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Aerosol-Assisted Solid Debris Collection for the National Ignition Facility

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Disclaimer

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The National Ignition Facility (NIF) has been completed and has made its first shots on-target. While upcoming experiments will be focused on achieving ignition, a variety of subsequent experiments are planned for the facility, including measurement of cross sections, astrophysical measurements, and investigation of hydrodynamic instability in the target capsule. In order to successfully execute several of these planned experiments, the ability to collect solid debris following a NIF capsule shot will be required.

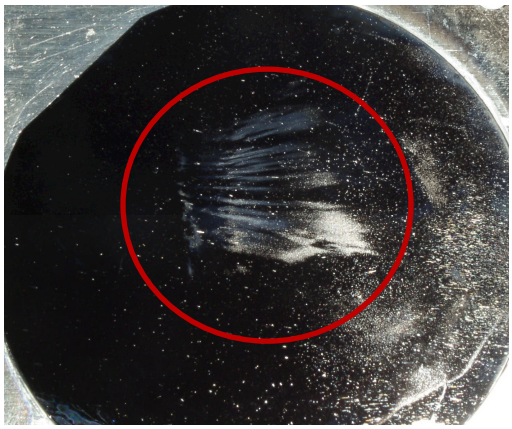
The ability to collect and analyze solid debris generated in a shot at the National Ignition Facility (NIF) will greatly expand the number of nuclear reactions studied for diagnostic purposes. Currently, reactions are limited to only those producing noble gases for cryogenic collection and counting with the Radchem Apparatus for Gas Sampling (RAGS). The radchem solid collection diagnostic has already been identified by NIF to be valuable for the determination and understanding of mix generated in the target capsule's ablation.

LLNL is currently developing this solid debris collection capability at NIF, and is in the stage of testing credible designs. Some of these designs explore the use of x-ray generated aerosols to assist in collection of solid debris. However, the variety of harsh experimental conditions this solid collection device will encounter in NIF are challenging to replicate. Experiments performed by Gary Grim *et al*. at Sandia National Laboratory's RHEPP1 facility have shown that ablation causes a cloud of material removed from an exposed surface to move normal to and away from the surface. This ablation is certain to be a concern in the NIF target chamber from the prompt x-rays, gamma rays, etc.

generated in the shot. The cloud of ablated material could interfere with the collection of the desired reaction debris by slowing down the debris so that the kinetic energy is too low to allow implantation, or by stopping the debris from reaching the collection device entirely.

Our goal is to use this primary ablation wave to our advantage, by the creation of ionized alkali metal halide salt aerosols. This technique is similar to that used by many particle accelerator groups for gas-jet transport. Ideally the salt would be ablated from a substrate, encounter the reaction debris, agglomerate, and be collected for further study. We have done studies at laser and pulsed-power facilities (Titan laser at LLNL, Trident laser at LANL, Zebra z-pinch at Nevada Terawatt Facility) evaluating the hardiness of materials for placement in the NIF target chamber, as well as testing aerosol generation by the incident x-rays generated in device shots.

To test this method's potential success in the NIF environment, we have tested KCl, KI, RbI, and CsI films of 1 and 2 um linear thickness on aluminum and silicon wafer substrates in these aforementioned facilities, at varied distances. These salts do ablate in the presence of sufficient x-ray fluence. Further analysis to quantify the final ablation depth as a function of x-ray fluence is ongoing. Half of each sample was masked with a thick tungsten foil for photon opacity. KCl was the most difficult salt to ablate, from comparing the tungsten-masked side of the samples to the unmasked side of the samples. This is likely due to KCl's absorbance peak being at lower wavelengths than that of KI, ~160 nm vs. ~220 nm, respectively.



Samples with and without collimation were tested to identify if any condensation of these ablated salts occurred after ablation. Visual inspection of the silicon wafer witness plates placed parallel to the direction of the incident photons showed that a vapor was deposited on the wafers next to the collimators. (see figure 1, red oval indicates CsI vapor) Further analysis with EDS in the case of the collimated samples conclusively identified the vapor as CsI.

We also intend to examine samples of bare substrate exposed to the same experimental conditions for post-shot change via SEM images, optical microscopy, and atomic force microscopy (AFM). Furthermore, tests with separated isotopes may be done to reduce background contamination.

When sample optimization is complete, we plan to develop a "catcher" device for these desorbed aerosols. Current ideas include biased grids to either attract the ionized particles to the grid, or repel them towards a collection device.

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