UNITED STATES DEPARTMENT OF COMMERCE

National Institute of Standards and Technology

Electromechanical Studies for Coated-conductor Development

National Institute of Standards and Technology
Boulder, CO 80305

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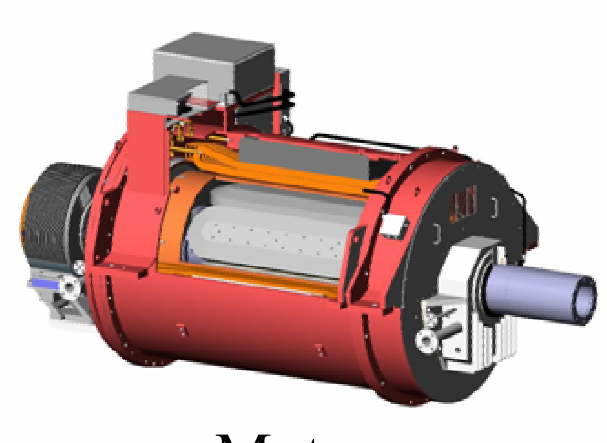
Conductor Mechanical Requirements

Cable

100 MPa $\sigma_{\parallel}$ tension @ RT
0.3% $\varepsilon_{\parallel}$ tension @ RT
Joint tensile strength @ RT
Low cycle (100) thermal stress



Motor

0.2% $\varepsilon_{\parallel}$ tension @ 20K-40K
0.1% $\varepsilon_{\parallel}$ comp. @ 20K–40K
Low cycle (100) thermal stress

Conductor Mechanical Requirements

Generator

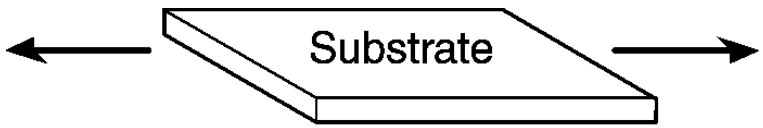
0.25% $\varepsilon_{\parallel}$ tension @ 20K-40K
0.1% $\varepsilon_{\parallel}$ comp. @ 20K–40K
10^4 g transverse loading
Low (100) and high (10^4) cycle
Epoxy fracture strain @ 20K-40K

Magnets

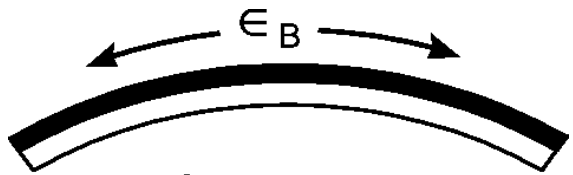
~100 MPa $\sigma_{\parallel}$ tension @ 30 K
0.1% $\varepsilon_{\parallel}$ tension @ 30 K

100 MPa $\sigma_{\perp}$ comp. @ 30 K
for HEP dipole magnets

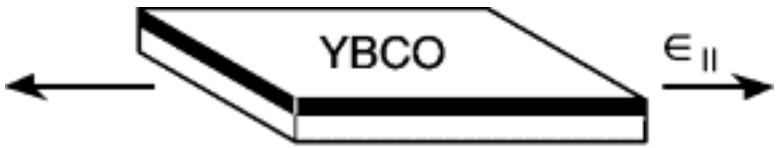
Electromechanical Measurements



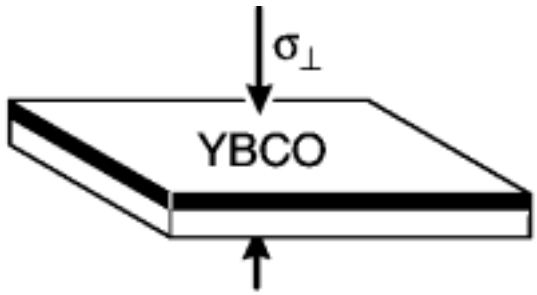
σ vs. ϵ
Stress-strain characteristic



J_C vs. ϵ_B
Bending strain limit

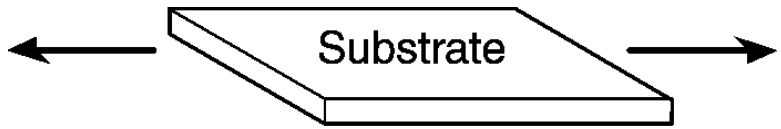


J_C vs. $\epsilon_{\parallel}$
Axial strain limit



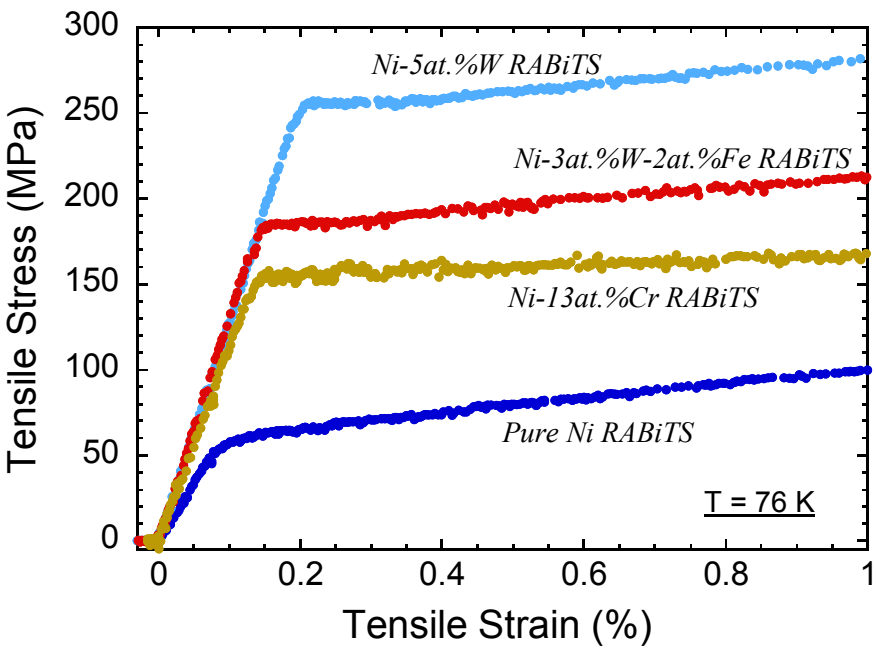
J_C vs. $\sigma_{\perp}$
Transverse compression limit

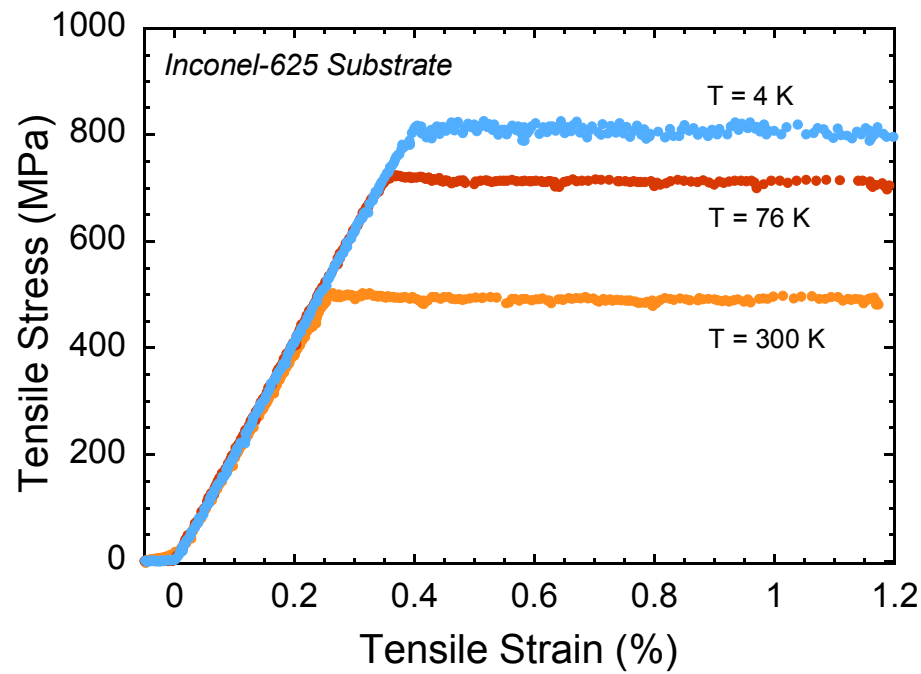
Substrate σ vs. ε Characteristics



σ vs. ∈

Stress-strain characteristic





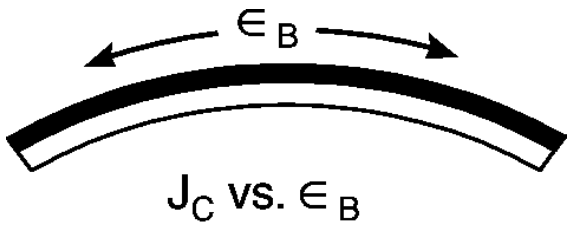
Cheggour N, Ekin JW et al., *IEEE Trans. Appl. Super.*, in press (2003)

Ekin JW and Cheggour N, DOE Peer Review 2002

Data Base of mechanical properties for different RABiTS materials

T = 76 K	*Proportional Limit of Elasticity, ε_p (%)*	*Tensile Yield Strength (MPa); 0.02 % offset criterion*	*Young's Modulus, E (GPa); first stress-strain slope*
Pure Ni	0.08	59	72
Ni-13at.%Cr	0.15	157	104
Ni-3at.%W-2at.%Fe	0.15	183	128
Ni-5at.%W	0.2	254	128

Bending Strain J_c Degradation (5%) at Room Temp.



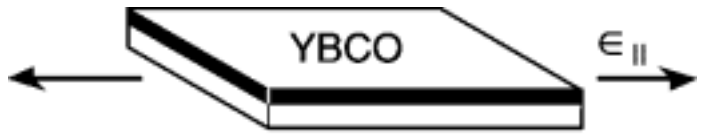
J_C vs. ϵ_B
Bending strain limit

	ε_B Comp.	ε_B Tens.
Hastelloy IBAD		
~1 μm YBCO	~ -0.8%	+0.4%
Ni RABiTS		
1-1.1 μm YBCO	-0.7%	+0.38%
1.6 μm YBCO	-0.4%	--
2.4 μm YBCO	--	+0.18%

- Wu XD, Foltyn SR, Arendt PN et al., *Appl. Phys. Lett.*, **67**, 2397 (1995)

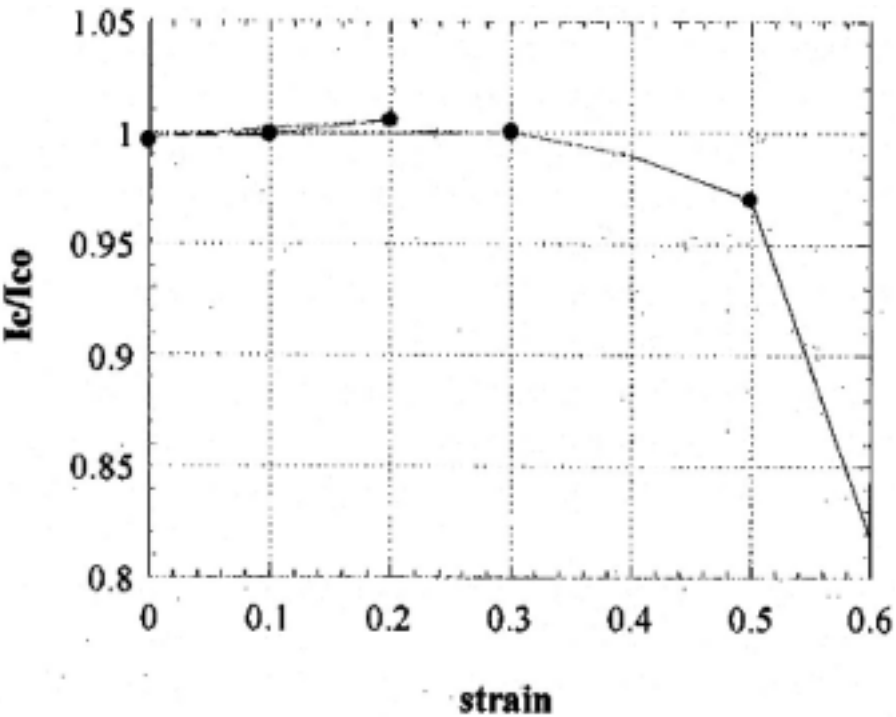
- Park C, Norton DP, Budai JD et al., *Appl. Phys. Lett.*, **73**, 1904 (1998)

Axial Tensile Strain J_c Degradation at 77 K



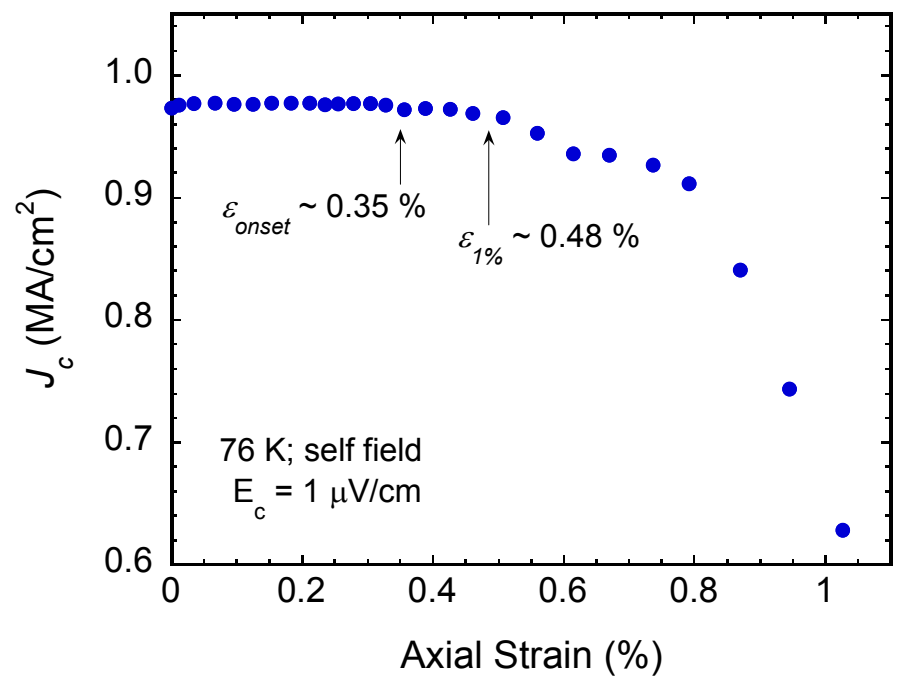
J_C vs. $\in_{II}$
Axial strain limit

Inconel 625 IBAD
(2.5 μm YBCO)



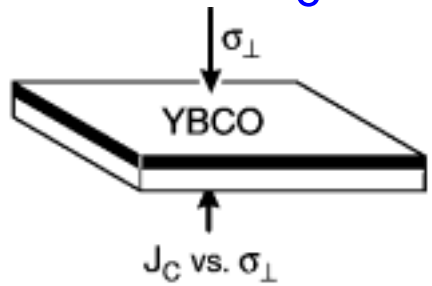
Thieme CLH et al., *IEEE Trans. Appl. Supercond.*, 1494 (1999)

Ni-5%W RABiTS
(1 μm YBCO)



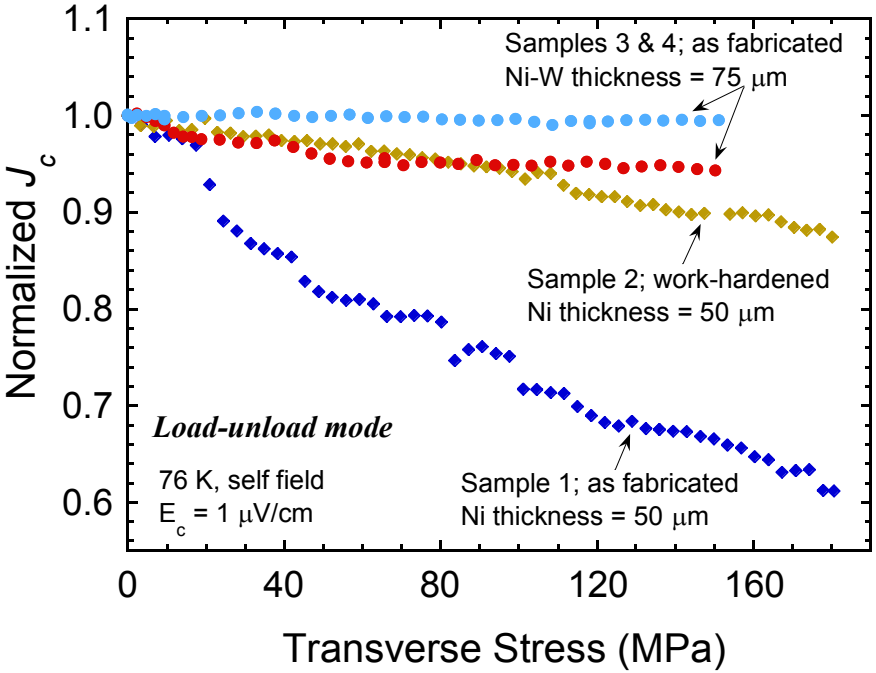
Ekin JW and Cheggour N, unpublished

Trans. Compressive Stress J_c Degradation at 76 K



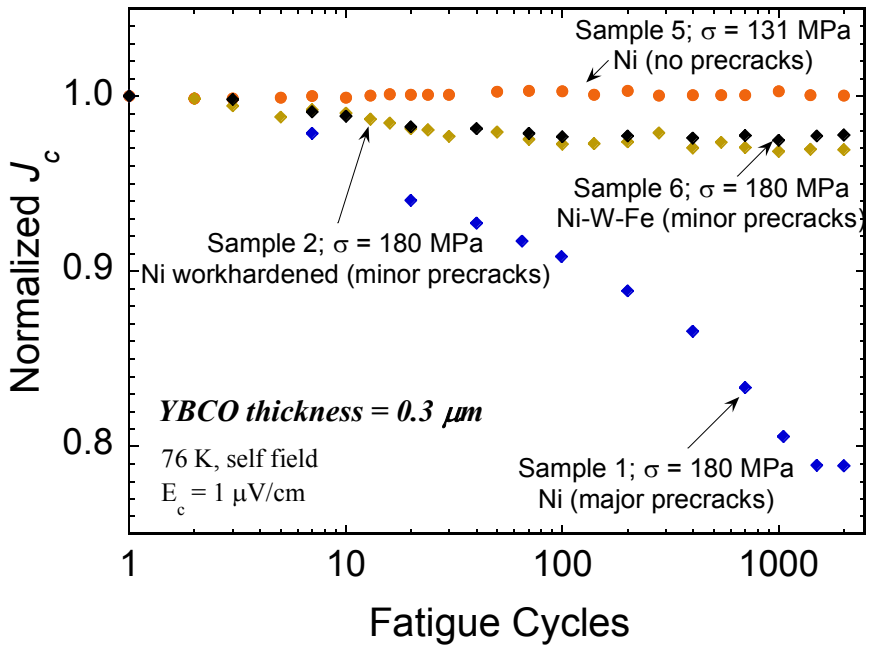
J_C vs. $\sigma_\perp$
Transverse compression limit

Transverse Stress



Cheggour N, Ekin JW et al., *IEEE Trans. Appl. Supercond.*, in press (2003)

Fatigue



Cheggour N, Ekin JW et al., *Ceramic Transactions*, in press (2003)

Conductor Mechanical Needs

Stress-Strain Characteristics:

- Expand data base to include new substrates under development
- Characterize coated-conductor composite

$J_c(\varepsilon_B)$: (Bending Strain, standard and transverse)

- New conductor geometries
- YBCO thickness dependence
- Is ε_B equivalent to $\varepsilon_{//}$?

$J_c(\varepsilon_{//})$: (Axial Strain)

- New conductor materials under development
- YBCO thickness dependence
- Fatigue
- Axial compression

Conductor Mechanical Needs (contin.)

$J_c(\sigma_\perp)$: (Transverse Stress)

- New conductor materials
- Transverse tension (delamination)

Fatigue: low cycle (100) and high cycle (10^4);
effect on J_c degradation criterion, is 5% too large?)

Epoxy mechanical properties

Joints (electrical and mechanical)

Complete *cable* electromechanical testing