NRL LASER FUSION PROGRAM

November-December 2002 Bimonthly Highlights

Laser Imprint Reduction with a Short Shaping Pulse

Use of a short pre-pulse or picket prior to the main drive pulse in order to suppress laser imprint and mitigate the RT growth through tailoring of the target adiabat has recently attracted attention at NRL [Metzler *et al*., Phys. Plasmas **9**, 5050 (2002)], LLE [Goncharov, BAPS **47**, 284 (2002)] and LLNL (Perkins *et al*., op. cit., p. 101). The laser imprint can be reduced by the use of a short "shaping" laser pulse that hits a sandwich plastic-foam target prior to the arrival of the drive pulse, as shown in Fig. 1, where the Nike drive pulse is plotted. This method is based on the mechanism of laser imprint reduction in targets with tailored density profiles, which was suggested and described by Metzler *et al*. in Phys. Plasmas **6**, 3283 (1999). A smooth increase of the target density from the irradiated surface to the main accelerated mass was shown to be the most imprint-resistant density profile compared to either a uniform density or a two-slab target of the same mass and thickness. A target with a smoothly graded density, however, is difficult to manufacture. The role of the shaping pulse is to dynamically transform a density step of the initial sandwich target into a smooth density gradient, as demonstrated in Fig. 2, plotted for a 0.325 ns long shaping pulse (no drive pulse) irradiating a foam-plastic sandwich target. Then the strong shock wave launched by the drive pulse decelerates as it propagates through this density gradient, and so does the ablation front, effectively mitigating the imprint.

If the drive laser pulse has been sufficiently smoothed, then the use of a shaping pulse can completely suppress its imprint. In this case, however, the emphasis is shifted to the imprint produced by the shaping pulse. Non-uniformity of the shaping pulse generates strong sonic waves in the shocked target, which get amplified when the shock wave launched by the drive pulse arrives.

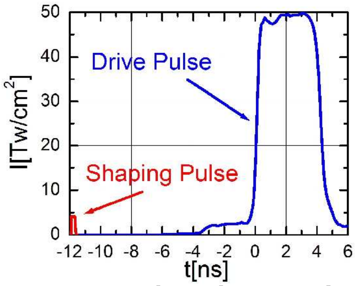

Fig. 1. A short shaping pulse precedes the Nike drive pulse with a low-intensity foot.

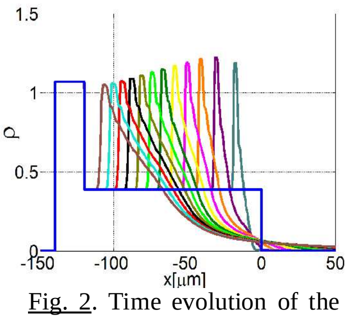

Fig. 2. Time evolution of the density profiles shown with a 1 ns interval.

This is illustrated by Fig. 3, showing the simulated density contours in the target shown in Fig. 2 at the end of the drive pulse illustrated by Fig. 1 (dashed line shows the initial foam/plastic interface). Figure 3(a) corresponds to the case when there is no imprint mitigation due to shaping pulse, and the target at the end of acceleration is strongly distorted by the RT instability. Figure 3(b) corresponds to the case of a pre-pulse formed by a single Nike beam smoothed with ISI technique at 1 THz bandwidth. The short averaging time, 0. 325 ns, implies a large non-uniformity, ~5% (vs. 1.5% in a 4-ns Nike beam). As shown in Fig. 3(b), strong sonic waves produced by this shaping pulse make thing worse than in the absence of this pulse. Finally, Fig. 3(c) shows the result obtained for the shaping pulse formed by 36 statistically independent overlapping Nike beams, which reduce its rms non-uniformity by a factor of 6 compared to the case of Fig. 3(b), and result in a very good uniformity of the accelerated target.

Our conclusion is that the use of a short shaping pulse for mitigating imprint, tailoring the target adiabat, etc., could be very effective if this pulse is sufficiently smoothed by overlapping multiple smoothed laser beams.

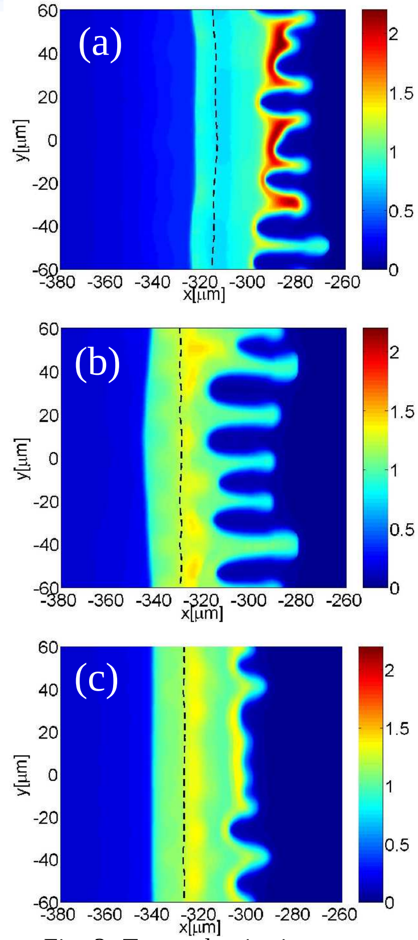

Fig. 3. Target density images at the end of the drive pulse: (a) without a shaping pulse; (b) with a shaping pulse smoothed as a single Nike beam; (c) with a shaping pulse smoothed as 36 overlapping Nike beams. The dashed line is the plastic-foam interface. The target is initially smooth, and all nonuniformity is due to the laser.

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