Characterization of Powder in Tube Superconducting Nb_3Sn Wires

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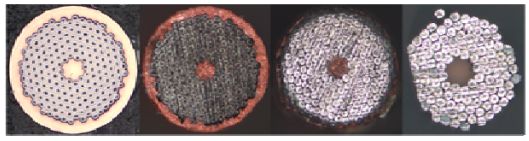
Introduction

Diffusion barrier integrity is crucial to magnet protection. Our previous work has shown that modern PIT (and RRP) conductors show filament shape degradation that increases with radial position. With only a handful of diffusion barriers in outer filament rings breaking, the RRR degradation can rapidly drop to below 150. Here we quantify this behavior. These Bruker-made PIT samples from CERN contain 192 Nb7.5wt.%Ta tube filaments of remarkable uniformity, but there is measureable non-uniform filament deformation.

Experimental

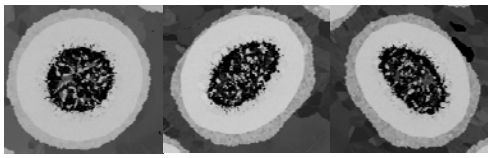
Digital imaging using the NHMFL Zeiss EsB SEM coupled allows rapid and accurate evaluation of the positional variation, ring by ring allowing us to clearly see a small filament ovalization that increases with increasing radius. To determine how drastically the RRR is affected by barrier breakthrough and Sn leaking into the Cu, we employ an acid etching procedure and subsequent resistivity measurements. First, 4 point contacts were made with silver epoxy and initial resistivity measurement is taken. Then the silver epoxy was removed and the sample immersed in a dilute nitric acid bath for 5-10 minutes. After etching, 4 point contacts with silver epoxy were made again and the measurement repeated, this time with an annulus of Cu removed. This acid treatment was repeated 3 times giving a RRR distribution as a function of the remaining Cu.



	Initial sample	Etch 1	Etch 2	Etch 3
120h620C+ 120h640C	175	157	127	172
280h625C	166	138	93	173

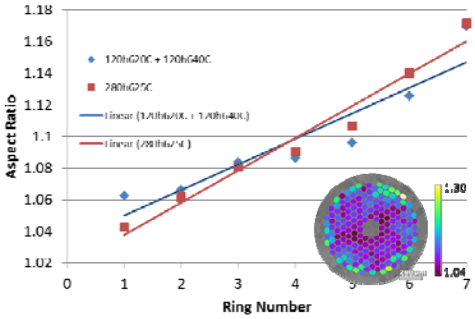
*RRR is clearly not monotonic with amount of Cu removed

Results and Discussion

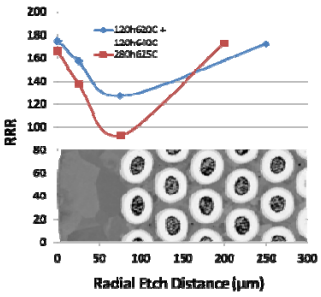


Circular filament diameter is approximately 50um.
1) A typical inner ring filament has an aspect ratio close to unity, uniform barrier thickness, very isotropic. 2) A typical outer ring filament, aspect ratio up to 1.3, thinning of barrier on one side with thickening on the other. 3) An outer ring filament that has succumb to barrier breakthrough and subsequent Sn leak due to non-uniform deformation

Since the A15 reaction front occurs radially from the filament centers, the deformation of the external filament leads to breakthrough of the DB bringing the A15 into contact with the stabilizer. This typically occurs in 2-3 filaments. Looking at the aspect ratio versus ring number (numbered from inside to out), filament aspect ratio increases almost linearly with radial position. It is evident that the heat treatment (HT) has a negligible impact on the deformation and if we color each filament by aspect ratio this can be easily visualized.



Conclusions



It is expected that the worst quality Cu to be around the outer two rings where barrier breakthrough is most common. Inversely, the best Cu should be furthest from the Sn sources, namely the outermost Cu as well as Cu surrounding the core. Results are plotted with an inset to the guide the eye to the left.

Acknowledgements

Funding provided by DOE- HEP and CERN