Review and critical assessment of dislocation loop analyses on EUROFER97

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Neutron irradiation induced microstructural defects deteriorate mechanical properties of structural materials. Even though reduced activation ferritic / martensitic (RAFM) steels like the European variant EUROFER97 are especially designed for withstanding the harsh environment in future fusion reactors, they still suffer from low temperature hardening and embrittlement which limit their application.

Dislocation loops, which form from interstitial atoms under neutron irradiation induced displacement cascades, are held responsible for the dominant contribution to hardening of EUROFER97. Therefore, microstructural analysis of dislocation loops is the key for understanding irradiation effects and subsequent changes in mechanical properties. Transmission electron microscopy (TEM) is a powerful tool to analyze microstructural defects like dislocation loops since it provides a direct observation of the respective defect based on its diffraction contrast. Unfortunately, TEM has several drawbacks that have to be addressed when analyzing dislocation loop types, densities and size distributions. Analyses are affected by the lateral resolution of TEM, which is limited to defects larger than ~1nm. While larger dislocation loops show a loop-like contrast, smallest loops only appear as black dots in TEM. Depending on resolution and quality of prepared samples, a difference in experimental results arises. Further, at highest resolution the investigated sample volume is small i.e. statistics on defect densities are quite low and less reliable.

In this work new results on dislocation loop microstructure in neutron irradiated EUROFER97 are compared to previous investigations after SPICE (15dpa, 300°C, HFR), WTZ (15dpa, 330°C, BOR-60) and ARBOR1 (32dpa, 330°C, BOR-60) irradiation experiments. Discrepancies in loop mean diameters and densities as well as their division in *a*<100> and *a*/2<111> type loops are observed in different studies under similar neutron irradiation conditions, and impede straightforward and conclusive findings. Possible reasons for these differences are discussed including experimental and analytical conditions and sample preparation. A systematic analysis of existing microstructural data is performed and will contribute to deeper understanding of underlying effects.

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