STATUS OF THE COATED CONDUCTOR RESEARCH IN JAPAN

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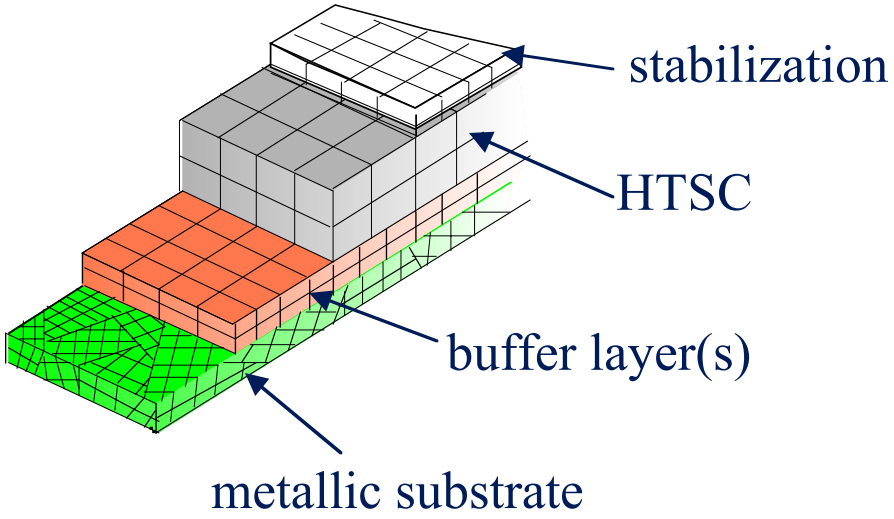
Argonne National Laboratory



(Presented at the DOE Wire Development Workshop, St. Petersburg, FL, Jan. 21-22, 2003)

Information Sources

- International Workshop on Processing & Applications of Superconductors, Gatlinburg, TN, July 31-Aug. 2, 2002.
- Applied Superconductivity Conference, Houston, TX, Aug. 4-9, 2002.
- 15th International Symposium on Superconductivity, Yokohama, Japan, Nov. 11-13, 2002.
- Materials Research Soc. Fall meeting, Boston, MA, Dec. 2-6, 2002.
- Superconductor Week, 2002.
- Shiohara (ISTEC), Yamada (ISTEC), Togano (NIMS), Fujino (Sumitomo), Iijima, (Fujikura), and Hasegawa (Showa Electric).

Japanese Organizations Supporting Superconductor R&D

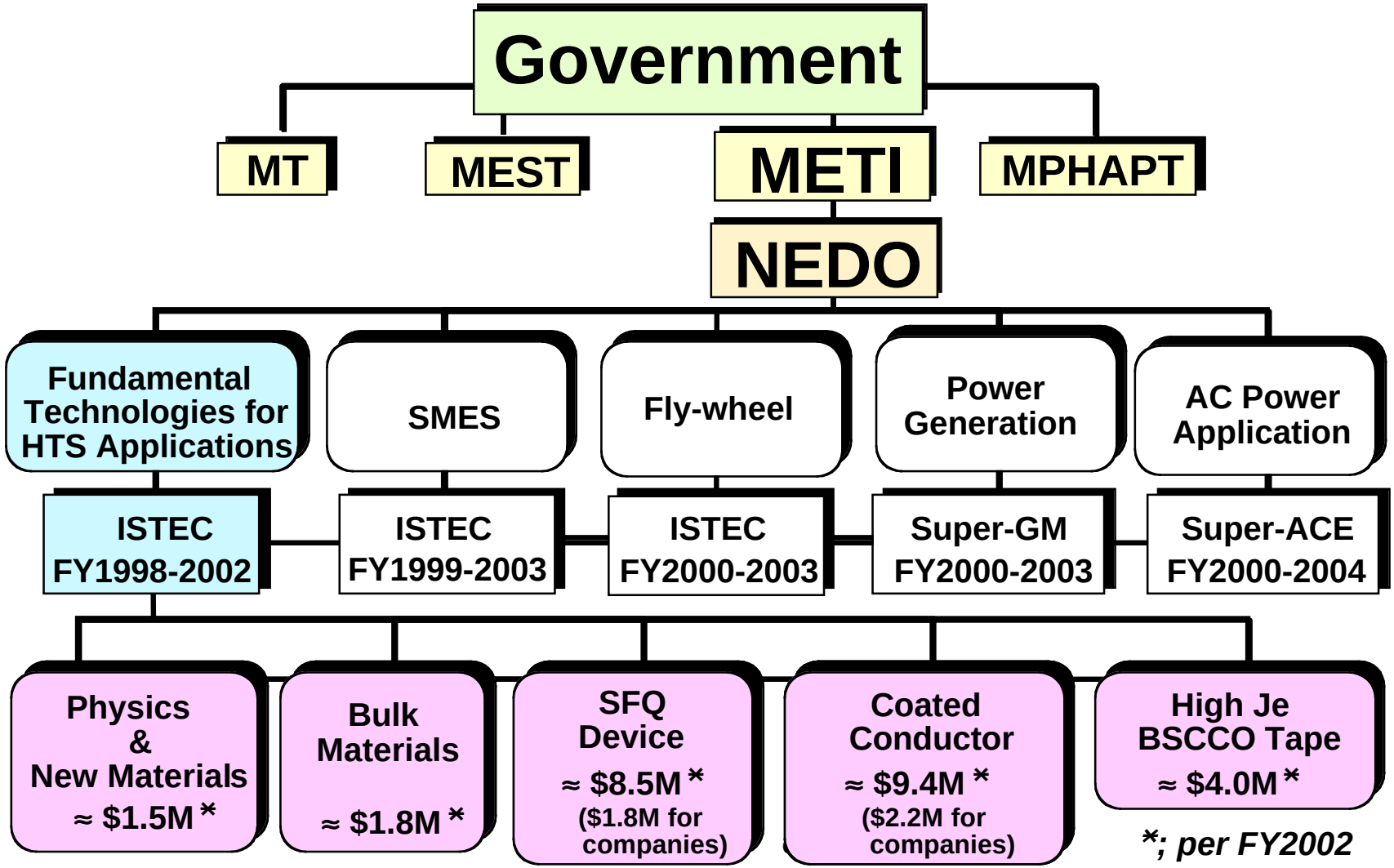
- METI - Ministry of Economy, Trade, and Industry
- NEDO - New Energy and Industrial Technology Development Organization
- MEST - Ministry of Education, Culture, Sports, Science and Technology
- MT - Ministry of Land, Infrastructure and Transport
- MPHAPT - Ministry of Public Management, Home Affairs, Post and Telecommunications

METI/NEDO Superconductivity Budget for FY 2002* ($1 = 115 Yen)

	Request (M$)	Actual (M$)
Fundamental Technology:	30.4	25.2
SMES	9.1	–
Flywheel	3.0	–
Generator	7.0	–
AC Power application	12.6	–
	62.1	

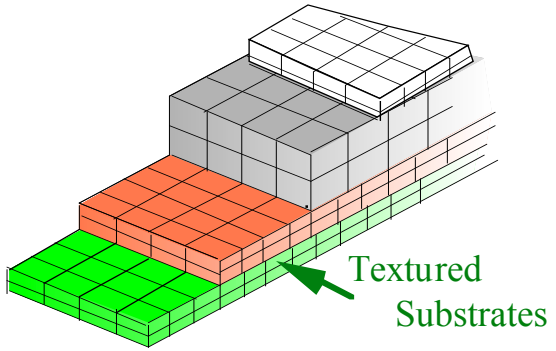
* Numbers are approximate only

Superconductivity Projects in JAPAN

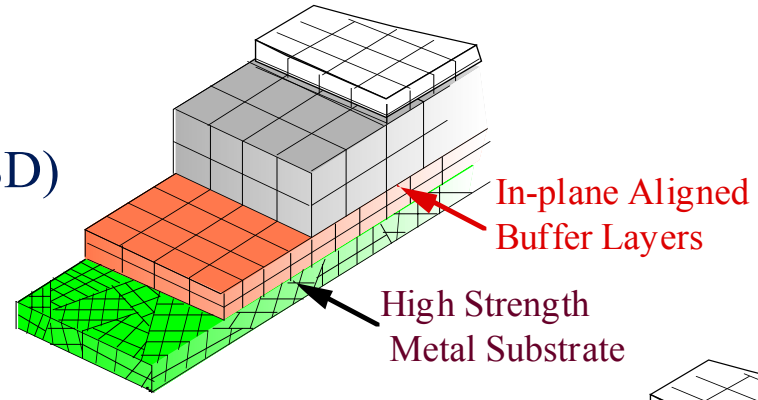


Approach

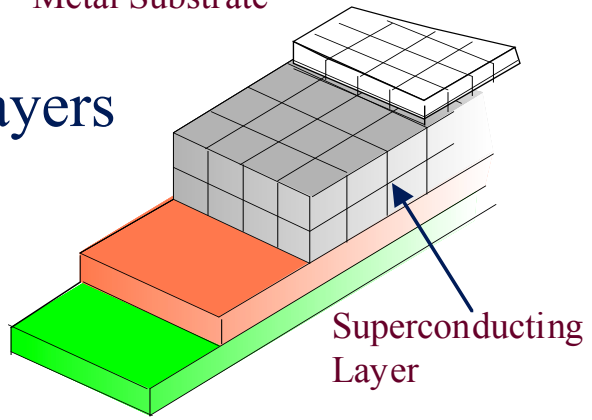
- Process for Textured Metallic Substrate
  - RABiTS™
  - SOE, Cute



- Process for In-Plane Aligned Buffer Layers
  - Inclined Substrate Deposition (ISD)
  - Ion Beam Assisted Deposition (IBAD)



- Innovation Process for Superconducting Layers
  - Metal Organic Deposition (MOD)
  - Metal Organic Chemical Vapor Deposition (MOCVD)



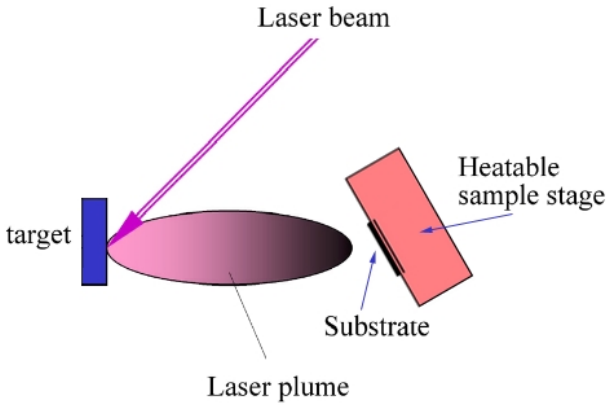
Process for Textured Metallic Substrate

RABiTS (Ni & Ag) & Surface Oxidation Epitaxy (SOE)

- Major Results
  - ① Development of Long Length SOE Tape;
    50m SOE-NiO/Textured Ni (Furukawa)
  - ② High Strength & Low Magnetic Substrates using Clad-type Metallic Substrate ; SOE-NiO/Ni/Ni-Cr (30m)
  - ③ Ag-Cu/Ag-Ni/Ag-Cu clad tapes: 100-m (Toshiba)
  - ④ $J_c = 1.3 \times 10^6$ A/cm^2 (I_c = 137 A/cm-w) YBCO on BZO/SOE - NiO/Ni (short sample, stationary, 1-cm wide)
    - $J_c = 1.8$ MA/cm^2 (I_c - 12.7A on 10-mm wide, ≈2.5cm long moving substrate)
  - ⑤ $J_c = 1.8 \times 10^5$ A/cm^2 & L=10m YBCO/Ag-Cu/Ag-Ni/Ag-Cu (PLD rate of 2.5 m/hr)

Ref: ISS 2002

Inclined Substrate Deposition (Sumitomo Electric Industries)

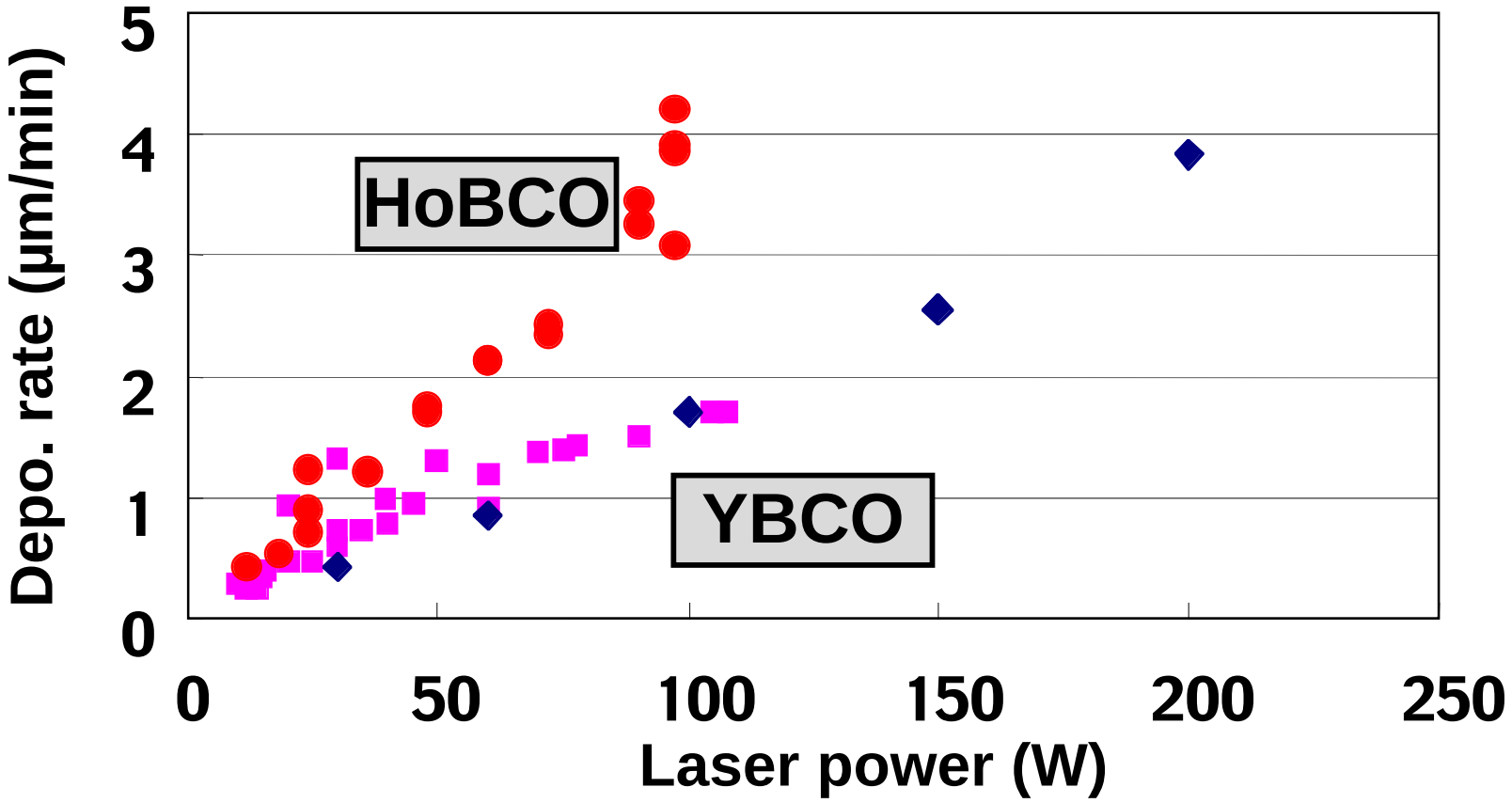


- L = 10-m, YBCO/ISD-PLD YSZ/HC, $J_c = 10^5$ A/cm^2, $I_c \approx 11$A
- L = 55-m, HoBCO/ceria/ISD-PLD YSZ/HC, $J_c = 2 \times 10^4$ A/cm^2, $I_c = 4$-13.2 A
  - Short sample with no ceria-cap layer, $J_c = 0.5$ MA/cm^2, $I_c = 60$ A
- L = 50-m, HoBCO/ISD-PLD-ceria/HC, $J_c = 1.5 \times 10^5$ A/cm^2, $I_c \approx 15$A
  - Short sample with YSZ cap layer, $J_c = 2.7 \times 10^5$ A/cm^2, $I_c = 29$A

ISD layer thickness ≈ 2μm
ISD deposition rate ≈ 0.3 - 0.5 m/hr
HTS layer thickness = 1.5 - 2 μm
HTS deposition rate ≈ 0.5 m/hr
Hastelloy substrate = 10-mm x 0.1-mm

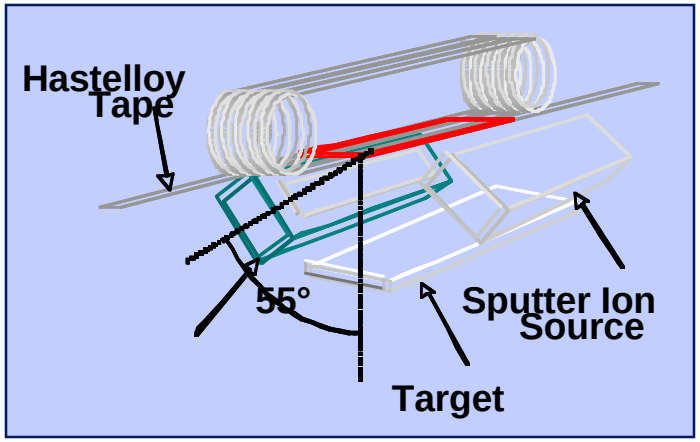
Sumitomo will start doing ISD-MgO by e-beam evaporation starting April 2003 - - ANL Approach

Major Results (High Deposition Rate)



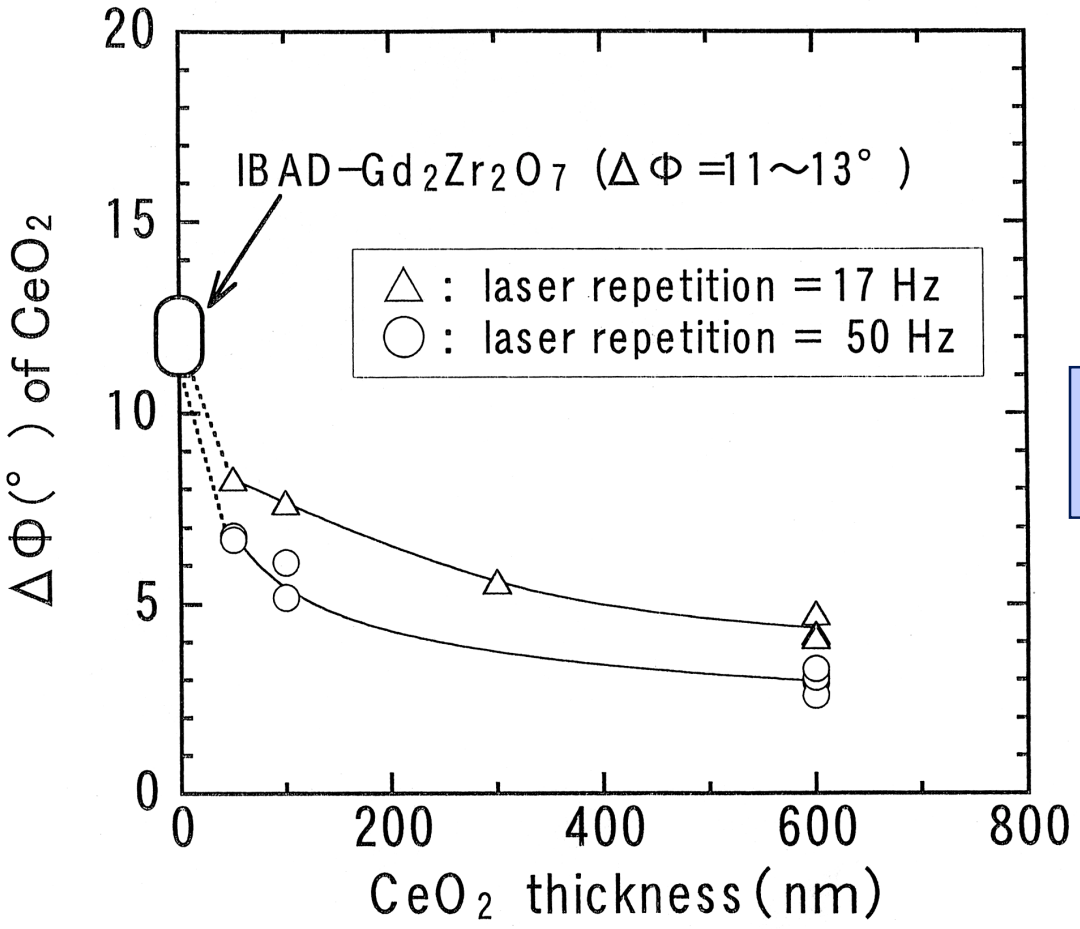
Ref: Y. Shiohara, ISTEC-SRL
Fujino, Sumitomo

Ion Beam Assisted Deposition (IBAD) (Fujikura, ISTEC-SRL)



- Enlargement of IBAD system
  - Rectangular ion source, deposition time >500 hr
- New buffer layer material: $Gd_2Zr_2O_7$ (GZO)
- Fabricated 100-m long GZO IBAD tape (rate:0.5 m/hr; 1.2 μm thick) with $\Delta\phi = 10°$
- Long-length IBAD tape results:
  - 10-m; $I_c = 49$ A, $J_c = 0.99$ MA/cm^2
  - 30-m; $I_c = 40$ A, $J_c = 0.8$ MA/cm^2
  - 46-m; $I_c = 74$ A, $J_c = 0.5$ MA/cm^2 (10-mm x 0.4 μm)

Self-epitaxy in CeO_2 on IBAD-GZO (Fujikura, ISTEC-SRL)



HC/IBAD-GZO/PLD-CeO_2/YBCO
IBAD-GZO rate: ≈5.5 nm/min
PLD-CeO_2 rate: ≈100 nm/min

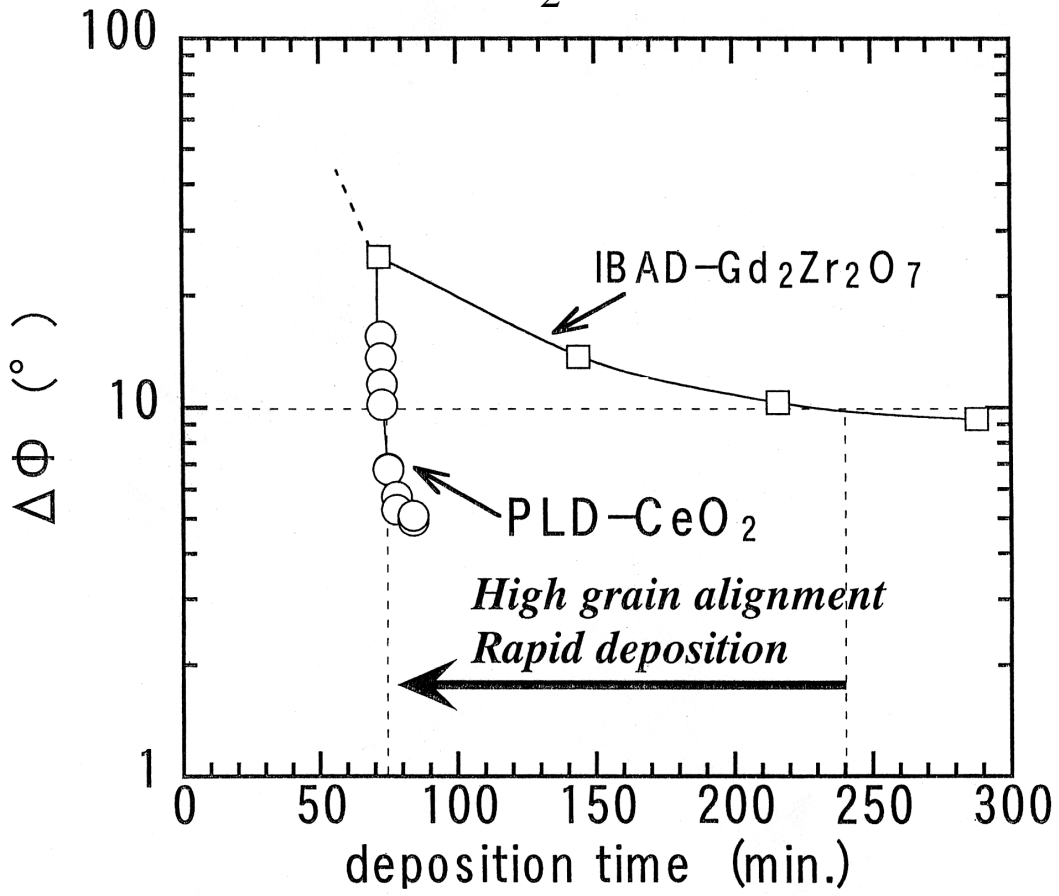
Approach: Thin IBAD GZO + Thick PLD CeO_2

J_c =3.8 MA/cm^2 (0.3 μm thick)

Ref: T. Muroga, et al., ISS 2002

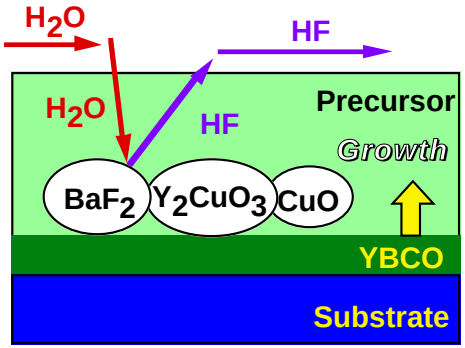
Self-epitaxy in CeO_2 IBAD-GZO

Dependence of $\Delta\phi$ on deposition time
for PLD-CeO_2 on IBAD-GZO



Ref: T. Muroga, et al., ISS 2002

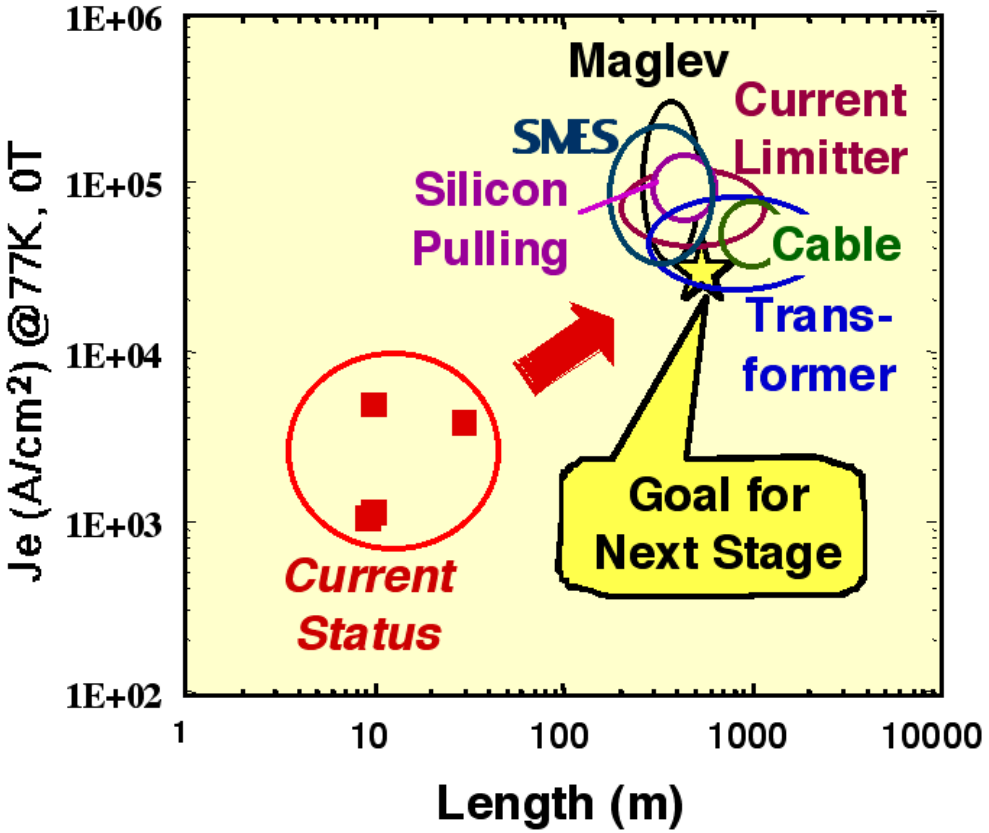
Innovative Process for HTS Layer
(ISTEC-SRL, Fujikura, Furukawa, Showa Electric)



- Approach
  - Metal organic deposition (MOD/TFA)
  - Metal organic chemical vapor deposition (MOCVD)
- Major results
  - HC/IBAD-GZO (1 μm)/CeO_2 (0.5 μm)/TFA-YBCO (1.4 μm); I_c = 210 A, J_c = 1.5 MA/cm^2 (≈0.2 μm film, J_c = 2.5 MA/cm^2 @ 0 T and 0.17 MA/cm^2 @ 5 T)
  - Untext. Ag/MOCVD-YBCO (0.4 μm @ 10 m/hr) ; 100-m, J_c = 6.1x10^4 A/cm^2, (I_c = 2.43 A); range: 4.5-7.6 x10^4 A/cm^2
  - Text. Ni/CeO_2, GdO_3 -MOD/TFA-YBCO; 1-m; J_c =10^5 A/cm^2

Goal in Next Stage and Requirements – Japan

Current Status
Long Length: 46-m with J_c = 0.5 MA/cm^2
Innovative Processing: <10-cm, J_c = 1.5 MA/cm^2



Goal for Next Stage
Length: 500m
Cost:$100/kAm
I_c*: 300A/cm-w
Production Rate: 5m/hr

Ref: Y. Shiohara, ISTEC-SRL