Multiple Characterization Approach to Enhance the Performance of PIT Nb_3Sn Conductors

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Abstract— Optimization of critical current density, J_c, in modern PIT Nb_3Sn superconducting wires is both a question of maximizing the amount of Nb3Sn and its quality, while avoiding any diffusion barrier (DB) breakdown that will poison the stabilizing and protecting Cu. Multiple superconducting and microstructural characterizations have been used to follow the progression of the A15 reaction across the Nb(Ta) tubes and the residual annulus of unreacted tube that acts as the DB. We found that the non-Cu J_c (12T, 4.2K) reached 2400-2500 A/mm^2 for heat treatments (HT) between 620°C and 670°C without degradation of RRR below 100. This J_c was developed by conversion of 52-55% of the non-Cu package to A15, with DB and core residues of about 25% and 22% respectively. However about a quarter of the A15 in the high J_c samples was A15 formed at the interface between the core and the DB that has grain size well over 1 µm. This large grain A15 fraction is rather independent of HT condition, representing 14%-16% of the total non-Cu after short reaction time when very little fine grain A15 has formed and J_c is low. By comparison with RRP conductors, we found that this conductor produced only about 2/3 as much current carrying A15 as in recent RRP conductors. However the Jc referred to the fine-grain layer is about 20% higher than in RRP conductors. Our detailed evaluation of the A15 layer by magnetization, specific heat and microstructure leads us to conclude that the large grain A15 layer plays little or no role in the transport J_c.