Effect of neutron irradiation on the superconducting properties of REBCO tapes

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Outline

- Experimental setup
- Decrease of critical temperature
- Degradation of critical currents, role of temperature
- Influence of artificial pinning centers (APCs)
- Pinning mechanism
- Conclusions & summary
Fusion reaction & neutron energy

Neutron attenuation \( \sim 10^{-6} \)

14 MeV neutrons scatter → broad energy spectrum
Neutron energy spectra

- Similar spectrum, but neutron flux density in fission $\sim 10^4$ higher
- $\rightarrow$ neutron irradiation of fusion magnet materials for testing in TRIGA MARK II reactor suitable
- Fast neutron flux density $E > 0.1$ Mev: $\sim 4.1 \times 10^{16}$ m$^{-2}$s$^{-1}$

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Samples, measurement devices & method

- Superconductor: YBCO, GdBCO
- Manufacturer: AMSC, SuperPower, SuNAM, SuperOx
- 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
Fluence dependent critical temperature

No influence of APCs on $T_c$ degradation
Universal $T_c$ decline of $\sim 3\%$ per $10^{22}\text{ m}^{-2}$
Influence of temperature on the fluence dependence of critical currents

The effect of fast neutron irradiation on the superconducting properties of REBCO coated conductors with and without artificial pinning centers
Differences in critical currents of irradiated tapes with and without APC

Point of degradation tapes with APC
Point of degradation tapes without APC

all data: 30 K, 15 T, H || c
Understanding the effect of APCs on radiation robustness of coated conductors

Normalized volume pinning force

Initial differences vanish after irradiation
→ induced defects become dominant pinning mechanism
Summary & conclusions

- No influence of APCs on $T_c$ degradation
- Lower operation temperatures $\rightarrow I_c$ degradation at higher fluences
- Tapes with APCs degrade earlier
- High total defect density $\rightarrow$ less radiation robustness
- Radiation induced pinning dominant
- For European DEMO design: all tapes suitable
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