

Resilience of Stabilized Nanocrystalline Metals Against Multi-Energy Degradation in Extreme Environments

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The absorption of various energy forms—such as intense heat, ionizing radiation, mechanical loading, and high electric fields—can degrade materials through rapid defect formation and microstructural changes, ultimately leading to failure. Each energy type interacts with materials differently: thermal energy increases kinetic activity, resulting in vacancies and phase transformations; ionizing radiation induces atomic displacements that create vacancies and interstitials, leading to embrittlement and swelling.