Direct measurement of modified Interconductor Contact Resistance in REBCO coated conductor stacks and Roebel Cable at variable temperatures

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Introduction

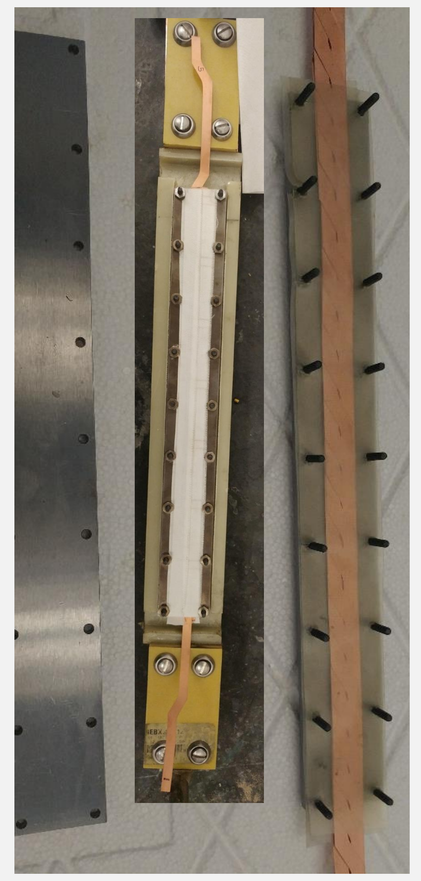
- Many next generation high-field magnets and applications have been designed to utilize ReBCO coated conductor to maintain large J_e in the presence of large magnetic fields.
- Multiple ReBCO cable geometries have been fabricated to meet the demands of a high J_e while keeping AC-loss, inductance, and stored energy of large windings to a minimum.
- As wound, the intertape contact resistance (ICR) of some HTS cable designs will have negligible current sharing [1].
  - While this will decrease AC-Loss, stability and current sharing will also decrease.
  - Similar to LTS cables, a balance needs to be pursued to find an acceptable level of ICR.
- Other HTS cables and coils have excessive current sharing.
  - This can be reduced with low RRR resistive metal layers or Metal-to-Insulator-Transitioning (MIT) "smart" layers [2,3].
- Low-Temperature Diffusion Bonding and electodeposited coatings have been a proven method to control ICR in LTS cables and this methodology will be pursued for HTS cables by OSU [4].
- Even very thin coatings can change ICR drastically, introducing a means to optimize stability and current sharing with little penalty to J_e of the winding.

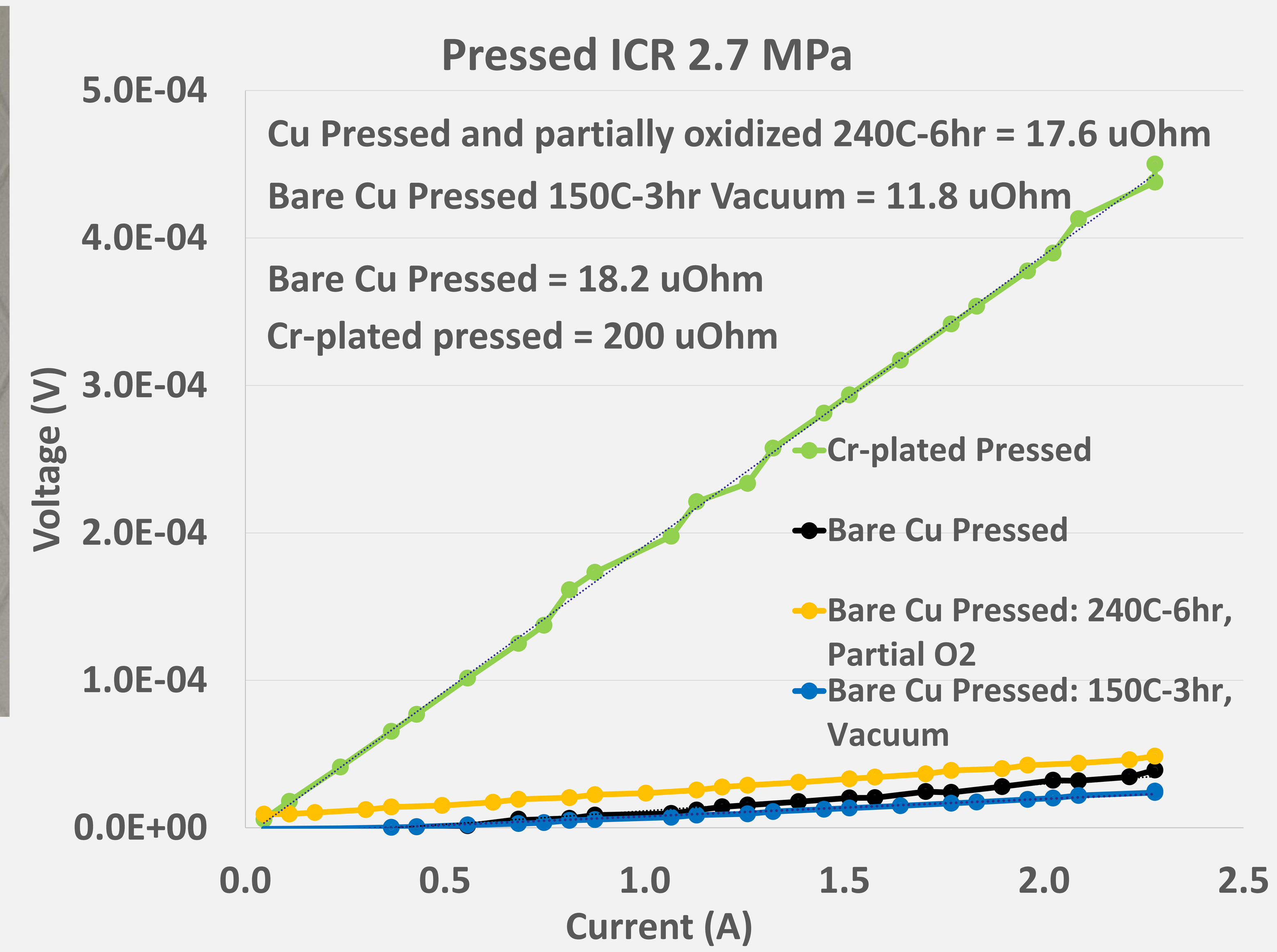
REBCO Roebel cable

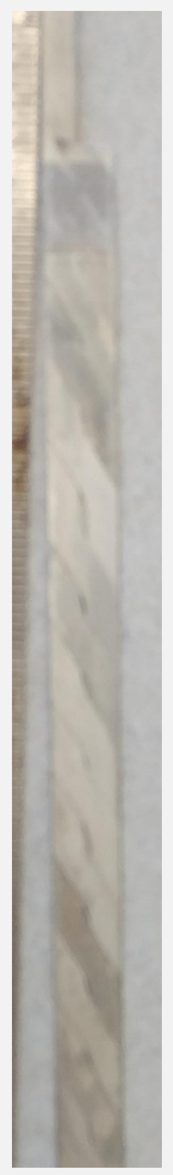
- For this study, Roebel cable received from KIT was used. The properties of this cable are shown below.
- The 9-tape cable was pressed in a fixture over a length of 300 mm.
- Tapes 1 and 5 were revealed on both ends of the fixture to transfer current across the entire cable.
- Measurements were performed in a LN_2 bath.

Parameter	Specification
Roebel cable manufacturer	Karlsruhe Institute of Technology
ReBCO tape manufacturer	SuperPower Inc.
Type of Roebel cable	9/5.6
Number of Tapes	9
Tape Width, w_{tape} (mm)	5.6
Cable Width, W_c (mm)	11.8
Tape thickness, t_{tape} (mm)	0.1
Pitch Length, L_p (mm)	126
Cross-over angle, φ (degrees)	30
$L_{Inter\text{-}strand\ gap}$ (mm)	0.4
$W_{Cross\text{-}over}$ (mm)	5.6
I_c @ 77 K, sum of tapes (A)	1168

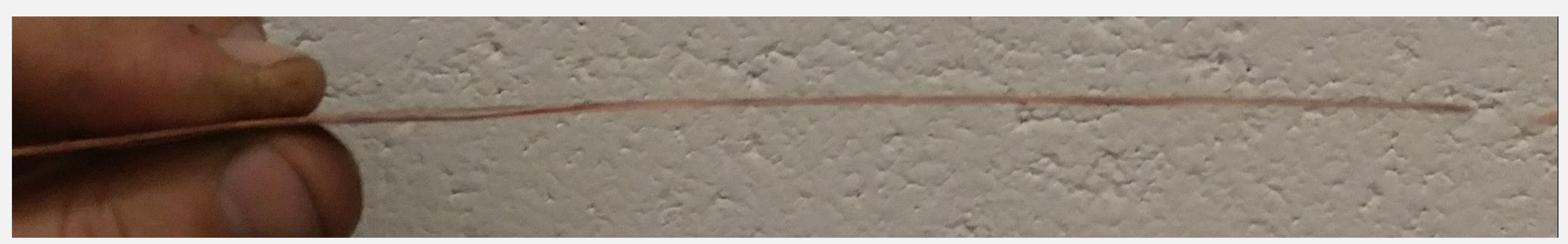
Roebel Cable ICR measurement results at 77 K





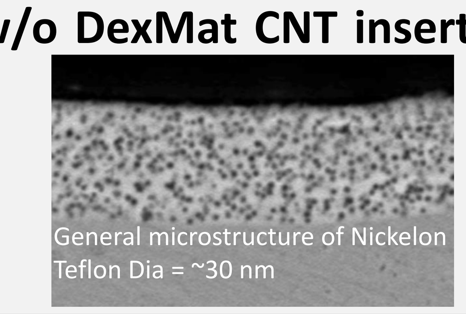


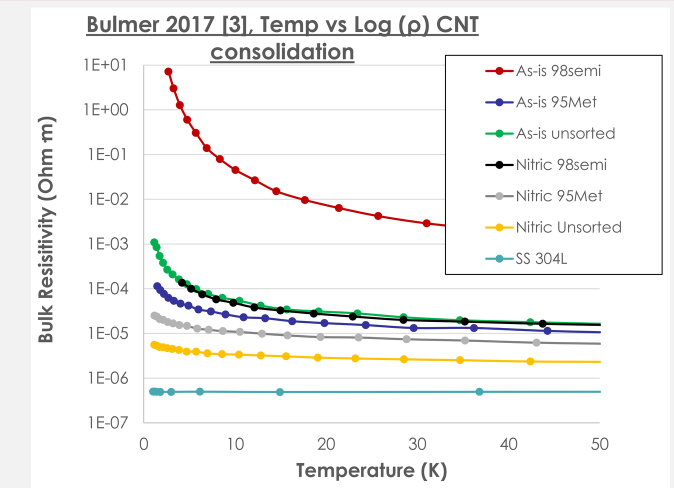
- Low-temperature diffusion bonding experiments were performed on ReBCO Roebel cable.
- A 20% decrease in ICR was seen for processing (150 C / 2.7 MPa) which shouldn't negatively degrade superconducting properties.
- Cable flexibility decreases with diffusion bonding, but modulated pressing techniques are possible to maintain flexibility while still decreasing ICR.
- Cable precleaning may be required.
- Chromium plating increased resistance and maintained cable flexibility.
- Chromium plating needs to be performed on a disassembled Roebel cable to ensure an even electrodeposited layer.



REBCO coated conductor stacks at 77 K and 4.2-300 K

- A single lap joint was created with 14 mm wide as received Superpower coated conductor.
- Measurements were performed at 77 K and 200 MPa and 4.2-300 K and 20 MPa
- Tests: Cr, Ni, Nickelon (Ni-Teflon), As-rec Cu and Ag w and w/o DexMat CNT insert (heat treated under Ar at 400 C and as-is)

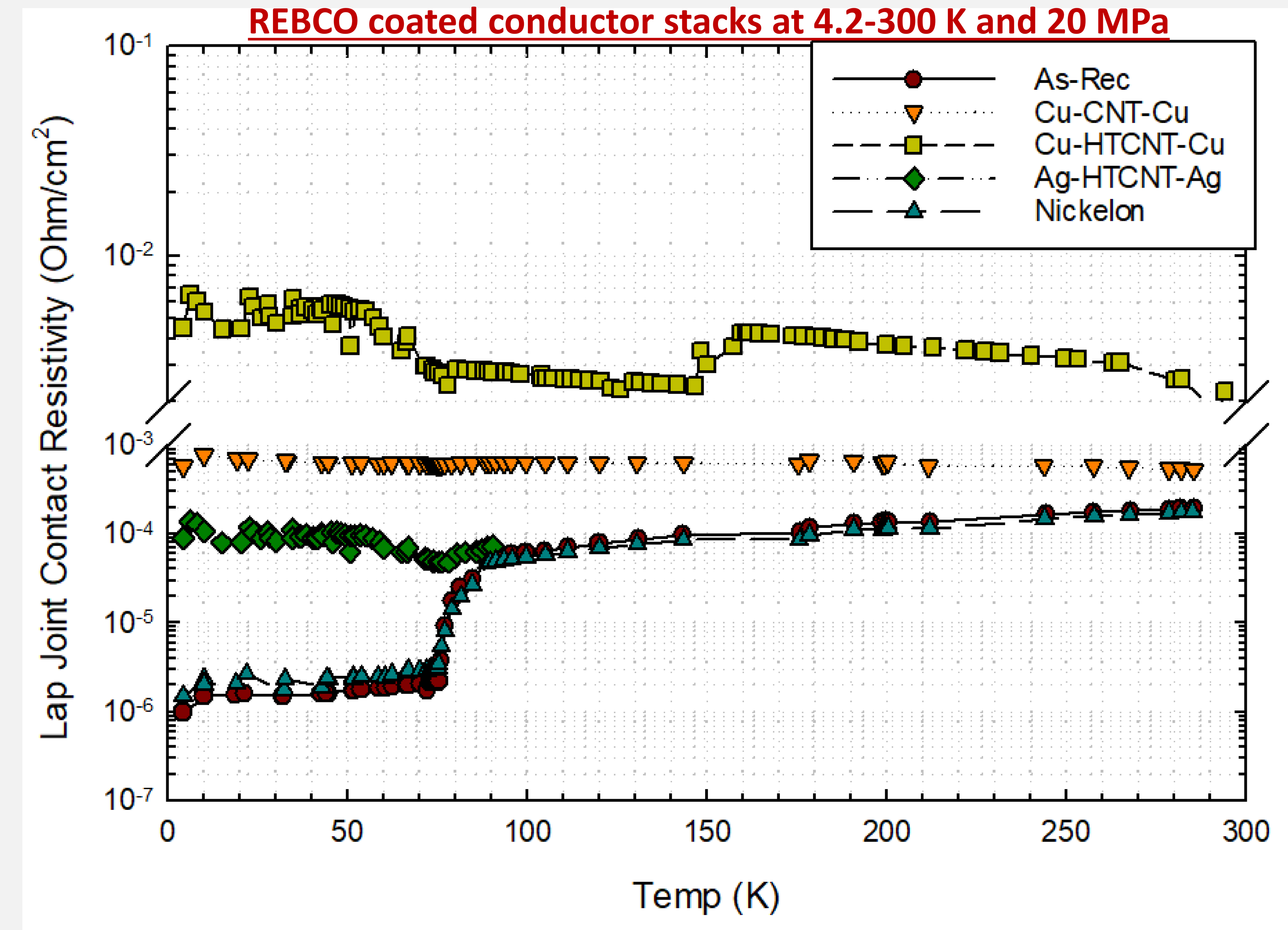




REBCO coated conductor stacks 77 K and 200 MPa

• Chrome electrodeposition	564 μΩ·cm2
• Silver electrodeposition	<1.2 μΩ·cm2
• Nickel electrodeposition	2986 μΩ·cm2
• Nickel-Teflon composite	94 μΩ·cm2
• Cu-CNT-Cu	32 μΩ·cm2

REBCO coated conductor stacks at 4.2-300 K and 20 MPa



Conclusions

- A 20% decrease in ICR was seen for low-temperature diffusion bonding processing with (150 C / 2.7 MPa); this shouldn't negatively degrade superconducting properties.
- Cable flexibility decreases with diffusion bonding and the bonding has low adhesion.
- Thin Chromium plating of Roebel cable results in a higher ICR option
- Silver plating results in a very low ICR option
- Nickelon (Nickel-Teflon nanocomposite) is a low-friction, durable, chemically resistant coating that results in ICR values similar to as-received Cu-Cu lap joints
- CNT tape functions as a high-tensile strength, thin, and low-friction "smart" insulation

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Acknowledgments

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