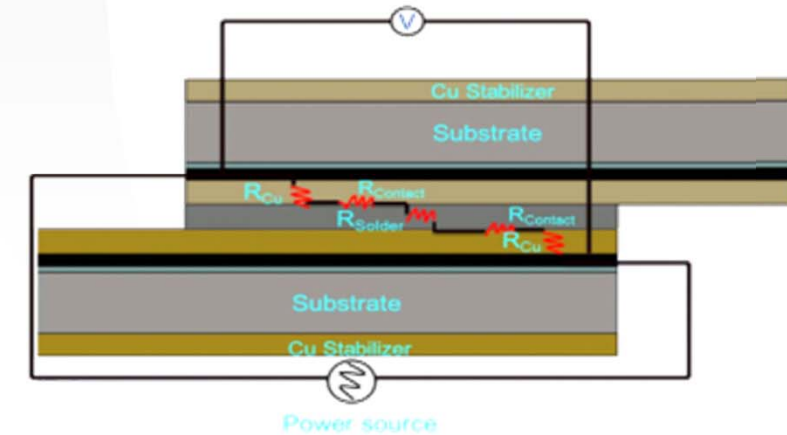
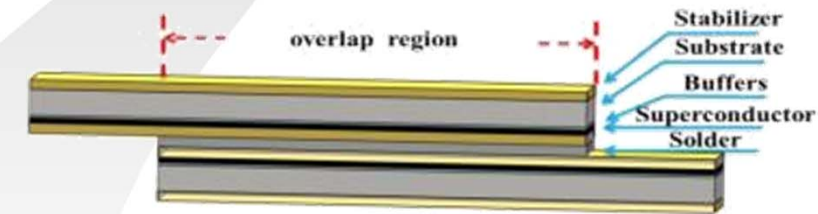
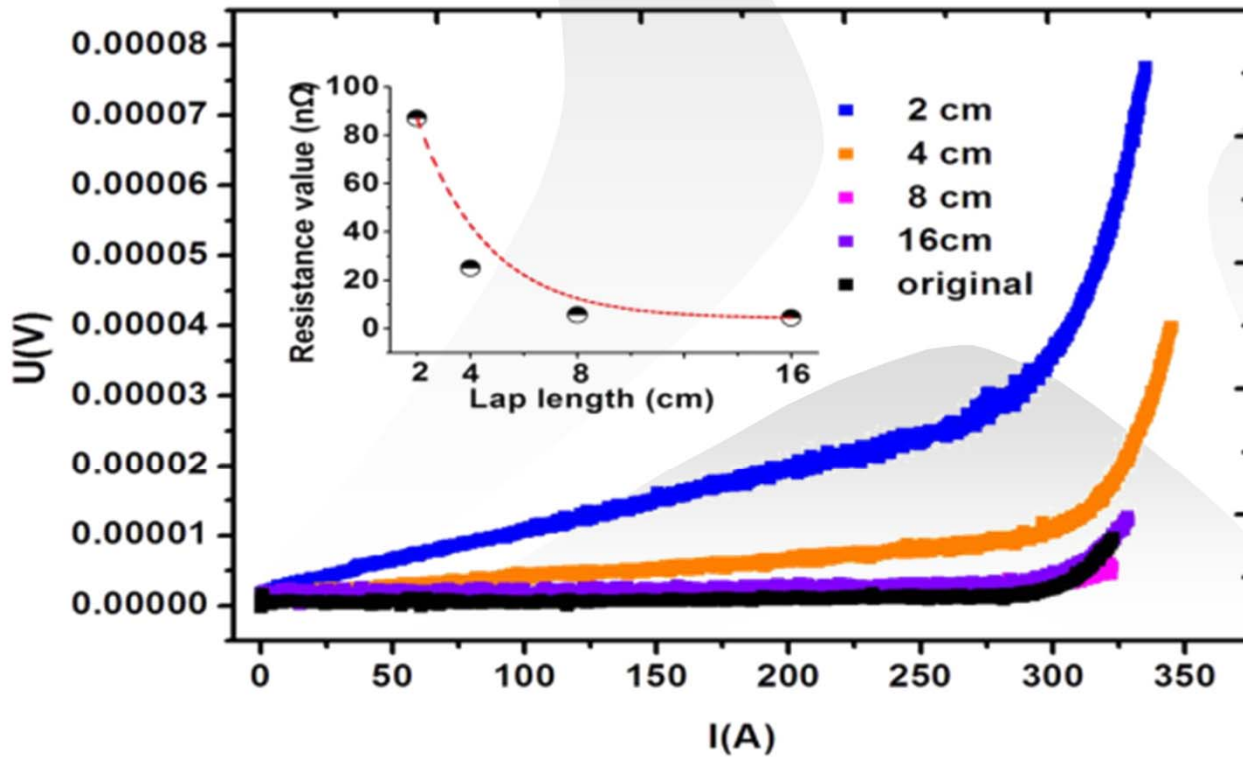
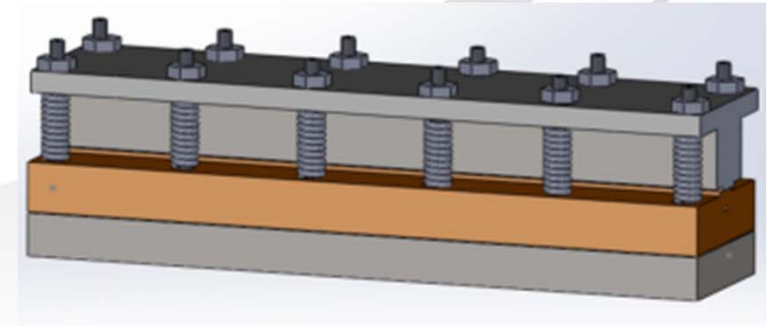
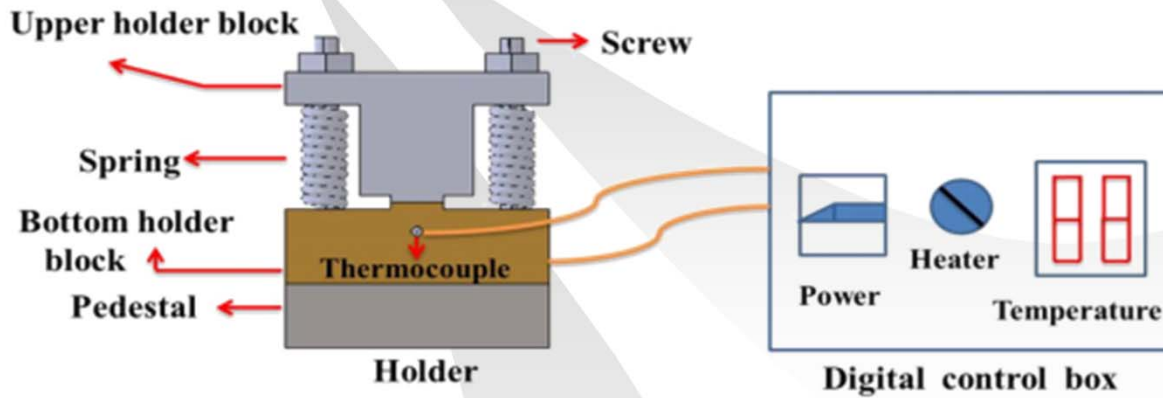


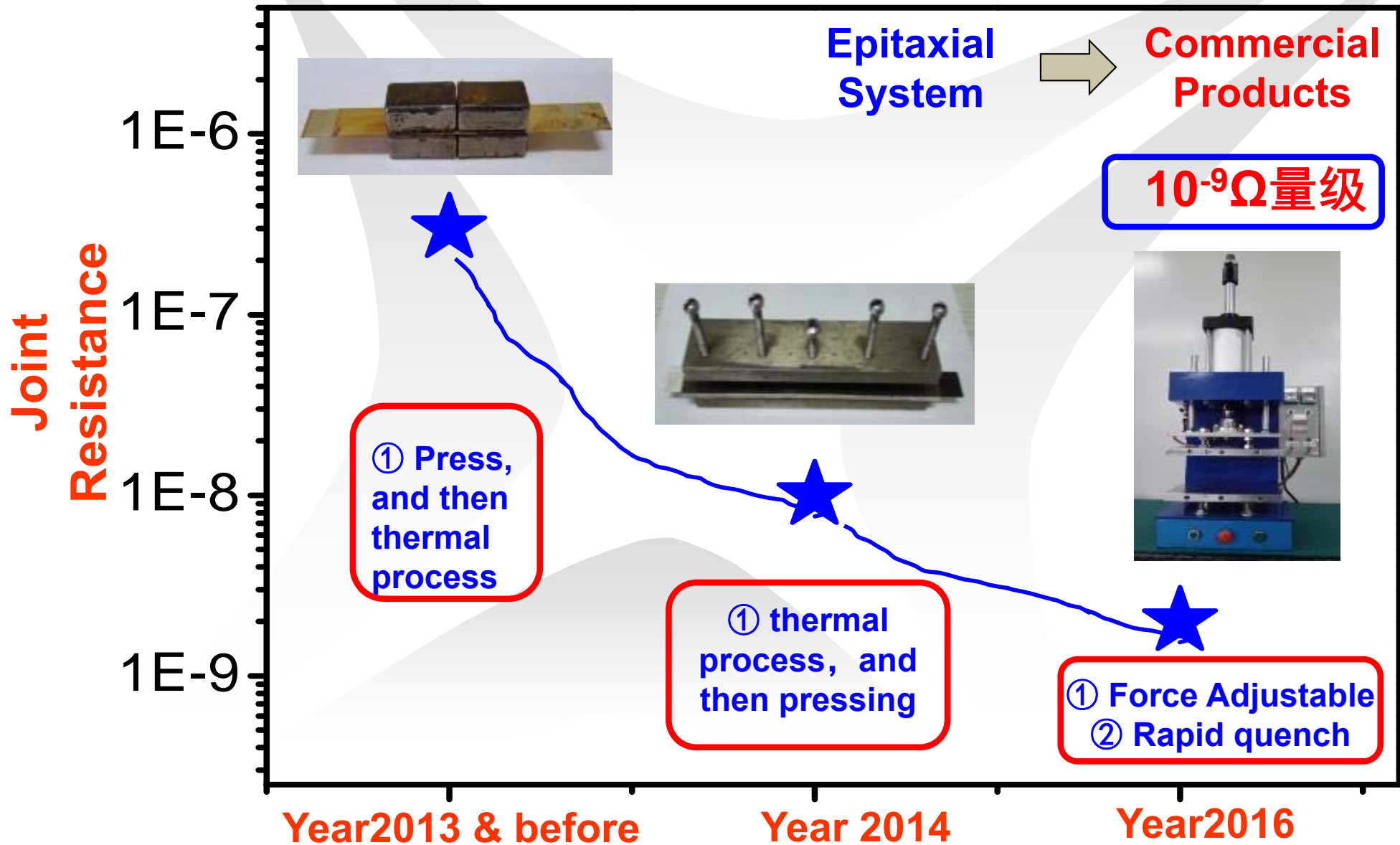
Laminated with Brass and Polyimide Insulating Tapes 17



Commercial 4mm-width HTS tapes laminated

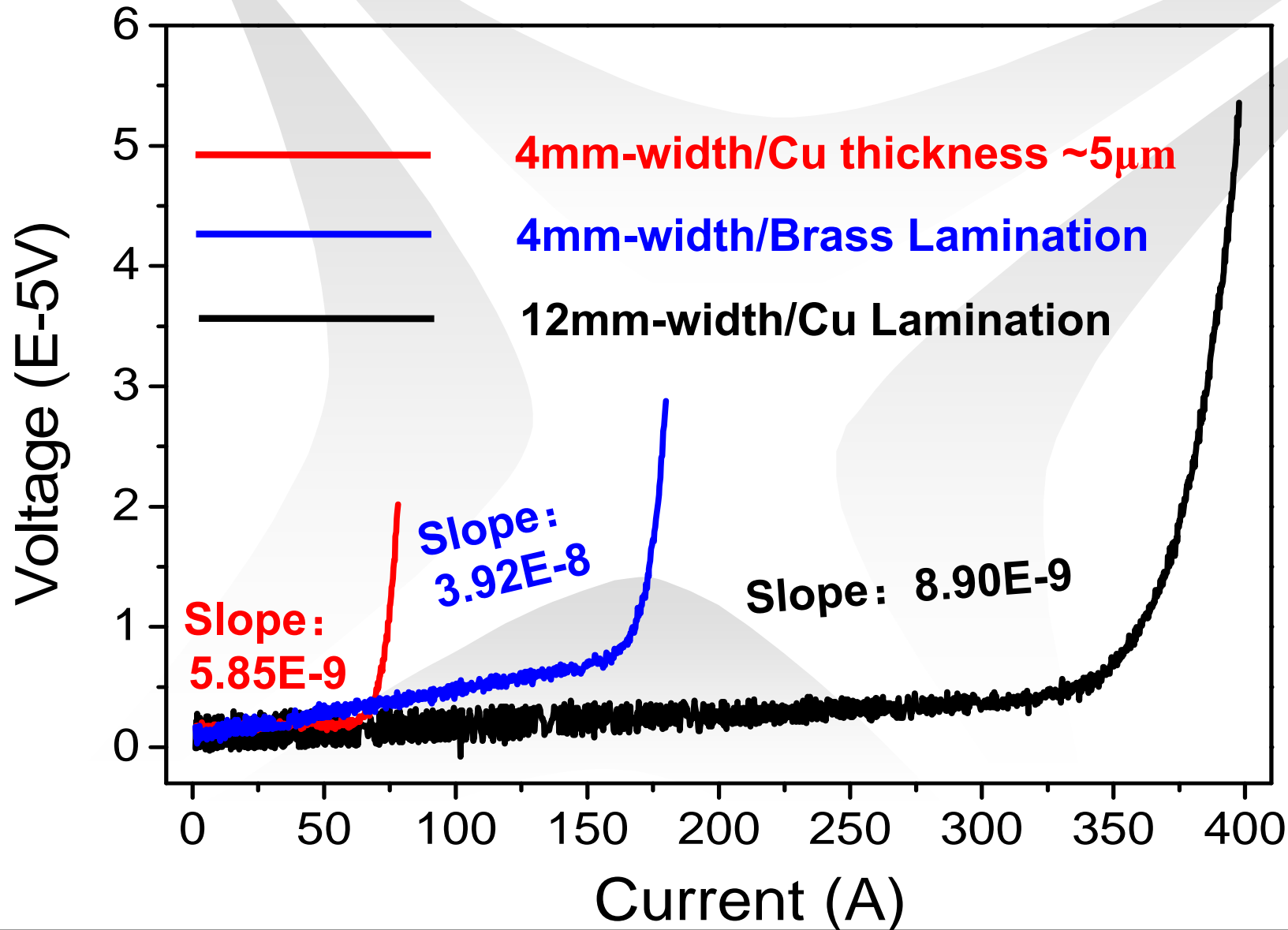








Lapping length: 10cm; Solder material: Sn-Bi



- ◆ **Main technology routes for 2G HTS tapes, including IBAD buffer and MOD HTS processing, and the industrial production lines are developed well in Shanghai University and its spinning off company, SCSC.**
- ◆ **X-ray diffraction measurements show FWHM values for both in-plane and out-of-plane are as low as 3 and 1 degree, respectively, and the critical currents along hundred meters of long tapes reach 350-450 A/cm-w (77 K, self-field), making a solid evidence after AMSC and SHOWA, for the cost-effective MOD technique applicable and promising for long-length high-quality 2G HTS Tapes.**
- ◆ **Commercial laminated MOD tapes are scaling up, with typical critical current of 110-150 A/4mm-w(77K, self field) for hundred meters of long tape, and the joint resistance of $10^{-9}\Omega$ using relatively short overlapping for a longer tape.**

Acknowledgement:

- Z.Y. Liu, L. M. Lu, C. Y. Bai, F. Fan, M. J. Li, Q. Lu, et al., at Shanghai University,
- H. B. Jian, Y. J. Zhang, H. Zhang, R. T. Huang et al., at SCSC

HTS Applied Researches & Demos in China

HTS Tape	Research Institution	○
Power Application	Research Project	△



HTS Tape Manufacturer	●
Application demo	▲

Main Research Projects and Application Demo in China

Welcome visit



**Shanghai Creative
Supercond. Technol. Co. Ltd.**



**We are making efforts to promote and develop
various HTS Power Applications in China**

Thank you for your attention

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Spinning off



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SHANGHAI UNIVERSITY

上创超导
SCSC

