Laser Inertial Fusion Dry-Wall Materials Exposure to X-rays and Ions* **

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We are investigating the response of candidate first-wall materials under consideration for future Inertial Fusion Energy (IFE) power plants. The materials are separately exposed to multi-pulsed intense ions on RHEPP-1, and to x-rays on the Z facility, both located at Sandia National Laboratories. Details of the exposure conditions have been described previously.[1] The RHEPP-1 accelerator produces ion fluences up to 10 J/cm^2 per pulse, and can expose materials up to 2000 ion pulses per sample. The Z machine fluence from tungsten z-pinch discharges (several J/cm^2 of up to 5 keV photons) is used to expose samples to single-shot x-ray pulses.

Since ~ 10^8 pulses may impinge on a reactor wall over its lifetime, almost no erosion of a flat wall surface per pulse can be tolerated (<1 nm). Since the energy delivery is pulsed, thermomechanical effects such as roughening and surface fatigue can be expected. The materials studied here include primarily tungsten in either pure or alloy form, and graphite and/or carbon composites. Materials are either flat monolithic (single material), or "engineered" materials of 3-dimensional character such as foams or velvets. After exposure to either ions or x-rays, effects on the surface topology and near-surface microstructure are analyzed, and materials response compared with predictions from BUCKY and other modeling codes. Most samples are DC heated at up to 600C, to measure their response under expected reactor wall operating temperatures.

Tungsten in all forms is observed to undergo surface roughening at or below its melting point when exposed to ions. Deep-lying cracks are also observed, evidently due to fatigue. The powder metallurgy (PM) form of W shows the worst tendency for roughening and cracking. The surface morphology can evolve into a complex structure, which can take hundreds of pulses to develop. The roughness can appear to saturate (PM W), or appear open-ended (Ti), or can be minimally present (Cu). In the case of carbon materials, the fiber structure in carbon composites is observed to withstand ion exposure well, whereas the matrix material is readily removed at fluences even below the predicted surface sublimation temperature.

Further multi-pulsed ion exposures to various ion fluences of tungsten/tungsten alloys are planned, both in flat form and 'engineered' geometries. Post-exposure analysis will include surface profilometry, SEM imaging, and XTEM. Also, since roughening of materials treated on RHEPP may be due to plastic flow induced by thermal gradients, the BUCKY computer code is being modified to enable the modeling of plastic flow. BUCKY studies of both W and Ti are planned to better understand material roughening.

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[1]T. J. Renk, C. L. Olson, T. J. Tanaka, M. A. Ulrickson, G. A. Rochau, R. R. Peterson, I. E. Golovkin, M. O. Thompson, T. R. Knowles, A. R. Raffray, and M. S. Tillack, *IFE chamber dry wall materials response to pulsed X-rays and ions at power-plant level fluences*, Fusion Engineering and Design **65**, 399-406 (2003).