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Primary defect production in displacement cascades in beryllium

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Beryllium is an important part of the future fusion reactor blanket. The degradation of beryllium properties in severe radiation environment is caused by the accumulation of microstructural defects (dislocations, voids, gas bubbles) that arise as a result of radiation damage accumulation. The creation of primary damage mostly occurs in collision cascades initiated by fast neutrons escaping the hot plasma. In contrast to other reactor structural and functional materials, little is known about cascade damage in beryllium.

Here we report the results of a systematic investigation of collision cascades in beryllium. Applying Molecular Dynamics (MD) at 600 K, we demonstrate that cascades in Be are remarkably different from cascades in more heavy metals. For example, the collective mode of damage production in Be is manifested in the low and relatively narrow recoil energy range of 0.5-3 keV. Recoils of higher energies are easily transported in the matrix, creating along the trajectory multiple subcascades from secondary recoils in the above-mentioned energy range. The efficiency of point defect survival after the cascade ballistic stage is less than 25%, as compared to NRT standard, while the created damage consists of individual vacancies and interstitials, with a marginal admixture of di- and tri- vacancies. Finally, we demonstrate (both by MD and first-principles simulations) that self-interstitials are highly mobile in Be and cause strong in-cascade recombination that remarkably decreases the number of defects escaping the cascade region and contributing to the development of secondary damage.