



Influence of artificial pinning centers on the radiation resistance of coated conductors

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Outline

- Fusion as motivation for neutron irradiation studies
- Influence of the operating temperature on the radiation induced degradation of the critical currents
- Influence of artificial pinning centers (APCs) on the fluence dependence of the critical currents
- Understanding the different radiation robustness of tapes with and without APCs
- Volume pinning force curves
- Conclusions & summary







Fusion reaction & neutron energy







Neutron energy spectra

- Similar spectrum, but neutron flux density in fission ~10⁴ higher
- → neutron irradiation of fusion magnet materials for testing in TRIGA MARK II reactor suitable
- Fast neutron flux density E > 0.1 Mev: $\sim 4.1 \times 10^{16} \text{ m}^{-2}\text{s}^{-1}$



NORMALIZED FLUX DENSITY







Samples, measurement devices & method

- Superconductor: YBCO, GdBCO
- Manufacturer: AMSC, SuperPower, SuNAM
- Samples size: 25x4 mm²
- Two tapes from SuperPower with APCs
- 17 T helium flow cryostat
- 300 A current source
- Transport current measurements
- Temperature range 30 64 K
- Field orientation H || c











Influence of temperature on the fluence dependence of critical currents

AMSC 344C, 15 T, H || c





Most data were previously published in:

Suitability of coated conductors for fusion magnets in view of their radiation response Prokopec R, Fischer D X, Weber H W, Eisterer M 2015 Supercond. Sci. Technol. **93** 014005





Differences in critical currents of irradiated tapes with and without APC







Understanding the effect of APCs on radiation robustness of coated conductors



Optimization of vortex pinning by nanoparticles using simulations of the time-dependent Ginzburg-Landau model Koshelev A E *et al.* 2016 *Phys. Rev. B* **93** 060508









Normalized volume pinning force







Summary & conclusions

- Critical currents degrade at lower temperatures at higher fluences
- Tapes with APCs degrade at lower neutron fluences than tapes without APCs
- The higher total defect density (initial defects + irradiation defects) of tapes with APC compared to tapes without APCs makes these tapes less radiation resistant
- After irradiation the pinning mechanism is dominated by induced defects, differences in the normalized volume pinning force curves of tapes with APCs and without APCs vanish after irradiation
- For the actual European Demo design, tapes with and without

APCs would be suitable in view of their radiation robustness







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