High temperature superconductors for fusion applications

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High temperature superconductors (HTS) in the form of coated conductors are an enabling technology for the next generation of compact nuclear fusion reactors that require higher magnetic fields than low temperature superconductors can provide. However, in operation, the superconducting magnet windings will be exposed to a flux of fast neutrons which will introduce structural damage at cryogenic temperatures.

Here, I will discuss two facets of the work being carried out by the Oxford group to improve understanding of radiation damage of coated conductors. The first is our innovative in situ ion irradiation experiments for assessing radiation damage at the cryogenic temperatures relevant for operation in a fusion magnet. Performing these experiments in situ is crucial because early work has shown that excursions to room temperature lead to an evolution of the defect landscape and a partial recovery of the superconducting performance which it may be possible to exploit to extend magnet lifetime. Secondly, I will discuss our recent studies aimed at understanding the nature of irradiation-induced lattice defects using a combination of atomic resolution electron microscopy, high energy resolution x-ray absorption spectroscopy (HERFD-XAS) and DFT modelling. By comparing the effects of He+ irradiation with neutron irradiation, I will comment on the extent to which ion irradiation can serve as an easy and safe proxy for understanding neutron damage in these complex materials.