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High-Velocity Impact of Tungsten Dust on Helium-Implanted Tungsten: Molecular Dynamics Insights

Understanding the impact dynamics of high-velocity tungsten (W) dust on helium-implanted W targets is crucial for predicting material degradation in fusion reactor environments. In this study, we employ large-scale molecular dynamics (MD) simulations to investigate the interaction mechanisms governing the response of W surfaces under extreme impact conditions. The simulations reveal the formation of localized defects, including dislocation loops, vacancy clusters, and potential phase transformations induced by the high strain rates. The presence of helium significantly alters the mechanical response by promoting bubble rupture, enhanced vacancy mobility, and localized melting in the impact zone. We systematically analyze the effects of impact velocity, dust particle size, and helium concentration on the damage evolution, providing fundamental insights into the underlying deformation mechanisms. These findings contribute to a deeper understanding of plasma-material interactions in nuclear fusion environments and offer valuable input for developing radiation-resistant tungsten-based plasma-facing components.

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