Abstract:

This paper explores the effects of changing various Cu-Sn parameters in Nb3Sn Rod in Tube (RIT) wires made both with Nb4at%Ta and Nb4at%Ta1at%Hf to gain a better understanding of the influence of the Cu-Sn mixing process occurring before the Nb3Sn reaction step. Internal Tin Nb3Sn wires like the Rod Restack Process ® (RRP ®) always have complexities associated with the Cu-Sn mixing step. Imperfect mixing compromises the ultimate performance of the wire. From this point of view RIT wires are of special interest because all the Cu and Sn is contained with one tubular filament that in principle offers a simplified window into the mixing and subsequent A15 layer growth. Here we examined wires with Cu:Sn atomic ratios of 3:1 (filament diameter ~100 um and ~25 um) and 6:5 wires (filament diameter ~150 um). We tested new multistep heat treatments motivated by the Cu-Sn phase diagram, observing both Cu-Sn and A15 phase formation around key transition temperatures. Problems with creating a fully mixed RIT wire with a Cu-Sn ratio of 3:1 were previously discussed by Segal *et al.* and here his experiments were extended by using higher temperature Cu-Sn mixing steps above 500C. Using the heat treatment 210C/48h + 425C/48h + 525C/96h, we were able to create 3:1 wires with significantly improved Cu-Sn mixing prior to the A15 reaction step. However, despite good Cu-Sn mixing inside NbTaHf alloy (FMF 23) tubes, we always found *Tc* and Kramer field values to be depressed compared to RRP (Cu:Sn ratio ~ 3.5:1, bronze (Cu:Sn ratio ~8:1) and 6:5 wires. We found that the reaction path for 3:1 (and bronze wires) avoided the Nausite phase (generally thought to be deleterious to *Jc*) always found in RRP wires while the 6:5 wire reaction always went through Nausite with decomposition into NbSn2, Nb6Sn5 and then A15 at high temperatures. We have found that it is very hard to completely mix Cu and Sn at any temperature below the A15 reaction temperature and are further exploring the reasons for A15 quality difference as the Cu:Sn ratio changes.

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