Molecular dynamics investigation of radiation damage in high temperature superconducting tapes for compact fusion reactors

D. Gambino[1], D. Torsello[2,3], F. Ledda[2,3], F. Laviano[2,3]

[1] *Department of Physics, Chemistry and Biology, Linköping University, Linköping, Sweden*

[2] *Department of Applied Science and Technology, Politecnico di Torino, Torino , Italy*

[3] *Istituto Nazionale di Fisica Nucleare, Sezione di Torino, Torino, Italy*

Compact fusion reactors have been proposed as a timelier and cheaper alternative to large-scale fusion reactors. The design of such devices relies on high-temperature superconductors (HTS) technology, which enables much higher magnetic fields than conventional superconducting magnets and therefore stronger confinement of the plasma. However, because of the compact design, the HTS materials will likely experience radiation damage due to neutrons escaping the vacuum vessel. Since the superconducting properties of HTS materials are extremely sensitive to lattice defects, the lifetime of these fundamental components is of great concern. For this reason, we have investigated [1] the expected radiation damage of $YBa_2Cu_3O_7$ (YBCO) in a compact reactor design with computational methods, namely Monte Carlo (MC) and molecular dynamics (MD) simulations, to guide the experimental development of this technology. In this talk, I will present our MD investigation of YBCO together with recent developments.

The expected neutron spectrum at the HTS tape position in the compact design, calculated with MC simulations, is used to obtain the energy distribution of primary knock-on atoms (PKAs) for each species in YBCO. Representative energies are extracted from this spectrum for Ba and O and employed in MD collision cascade simulations where the radiation damage is investigated at T=20 K and at room temperature, enabling a comparison between operational conditions and available experiments. Results in terms of number of defects, defect morphologies, and local temperature transients are discussed. We then assess the effect of the electronic stopping power on the number of defects for representative energies and PKA species, and we discuss the differences in damage due to different PKA species. These results will enable more refined models to predict damage in these complex materials at operational conditions.

References

[1] D. Torsello et al., Supercond. Sci. Technol. **36**, 014003 (2023)