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USE OF RHEPP-1 FOR LONG-TERM MATERIALS EXPOSURE FOR IFE AND MFE* **

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In future Laser Inertial Fusion Energy (IFE) power plants, MeV-ions will impinge on the chamber wall at high fluence (up to 20 J/cm^2) and at rates up to 10 Hz. The effects on proposed chamber materials subjected to long-term pulsed ion beam exposure (up to 2000 pulses) are being investigated on the 800 kV RHEPP-1 facility at Sandia National Laboratories. For these studies, beams of helium and nitrogen ions (200-400 ns pulsewidth on target, at fluences up to and exceeding ablation threshold) are directed onto samples of candidate wall armor materials such as tungsten, tungsten alloy and graphite. Samples are exposed at room temperature, or up to 600° C.

It is important to determine the threshold for surface morphology changes in these materials, for two reasons. Any developing surface morphology may be mechanically unstable, i.e., may lead to loss of material by exfoliation or similar mechanisms. In addition, surface microcracks and roughness may act as initiation sites for fatigue cracks which may then propagate below the surface. It appears that (powder metallurgy) tungsten exposed below about 1 J/cm^2 (nitrogen beam) remains unaffected by up to 1200 exposures. SEM imaging at 15,000 magnification shows no evident micro-cracking. This corresponds to a peak surface temperature of 2,000 – 2,500K, depending upon if the sample is heated or not. Above this level, however, tungsten evolves surface relief rapidly with pulse number, although evidence of a saturation mechanism after about 1000 pulses is clearly seen. The level of roughness increases with the per-pulse fluence. This evolution happens both below and above the nominal melting temperature. Tungsten surfaces exposed to hundreds of ion pulses appear to suffer fatigue-related stress fracturing in addition to this relief formation. Alloying of the tungsten, or heating to beyond the brittle-to-ductile transition temperature, is observed to reduce but not eliminate these effects. Other metals studied (Ti, Cu, Al) also appear to undergo complex surface relief development, an evolution which takes hundreds of pulses to occur. The surface morphology is observed to be quite complex, and differs with each metal. The mechanism is evidently a thermomechanically based surface instability. The implications for both inertial and magnetic fusion energy reactors will be discussed.

Measurements of surface roughening and removal, as well as SEM and TEM observations will be presented, and compared to materials response predictions with simulation codes.

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