Joint resistance evaluation of longer HTS tape joints with indium insertion

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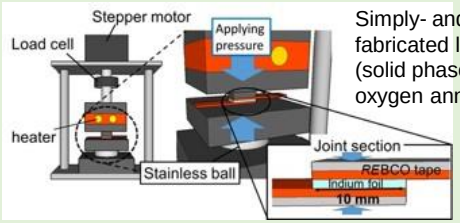
WED-PO2 -613-10

1. Introduction

Pressure welding with indium insertion at room temperature or using low-temperature heat treatment below 400 K [1–3]



Simply- and quickly fabricated low-resistive joint (solid phase bonding) with no oxygen annealing process

Fig. 1 Pressure welding with indium insertion

[1] T. Nishio et al., IEEE TAS, 27 (2017) 4603305.
[2] S. Ito et al., IEEE TAS, 29 (2019) 6600405.
[3] R. Hayasaka et al., J. Phys. Conf. Ser. 1559 (2020) 012034.

Achieved joint resistivity at 77 K, s.f. (B: BSCCO, R: REBCO)

BB joint: 11–15 nΩcm², RR joint: 20–35 nΩcm²
(Joint resistivity (R_JS_J) = Joint resistance (R_J) x Joint area (S_J))

→ Comparable to or less than joint resistivity of well-fabricated soldered joint

This study's objective: evaluate joint resistance depending on joint length, temperature, magnetic field and combination of HTS tapes

Acknowledgement:
This work was partially supported by JSPS KAKENHI Grant Number 20H01884; and by the JST-Mirai Program Grant Number JPMJMI17A2, Japan. This work was partially performed at the High Field Laboratory for Superconducting Materials (HFLSM), Institute for Mate-rials Research, Tohoku University (Project Numbers 20H0205).

2. Joint performance of short joints

Utilized HTS tape

B(H): Ag-sheathed BSCCO tape (DI-BSCCO Type H, SEI)
B(HC): Cu-alloy-laminated BSCCO tape (DI-BSCCO Type HT-CA, SEI)
R(SEI): Cu-stabilized REBCO tape (SCC, SEI)
R(SP): Cu-stabilized REBCO tape (SCS4050-AP, SuperPower)

Joint condition

- Joint length: 10 mm
- In foil thickness: 100 μm
- Polishing HTS tape with a #1500 sandpaper
- Picking HTS tape with flux, In foil with HCl
- Joining pressure 100 MPa for 1 min
- Heat treatment at 120°C

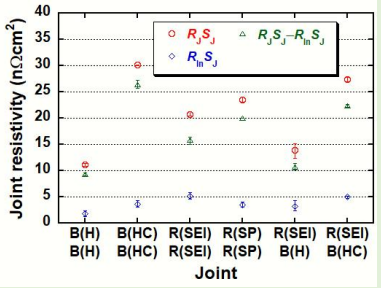


Fig. 2 Joint resistivity for various HTS tape joints at 77 K, s.f.

B: Ag-sheathed BSCCO tape (DI-BSCCO Type H, SEI)
R: Cu-stabilized REBCO tape (SCC, SEI)

- BB: 12 nΩcm² → 4 nΩcm² ← Joint resistivity (77 K → 10 K)
- RR: 21 nΩcm² → 11 nΩcm²
- RB: 17.5 nΩcm² → 7.5 nΩcm²

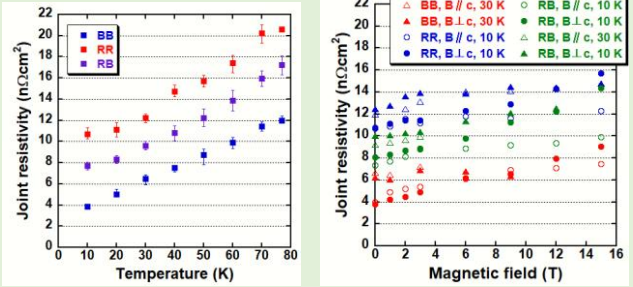


Fig. 3 Temperature and field dependence of joint resistivity for different HTS tape joints

3. Sample preparation of longer joints

Utilized HTS tape

1) B(H): DI-BSCCO Type H, SEI, I_C = 180 A
2) B(HC): DI-BSCCO Type HT-CA, SEI, I_C = 200 A
3) R(SP): SCS4050-AP, SuperPower, I_C = 100 A

Joint structure

A) Multiple lap joint: fabricated for 1), 2), 3)
B) Longer lap joint: fabricated for 1)
C) Multiple bridge joint: fabricated for 1), 2), 3)

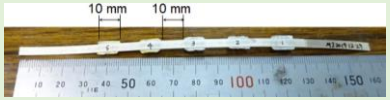


Fig. 4 Multiple lap joint

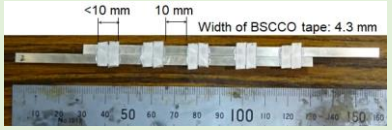


Fig. 5 Multiple bridge joint

A) Multiple lap joint:
10 mm long joint section is pressed individually.

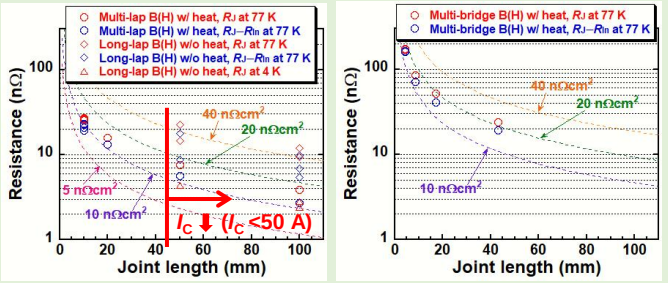
B) Longer lap joint:
50 or 100 mm long joint section (only one joint section) was pressed

C) Multiple bridge joint:
Two HTS tapes for the "bridge" are placed and each bridge is pressed individually.

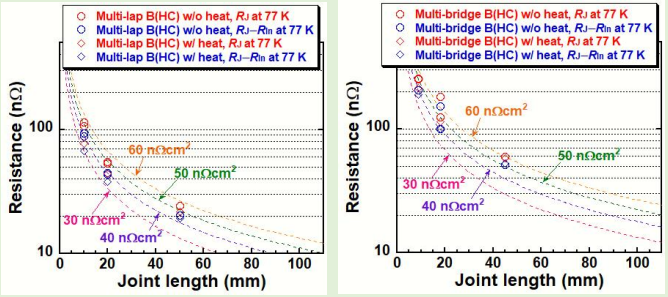
Joint condition

- In foil thickness: 50 μm for A), C), 100 μm for B)
- Polishing HTS tape with a #1500 sandpaper
- Picking HTS tape with flux, In foil with HCl
- Joining pressure 100 MPa for 1 min
- Heat treatment: w/o heat (room temp.) or w/ heat (120°C)

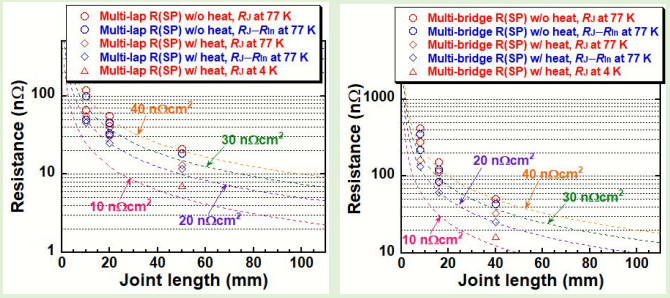
4. Resistance measurement for longer joints



BSCCO tape joint (DI-BSCCO Type H)



BSCCO tape Joint (DI-BSCCO Type HT-CA)



REBCO tape joint (SCS4050-AP)

Fig. 6 Resistance as a function of joint length (R_J: Joint resistance, R_{In}: Indium resistance)

- I_C of multiple and longer lap joints with DI-BSCCO Type H was reduced whereas no *I*c degradation was confirmed for the other joints.
  ➔ Reinforcement of the tape structure is key factor.
- RR joint tends to keep joint resistivity even with longer joint length. Improvement of BB joint and demonstration of further long joint will be planned in our future work.