Experimental verifications of REBCO layer winding aimed at persistent current operation

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Background

HTS-HTS joint with R < 10^{-12}Ω ⇨ persistent mode HTS magnet

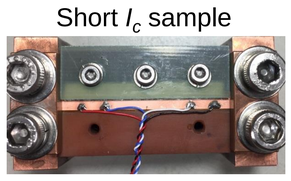
Demonstrate REBCO joint in a cryocooled REBCO magnet e.g. at 1 T, at 50 K

- REBCO coated conductor layer winding
- Conductor feed from winding to joints

Experimental set up

- 13 T–ø130 mm SC magnet + VTI @ NIMS
- Short sample probe up to 600 A
- Coil probe up to 300 A

Short I_c sample



Coil I_c sample

G. Nishijima *et al.*,
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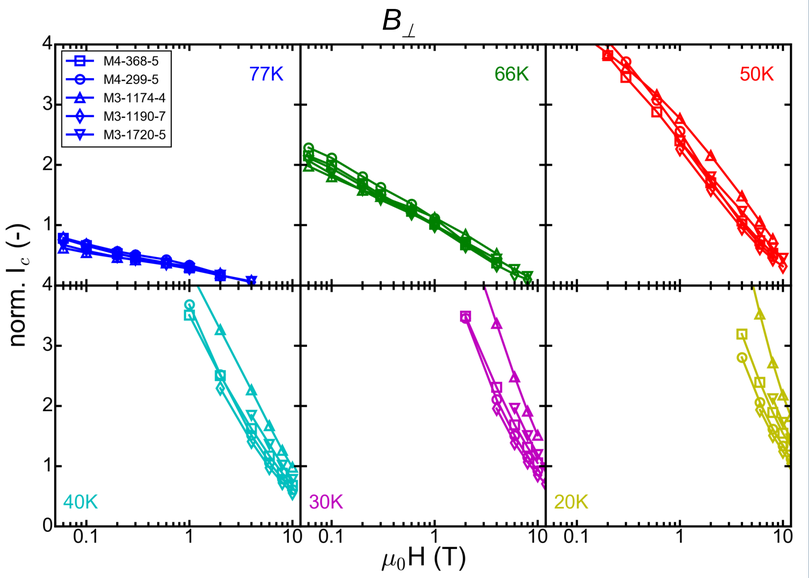
Conductors

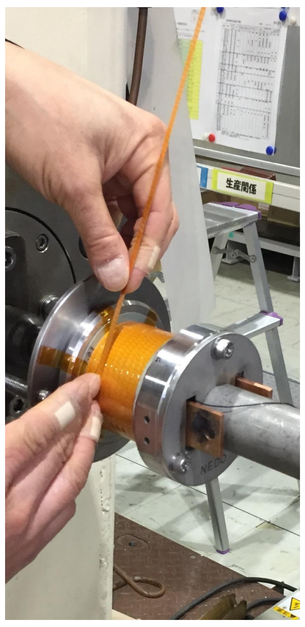
- SuperPower REBCO conductors
- 5 different conductors characterised with $B_{||}$ and $B_{\perp}$ to tape surface
- I_c normalised w.r.t. 77 K self-field values show uniform performance till 50 K

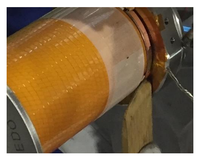
Tape ID	Width	I_c @ 77 K s.f.	Usage
M4-368-5	4 mm	158 A	Coil 1, Coil 2, Lead 1, Lead 2
M4-299-5	4 mm	155 A	Coil 3
M3-1174-4	4 mm	120 A	Coil 4
M3-1190-7	6 mm	249 A	Coil 5, Lead 3, Lead 4
M3-1720-5	6 mm	238 A	Coil 6



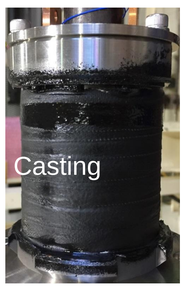
Coil layer winding

- Manual winding by an operator with tension <1kg
- Max line speed 0.8 m/min
- Edgewise pressure applied for layer winding





Low temperature solder with melting point 140℃

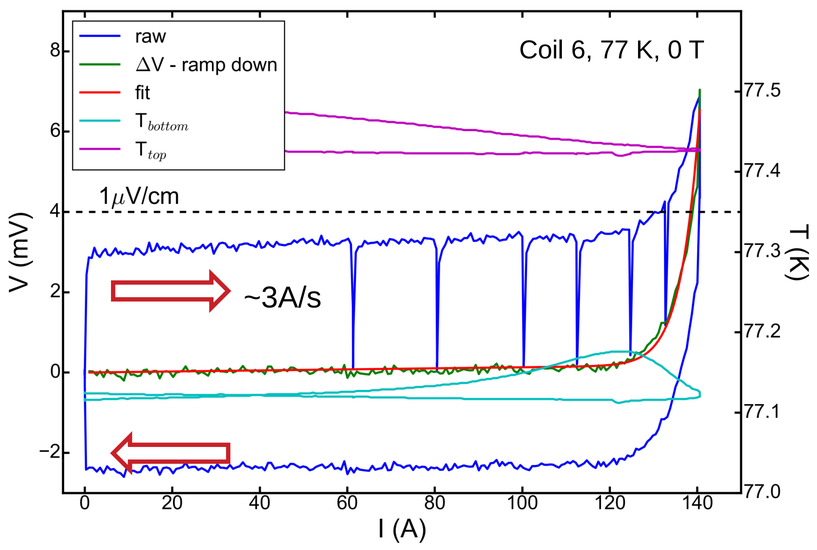


Manually guided REBCO layer winding at JASTEC

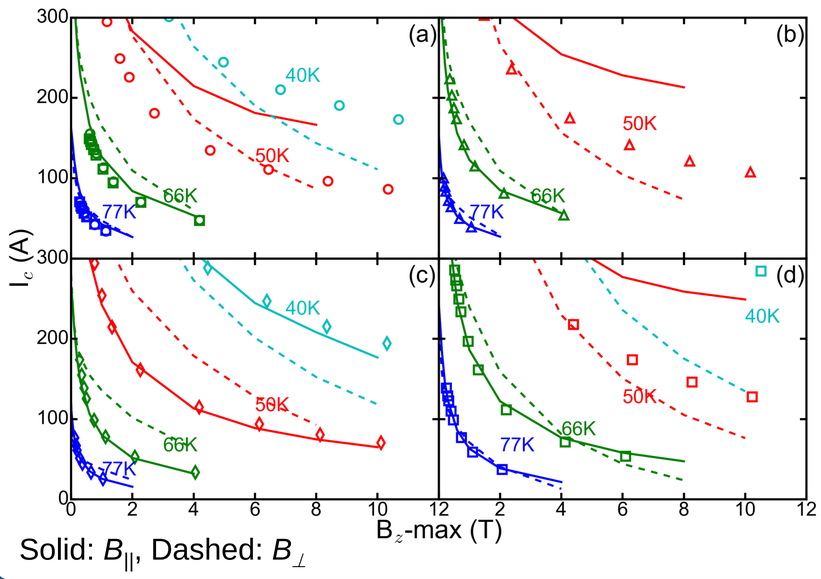
Coils 5 and 6 are casted with glass cloth and Stycast® for reinforcement before wax impregnation

Coil characterisations

- 6 coils wound on ø65 mm bobbin
- I_c measurement by slow ramp up (in steps) till 1μV/cm then slow ramp down
- Coil temperatures measured at the top and the bottom of the winding



Coil ID	Turns / Layer	Layers	Wind length	L
Coil 1	9	20	41 mm	2 mH
Coil 2	9	20	41 mm	2 mH
Coil 3	28	6	120 mm	0.8 mH
Coil 4	28	6	120 mm	0.8 mH
Coil 5	9	20	56 mm	1.6 mH
Coil 6	19	10	118 mm	1 mH

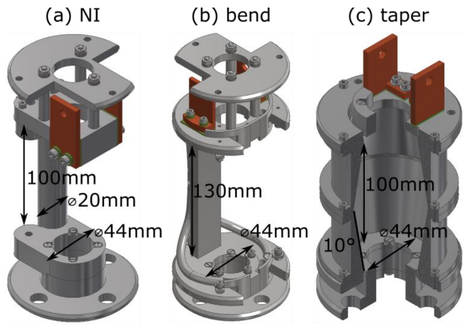


Solid: $B_{||}$, Dashed: $B_{\perp}$

Coil ID	Plot	Result
Coil 1	(a) Fill	Quenched at 50 K, Overcurrent
Coil 2	(a) Open	Quenched at 40 K, Overcurrent
Coil 3	(b)	Quenched at 40 K
Coil 4	(c)	Quenched at 40 K
Coil 5	--	LN_2 test failed ☹
Coil 6	(d)	☺

Lead designs and fabrications

- Conductor feed from winding to joint
- A small coil + lead test jigs
- Three types designed and fabricated



(a) Non-inductive (NI) type
- Conductors wound non-inductively around a support rod ø20mm.

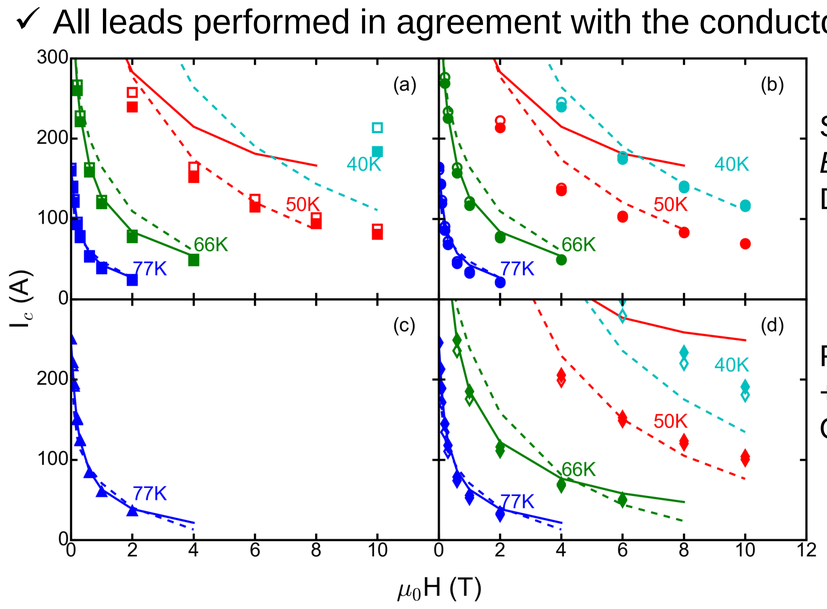
(b) Bend type
- Conductors propagate freely bending and twisting inside stainless steel conduits, then fully impregnated by Stycast®.

(c) Taper type
- Conductors propagate along a tapered wall.

Conductors fixed to the jigs by glass cloth tapes and Stycast®

Lead evaluations

✓ All leads performed in agreement with the conductor I_c



Solid: $B_{||}$
Dashed: $B_{\perp}$

Fill: +ve leg
Open: -ve leg

(a) 4 mm NI: OK till 40K
(b) 4 mm bend: ☺
(c) 6 mm NI: OK at 77K
(d) 6 mm taper: ☺

Summary

- ✓ Conductor I_c measured with $B_{||}$ and $B_{\perp}$
- ✓ 5 out of 6 coils validated by I_c measurements
- ✓ Three new types of leads designed and fabricated
- ✓ Lead designs validated by I_c measurements

- ◆ Coils quenched during measurements due to overcurrent
- ◆ Some uncertainty with coil winding technique remains

Acknowledgement

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