Materials Science and Engineering

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Plasmas Ablation and Shock Generation to Study the Effect of Laser Impulse

X-ray driven thermo-mechanical shock (TMS) is a major risk for electronics operating outside the Earth's atmosphere. Direct measurements using X-rays to drive TMS are of significant interest Experimental platforms with high X-ray flux are limited. However, high power lasers can be used to mimic intense X-ray pulses to drive target ablation and the production of TMS at the relevant multi-Mbar levels.

One important question that needs to be addressed is: how does the target ablation and subsequently TMS properties change with the laser pulse length. Experiments were performed at the Omega laser facility at a constant laser intensity of 6×1014 W/cm2 with a varying laser pulse length (100 ps, 500 ps, 1 ns, 10 ns). The targets consisted of three layers of single crystalline nominally undoped silicon, polycrystalline Copper, and crystalline SiO2 quartz (Si/Cu/Qz). The ablation front temperature was found to be independent of pulse duration, measuring ~500 eV across all cases. Ablation density was indirectly inferred from the Angular Filter Refractometer (AFR) diagnostic through a comparison with synthetic AFR images post-processed from the rad-hydro simulations.

The resulting TMS propagation into the dense target was measured in the quartz witness layer using ASBO (shock velocity) and SOP (shock temperature) diagnostics. For the longest pulse length (10 ns), the measured shock velocity was ~35 km/s (~22 Mbar), in agreement with the analytical scaling laws after considering the shock impedance matching of the Si/Cu/Qz layers. Interestingly, the measured shock velocity for the shortest pulse (0.1 ns) is <5 km/s (<1 Mbar), marking a significant decrease in the shock pressure for sub-ns pulses. This trend is also observed to a lesser extent in the 0.5 ns and 1 ns pulse lengths, signaling that the supported shock pressure is proportional to the pulse duration and that shock decay effects (rarefaction, dispersion, reflection/transmission) are not insignificant. The detailed experimental data and radiation hydrodynamics results will be presented.

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Farhat Beg received his Ph.D. from Imperial College London. His expertise is in the field of laser plasma interaction, pulsed power-driven X- and Z-pinches, and neutron sources. He has published over 250 papers in refereed journals, including Nature, Nature Physics, Nature Photonics and Physical Review Letters, with total citations exceeding 9000 and with an H-index of 50, according to the ISI Web of Knowledge.

He is the fellow of the American Physical Society, the Institute of Electrical and Electronics Engineers (IEEE) and the American Association for the Advancement of Science (AAAS). He has been a winner of the Department of Junior Faculty Award (2005) and IEEE Early Career Award (2008). This year he received IEEE Plasma Science and Applications Award. He has served as the Chair of the High-Energy Density Science Association (HEDSA) in 2009/10 and in 2017/2019 and NIF/Jupiter User group in 2017/2019.