ISS 2013, Tokyo, Nov. 20, 2013

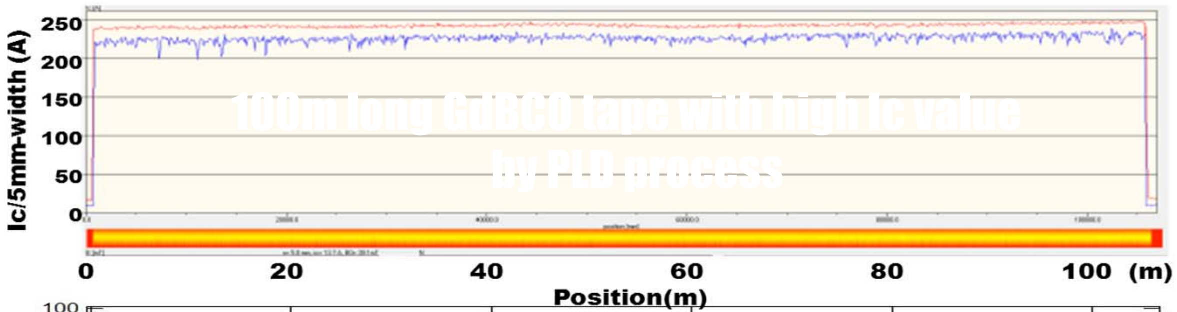
Nov. 20, 2013
Sang-Soo Oh (KERI)
Teruo Izumi (ISTEC)

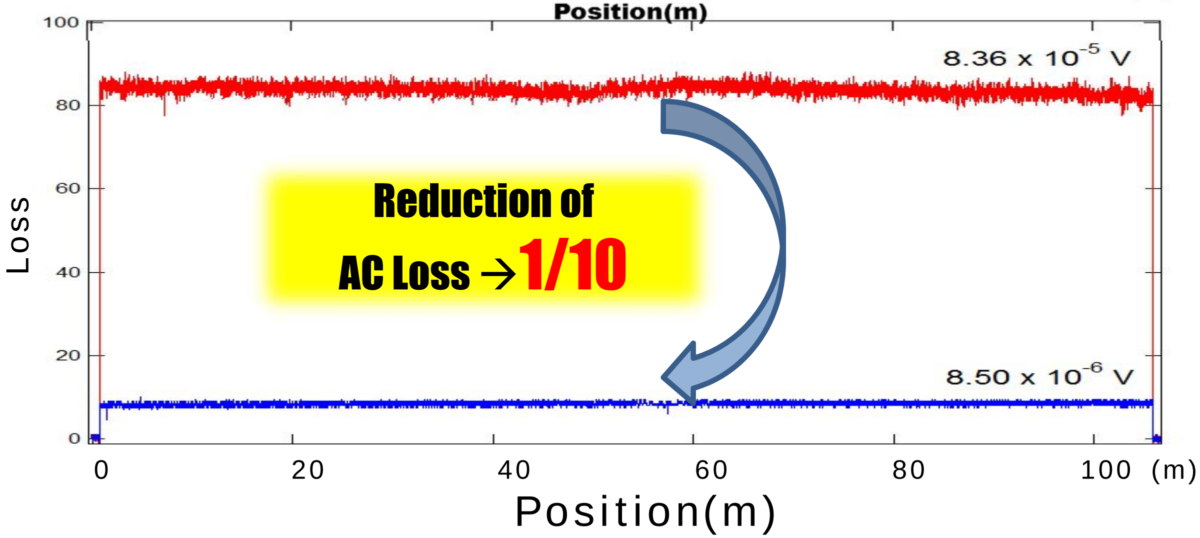
# Summary of Wires, Tapes & Characterization Talks in ISS 2013

# Statistics of Oral Session

- Plenary Talks : 2 for REBCO (Japan, US)
- Categories of Oral Session
  - Nb3Sn : 1
  - REBCO : 20
  - BSCCO : 2
  - MgB2 : 3
  - Other materials : 3
- Total Presentation No.(Oral) : 29

# AC-loss Reduction in PLD Tape by Multi-filamentation



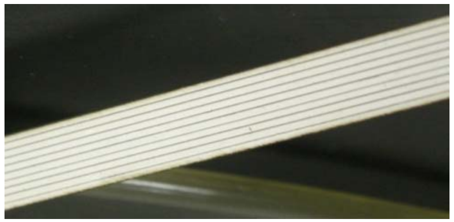

**Cleaning $CeO_2$ surface**

↓

**PLD-GdBCO Fabriction**
**30m/h 1.6μm**

↓

**Multi-filamentation**
**Chemical Etching→**
**10-filaments**



ISTEC

***Loss reduction of 1/10 was confirmed in 100m tape.***

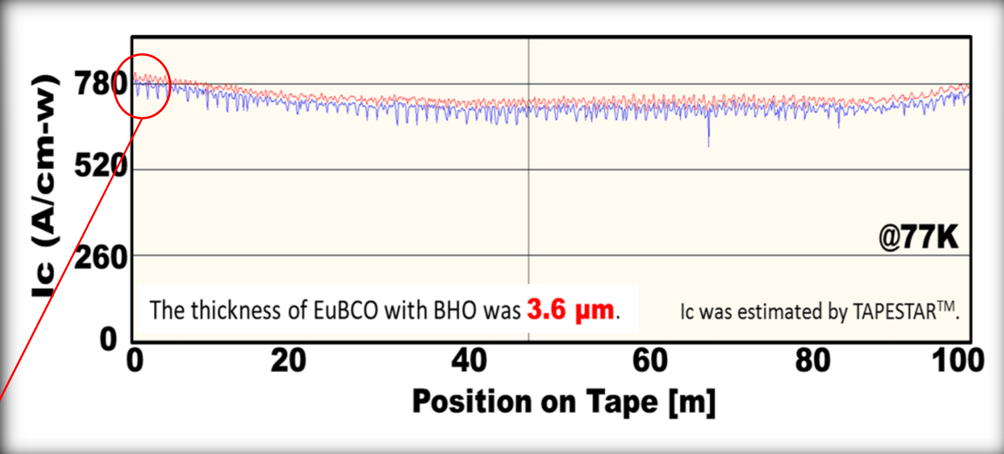
T.Izumi(ISTEC-SRL)

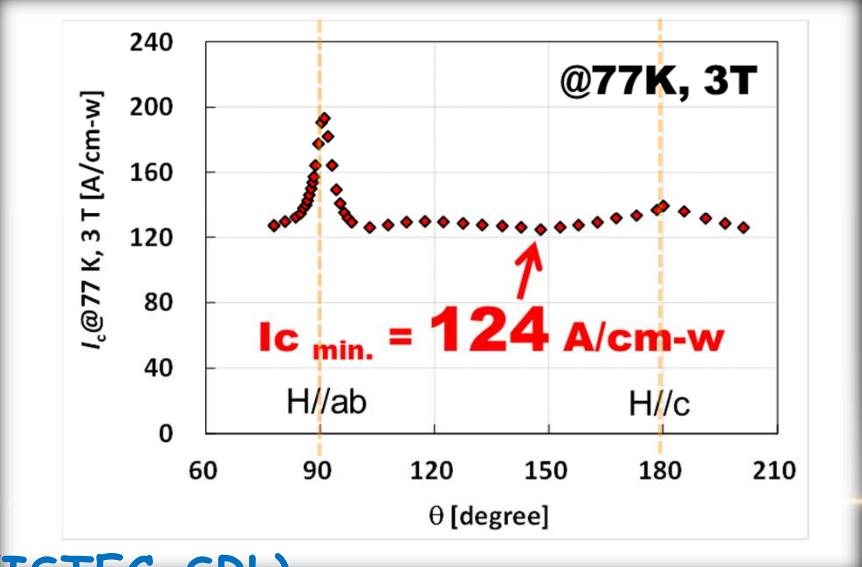
**WT-5-INV A. Ibi et al.    WT-14-INV T. Machi et al.**

# Hot News!!!!!!

## 94m long C.C. with thick EuBCO + BHO film

**PLD on IBAD**




Ic = 866 A/cm-w (77 K, s. f. )
2.40 MA/cm² (EuBCO : 3.6 µm)

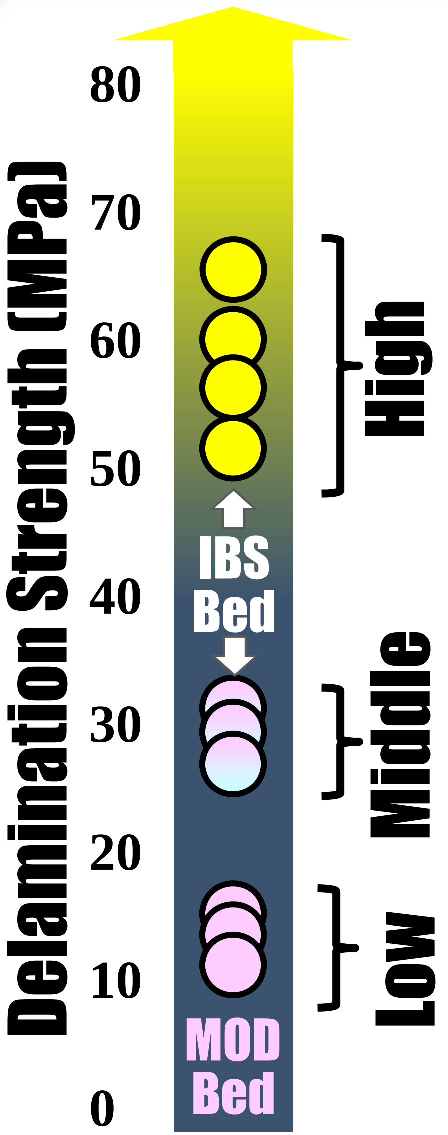
$Ic_{min.}$ > 100 A/cm-w (77 K, 3 T)

Estimation

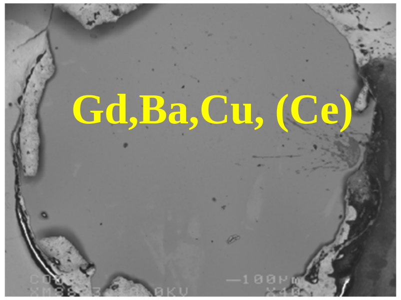
$Ic_{min.}$ > 500 A/cm-w
(65K, 3 T)

T.Izumi(ISTEC-SRL)

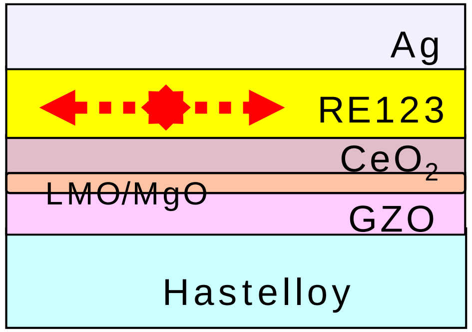
# Delamination

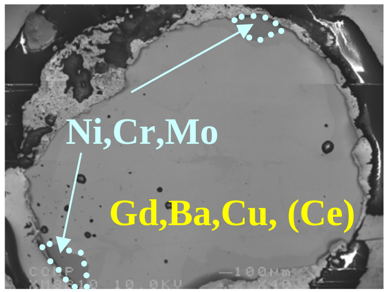



## Delaminated Interface

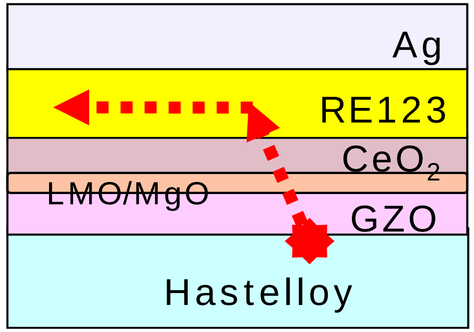


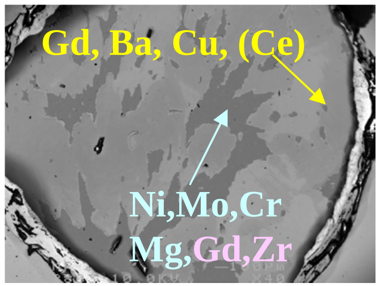

**[High]**
**Starting Points in REBCO**



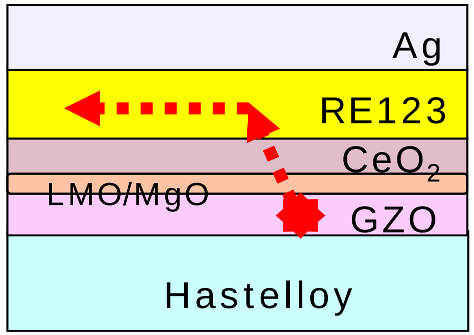




**[Middle]**
**Starting Points at Bed/Hastelloy**




**[Low]**
**Starting Points in MOD Bed**

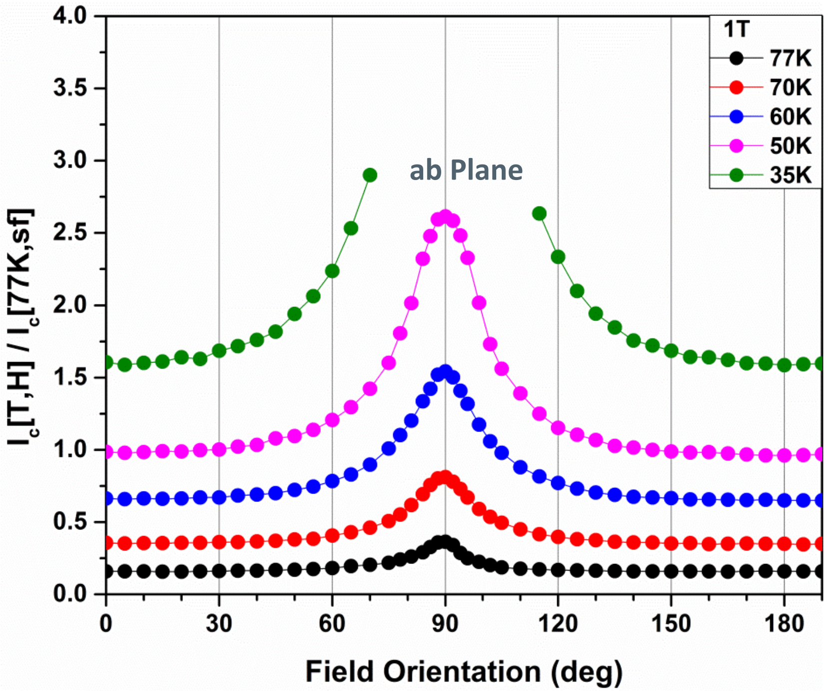





WT-12-INV M. Yoshizumi et al.

# New 1.2μm HTS Wires Optimized for Application Specific Operating Conditions

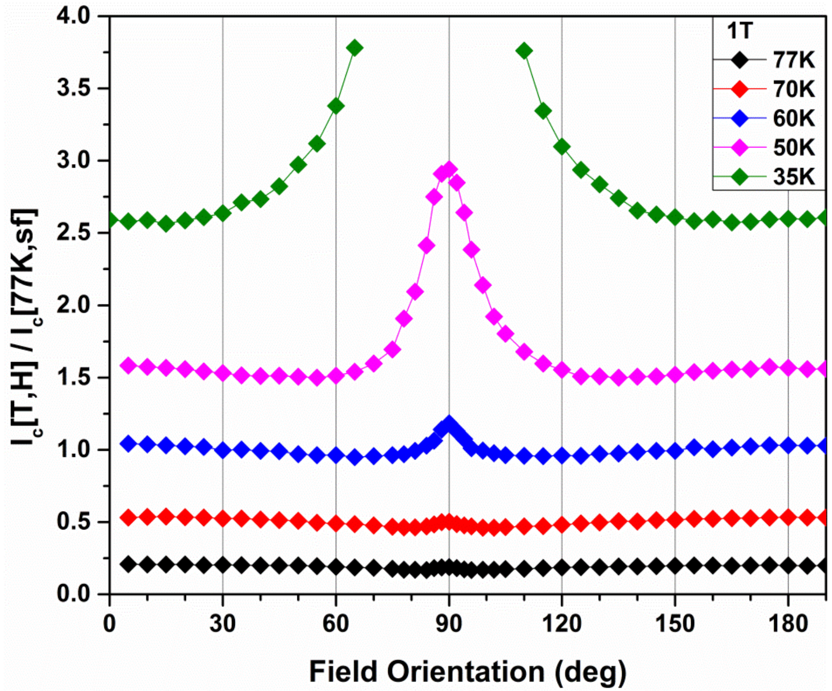
**1.2μm Cable Wire**




High temperature, low field applications

N. Strickland - Callaghan Innovation

**1.2μm Coil Wire**




Low temperature , perpendicular field applications

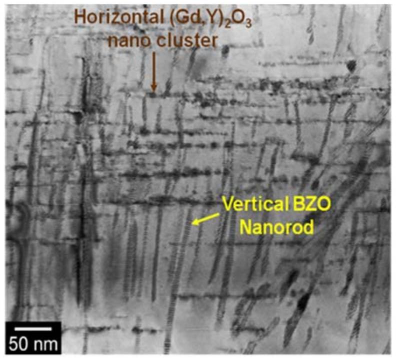
**V.Selvamanickman(U. of Huston)**

UNIVERSITY of HOUSTON

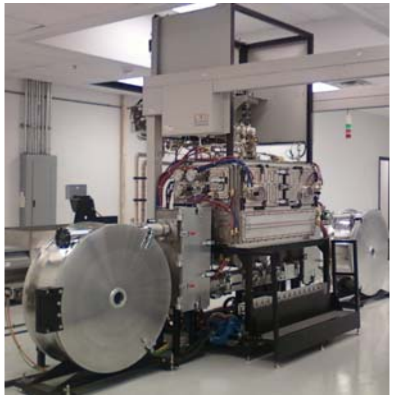
SuperPower Inc. A Furukawa Company

# 4X HTS conductor performance improvement targeted for high power wind generators

- ARPA-E REACT program targeted on 10 MW wind generator operating at 30 K, 2.5 T
- Improved approaches to engineer nanoscale defects in coated conductors
- New pilot MOCVD system set up in UH Energy Research Park to rapidly scale up new technology advances to long-length manufacturing.




*Engineered nanoscale defects*



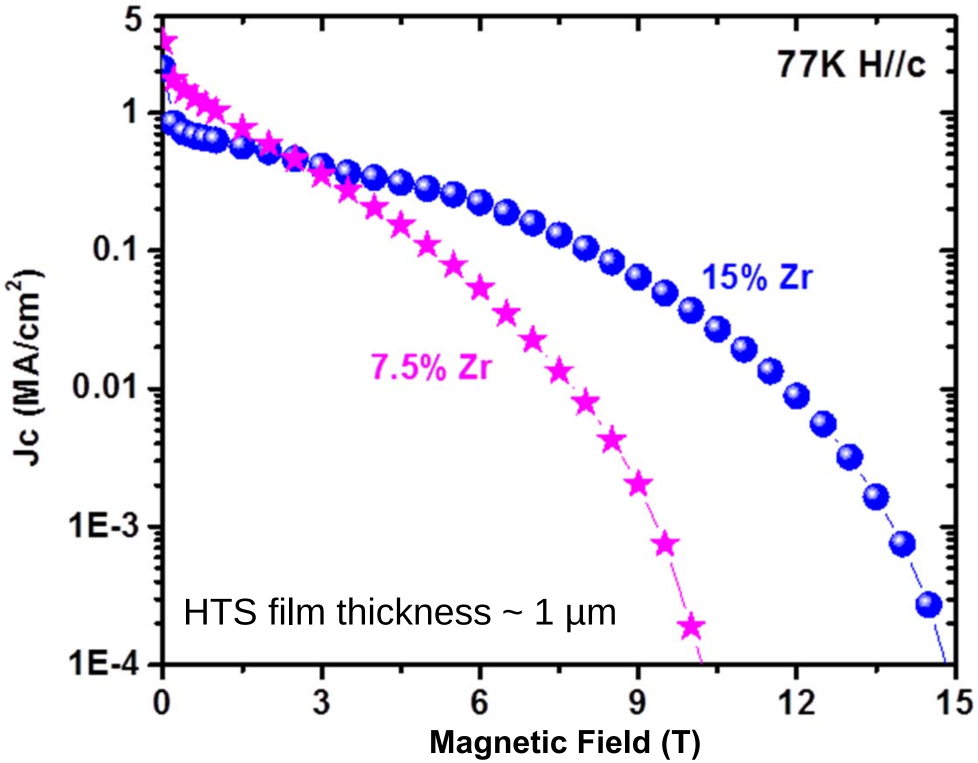
*4x improved wire manufacturing*

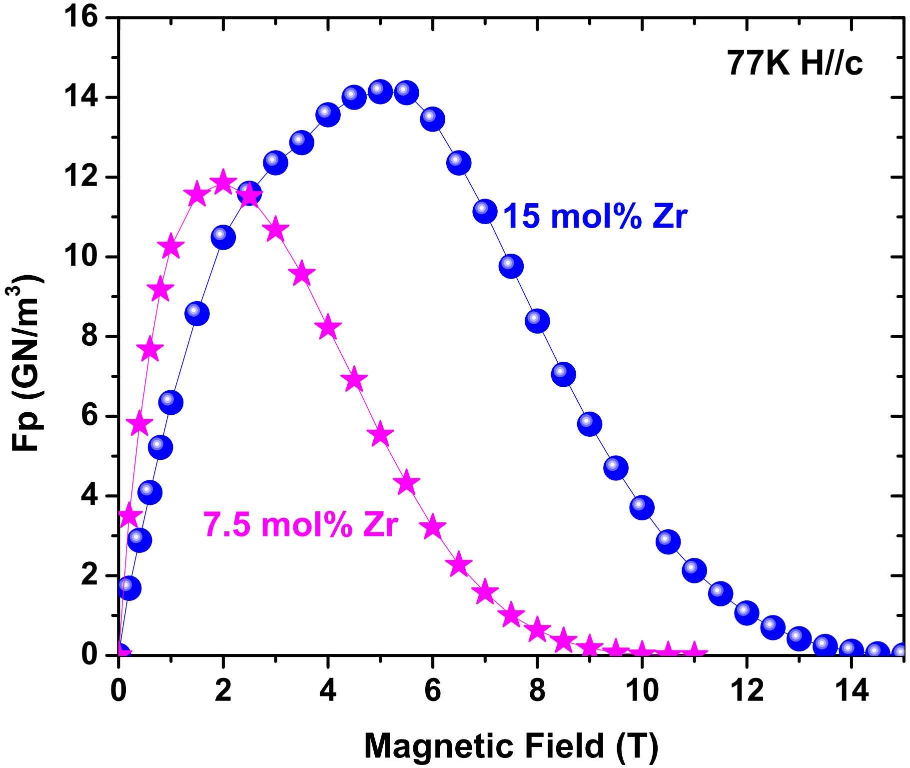
*High-power, Efficient Wind Turbines*

- *Quadrupling superconductor Performance at 30 K, 2.5 T for commercialization of 10 MW wind generators to reduce wire cost by 4x*
- *Advances will also lead to high-performance HTS conductors for other high-field applications*

UNIVERSITY of HOUSTON

# At 77 K, 15%Zr-added tape superior to the best 7.5%Zr-added tape measured to date




- Jc of 15%Zr tape is higher above 3 T.
- Maximum pinning force at 5 T up from 2 T.
- Irreversibility field increases from 10.2 T to 14.8 T
- Tc of both 7.5% & 15%Zr-added tapes ~ 91 K
  → Increase in irreversibility field is not due to Tc difference

***Measurements at NHMFL***
***by A.Xu, J. Jarozynski, D. Larbalestier***

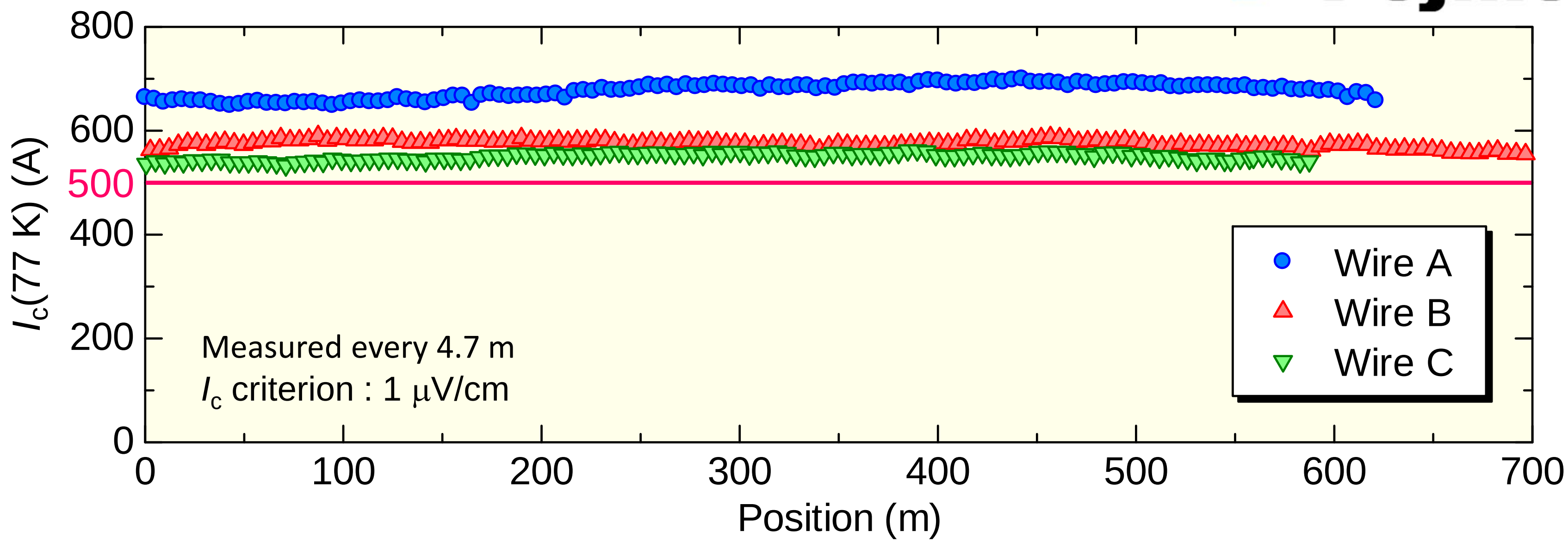
| | Jc (77K, 0T) |
|---|---|
| 7.5%Zr | 3.75 MA/$cm^2$ |
| 15%Zr | 3.4 MA/$cm^2$ |

V.Selvamanickman(U. of Huston)

# Typical $I_c$ uniformity of commercial wire

Fujikura

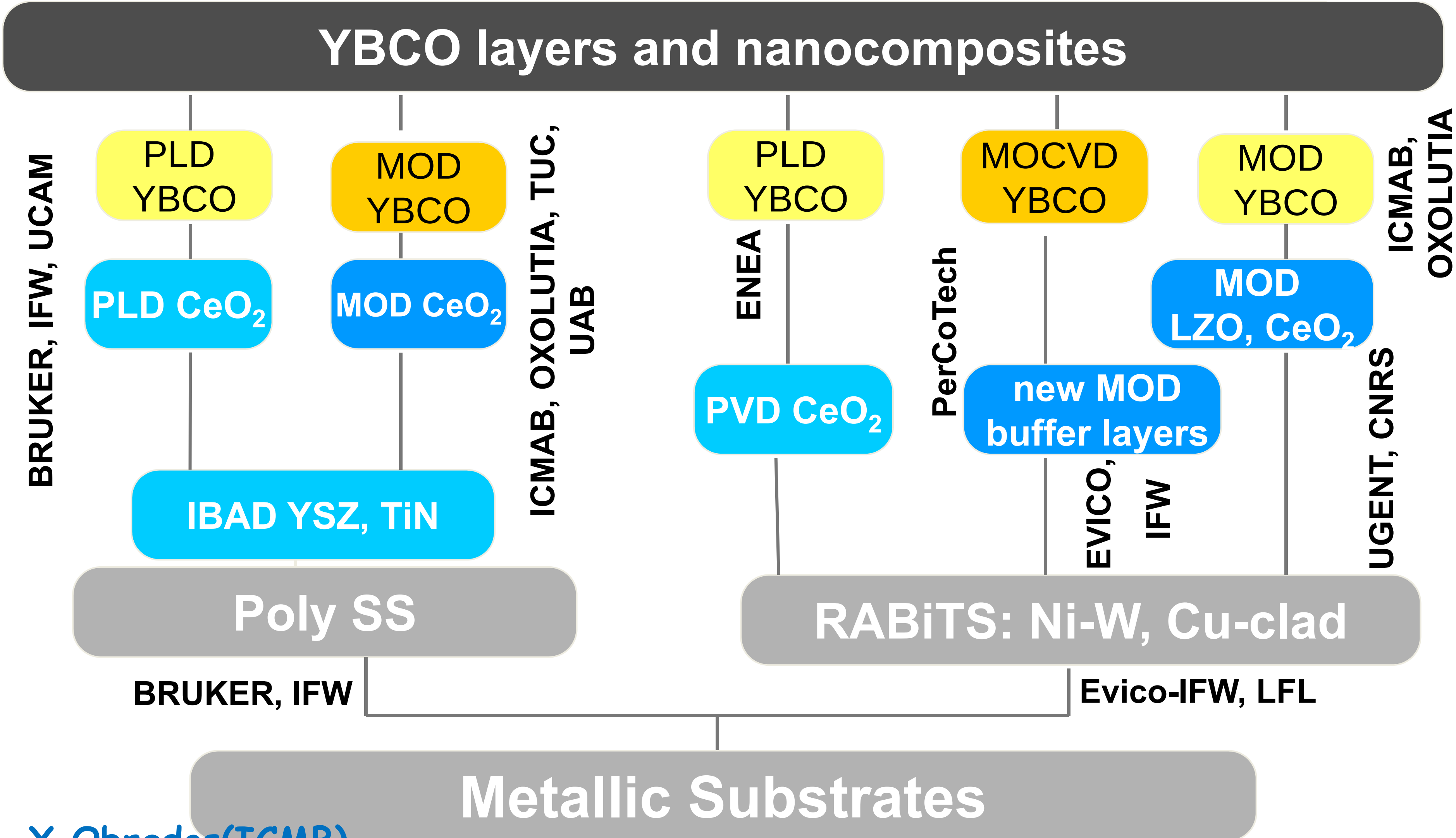
- Current-transport measurement at every 4.7m long




| | Wire A | Wire B | Wire C |
|---|---|---|---|
| 1. Piece length | 621 m | 700 m | 587 m |
| 2. $I_c$ (max.)* | 700 A | 590 A | 562 A |
| 3. $I_c$ (min.)* | 649 A | 555 A | 533 A |
| 4. $I_c$ (avg.)* | 677 A | 575 A | 550 A |
| 5. Uniformity** | 7.5 % | 6.1 % | 5.2 % |

*10 mm-W **Uniformity : {$I_c$ (max.) - $I_c$ (min.)} / $I_c$ (avg.) x 100

# EUROTAPES project



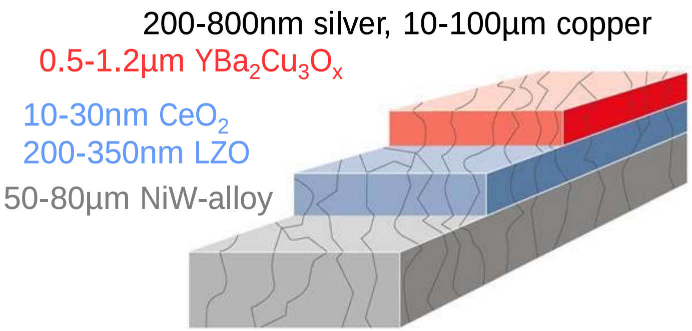

X.Obrados(ICMB)

**Advanced characterization and in-situ monitoring: TUWien, UAntwerpen, THEVA**
**Striations, ac losses, round wire : UCAM, Bratislava, NEXANS**

# Ink-Jet Printed RABiT CC's

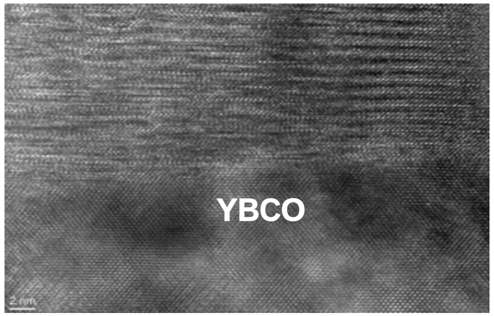
deutsche nanoschicht

*BASF GmbH owner*




- **CSD for all layers is considered to be the "most promising and most challenging process**
- **Unique and protected CSD-multi-layer technology, IJP.**
- **Established industrial cooperations on metallic substrates (Thyssen Krupp), coating solutions (Honeywell) and insulation (Elektrisola)**

universitätbonn



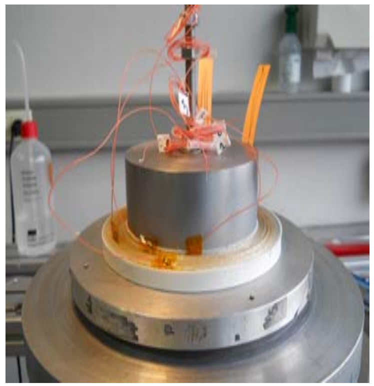

Ink-jet printing in continuous processing

✓ **All samples continuously processed in minimum 10 m lengths**

✓ $J_c$ (77K, sf) = 1.2 -1.8 MA/cm$^2$ for 1 µm HTS

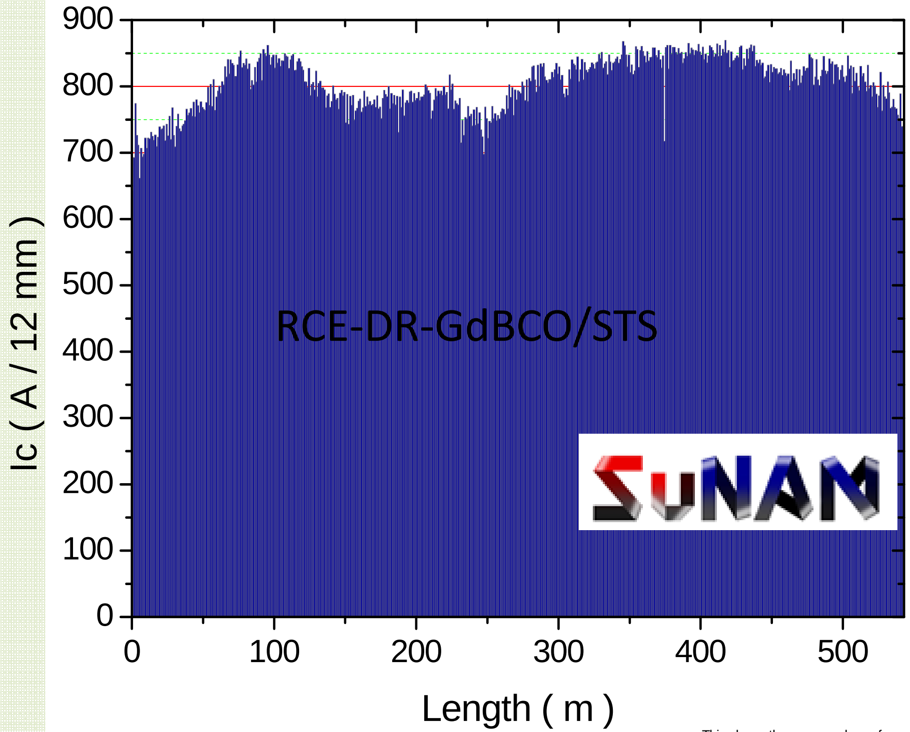
✓ 7mm wide slitted and stabilized sample, $I_c$ /cm-w > 160A

✓ 100 m wound to coil with overall $J_c$ =1.4 MAcm$^2$



UNIVERSITY OF CAMBRIDGE

**X.Obrados(ICMB)**



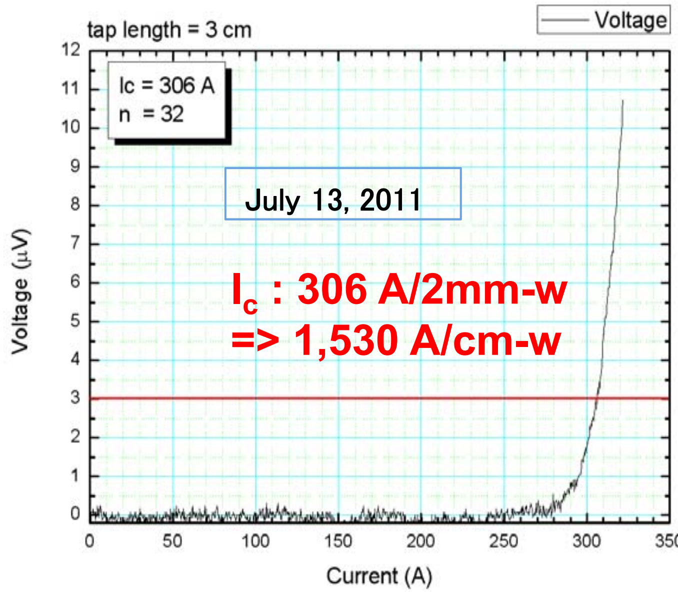

This shows the average vlaues for each 1 meters.

4 T magnet

KERI

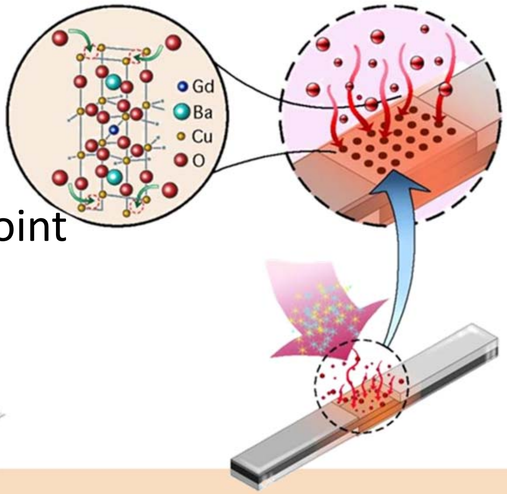
**5 µm-thick,**
**20 m-long SmBCO-CC**

EDDC-SmBCO




KOREA UNIVERSITY

Superconducting joint
for GdBCO-GdBCO

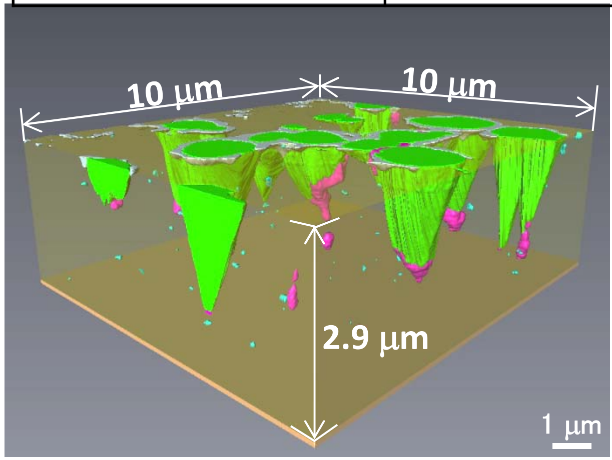


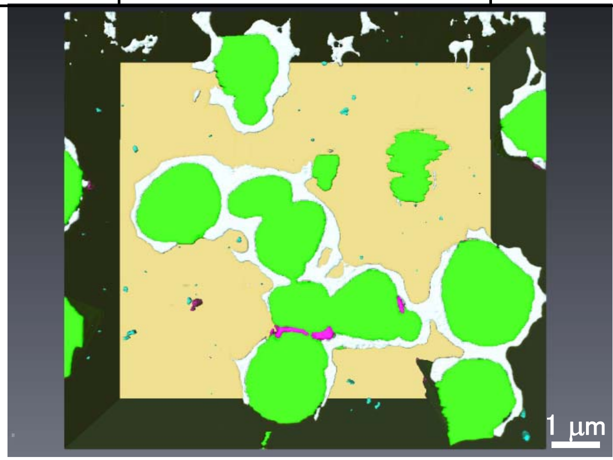

**S.S. Oh(KERI)**

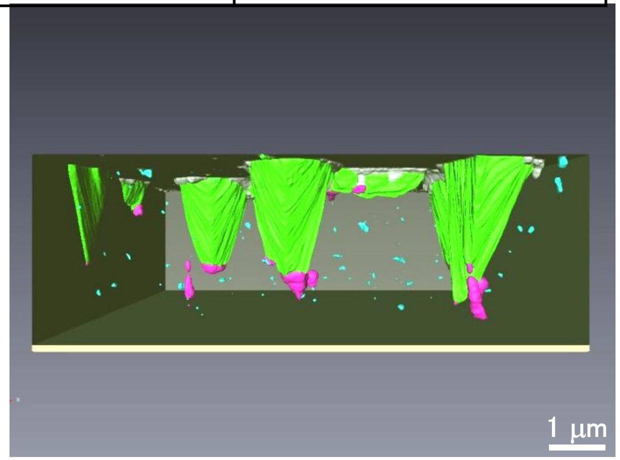
# 3D reconstruction of GdBCO and EuBCO with BHO nano-rods

## ・3.5mol%BHO-GdBCO($I_c$ = 705 A/cm@77 K , self; 2.9 μm-thick)

| c-axis oriented grains | Outer growth grains | CuO | $Gd_2O_3$ | voids |
|---|---|---|---|---|
| 91.77 % | 7.51 % | 0.29 % | 0.04 % | 0.38 % |



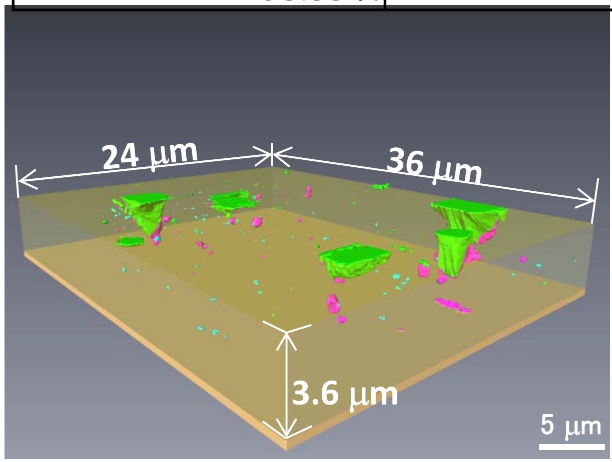



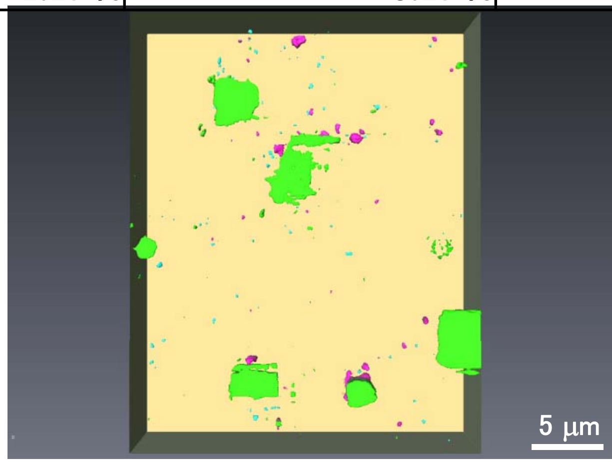



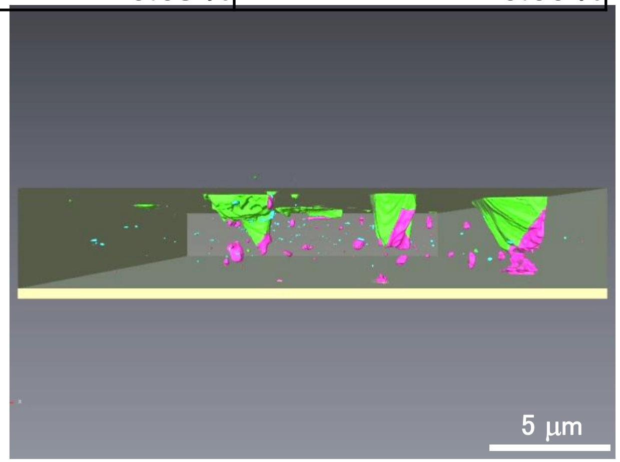

■: Outer growth grains ■:CuO ■:$Gd_2O_3$ ■:Voids ■:$CeO_2$

## ・3.5mol%BHO-EuBCO($I_c$ = 955 A/cm@77 K, self; 3.6 μm-thick)

| c-axis oriented grains | Outer growth grains | CuO | $Eu_2O_3$ | voids |
|---|---|---|---|---|
| 98.53 % | 1.17 % | 0.27 % | 0.03 % | 0.00 % |



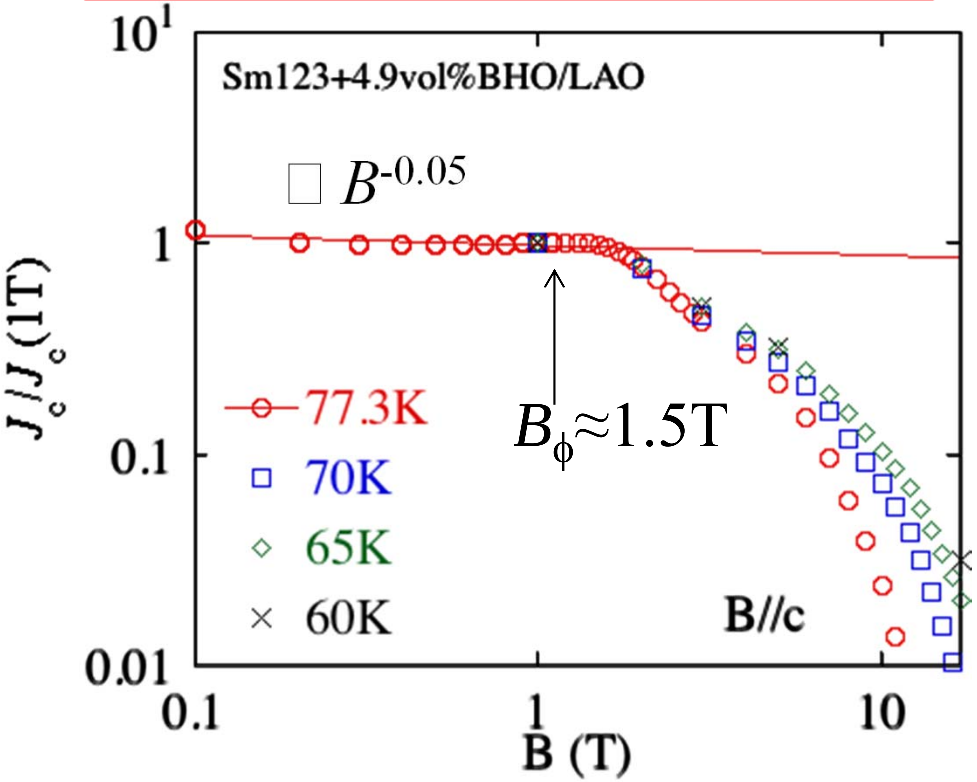

■: Outer growth grains ■:CuO ■:$Eu_2O_3$ ■:Voids ■:$CeO_2$

T.Kato (JFCC)

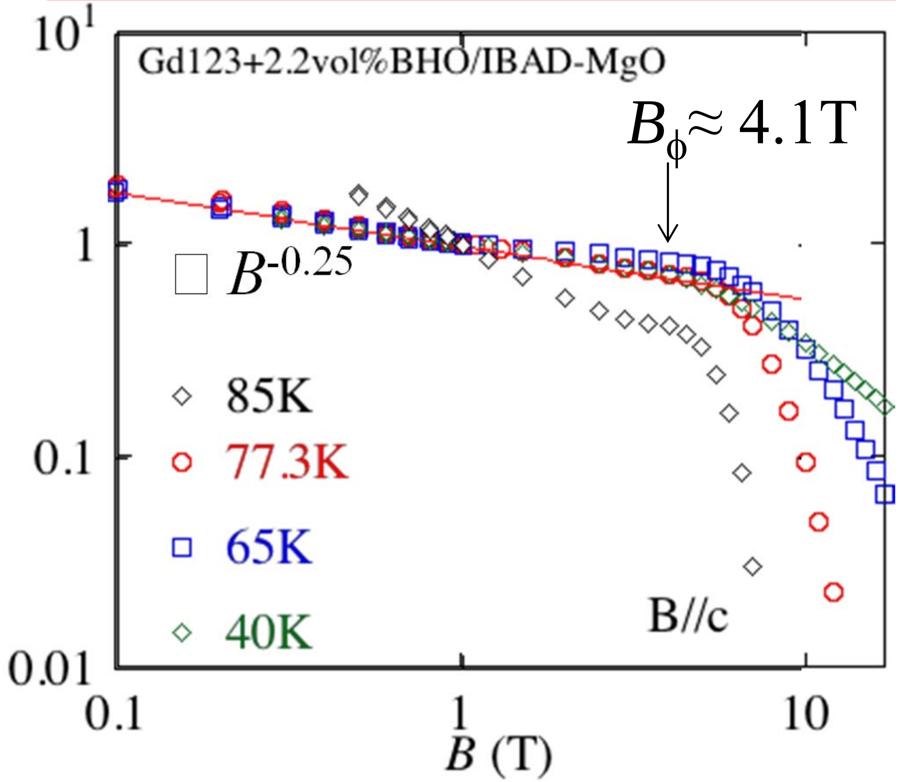
# C-axis correlated pinning behavior by nanorods



Low density and large diameter




High density and small diameter

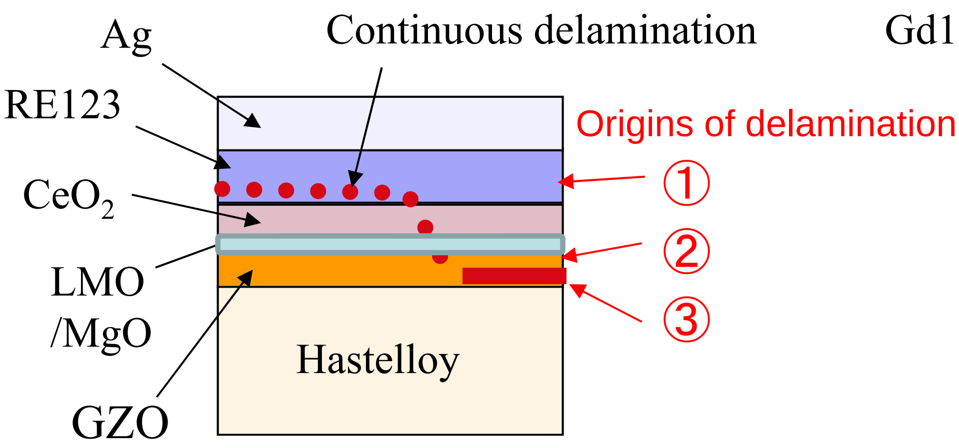


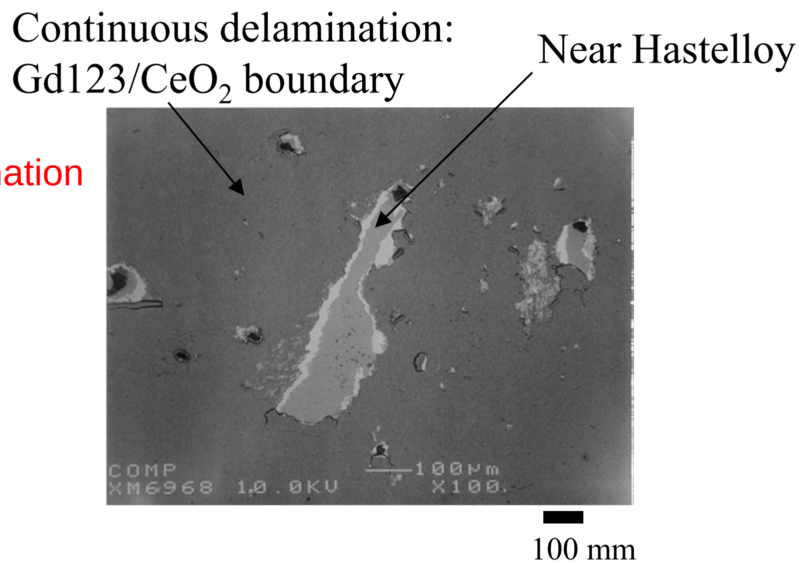

The weak field dependency below $B_\phi$ can be observed!

C-axis correlated pin is effective but related to the nanorod structures.
(The $\alpha$ values may relate to the size and bending of nanorods ?)

S. Awaji (Tohoku U.)

# Short Summary: effect of fabrication process on delamination



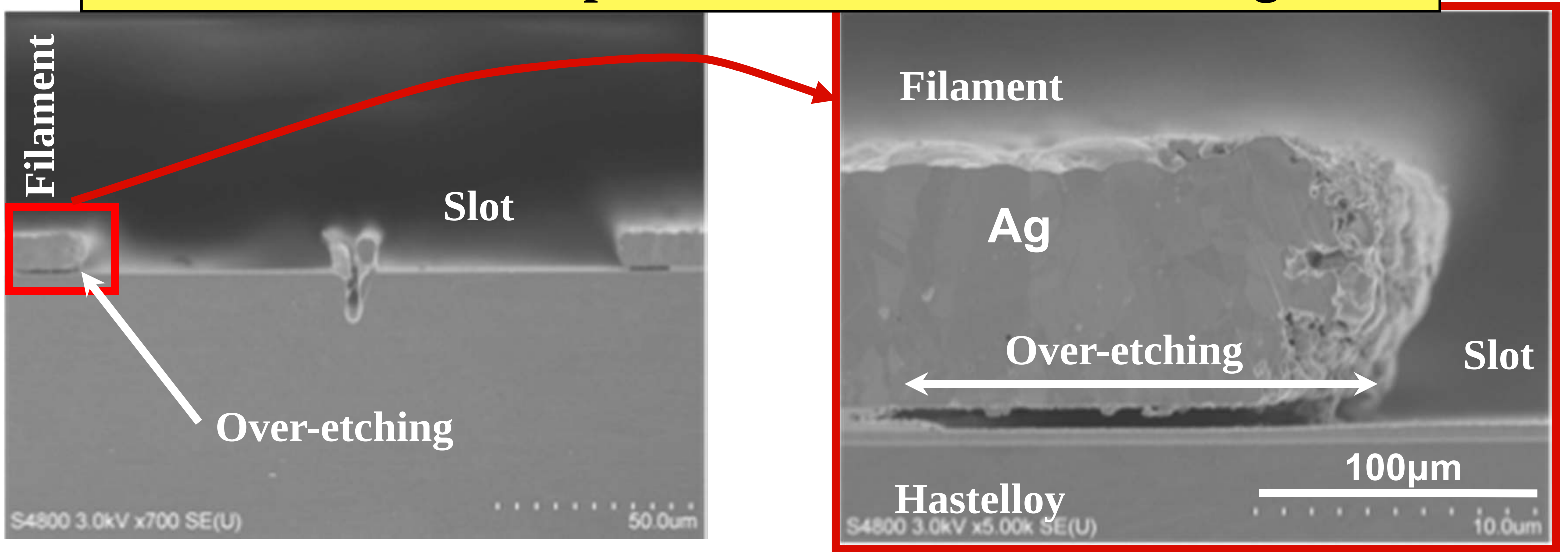

| | Origin of delamination | strength | Reason of weakness | Way to overcome |
|---|---|---|---|---|
| ① | RE123 | ＞50MPa | | |
| ② | GZO | ＜20MPa | Pores in MOD-GZO | Optimization of MOD conditions |
| ③ | Near substrate | ＜50MPa | Oxygenation during buffer and REBCO layers deposition | Fast deposition<br>Low deposition temp. |

ISTEC

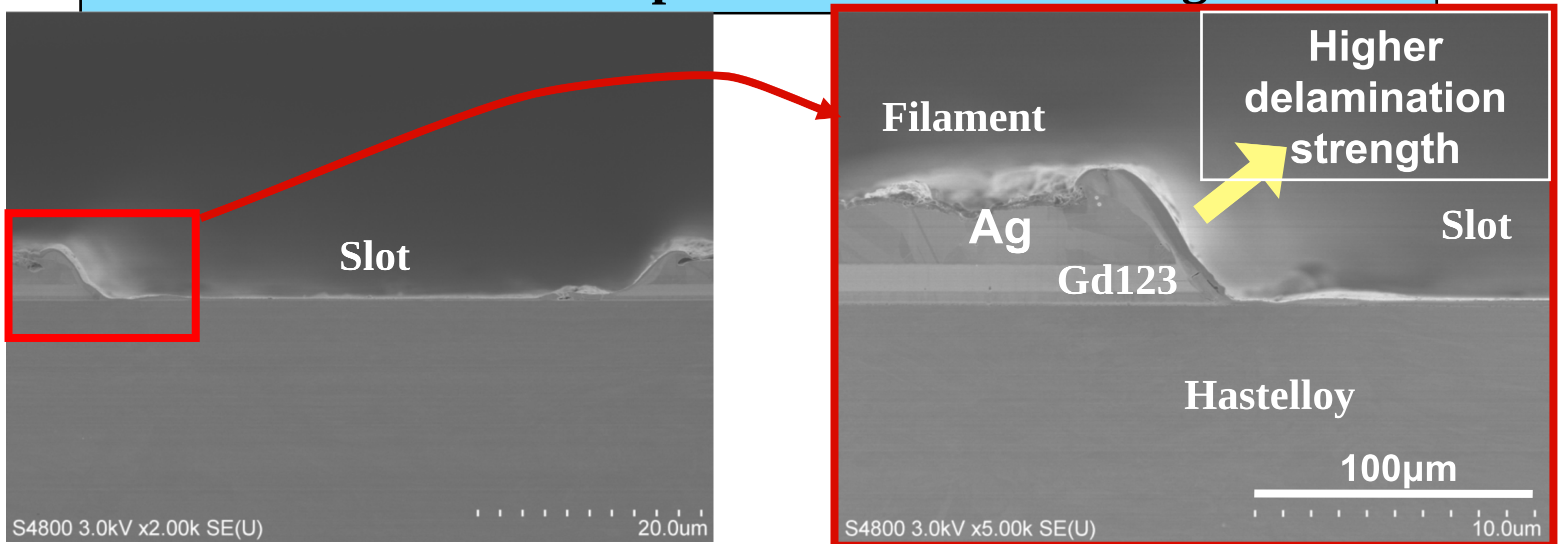
M.Yoshizumi (ISTEC-SRL)

# Comparison of morphology of scribed C.C.

**Laser scribed specimen with chemical etching**

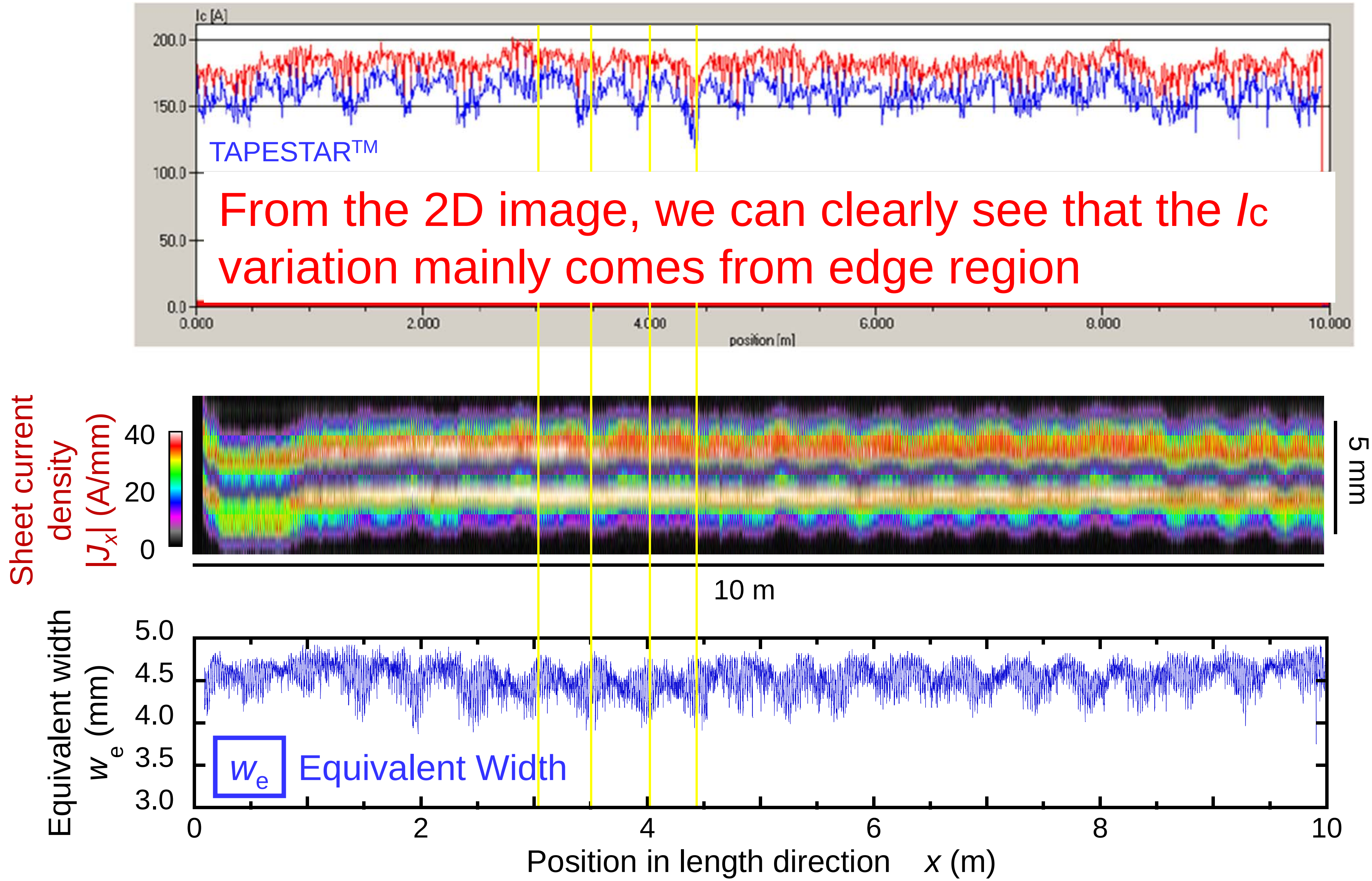



**Laser scribed specimen without etching**




Sakai et al.

# Information along Width (RTR-SHPM)



# Conclusion

- Low cost processes for commercial CC were presented.
- Higher in-field properties of CC have been demonstrated by artificial pinning center technology with BZO or BHO in US, Japan, EU.
- Low AC loss CC tape was demonstrated in long length in Japan.
- Delamination behaviors of CC were systematically evaluated.
- Various advanced characterization technologies for CC were presented.
- CC with nano APC was well analyzed and described by TEM and a pinning theory, respectively.
- 16% Sn added Nb3Sn contributed to the 930 MHz NMR.
- Mechanical property was improved in DI-BSCCO tape.
- Progresses of MgB2 and iron-based wire were also presented.