

Strain and magnetic field response of I_c in reinforced GdBCO CC tapes at 77 K

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Introduction

- Under high magnet field applications, superior electro-mechanical characteristics of Coated Conductor (CC) tapes are important
- Therefore, CC tapes have adopted substrate materials with good mechanical property and usually used at a laminated state.
- The characteristics of the strain effect on the current carrying capabilities of CC tapes both at self field and under magnetic field have been widely studied;
 - The reversible strain effect on the critical current, I_c , up to an irreversible strain limit, ϵ_{ir} .
 - At self field, the I_c of REBCO CC tapes may show a peak value at tension or compression strain depending on the induced pre-strain state. However, under magnetic field, this I_c peak strain cannot be solely determined by the pre-strain state of superconducting film.
- In this study, the following were investigated:
 - The effect of brass foil reinforcement in the mechanical properties of GdBCO CC tapes at 77 K under self and external magnetic fields.
 - The strain and magnetic field effect on I_c in brass laminated RCE-DR GdBCO CC tapes at 77 K.
 - The effect of the substrate material and brass foil lamination on ϵ_{ir} of I_c in GdBCO CC samples.
 - The reversible strain behavior of I_c and the strain sensitivity of I_c under magnetic field.

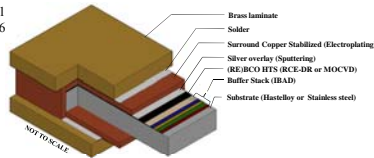
Experimental Procedure

Specifications and properties of GdBCO CC tape

	IBAD-RCE-DR	
Fabrication process	~ 1.5 μ m ~ 1.5 μ m	
GdBCO film thickness	~ 1.5 μ m ~ 1.5 μ m	
I_c	~ 170 A ~ 170 A	
Dimension, t x w (mm)	0.136 x 4.07	0.092 x 4.01
Cu-stabilized	0.232 x 4.20	0.175 x 4.16
Brass laminated		
Substrate thickness	Stainless steel ~100 μ m	Hastelloy ~57 μ m
Stabilizer technique	Copper Electroplating	
thickness	15 μ m	15 μ m
Laminate thickness	Brass 45 μ m	
Manufacturer	SuNAM	



Cross-sectional view of RCE-DR Brass laminated CC tape

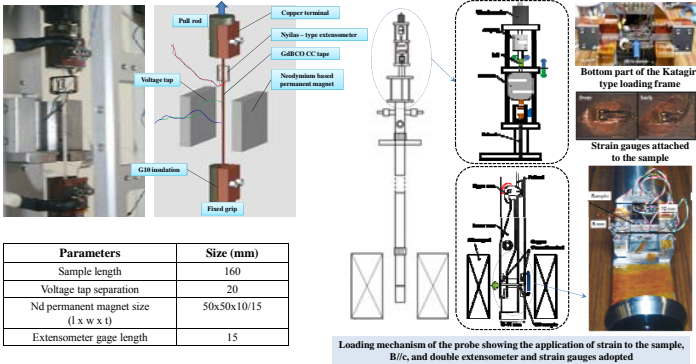


Schematic structure of typical GdBCO CC tape

Test system for electromechanical property measurement under magnetic field

Tensile loading fixture used under permanent magnet

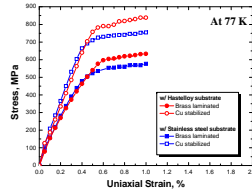
Katagiri-type tensile loading fixture used under superconducting magnet



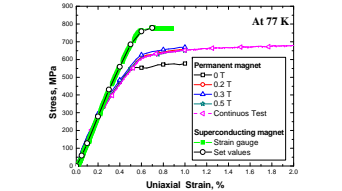
Results and Discussion

Mechanical properties of the reinforced RCE-DR GdBCO CC tape at 77 K under self field and external magnetic fields

Brass lamination effect on stress-strain curves of GdBCO CC tape at self field

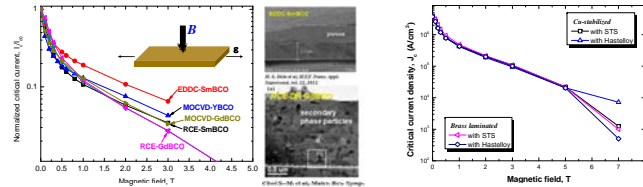


Stress-strain curves of reinforced RCE-DR GdBCO CC tapes w/ Hastelloy substrate under external magnetic field



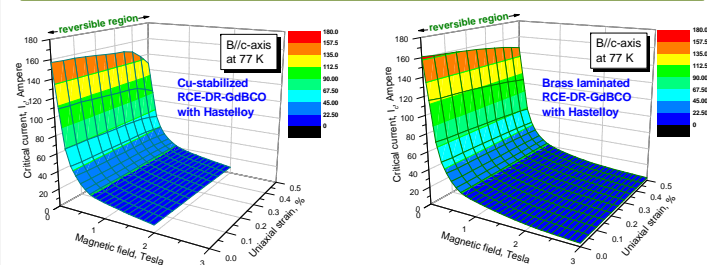
- Lamination of brass foils to both side of the CC tapes decreased both the Young's modulus (E) and yield stress (σ_y).
- Brass foil laminated CC tapes adopting the Hastelloy substrate showed a much higher yield strength compared with the one which adopted a stainless steel substrate.
- Variation in the S-S curves obtained is attributed to the different loading system. IMR (superconducting magnet) results showed higher stress value (higher load).

Magnetic field dependence of I_c in different REBCO CC tapes at 77 K



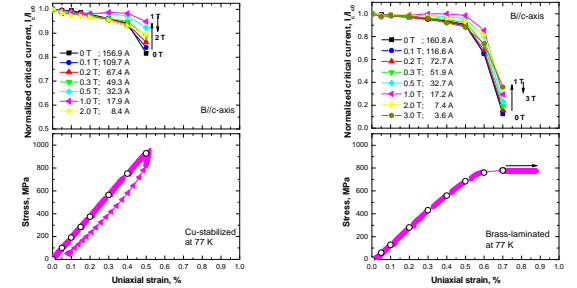
- Magnetic tolerance of I_c depends on the superconducting material and fabrication process adopted.
- Therefore, brass laminate has no consequent effect on the magnetic field dependence of GdBCO CC tapes but rather on the improvement of its tolerance on strain under uniaxial modes.

I_c -B- ϵ spaces at 77 K in RCE-DR GdBCO CC tapes with Hastelloy substrate (B//c-axis)



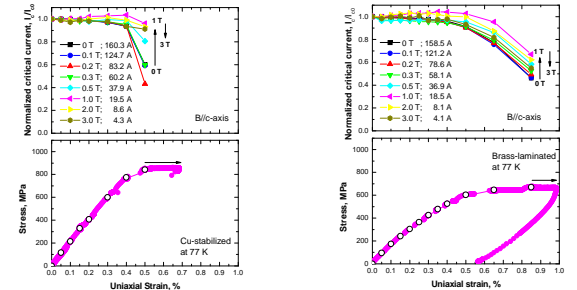
- I_c strongly depends on the magnetic field especially when it is oriented parallel to the c-axis (B//c-axis), showed an abrupt I_c degradation at 0.5 T.
- Better I_c -strain tolerance behavior is observed in brass-laminated CC tapes under magnetic field.
- I_c -B- ϵ behavior under B//c-axis will be useful to predict the CC tapes performance under strain.

Strain effect on RCE-DR GdBCO CC tape with Hastelloy substrate under magnetic field



- I_c/I_{c0} -strain behaviors of both samples were initially improved (or less strain sensitive) as the magnetic field applied increases from 0 T up to 1 T showing a reduced strain sensitivity. However, it was followed then with increasing strain sensitivity behavior when magnetic field was further increased to 3 T.
- At magnetic field over 1 T, a minimal I_c/I_{c0} peak strain existed.
- With additional brass laminate, strain window moved upward right showing an improved irreversible strain limit.

Strain effect on RCE-DR GdBCO CC tape with Stainless steel substrate under magnetic field



- Exhibits similar I_c degradation behavior with the one adopting Hastelloy substrate under magnetic field.
- Also, a minimal I_c/I_{c0} peak strain existed at magnetic field over 1 Tesla.
- Abrupt I_c degradation behavior was depicted by the corresponding stress-strain curve of the brass laminated CC tape sample.

Conclusions

- Mechanical properties of GdBCO CC tapes decreased with brass lamination as compared with the case when stabilized only by copper electroplating for both CC tapes adopting Hastelloy and stainless steel substrate.
- Additional brass lamination did not affect the magnetic field response of I_c in GdBCO CC tapes since it is intrinsic in nature and depends on the characteristics of the superconducting film.
- Additional brass laminate produces higher strain tolerance of I_c for both samples with Hastelloy and stainless steel substrate.

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