ASC Special Session: What will Drive Market Maturity for HTS Applications in the Electric Power Sector?
9/5Mon. 14：30－16：30

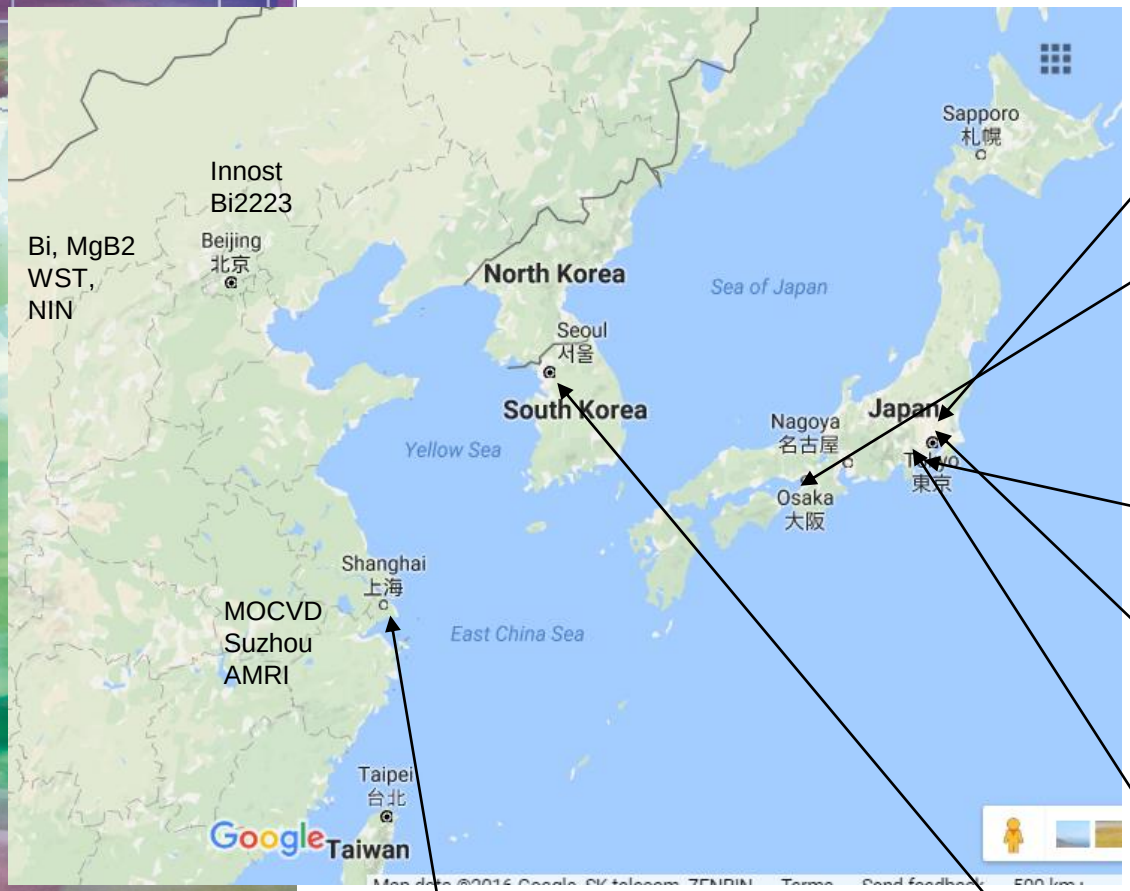
Wire Activity: Updates from Japan and Asia

Yutaka Yamada
(SIT, Shibaura Institute of Technology)
and
NEDO

Acknowledgements to the companies in Asia;
HITACHI
SEI
Fujikura
Furukawa
SuperOx and SuperOx, Japan
SuNAM (Korea)
SSTC (Shanghai Superconductor Tech., China)
SCSTC (Shanghai Creative Superconductor Tech., China)

1975 - 2015 iea Energy Technology Network
Accelerating results for 40 years

Recent Topics in Commercial HTS Wire in Asia



Hitachi entered in MgB2 wire commercialization.

Sumitomo developed high tensile Bi2223 wire and Low cost (single buffer) REBCO wire.

NEDO: new project: train cable, MRI, Wire (Fujikura) ….

Furukawa developed superconducting junction (no limitation of length).

SuperOx and Japan starts to scale-up: ~1000km-4mm/year

SUNAM starts to sell also magnet (and Soul Cable commercial cable started by KEPCO)

China (Shanghai) found 2 HTS .(REBCO) companies, SSTC, SCSTC.

Hitachi

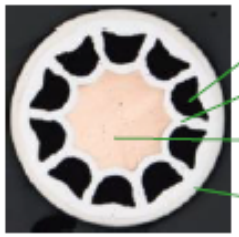
MgB2

Hitachi's R&D Activities on MgB_2 Wires

HITACHI
Inspire the Next

	Presentation No.	Remarks
#1 PIT wire	1MOr3A-02	300m length, J_e > 250A/mm2 @ 20K, 3T
#2 Dense PIT wire	3MPo2B-01	Higher J_c with mechanical milled powder
#3 Tape wire	3MPo2B-10	Superior J_c on MgB_2 thin film

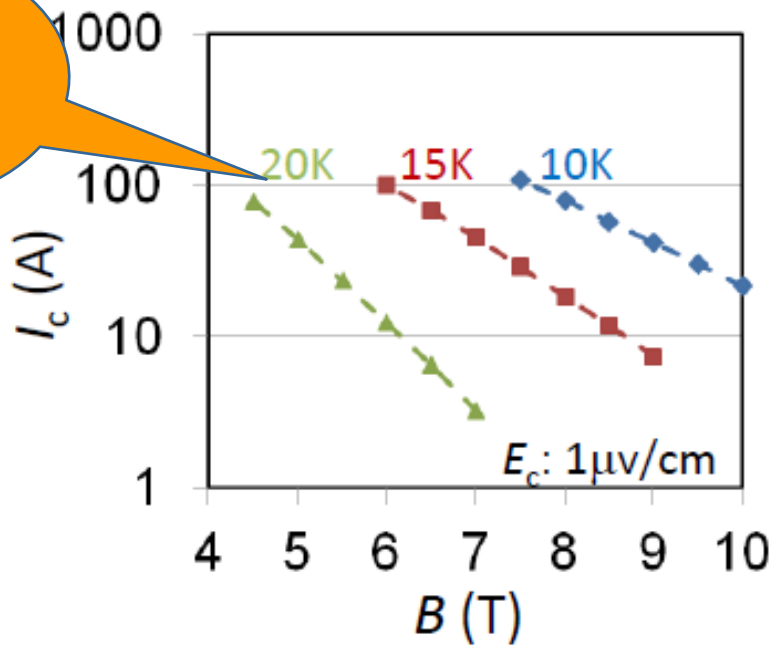
Cross-section of PIT wire



Made by
- In-situ method and carbon doped
- Drawing machine for NbTi wire

Same Ic level as the forerunners.

I_c-B-T of PIT wire (O.D. 1.5mm)



Exit

MRI and other applications
e.g. rotary machine cooled by liquid hydrogen.

SEI

Lineup of DI-BSCCO

SUMITOMO ELECTRIC

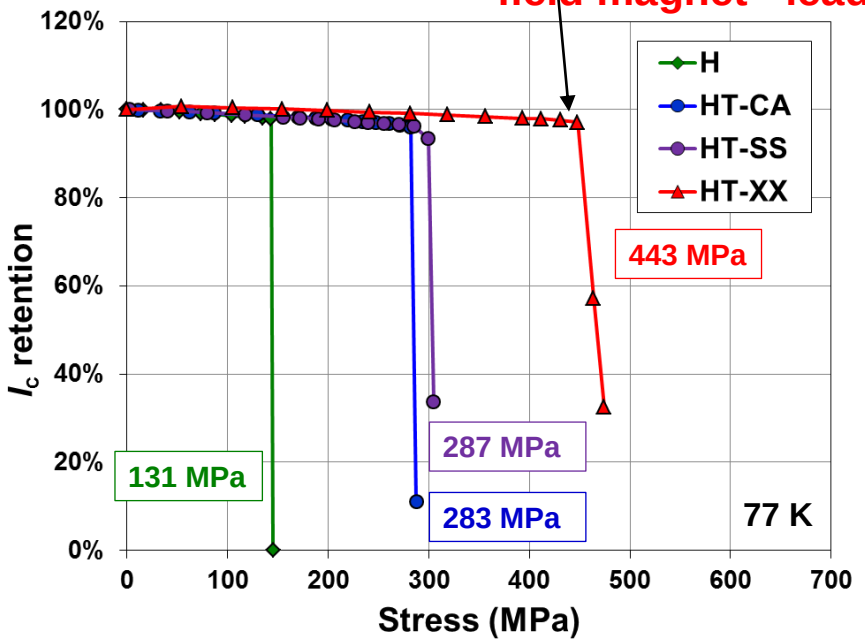
	Type H	Type HT-SS	Type HT-CA	Type HT-NX	Type G
Width	4.3+/-0.2mm	4.5+/-0.1mm	4.5+/-0.1mm	4.5+/-0.2mm	4.3+/-0.2mm
Thickness	0.23+/-0.01mm	0.29+/-	4+/-0.02mm	0.31+/-0.03mm	0.23+/-0.01mm
Reinforcement	—	St	r Alloy	Nickel Alloy	— (Ag-Au matrix)
Critical tension * (RT)	80N **			410N **	80N **
Critical tensile stress * (77K)	130 MPa **	270 M	250 MPa **	400 MPa **	130 MPa **
Critical tensile strain * (77K)	0.2% **	0.4% **	0.3% **	0.5% **	0.2% **
Critical double bending diameter * (RT)	80mm **	60mm **	60mm **	40mm **	80mm **

Higher strength like REBCO

* Correspond to 95% of critical currents * * Reference

For magnet For cable For high field magnet For current lead

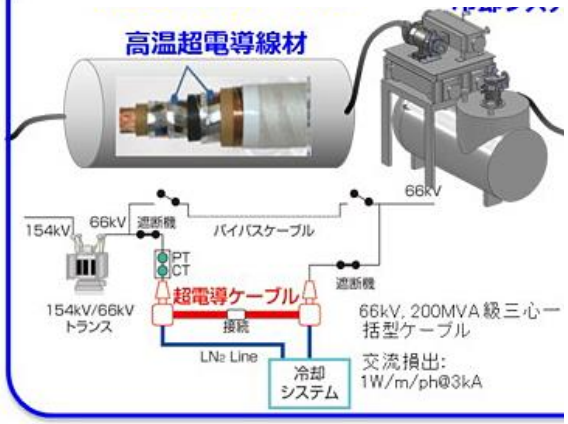
- Ic & n-value in long length
  - ✓ Uniform
- Production capacity now
  - ✓ 1,000km/year
- Produced Type G
  - ✓ More than 30km since 2011



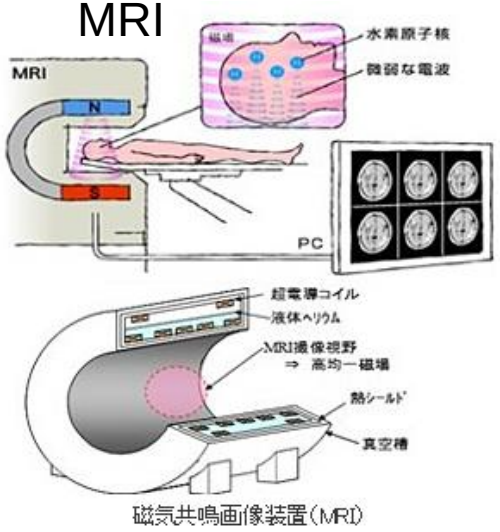
Fujikura and NEDO

NEDO NEW Project (2016-2020)

HTS power cable

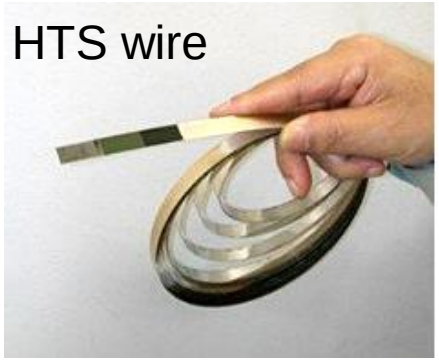


MRI



HTS train cable

HTS wire



Fujikura REBCO Wire

Present ability

Length: 1km/10-12mm width

~300m/ 4mm width

Ic: 200A/4mm width at 77K, sf

Ic enhancement:

- Hf addition
- 700A /4mm width, 50m at 4.2K、15T
- 4 filament-wire/4mm-w, 110m shielding current reduced.

NEDO project (2016-18) Target

1km wire with stable high Ic and production rate

REBCO Jc>400A/mm2

at 30K, 7T

1km, homogeneous Ic

Production speed increase

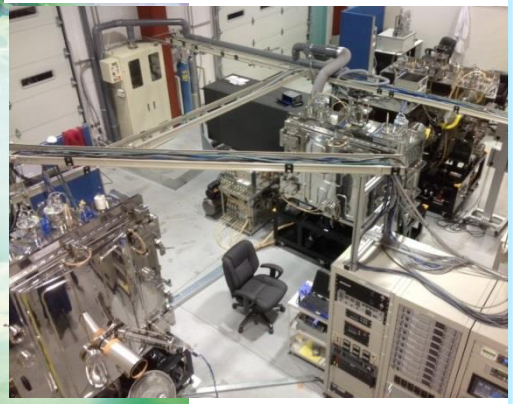
SuperOx

REBCO wire

SuperOx group

SUPEROX JAPAN
SUPERCONDUCTIVITY FOR LIFE

SuperOx



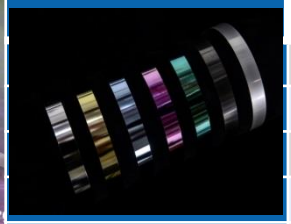
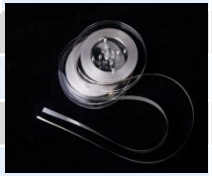
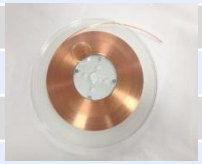
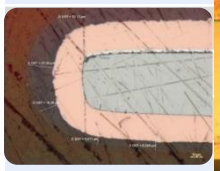
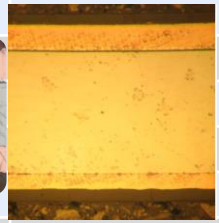
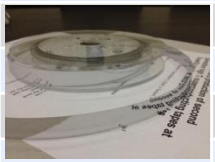
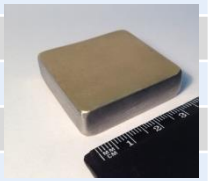
In year 2016 – SuperOx group increasing production capacity by installation of new IBAD-buffer
completed inde
both in Jap
Goal – 300 km/year of 12 mm wide tapes

Scale-up for mas production

SuperOx provide the widest range of customization options for 2G-HTS tapes

Parameter of 2G HTS tapes	Common value		
Production Length	50 – 300 meters (max 600 m)		
Tape Thickness	60 – 100 μm		
Tape width	4 mm	6mm	12mm
Critical Current @ 77K, s.f.	70-150 A	100-200A	250-500 A
Current Uniformity	±10%	±10%	±10%

Customisation options

Buffers	Silver	Copper plating	Lamination	Polyimide coating	Polyimide wrapping	Solder plating and joining	Tape stacks
							

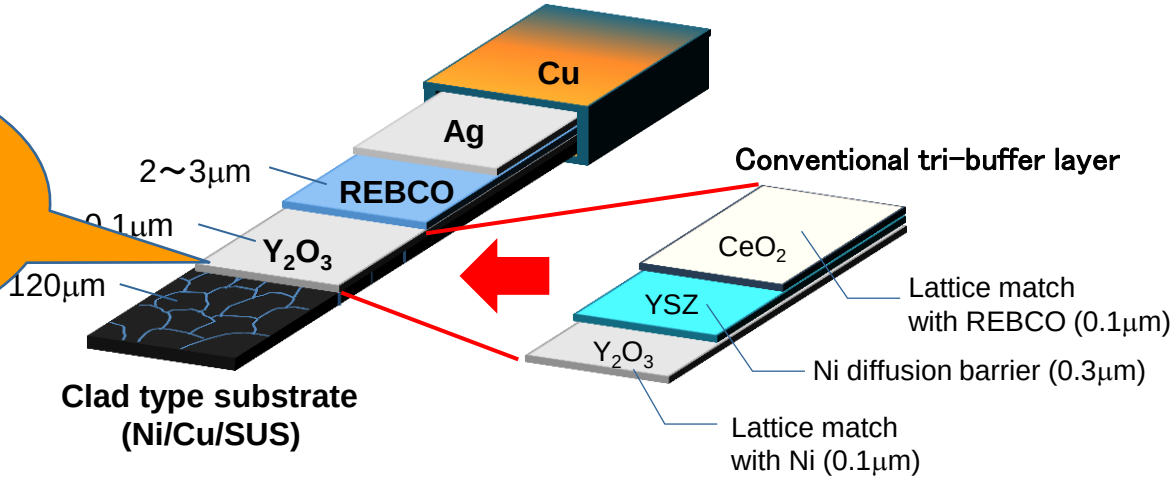
SEI

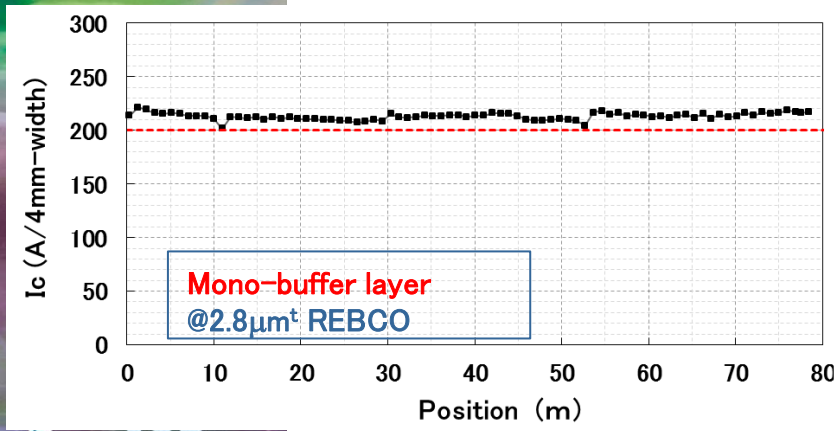
REBCO wire

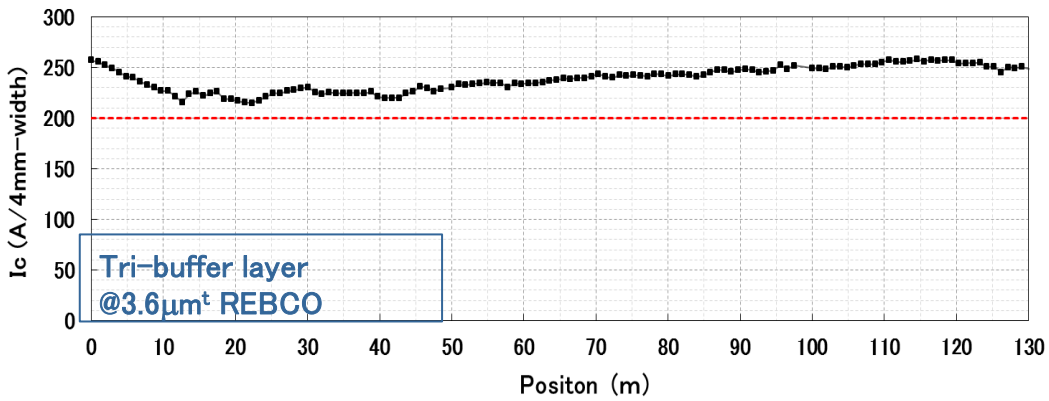
Low cost single buffer layer for a clad type substrate

Conventional tri-buffer layer was reduced to mono-buffer layer on a clad type substrate for low cost.

Low cost structure and same Ic ~200A/4mm





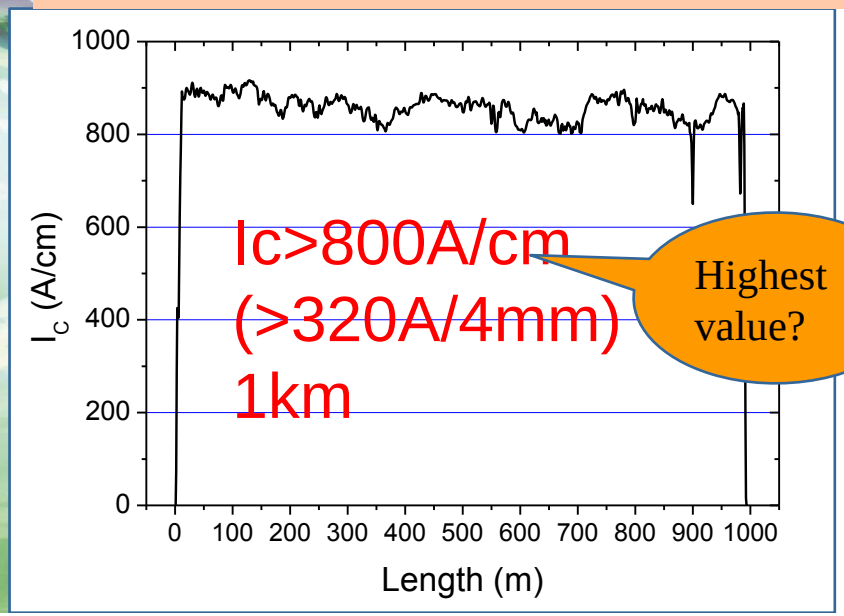


Comparison of PLD GBCO Ic distribution on mono-buffer layer and tri-buffer layer

Korea, SuNAM REBCO wire

SuNAM

Reactive Co-evaporation Method



60km/month=720km/year for >200A/4mm wire

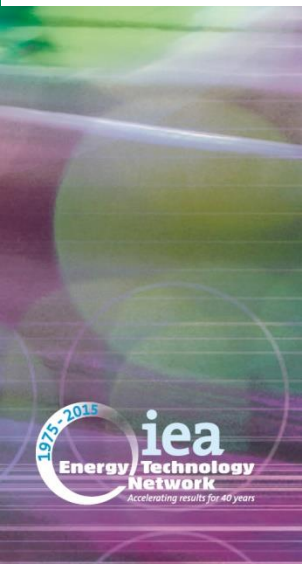
National Project

Target

- Critical current; I_C > 1,000 A/cm @77 K, s.f. (length > 1 km, uniformity > 96%)
- In-field performance; I_C > 1,000 A/cm @20 K, 10 T
- Stacked conductor; I_C > 1,800 A/cm @77 K, s.f.
- I_C measurement tech.; 0-10 T, > 1,800 A/cm, 20~77 K
- DC reactor demo; 400 mH, 1,500 A

Budget

~US$13M; $9M from Gov't, $4M from SuNAM
(June 2013 ~ May 2017, 4 years)



We Are Ready For Sale !!!

- High field 26.4 T(242A)
- Compact magnet
- **Self-protected** in 3 times quenches at 4.2 K

- High field magnet
  Over 20 [T] at center, Liquid helium cooling
- Racetrack magnet
  For motor application, Cryogen-free
- **Homogeneity magnet**
  For NMR application, Over 3 [T] at center, Cryogen-free

China

REBCO wire

80-200A/4mm, max 1km

SSTC (Shanghai Superconductor Tech., Co., Ltd) PLD

PRODUCT SPECIFICATIONS

	ST-04-E Series	ST-05-L Series	ST-05-E Ser	T-06-L Series	ST-10-E
Wire Structure	Copper Plating Strengthened	Encapsulation Strengthened	Copper Plati Strengthene	capsulation ngthened	Copper Streng
Width	4 mm	4.75 mm			10
Critical Current	80-200 A	80-200 A			
Thickness	100-180 μm	150-350 μm	100-		100-1
	>600 Mpa	>400 Mpa	>600 Mpa	>400 Mpa	>600
	0.4 %	0.4 %	0.4 %	0.4 %	0.4
	±10 %	±10 %	±10 %	±10 %	±1
	15 %	15 %	15 %	15 %	1
					30

Now they are at the same level.

Both have large factory buildings and facilities for mass-production.

SCSTC (Shanghai Cr ive Superconductor Tech., Co., Ltd) MOD

1km length

Present Status of Commercial REBCO wire

Method: PLD, RCE, MOD, MOCVD/IBAD, RABiTS

Property: 100-200A/4mm at 77K, sf

Length: 100-300m * maximum= 1km

Production Capacity: 100- 1000 km/year

Price: 30 to 100 US$/m (=150 to 1000 US$/kAm)
(my private opinion. Not official value by each company.)

Furukawa&Tohoku Univ.

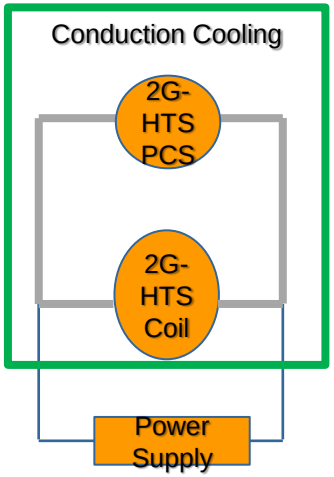
FURUKAWA ELECTRIC

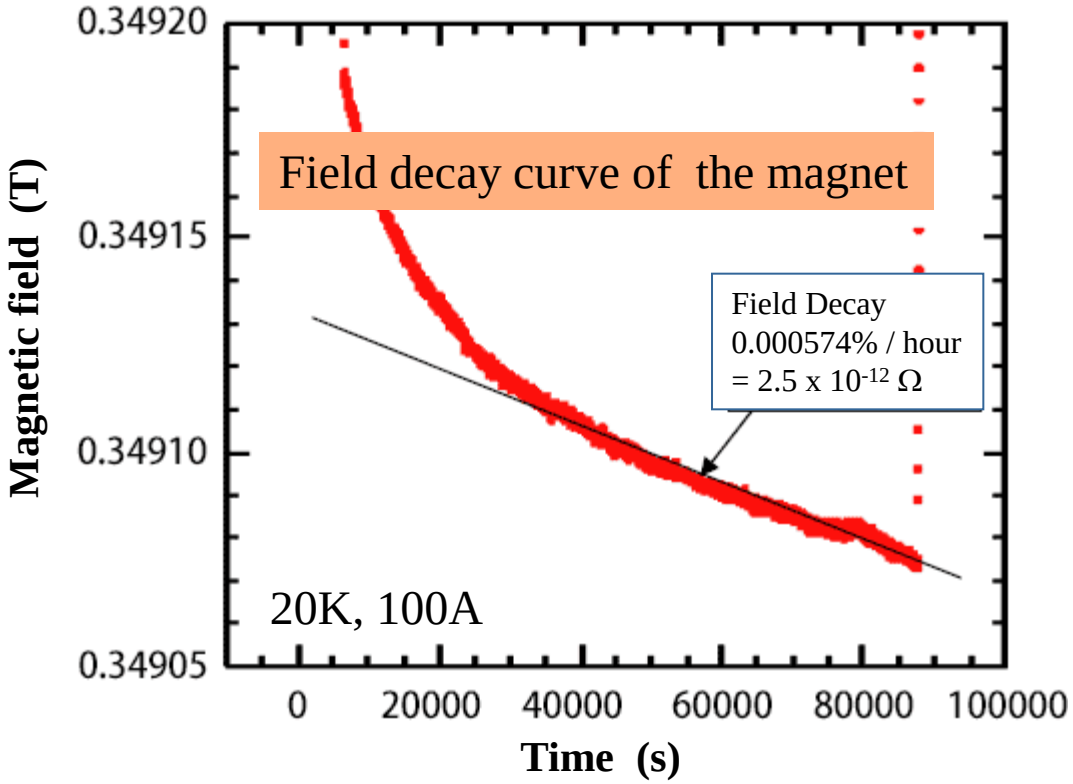
HFLSM

SC Junction: Persistent Current Circuit System with 2G-HTS

Resistivity ~$10^{-12}\Omega$
at 20K by refrigerator

3500 Gauss=100A for 24 hrs





This also means no limitation of length for some applications.

News-release (Aug. 25, 2016)
MEXT New Program

社会基盤刷新と新産業創出

「挑戦的」研究に助成

文科省

2017概算要求

日刊工業新聞　２０１６年８月２５日一面掲載

Program:
“High risk and high impact R&D for future society with revolutionary science and technology”

/ 90MUS$/ 2017 for 5- 7 items
/ >10M US$/year for 1 item
/ 10 years

.Superconducting R&D will be included, but not simply “increase Ic or length” or . demonstration.

Conclusion

/ Competition among companies getting harder

/ R&D still going for stable production, high Ic and low cost, considering more commercialization than before.

/ need “purchase order or large market” for the wire companies⇒real price, Ic

Hitachi entered in MgB2 wire commercialization.

Sumitomo developed high tensile Bi2223 wire and Low cost (single buffer) REBCO wire

Some Opinions

* Production capacity enough ?

*Target price: balance between cost in production and demand for applications

*Labor fee is also important as well as technology

*Need world-wide Supply&Demand system like fashion industry

* Regulations in each country should also be considered in some applications.

SUNAM starts to sell also magnet
(and Soul Cable commercial cable started by KEPCO)

China (Shanghai) found 2 HTS .(REBCO) companies, SSTC, SCSTC.