Pulsed X-Ray Exposures and Modeling for Tungsten as an IFE First Wall Material

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Dry-wall inertial fusion energy (IFE) power plants must survive repeated exposure to target threats that include x-rays, ions, and neutrons. While this exposure may lead to sputtering, exfoliation, transmutation, and swelling, more basic effects are thermomechanical in nature. In the present work, we use the newly developed RadHeat code to predict time-temperature profiles in a tungsten armor, which has been proposed for use in an IFE power plant.

The XAPPER x-ray damage experiment can be used to simulate thermal effects by operating at an x-ray fluence that produces similar peak temperatures, temperature gradients, or thermomechanical stresses. The x-ray source used within the XAPPER facility was designed and built by PLEX LLC. It produces short (30-50 ns) pulses of soft (80-150 eV) x-rays and focuses them upon a sample. X-ray fluences in excess of 1 J/cm^2 are possible. XAPPER can operate at up to 10 Hz for tens of millions of pulses before requiring minor maintenance.

Using RadHeat, we determine the XAPPER x-ray fluence needed to simulate the thermomechanical effects expected in a typical IFE case of interest. We have exposed a set of tungsten samples to varying fluences and numbers of pulses. Here, we report our findings and detail directions for future experiments and modeling.