Digital Holographic Analysis of Laser Induced Micro Plasma in Micro Machining Applications: Temporal and Spatial Comparisons to Thermo Nuclear Explosions

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Abstract:
In 1950 Sir G. Taylor formulated theoretical model for estimating the amount of energy released from a very intense explosion by observing the temporal evolution of the generated shock wave. Laser-material interactions are subject to a range of physical phenomena that closely resemble the dynamics of Nuclear Weapon releases: Early plasma, shockwave formation, intense plume and material ejection. We employ ultrafast Holographic methods to study the dynamics of laser-based single pulsed events and compare the temporal and spatial characteristics to Nuclear Weapon dynamics from available data (see Figure 1). We present the dynamics of Silicon and Titanium ablation from the early period (0 – 1000 ns) to the late period (1 – 500 µs) and compare the surface and volumetric heating regimes with that of nuclear detonations. We determine the energy efficiency as a function of removed material through the Sedov-Taylor approximations.

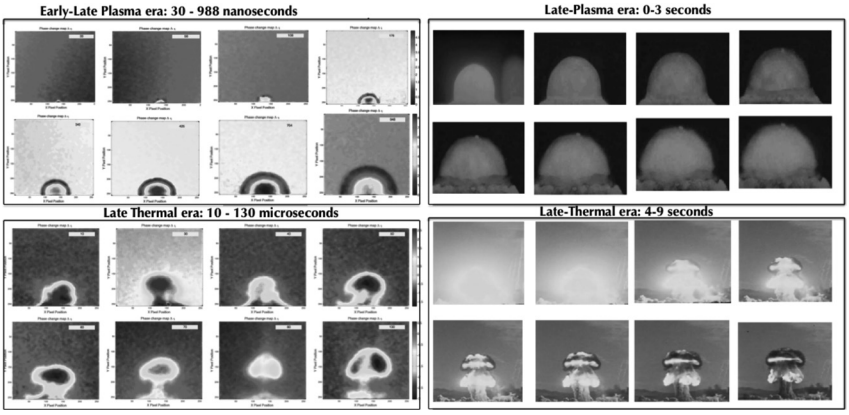

Figure 1: Shows (left) the temporal evolution of a single laser pulse on <1|1|1> Silicon and (right) the evolution of a nuclear explosion.

Statement of Significance:

- Demonstrate scaling phenomena in fluid dynamics from the micro to macro scales.
- Determine the dynamics and energy deposition regimes of a variety of advanced temporally shaped pulses, hitherto, largely unexplored.