2LO3-04

Recent progress in development of Bi2212 Cable-in-Conduit Conductors

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2017.09.19
EUCAS 2017, Geneva, Switzerland

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2. Recent Progress s on Sub-size Conductors
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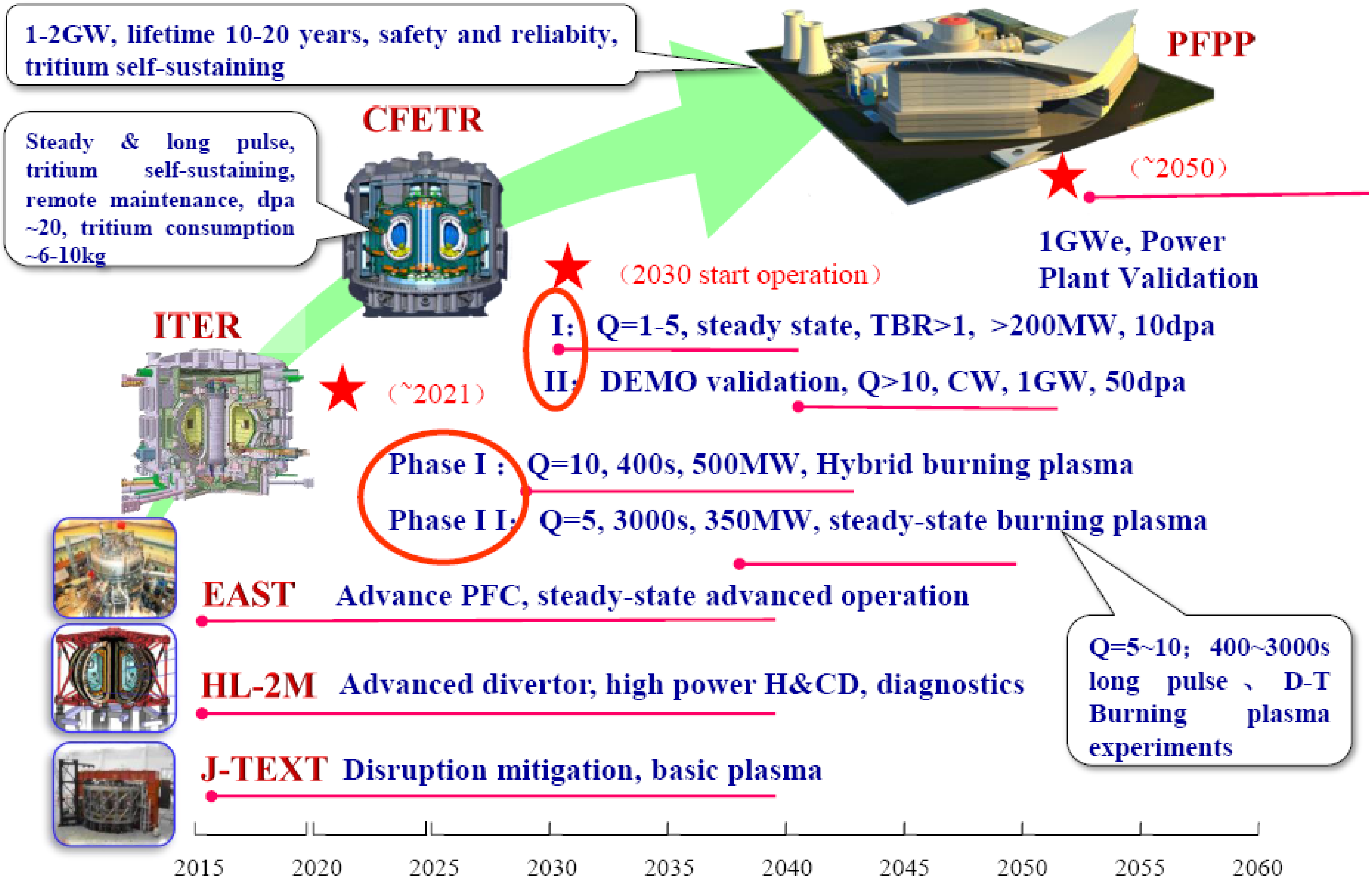
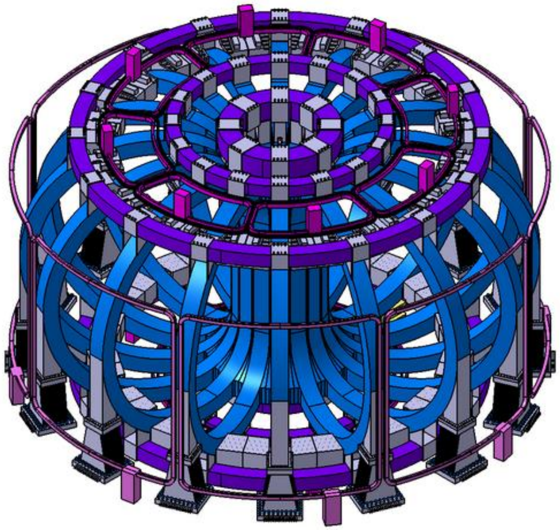
Roadmap of Chinese MFE Development

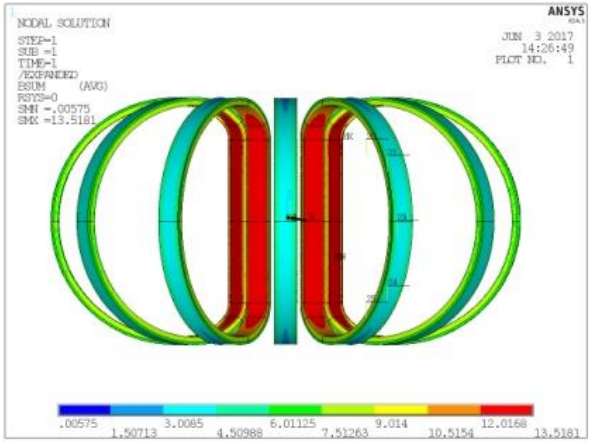


Key issues for CFETR-II

The optimized design is in process, but the maximum magnet field will reach to 15 T.

	16 Coils	12 Coils
Central magnetic field, Bt (T)	7.09	7.05
Operation current kA	66.6	52
Total turns	220	376
Large radius of plasma, R (m)	6.7	6.7
Minor radius of plasma, a (m)	1.8	1.8
Maximal field in TF coils	15.3	15
Toroidal field ripple	<0.3%	<0.3%
Maximal Equivalent Stress at the equatorial plane (MPa)	547	597

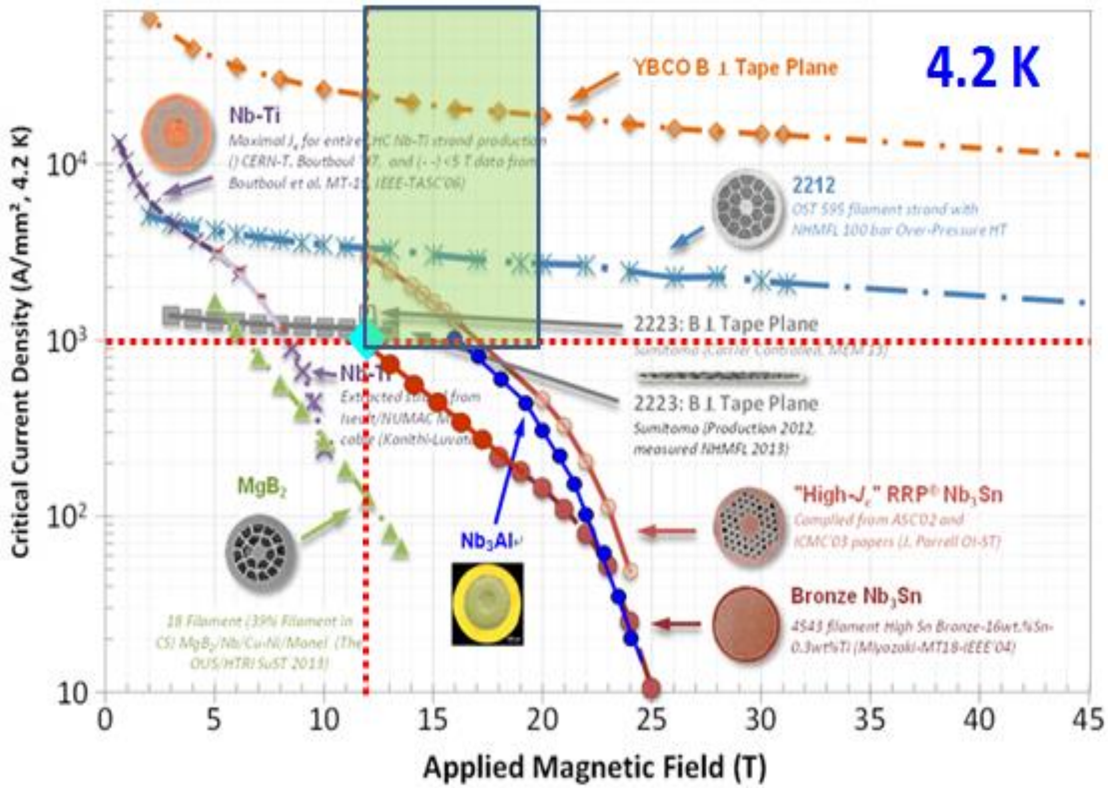


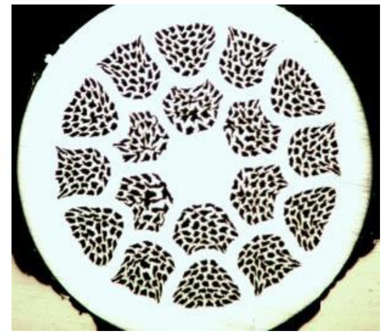


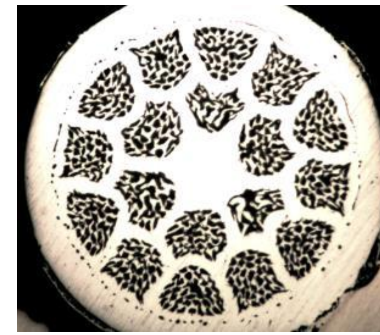
Superconductor material choice is very important

B-i2212 is one option

Superconducting materials properties for next generation of fusion reactor







Advantage:

- ☐ Round, twisted, multifilament, isotropic, low loss conductor with high RRR (> 100);
- ☐ Conductor technology is mature at present scale.

Disadvantage:

- ☐ Wire is brittle, easily to be damaged during cabling and conductor manufacturing;
- ☐ special heat treatment-with O2, high temperature, and high pressure.

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Sub-size Conductor

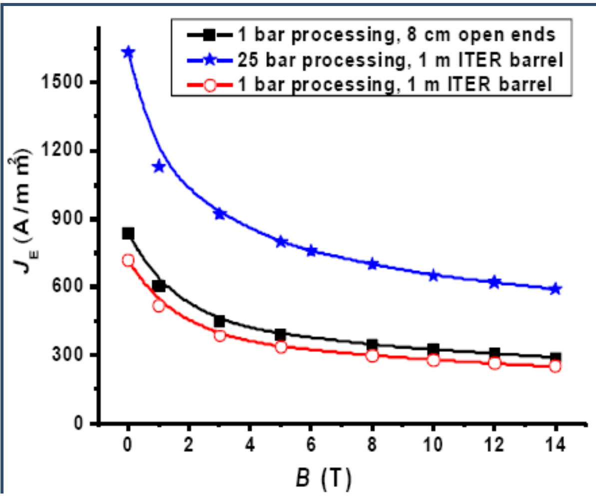
Principal question:

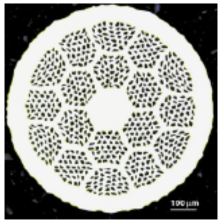
Whether Bi-2212 is suitable for CICC development

- **Cabling Technology Feasibility**
- **Heat Treatment Process (normal pressure to high pressure)**

Step 1: Normal pressure heat treatment

Step 2: High pressure heat treatment



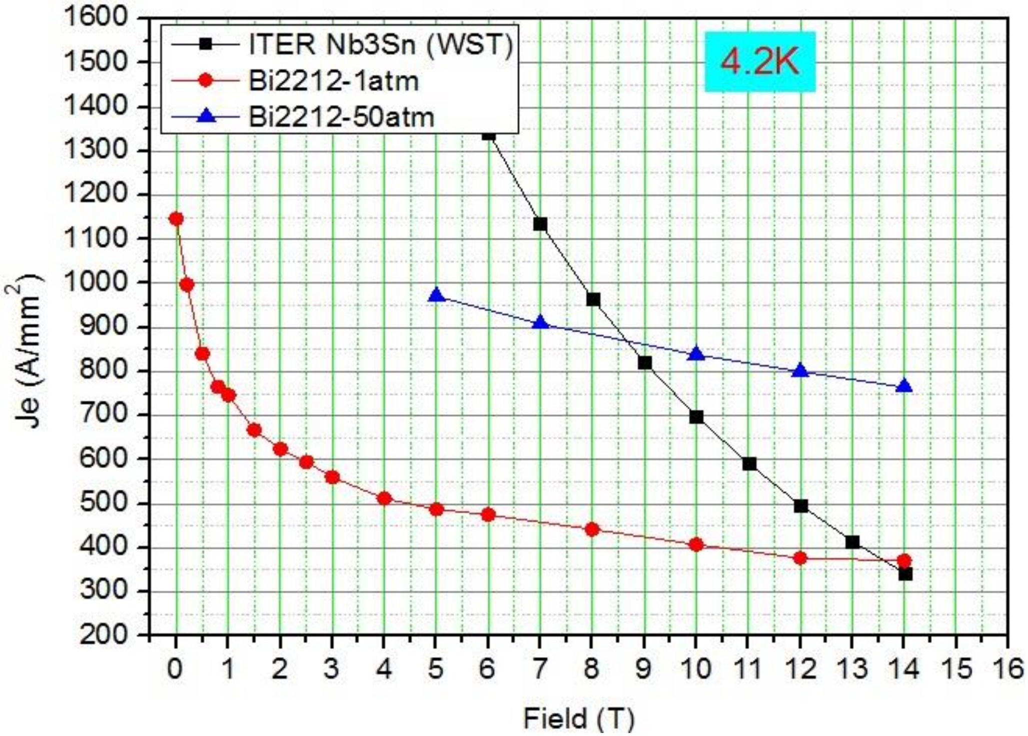


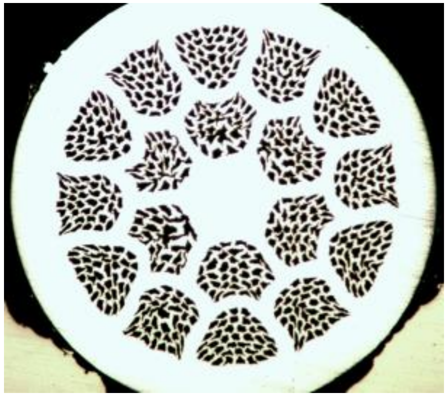
Shen et al, 2013 J. Appl. Phys. **113** 213901
Larbalestier et al. 2014 Nat. Mater. **13** 275

Bi-2212 Strand

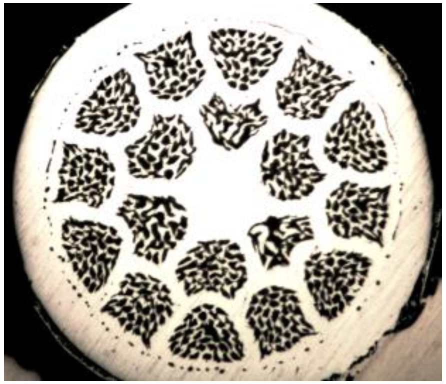
- The Bi-2212 strand was provided by Northwest Institute for Non-Ferrous Metal Research (NIN);
- Transport current performance is measured at ASIPP;

Material	Ag - 0.2wt% Mg sheathed Bi-2212
Diameter	1.0 mm
Filament configuration	19 x 18
Ag/Mg:Ag:Bi2212	1.8:1:0.9





Un-reacted



reacted

Bi-2212 Cable

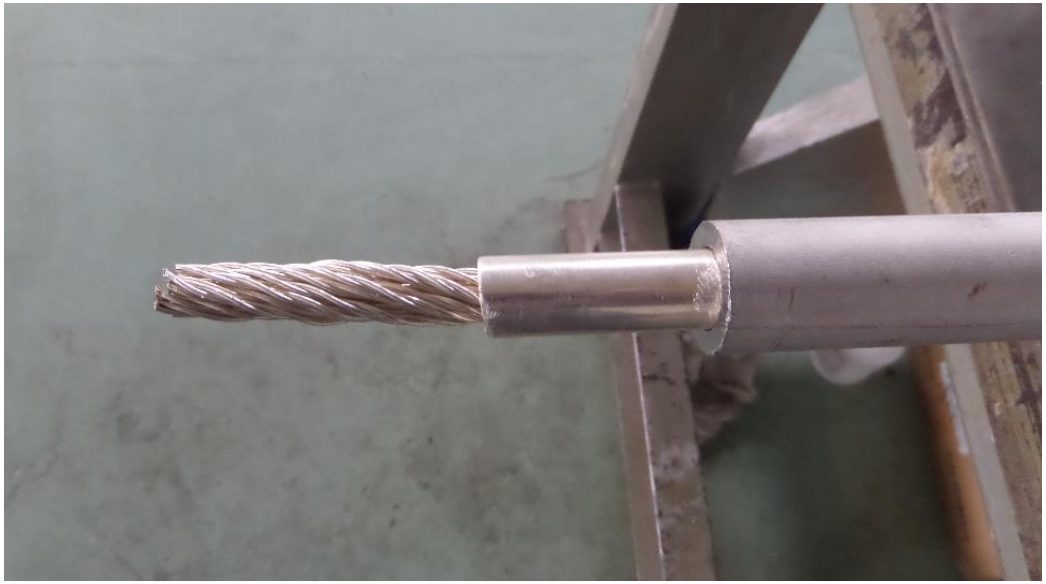
Item	Value
Bi-2212	1.0 mm
Cable layout	2 x 3 x 7
Pitch	20.7 x 50 x 87mm
diameter	10.0 mm

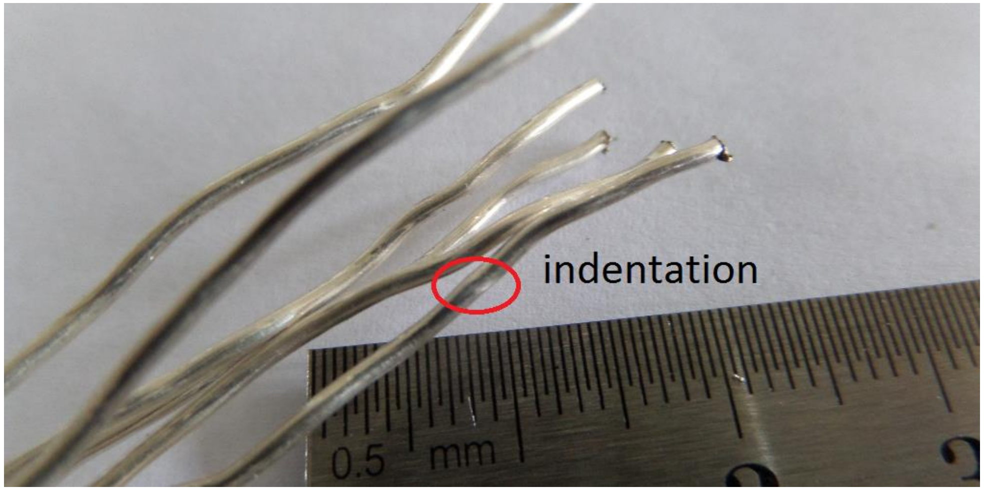
Cabling last stage

Final cable

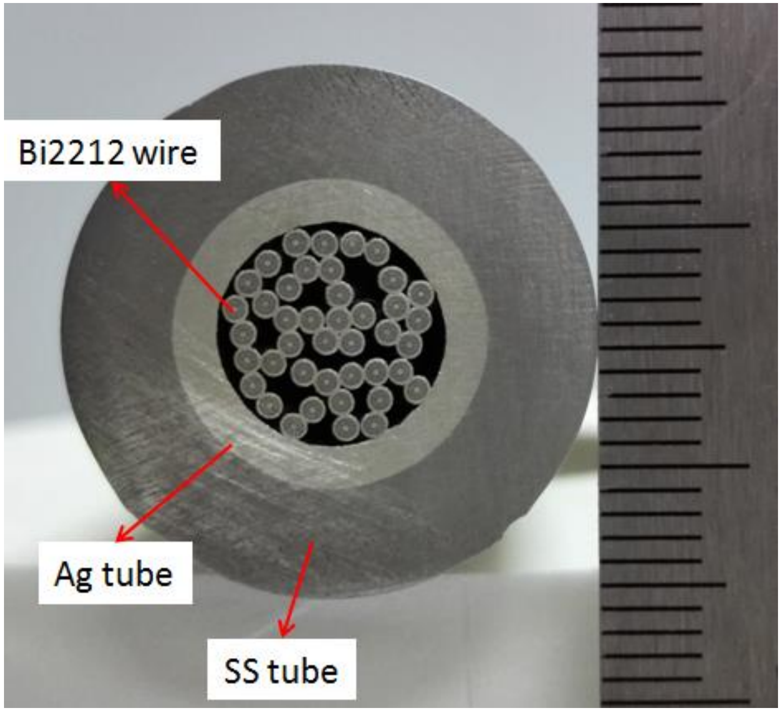
The cable is OK by visible examination!

Cable-in-Conduit Conductor





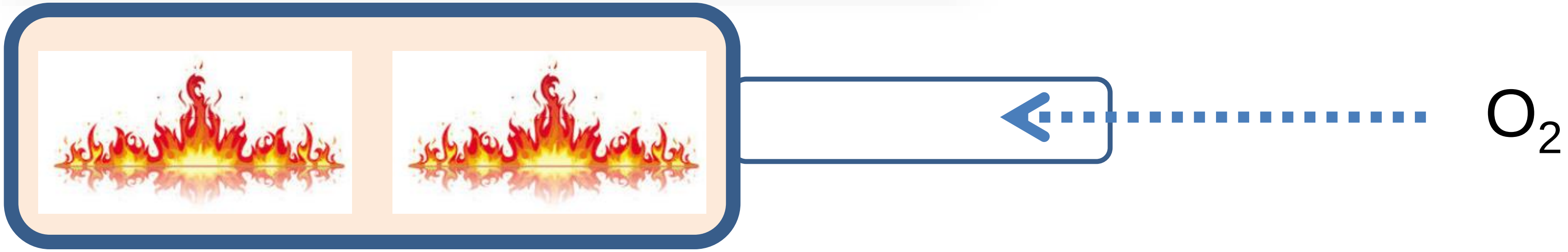
The small indentation was found.



Cable diameter (compacted)	9.0 mm
Void fraction (theoretical)	~40 %

Heat treatment

The O_2 was input from the inner of conductor during heat treatment.



Test facility for Bi-2212 CICC

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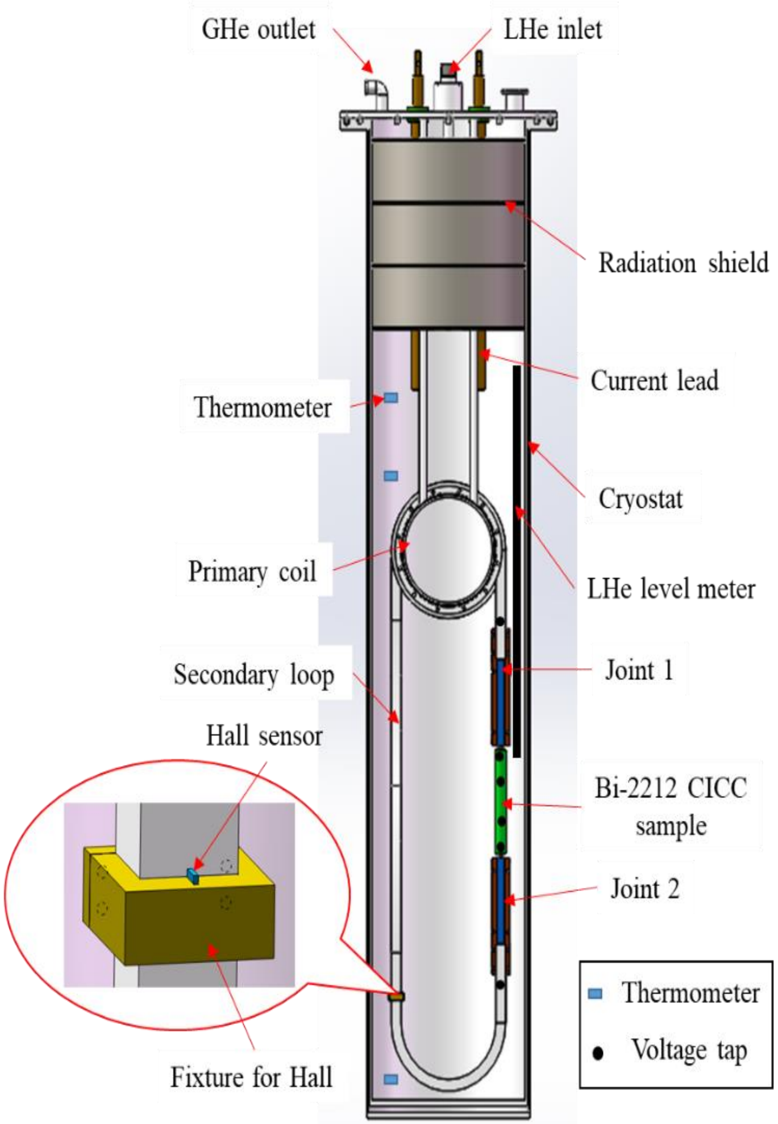
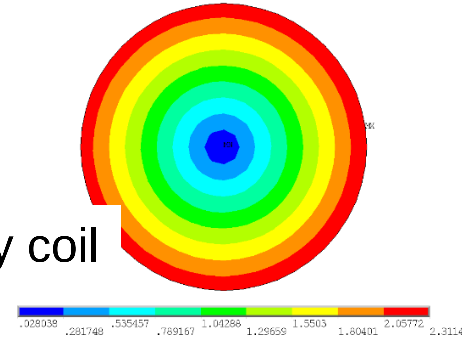
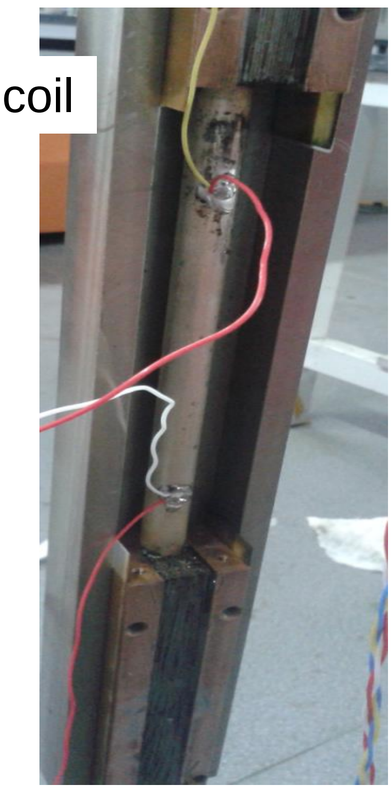


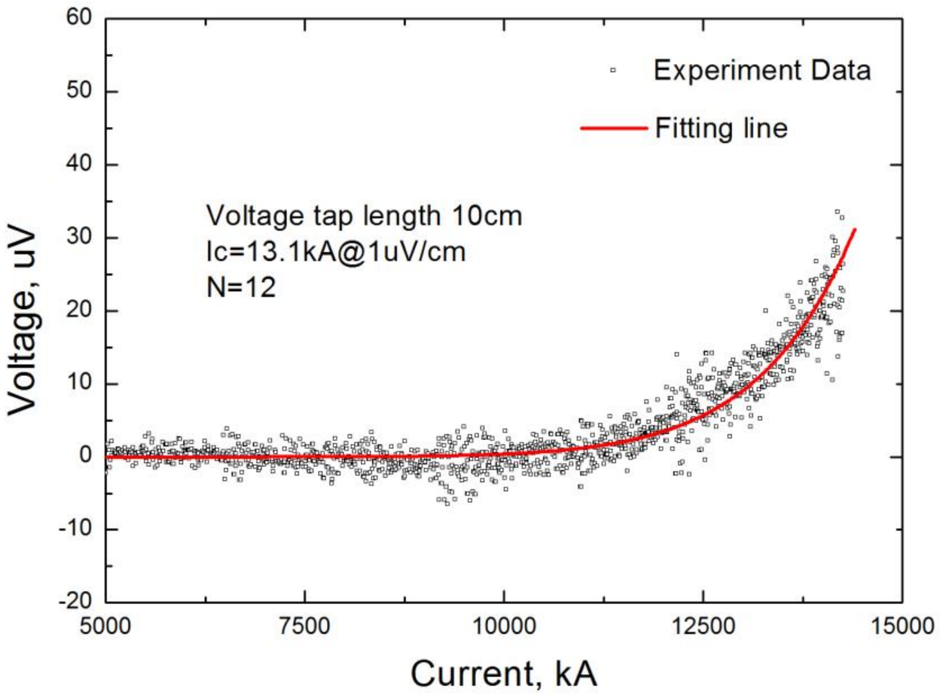
Superconducting transformer

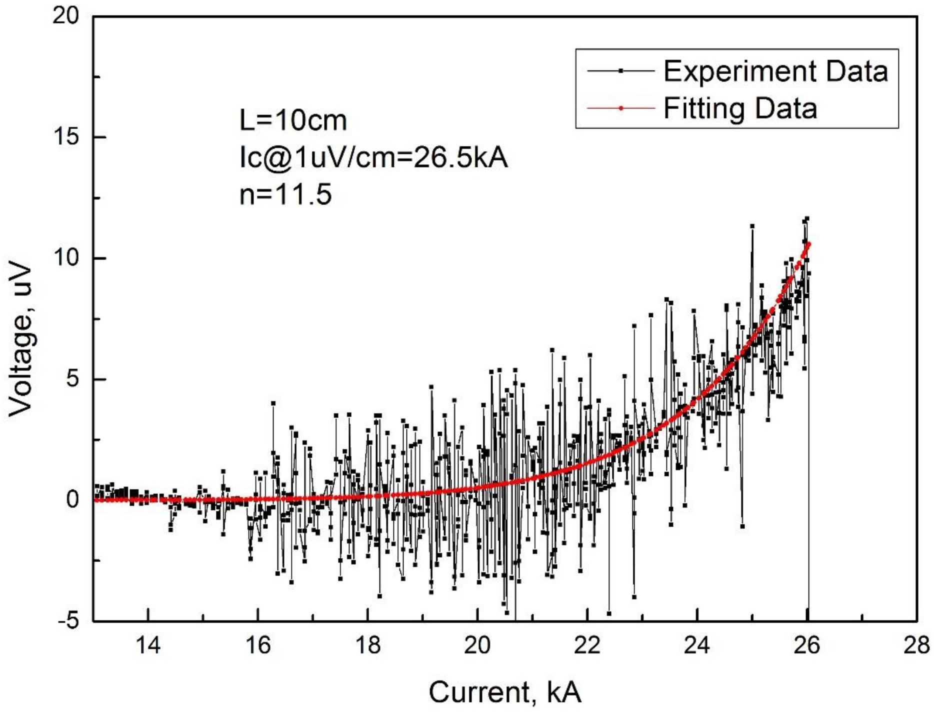




Testing results

heat treated with normal pressure	heat treated with 50 atm





	I_c (experiment)	I_c (evaluated by wire)	*n* value	Rc of loop
Normal pressure	13.1 kA	15.4 kA	12.0	19 nΩ
50 atm	26.5 kA	28.1 kA	11.5	8.25 nΩ

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3. Next plan

- During high pressure heat treatment, the diameter of wire reduced by 5%. (from 1.0 to ~0.95mm).
- For large scale conductor, this will increased the void fraction much.

E.g. ITER TF layout, the value could increase from 29 % to 39 %, which can not be accepted.

After heat treatment, the conductor can not be compacted.
So the problem must be solved firstly.

Next step: Pre-heat treated to reduce the wire diameter.
Conditions: 650-700 degree, >100 atm
It's in process
(1) Wire performance
(2) Conductor

It's will be verified before middle of next year.

Content

4. Conclusions

- We believe that Bi-2212 can be used for high field applications with CICC.
- The research is continuing at ASIPP.
- We would like to collaborate with group which is interested in this field.

The future aim: full size conductor

I_c>60kA @ 4.2K, ~15T

Thank you for your kind attentions！