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Uniaxial Strain Induced Critical Current Degradation of Ag-Sheathed Bi-2212 Round Wire

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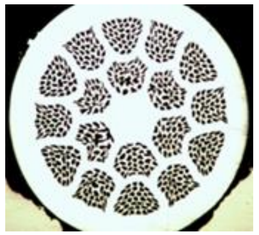
Background

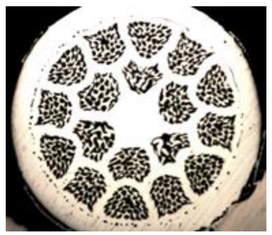
Bi2212 is a promising material due to its very high upper critical field. More importantly, it can be made in round wire, which means it can be a suitable candidate for cable in conduit conductor (CICC). Bi-2212 round wire is sensitive to strain. As a kind of cuprate superconductor, the Bi-2212 phase is brittle like ceramic, and its Ag/Ag-Mg sheath has low strength. Under operating conditions, electromagnetic force and thermal stress can initiate cracks on it easily, which would result in critical current (Ic) degradation.

Currently, a CICC is under development for the next generation fusion reactor at ASIPP (the Institute of Plasma Physics, CAS), The CICC design is based on Bi-2212 round wire developed by Northwest Institute for Non-Ferrous Metal Research (NIN). And the research on the strain induced critical current degradation is essential for cable layout design. In this work, the strain applied on the Bi-2212 round wire was from -0.6% to +0.3% with the U-spring device.

Sample preparation and experimental device



Cross-section pre-reacted

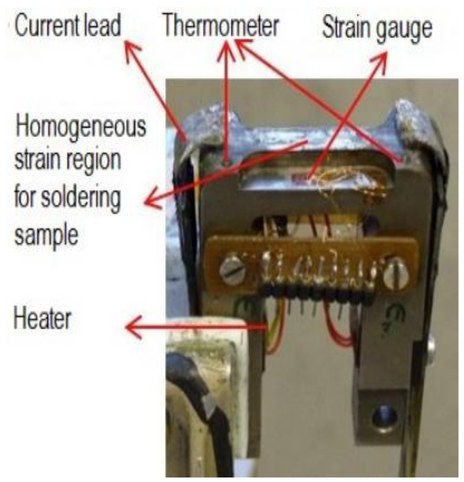


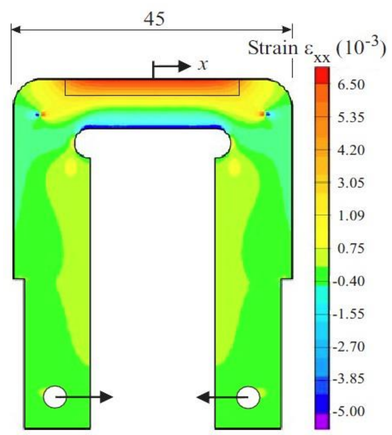
Cross-section after reaction

Sample parameters

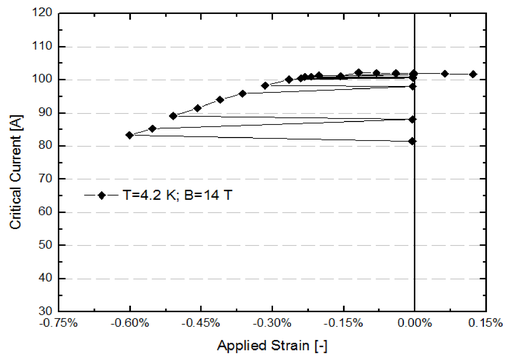
Material	Ag-alloy sheathed Bi-2212
Diameter	1.0 mm
Filament configuration	19 x 18
Ag/Mg:Ag:Bi2212	1.8:1:0.9
I_c at 0T, 4.2 K	about 400 A
I_c at 12T, 4.2 K	about 146 A

The U-spring instrument and FEM calculated strain profiles of the U-spring

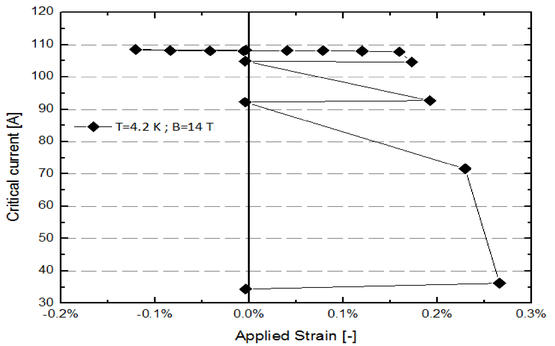




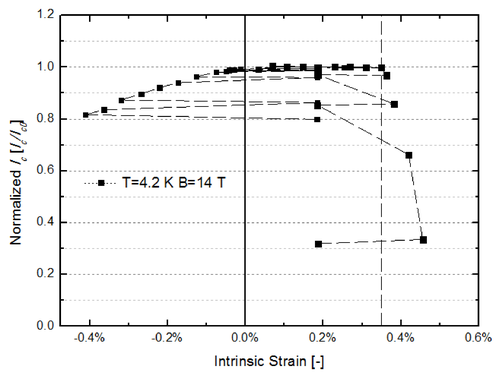
Test results and analysis



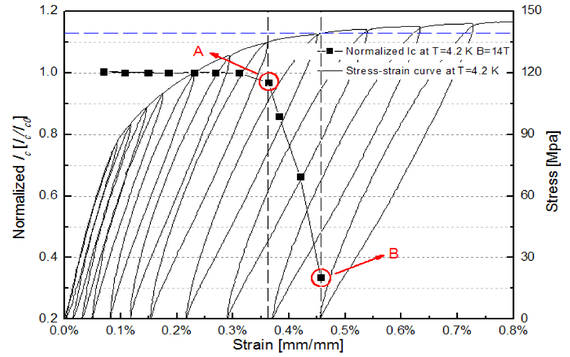
Applied compressive strain



Applied tensile strain



Intrinsic strain



Comparison of Bi-2212 wire stress and Ic versus strain curves at 4.2 K and 14 T

Conclusions

The impact of applied axial strain to Bi-2212 Ag/Ag-Mg sheathed round wire was investigated in both compression and tensile direction. The critical current degraded as a function of both compressive and tensile strain side. A correction was applied for the additional 0.185% tensile strain on the samples caused by the difference of the thermal expansion coefficient between Bi-2212 round wire and Ti-6Al-4V. No noticeable degradation of Ic was observed for the intrinsic strain up to 0.35%, while exceeding this irreversibility limit, a dramatic degradation occurred with increased strain. The Ic decreases almost linearly for compressive strain, but more gradual than under tension. The reduction of Ic on tension side agrees well with the yielding in the stress-strain characteristic. Further studies will be performed to verify whether this strain dependence of Ic is intrinsic to Bi-2212 round wire, a Cu-Be U-spring will be made for further experiments. Then the morphology of cracks will be investigated.