Seminar

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Institute for Plasma Research

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Title: 14-MeV Neutron Irradiation Experiments for Fusion Applications

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Abstract

A comprehensive series of neutron irradiation experiments were carried out at the Institute for Plasma Research using a 14-MeV neutron generator to support fusion technology development, nuclear data validation, and material qualification under high-radiation environments. Key investigations included neutron-induced reaction cross-section measurements for isotopes of Sb, Zr, Sn, Sr, Te and Re at a neutron energy of ~14.96 MeV using activation techniques. Reactions such as ^{90}Zr(n,p), ^{121}Sb(n,2n), ^{117}Sn(n,p), ^{118}Sn(n,α), ^{120}Sn(n,α), ^{86}Sr(n,2n), ^{185}Re(n,2n) and (n,p) and (n,2n) reactions cross section on Te isotopes were studied with detailed uncertainty quantification using covariance analysis, and the measured data were compared with predictions from nuclear model codes including TALYS-2.0, EMPIRE-3.2.3, and TASMAN-2.0 to address discrepancies in legacy datasets. In parallel, neutron irradiation experiments were conducted to qualify ITER-relevant materials and components under 14 MeV neutron exposure, including a stepper motor system for ITER CXRS pedestal diagnostics, which demonstrated stable operation, precise positioning, and repeatable performance up to a neutron fluence of $\sim 3.5\times10^{12}$ n/cm^2 under load conditions. Additionally, catalyst materials developed for the ITER hydrogen mitigation system and structural steel alloys were irradiated to evaluate neutron-induced effects and attenuation characteristics, while a conceptual neutron moderator design was developed using MCNP simulations to tailor the neutron energy spectrum for sensor qualification. In addition, radiation response studies were extended to semiconductor devices, including 4H-SiC-based power devices. The 4H-SiC devices comprising PiN, Junction Barrier Schottky (JBS), and Schottky diodes in both die-level and packaged configurations were irradiated to evaluate their electrical and structural stability under neutron exposure. The silicon detector was exposed to a neutron fluence exceeding 1×10^{13} n/cm^2, and its performance degradation was assessed through reverse leakage current measurements as a function of bias voltage before and after irradiation. These studies provide critical insight into radiation-induced damage mechanisms and confirm the suitability of these devices for operation in high-radiation environments. Overall, the results show good agreement with theoretical predictions for most reactions while resolving discrepancies in existing data, and confirm the robustness and functional reliability of ITER-relevant components under neutron irradiation, supporting their suitability for fusion reactor applications.
