

The Effect of Filtered Oxygen Ion Irradiation on the Critical Properties of REBCO Coated Conductors

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Abstract—The economic viability of fusion power plants such as UK Industrial Fusion Solutions' Spherical Tokamak for Energy Production (STEP) [1] is a function of their size, toroidal field (TF) strength and availability throughout their operating lifetime [2]. Cost optimisation has led STEP to adopt a compact design featuring TF cables comprising a stack of rare-earth barium copper oxide (REBCO) coated conductors (CC), given its excellent current carrying capacity at low temperature and high field [3]. However, neutron irradiation leads to changes in the superconducting properties of REBCO [4] which in turn the operating lifetime of tokamaks [5].

The STEP team developed a plan to characterise the superconducting properties of REBCO CC under representative fusion conditions [6], making progress as described in [7]. In this work, several commercially available REBCO CC were oxygen ion irradiated in steps of $\approx 10^{-3}$ displacement per atom (dpa) up to and beyond STEP relevant damage levels. The irradiation used an energy filter [8] to more closely mimic the effects of fusion-spectrum neutrons. After each step, critical current density, critical temperature and irreversibility line were measured, allowing changes in these properties to be tracked with changing damage level. Results show that the choice of rare-earth in REBCO affects both the starting critical temperature and the rate of its monotonic decline with damage level. Results also show that measurement temperature and field strength perpendicular to the tape plane affect the trajectory of the change in critical current density of REBCO with damage level, and that this trajectory can be modelled as a combination of changing pinning efficiency and a loss in superconducting volume.

In this presentation, the irradiation method and results are presented and discussed, along with the implications for the design of the STEP and tokamaks in general.

Keywords (Index Terms)—Irradiation, REBa₂Cu₃O₇, HTS Magnet, Tokamak, Toroidal Field Coils, Critical Current Density

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