Mini-Workshop@LCS
Oct 5, 2010

Recent Progress in Coated Conductor Development in Japan

Noriko Chikumoto

Superconductivity Research Laboratory
International Superconductivity Technology Center (ISTEC)

ISTEC

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1. Short introduction of SRL-ISTEC
2. Outline of M-PACC project
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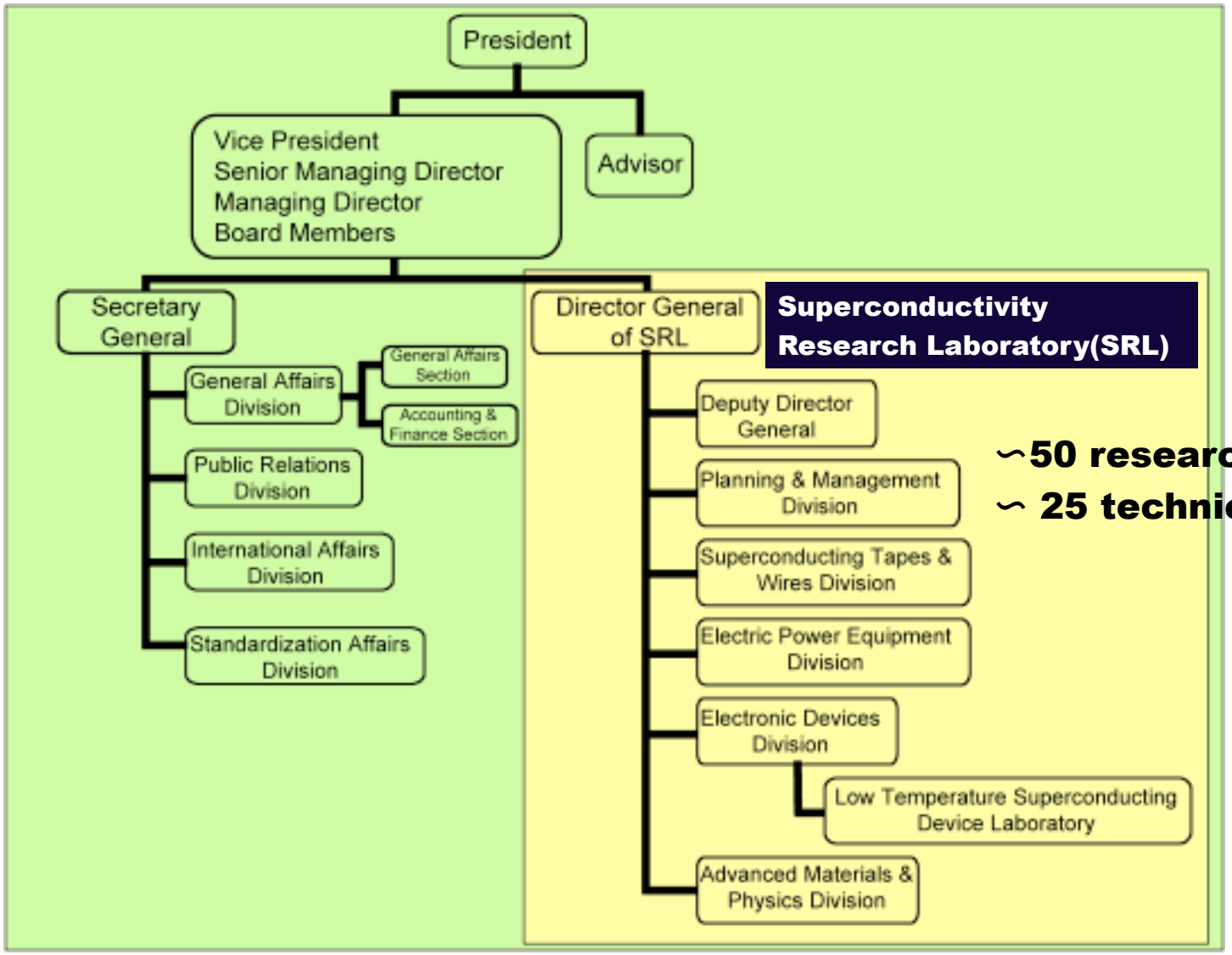
ISTEC (財) 国際超電導産業技術研究センター
International Superconductivity Technology Center
http://www.istec.or.jp

ISTEC was established as a nonprofit foundation in January, 1988, with the approval of the METI

The objectives of ISTEC

Contribute to the consistent advancement of superconductivity studies and the sound development of superconductivity-related industries. To meet these objectives, ISTEC actively promotes surveys, studies, basic research and development, and a variety of international exchange programs.

Organization of ISTEC



~50 researchers
~ 25 technicians

Conceptional View of Electric Grid System by Superconducting Power Devices for Stable and Large Capacity Electric Power Supply
– SMES, Cable and Transformer –

1. Stabilization of Electric Power System SMES

Solution for voltage deviation and step-out of power generator by controlling active power

Cooling Tower

Cooling Devices

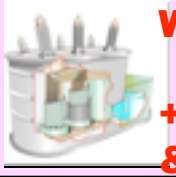
2. Superconducting Cable

Duct

Duct retrofitting

Cu Transformer

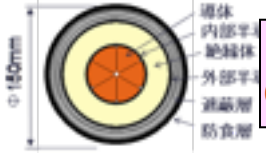
3. Superconducting Transformer



Weight:1/2 Area:2/3
Loss:1/3
+Fault Current Limiting & non-flammable

Underground Transformer

Cu CV Cable
500 MW/Circuit



3times Capacity

SC Cable
1500 MW/Circuit

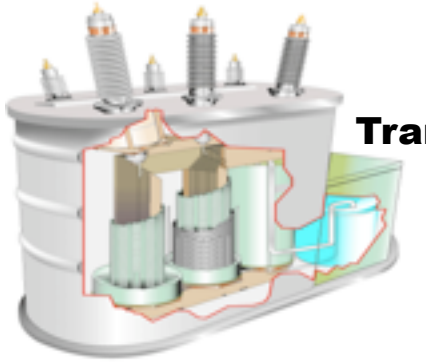
Estimation on the CO_2-emission reduction effect by the introduction of HTS cables

	AC		DC
Cable system	Current Cu Cable		HTS Cable
Transmission Capacity	1,500 MVA		
Transmission Losses	740kW/km	x1/3 → 200kW/km	20kW/km

390g-CO_2/kWh for Japan
560g-CO_2/kWh for U.S.A.
860g-CO_2/kWh for China

Depending on the Ratio of Non-Fossil Fuel Generation; Renewables, Hydro & Nuclear

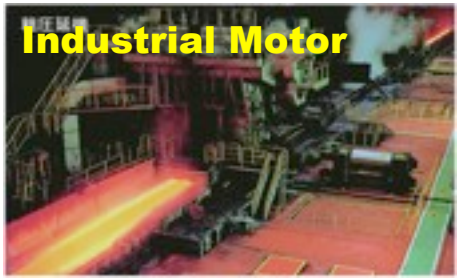
Possible application of superconducting tape



Transformer

Cable

SMES



Long Tapes with High Performance are required!

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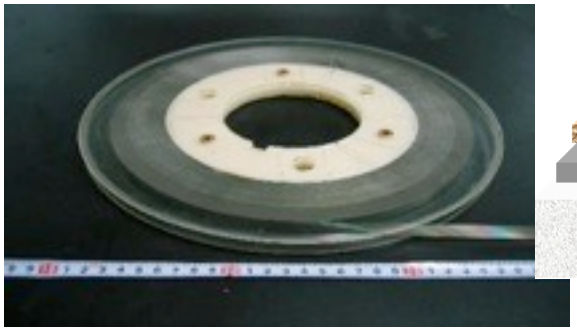
High-Tc superconducting tapes

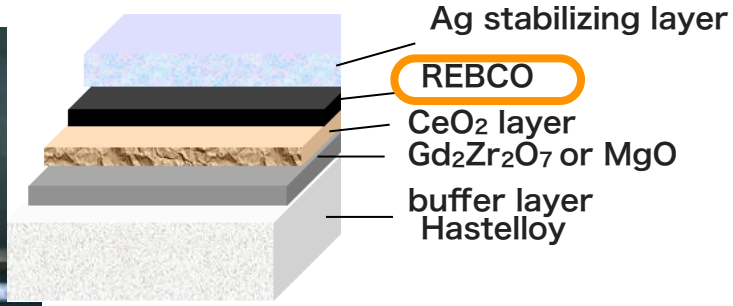
1st Generation:
BSCCO Tape

$Bi_2Sr_2Ca_2Cu_3O_y$

2nd Generation:
YBCO Tape

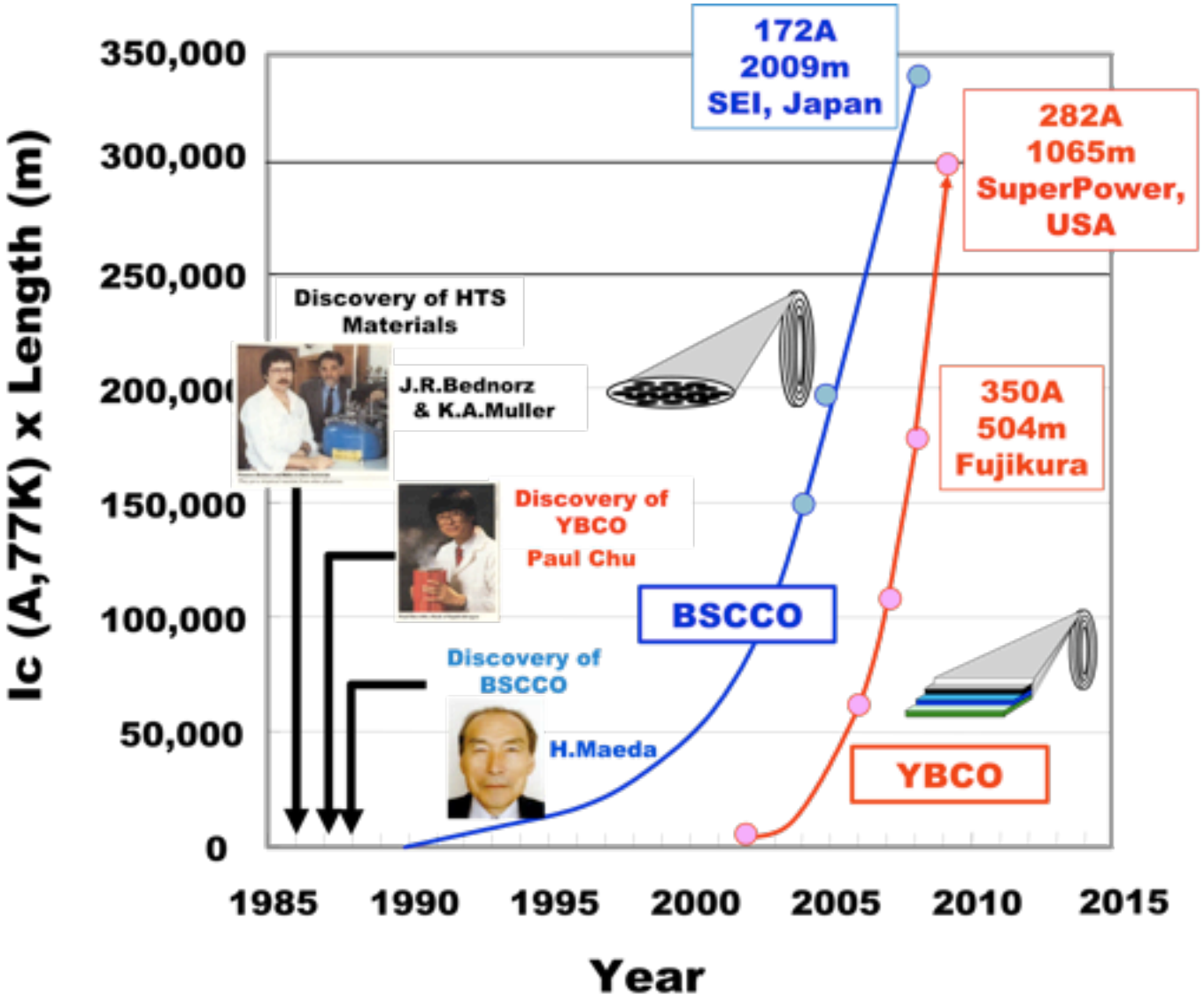
$YBa_2Cu_3O_y$





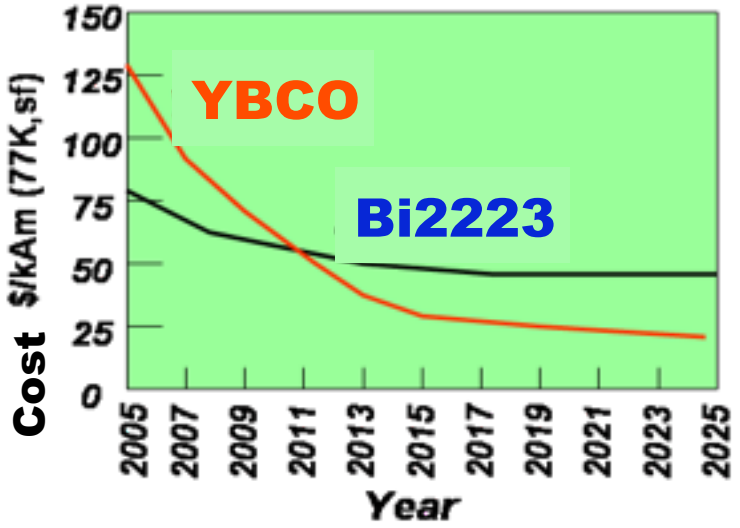
Typical structure of YBCO tape

R&D History of HTS Tapes@2008

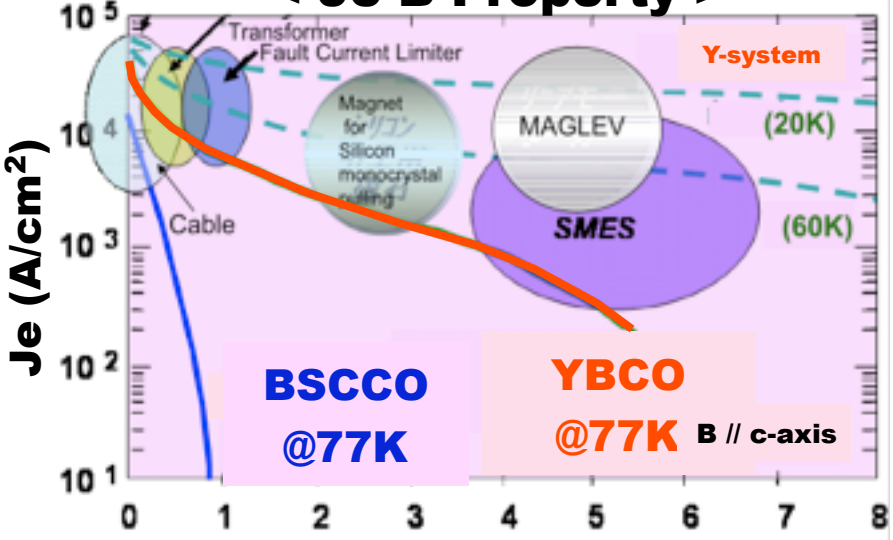


Advantages of YBCO

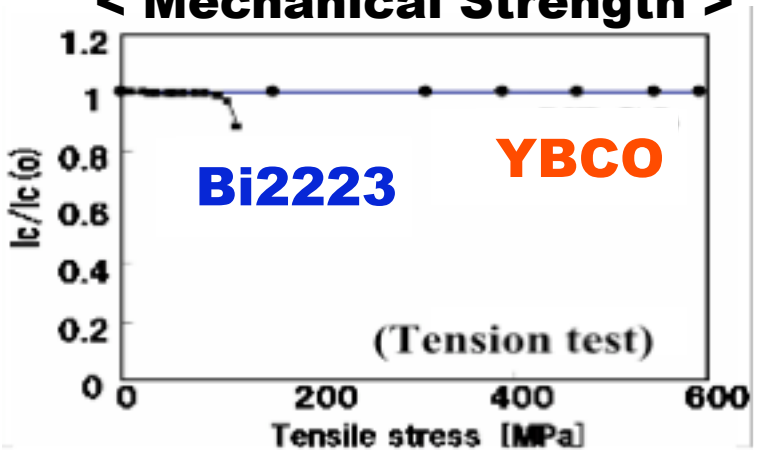
< Cost >



< Jc-B Property >



< Mechanical Strength >



< Low AC Loss >

B//Surface	B⊥Surface
Aspect ratio Bi:Y=1:100	For scribing Y : Layer structure⇒Easy Bi : Sheath⇒Difficult
1/100	Possible to scribe

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5 Year NEDO-METI Japanese National Project

“Materials & Power Applications of Coated Conductors”

M-PACC Project (2008-2012)

SMES, Cable, Transformer & C.C.

Budget: ~$30M/year x 5years

organization

METI → NEDO ↔ **Project Leader** ISTEC **Yuh SHIOHARA**

NEDO → SMES / Cable / Transformer / C.C. / Standardi-zation

SMES
SPL Nagaya

- 中部電力
- FURUKAWA ELECTRIC
- ISTEC
- KYUSHU UNIVERSITY
- Nagoya University
- 京都大学 KYOTO UNIVERSITY
- WASEDA University
- 鹿児島大学 KAGOSHIMA UNIVERSITY

etc.

Cable
SPL Okuma

- SUMITOMO ELECTRIC
- FURUKAWA ELECTRIC
- ISTEC
- Fujikura
- SWCC
- MAYEKAWA
- JFCC
- 京都大学 KYOTO UNIVERSITY
- WASEDA University

Transformer
SPL Hayashi

- KYUSHU ELECTRIC POWER CO.,INC.
- ISTEC
- TAIYO NIPPON SANSO
- Fujikura
- SWCC
- JFCC
- KYUSHU UNIVERSITY

C.C.
SPL Izumi

- ISTEC
- SUMITOMO ELECTRIC
- Fujikura
- SWCC
- 中部電力
- FURUKAWA ELECTRIC
- JFCC
- KYUSHU UNIVERSITY
- Nagoya University
- 京都大学 KYOTO UNIVERSITY
- WASEDA University

etc.

Standardi-zation

- ISTEC
- FURUKAWA ELECTRIC
- Fujikura
- SUMITOMO ELECTRIC
- SWCC

R&D Roadmap of C.C. Applications for Electric Power Devices

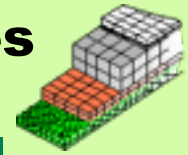
----	2006	'07	'08	'09	'10	'11	'12	

SMES Project

SMES using LTS Metal Super-conductors

Coated Conductors Project

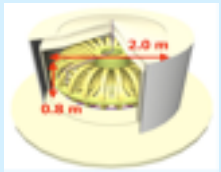
YBCO Tapes



Preliminary Works for Applications

Materials & Power Applications of Coated Conductors, M-PACC Project

2MJ SMES Model for >20MJ SMES



2MVA Transformer for 20MVA Transformer

66kV-5kA, 275kV-3kA Cables

Coated Conductors

for Mass-Production (10-20km)

High Yields, High Production Rate

Field Test

Market

Goals of Coated Conductor R&D

Themes	Interim Goals (2010)	Final Goals (2012)
(1)Degradation of Properties	•Endurance Test Conditions for Cable	• Evaluations for Other Applications
(2)High Ic under Magnetic Field	•30A/cm-w @77K,3T-50m •300A/cm-w @65K,0.02T-50m	•50A/cm-w @77K,3T-200m •400A/cm-w @65K,0.1T-100m
(3)Low AC Loss	•2mm-width & 300A/cm-w @77K,0T-50m •5mm-width & 5 filaments AC Loss Reduction to 1/5	•2mm-width & 500A/cm-w @77K,0T-200m •5mm-width & 10 filaments AC Loss Reduction to 1/10
(4) High Strength & High Je	•300 A/cm-w - 1 GPa @77K,0T-50m •Je=30KA/cm^2 – 200m	•500 A/cm-w - 1 GPa @77K,0T-50m •Je=50KA/cm^2 – 200m
(5)Low Cost & High Yield	•Lower Production Cost than 3 Yen/Am	• Low Production Cost toward 1 Yen/Am

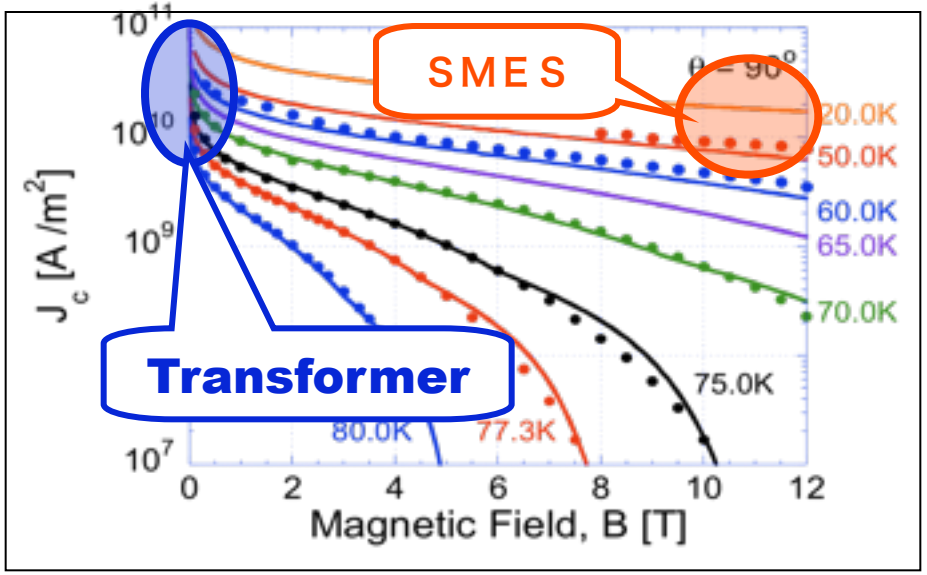
High Ic under Magnetic Field

< Outline >

High Ic Tapes under Magnetic Field for SMES & Transformer

< Goals >

Interim (2010)	Final (2012)
30A/cm-width @77K,3T-50m	50A/cm-width @77K,3T-200m
300A/cm-width @65K,0.02T-50m	400A/cm-width @65K,0.1T-100m



< Approaches >

(a) Introduction of APC

→BZO, RE-mixture etc.

(b) High Birr Materials

→Design & Synthesis

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Low AC Loss

< Outline >

Low AC Loss Tapes for Cable & Transformer

< Goals >

Interim (2010)	Final (2012)
2mm-w & 300A/cm-w @77K,0T-50m	2mm-w & 500A/cm-w @77K,0T-200m
5mm-w & 5 filaments	5mm-w & 10 filaments
Loss Reduction to 1/5	Loss Reduction to 1/10

< Approaches >

(a) Process Development for Uniform Tapes

→*Plume Control, Coating Technique etc.*

(b) Cutting & Scribing

→*Laser Cut, Chemical Etching, Mechanical Scribing etc.*

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Low Cost & High Yield

< Outline >

Realization of Low Cost Requirements from All Applications for "Field Test" & "Market" Stages

< Goals >

Interim (2010)	Final (2012)
Lower Cost than 3 Yen/Am	Low Cost toward 1 Yen/Am

< Approaches >

(b) High Rate & High Ic for Lower Cost
→*In-plume PLD, Multi-turn MOD etc.*

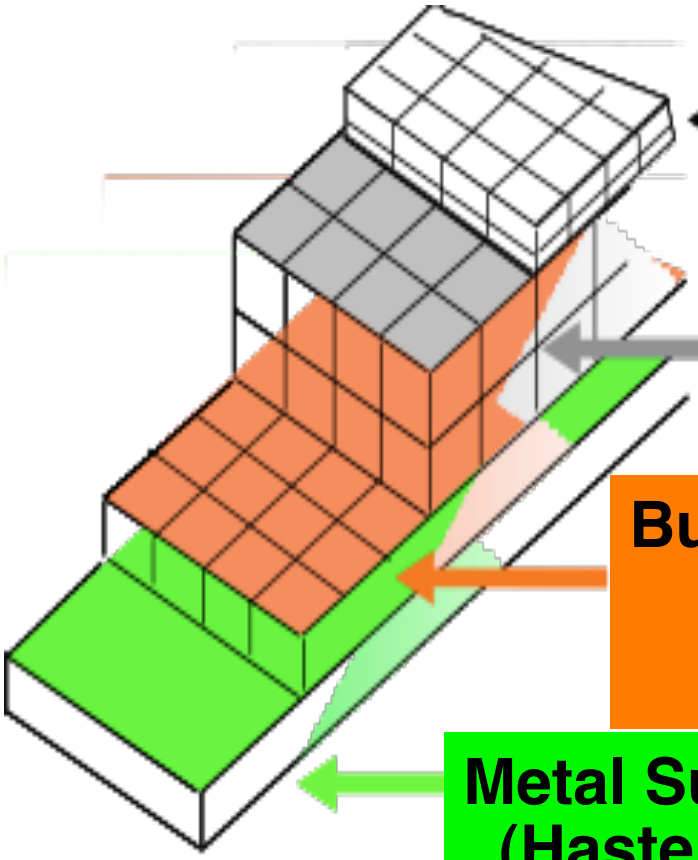
(c) Joining and Repairing

(a) Development of Process Stabilization for C.C. to "Field Test" (2013～)

→*Repeatability of Technical Level of Interim Goal (including Technical Transfer form ISTEC to Companies)*

Recent progress in CC R&D

Architecture of Coated Conductors



Stabilizing Layer: 25~100 μm
(Cu and/or Ag etc.)

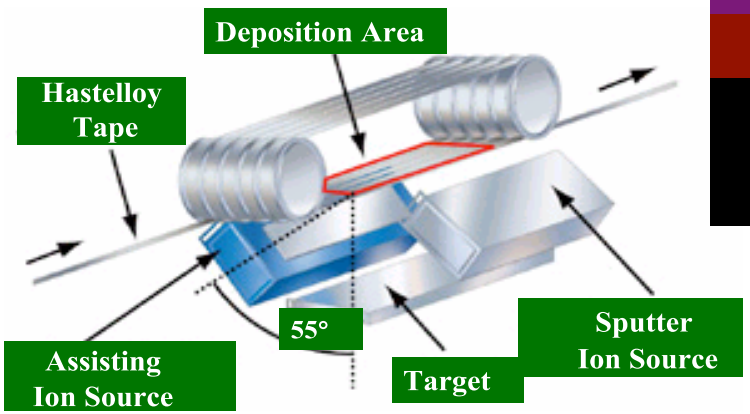
Superconducting Layer: 1~5μm
(YBCO and/or GdBCO etc.)

Buffer Layers:1~2 μm
(GZO, MgO, YSZ, Y_2O_3, Al_2O_3, LZO, CeO_2, LMO, etc.)

Metal Substrate: 50~100 μm
(Hastelloy ®, S.S., Ni-W, Cu, etc.)

Coated Conductor Processing

Ion Beam Assisted Deposition



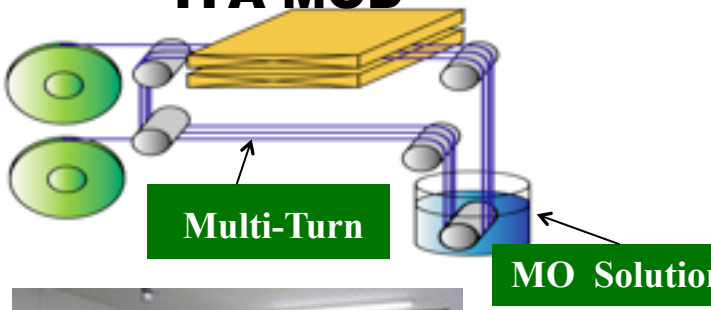
(YorGd)123

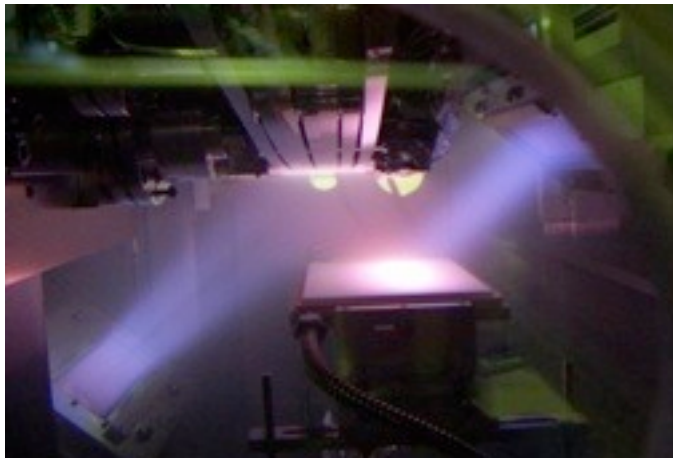
$PLD\text{-}CeO_2$

IBAD-GZO

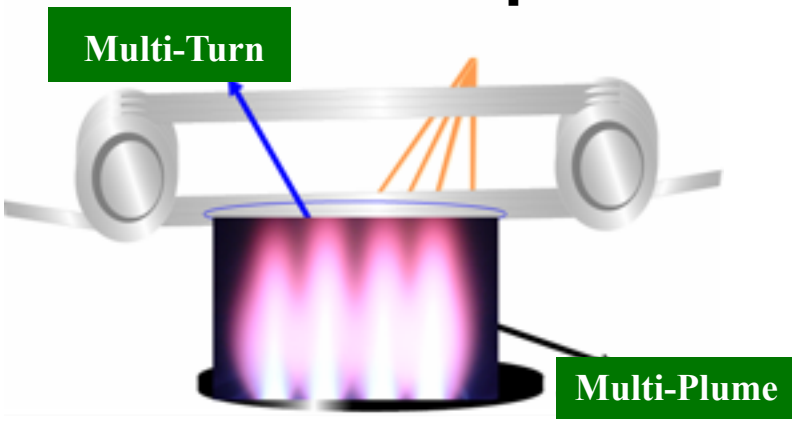
Hastelloy C-276

TFA-MOD



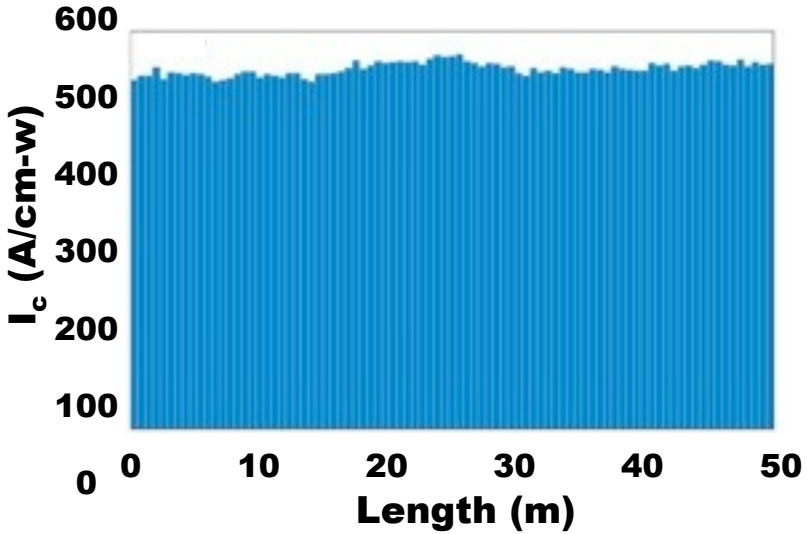


Pulsed Laser Deposition



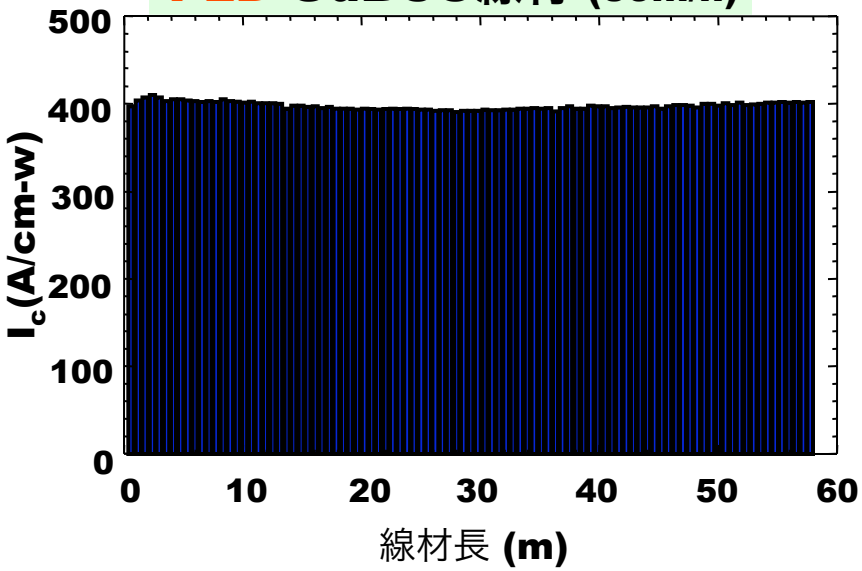
Examples of properties of CC

Production speed 10m/h
@Fujikura



Maximum length ~500m

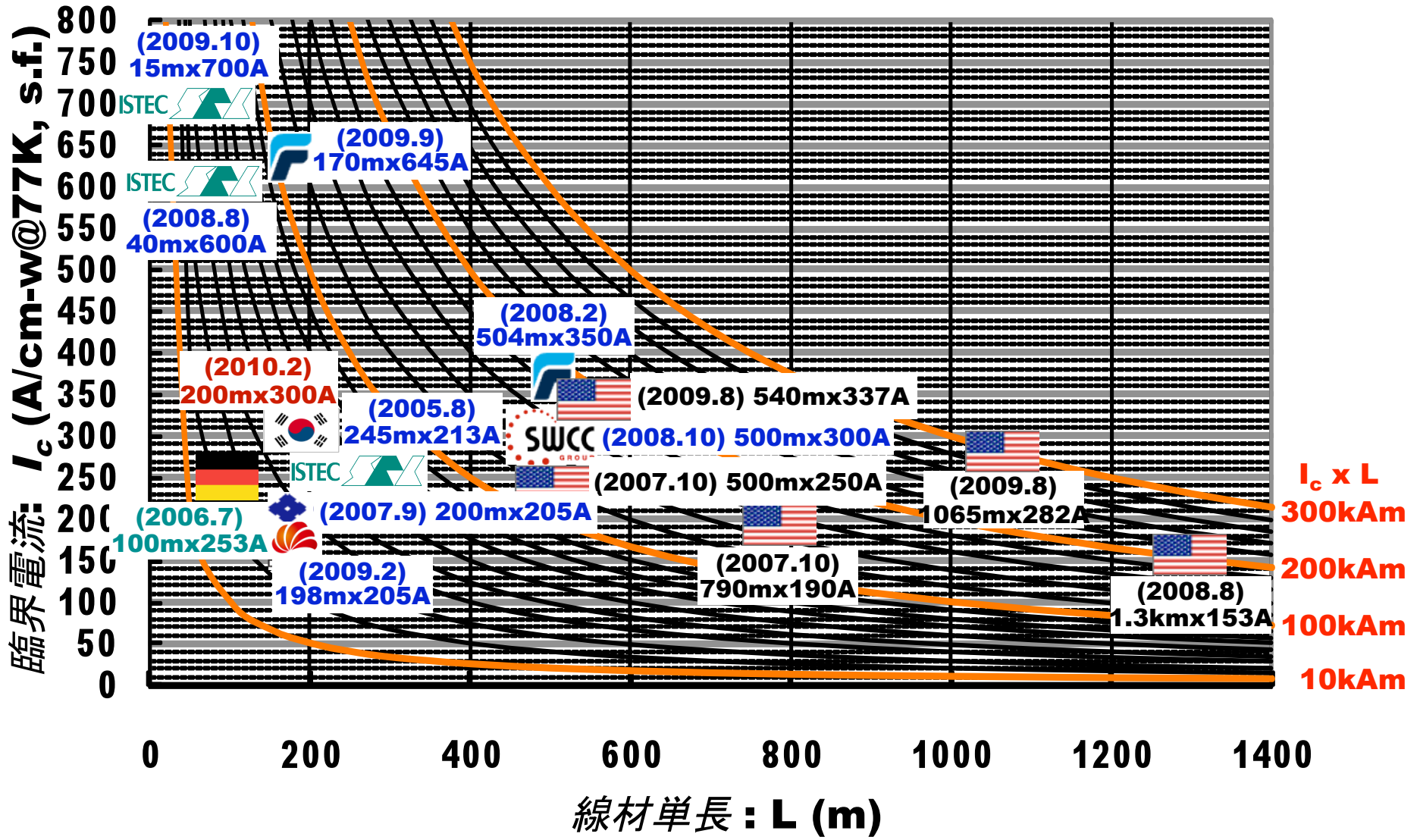
Production speed 30m/h
@ISTEC
PLD-GdBCO線材 (30m/h)



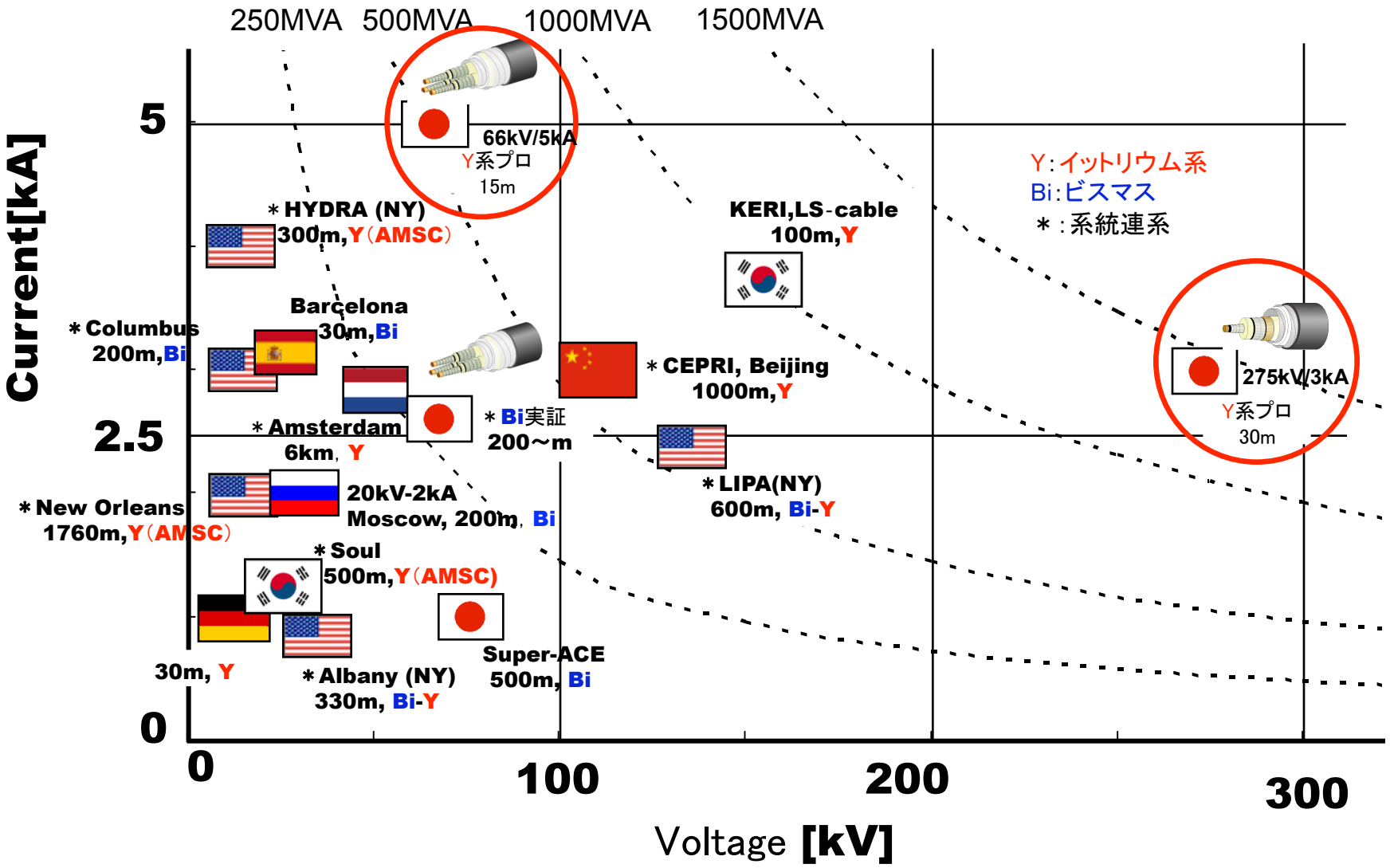
(PLD method)

Almost ready to provide for application test!!

Development of Coated conductors



Cable


250MVA
500MVA
1000MVA
1500MVA
Current[kA]
5
2.5
0
0
100
200
300
Voltage [kV]
66kV/5kA
Y系プロ
15m
＊HYDRA (NY)
300m,Y（AMSC）
KERI,LS-cable
100m,Y
Y:イットリウム系
Bi:ビスマス
＊:系統連系
275kV/3kA
Y系プロ
30m
＊Columbus
200m,Bi
Barcelona
30m,Bi
＊CEPRI, Beijing
1000m,Y
＊Amsterdam
6km, Y
＊Bi実証
200～m
＊LIPA(NY)
600m, Bi-Y
＊New Orleans
1760m,Y（AMSC）
20kV-2kA
Moscow, 200m, Bi
＊Soul
500m,Y（AMSC）
30m, Y
＊Albany (NY)
330m, Bi-Y
Super-ACE
500m, Bi

This work was supported by the New Energy and Industrial Technology Development Organization.

Special thanks to Dr. T. Izumi, ISTEC-SRL for providing ppt files.