Conductive Micro-Path for Current Sharing between REBCO Tapes in High-T_c Superconducting Conductors to Improve Stability

TUE-PO1-609-03

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Introduction

- $REBa_2Cu_3O_y$(REBCO)
  High critical current I_c
- REBCO stacked conductors for fusion (e.q : FAIR conductor)

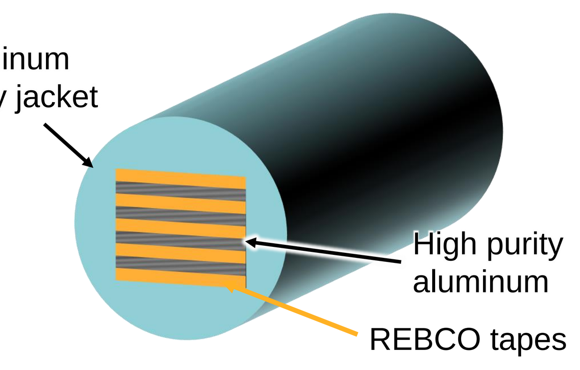
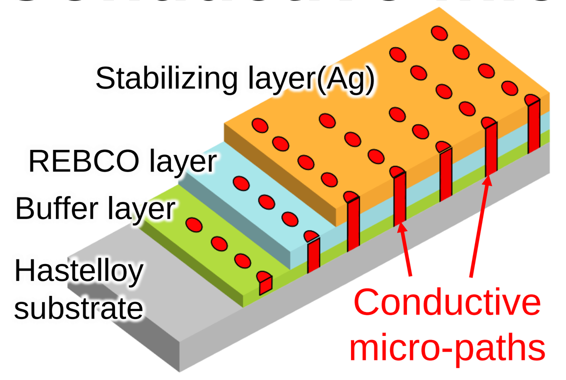


Fig. Schematic drawing of FAIR conductor.

Quench risks by local degradation

Improving thermal stability

Conductive micro-paths



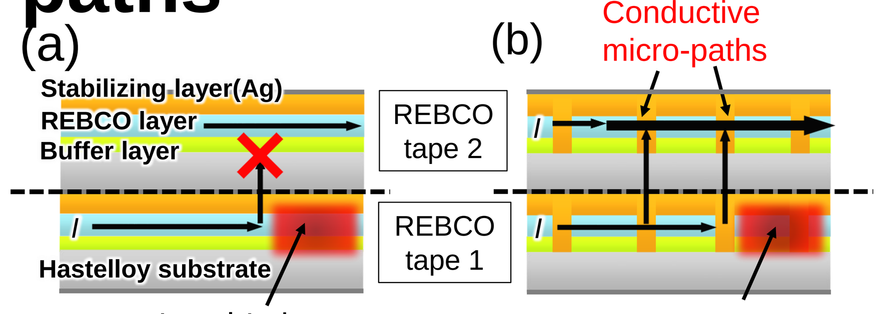


Fig. A schematic drawing of current sharing (a) without conductive micro-path (b) with conductive micro-path .

(a)
- Buffer layer insulate between tapes
- Current can't be shared between REBCO tapes

(b)
- Current is shared between REBCO tapes through conductive micro-paths
- ➡ improved stability

Objective

Fabrication of conductive micro-paths for current sharing between REBCO tapes to improve the stability of composite conductors.

Experiments (2)
- Current sharing between REBCO tapes -

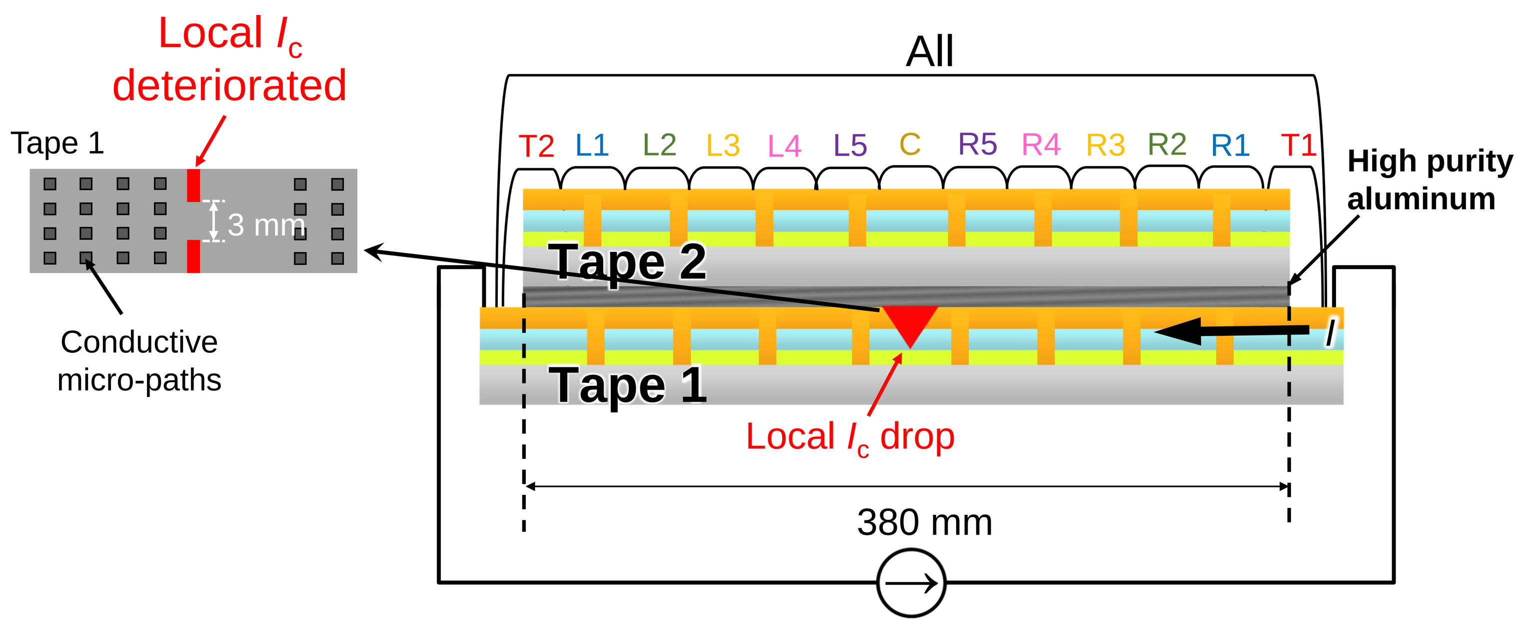
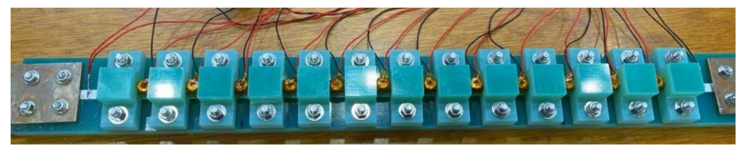


Fig. A schematic drawing of experimental setup. We introduced the local I_c drop in the middle section of Tape 1.



Parameter	With micro-path	Without micro-path
Tape width	7 mm	
Stacked length	380 mm	
Micro-path size	500 × 500 μm	—
Measured I_c of Tape 1 (after introduced defects)	124.3 A	174.2 A

- Two REBCO tapes were stacked.
- I_c deteriorated part was artificially introduced in Tape 1.
- The current was induced in Tape 1, and measured the voltage rise as a function of current at 77 K.

Results (2) Discussion

(a) Without Conductive Micro-paths

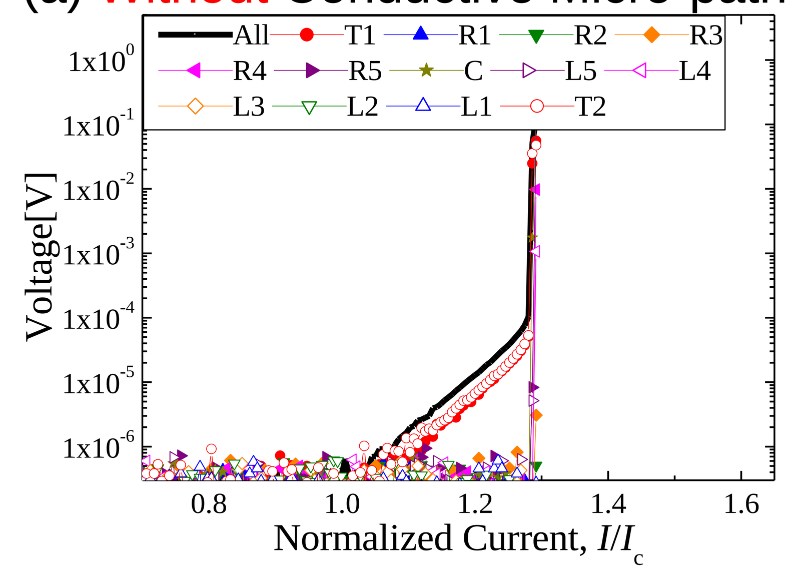


Fig. Current dependence of voltage of REBCO tapes without conductive micro-paths.

- Current was not shared.
- REBCO tapes were burned out at I / I_c ≒1.3

(b) With Conductive Micro-paths

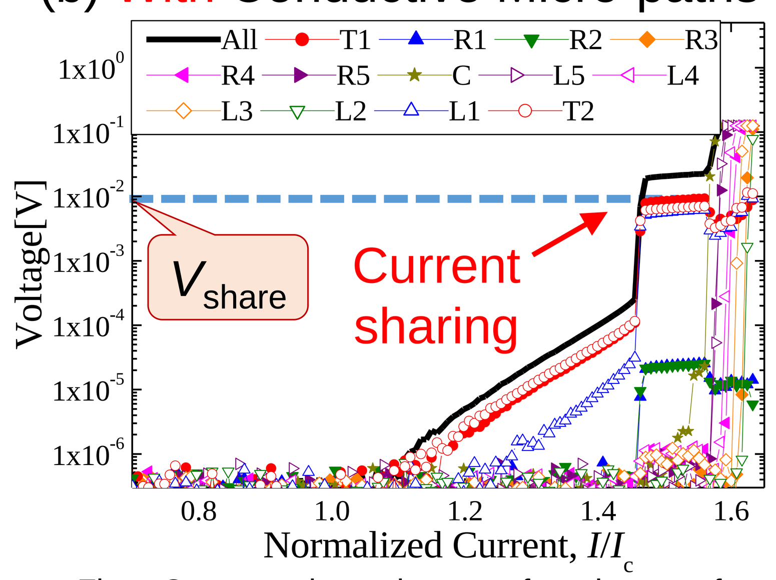


Fig. Current dependence of voltage of REBCO tapes with conductive micro-paths.

- Current was shared at I / I_c ≒1.6
- V_{share} = 8 mV.

※V_{share}: current sharing voltage

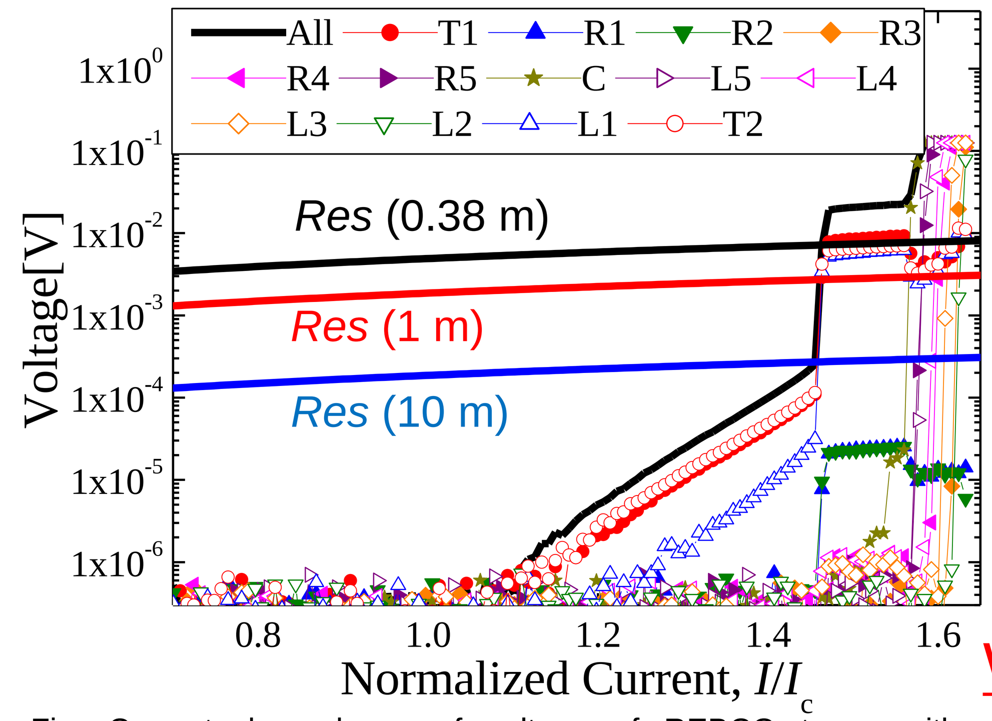


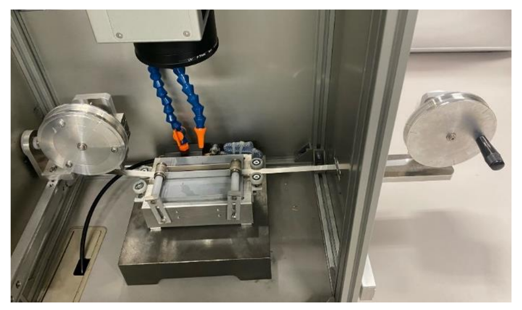
Fig. Current dependence of voltage of REBCO tapes without conductive micro-paths. Estimated resistance between tapes of each stacked length (0.38 m, 1 m, and 10 m) is shown.

Parameter	
Stacked length	380 mm
Tape width	7 mm
Resistance between tapes	39.5 μΩ

- At 0.38 m ➡ V_{share} = 8 mV.
- At 10 m ➡ V_{share} = 0.1 mV.
- Longer the stacked length is, Lower the V_{share} is

With conductive micro-paths improved stability

Experiments (1)
- Fabrication of conductive micro-paths -



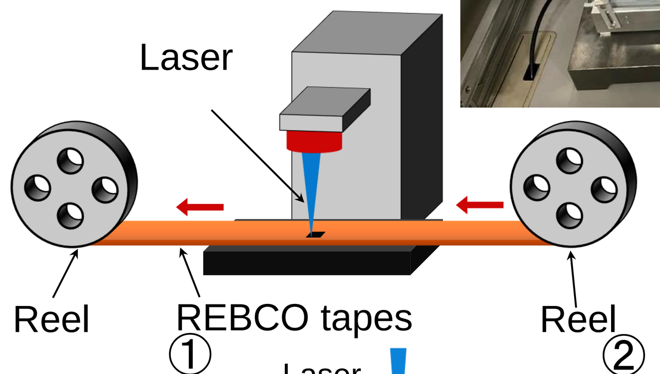
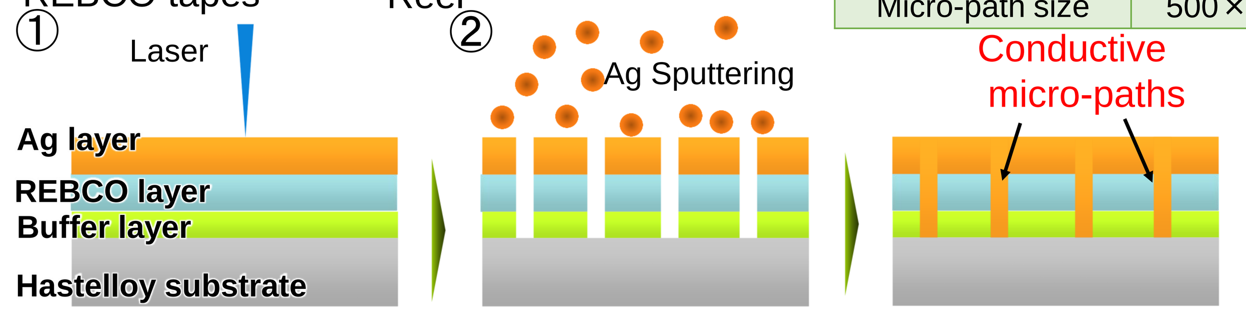


Table Laser parameter

Parameter	Condition
Laser Type (wave length)	UV-YAG laser (355 nm)
Laser Energy Density	0.53 J/cm²
Laser Frequency	80 - 120 kHz
Q-pulse width	0.1 μs
Scanning speed	50 mm/s
REBCO tapes	FESC-S12 (without Cu Stabilizing layer)
Micro-path size	500 × 500 μm



① Brind holes were made on REBCO tapes by irradiating laser.
② Ag films were deposited to make blind holes conductive.

Results (1)

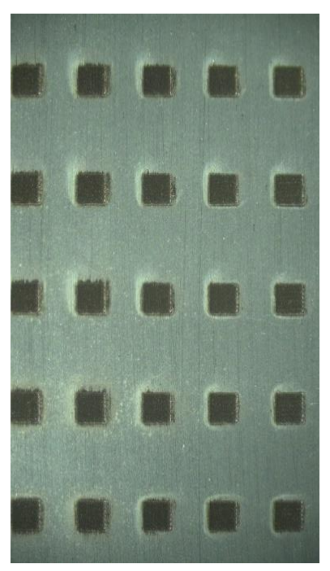
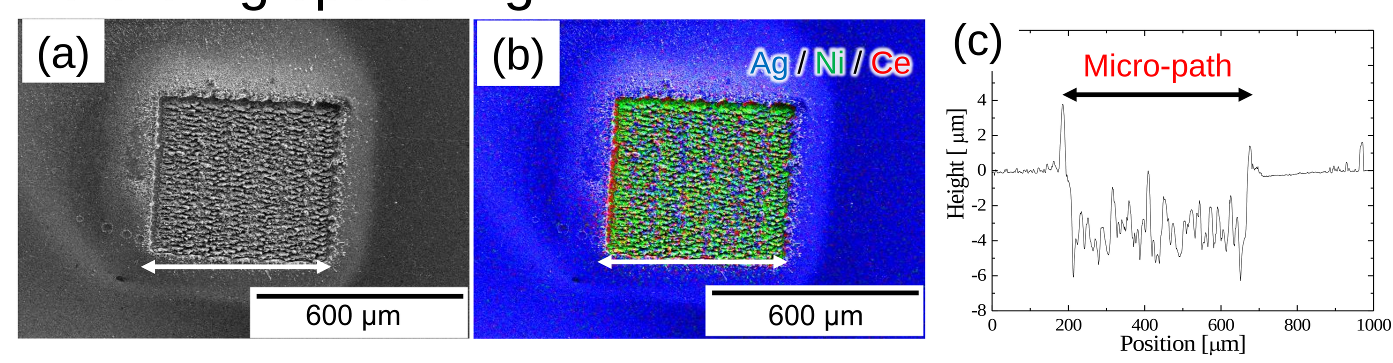


Fig. Conductive micro-paths into REBCO tapes.

Before Ag sputtering



After Ag sputtering

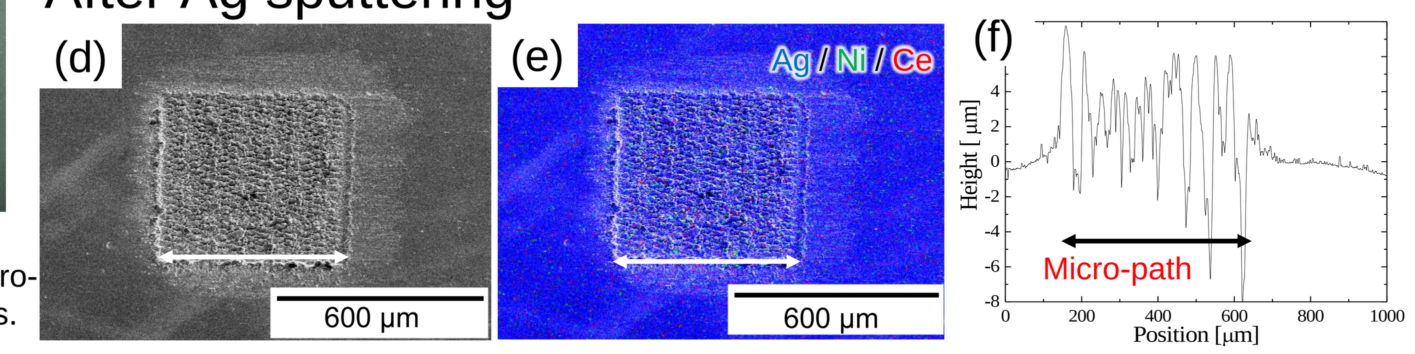


Fig. (a),(d)SEM images, (b),(e)EDX mapping analysis, (c),(f)cross-sectional profile of micro-paths

Before Ag sputtering
- Blind holes reached substrates of REBCO tapes.

After Ag sputtering
- Blind holes were filled by deposited Ag films.

Conclusion

(1) Conductive micro-paths were fabricated into REBCO tapes.
- Before Ag sputtering, Blind holes reached substrates of the REBCO tapes.
- After Ag sputtering, Blind holes were filled by the Ag films.

(2) Current was interchanged between tapes, through conductive micro-paths,
- With conductive micro paths, the stability of the conductor is expected to be improved.
- By increasing the current sharing length, current sharing voltage become lower.

Acknowledgement

This work was partly supported by the NIFS Collaboration Research Program (NIFS21KECA090, NIFS21KOBA034), JSPS-KAKENHI (20K15217, 20H02682), JST-A-STEP, and NEDO.