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Characterization of Helium Bubble Formation in FeCr Alloys Using Positron Annihilation Lifetime Spectroscopy

Positron annihilation lifetime spectroscopy (PALS) has been used to improve the understanding and prediction of early-stage helium-assisted radiation aging of structural materials. The present study integrates a unique high-energy helium ion irradiation experiment with spallation target irradiation experiments, offering experimental PALS data that reveal the microstructure and a wide range of radiation-induced cluster sizes. Through these analyses, the study estimates the helium-to-vacancy ratio and enhances the existing theoretical model of positron trapping coefficients to account for cluster size and irradiation temperature. The findings confirm the model's effectiveness in characterizing helium-vacancy clusters and helium bubbles up to 1 nm in diameter, formed at irradiation temperatures ranging from room temperature to 300℃. This validation underscores the feasibility of using helium implantations for experimentally simulating spallation radiation environments.

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