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EARLY-TIME MEASUREMENTS OF LASER-PLASMA CONDITIONS IN OMEGA-UPGRADE ICF TARGETS

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Semi-Annual Report

EARLY-TIME MEASUREMENTS OF LASER-PLASMA CONDITIONS IN OMEGA-UPGRADE ICF TARGETS

Since arrival of FY-98 funding under this grant in December, we have been preparing for our first series of experiments under this grant at the University of Rochester Laboratory for Laser Energetics (LLE) on the Omega laser facility, now scheduled the week beginning May 4, 1998. We will again be fielding our flat-field, grazing-incidence extreme-ultraviolet (euv) spectrograph with a four-channel gated-stripline microchannel plate (MCP) detector, which is mounted on the outside of the vacuum chamber approximately 60 inches from the center.

In addition, we will be using for the first time our newly constructed flat field spectrograph [1] covering the spectral range of 30-250 Å (hν=50-400 eV), designed to fit into a Ten Inch Manipulator (TIM). As such, it can be located closer to the central target position, with an expected enhancement in sensitivity of at least a factor-of-ten. It is the preparation of this instrument that mainly has occupied our attention so far in this grant period. A photograph of the new instrument in the open mode is shown in Fig. 1. In January 1998 a prototype was successfully test-fitted at LLE into a TIM. In March 1998 the light-tight enclosure was complete, and photographic spectra were successfully obtained using our ruby-laser beam focused onto a boron carbide target. The spectral range covered is 33-300 Angstroms. It will be fielded at LLE during our first FY-98 series of shots presently scheduled for May 4-8, 1998 in a photographic mode, and a remote-controlled shutter has been constructed. Also fielded in this series will be our earlier externally-mounted spectrograph incorporating time-resolved

MCP detection. In a later series of shots this year we plan to transfer the gated MCP detector to the new TIM-mounted instrument.

During this period we have also been comparing some of our data from the series of shots obtained in September 1997 with numerical modeling generously provided by Drs. J. Delettrez and R. Epstein of LLE. The results for the hydrodynamic modeling of the expansion of a initially 2000-Å thick Mg plus 300-Å thick Al coating and the collapse of the shell with increasing electron density are shown in Fig. 2a. In this figure, time is measured from the beginning of the nominally 1-ns Gaussian pulse, which is approximated by a triangular pulse beginning at the origin, peaking at 1 ns, and returning to zero at 2 ns. Corresponding computations of electron density N_e and temperature T_e are shown in Fig. 2b. Collapse occurs between 2.5 and 3 ns, which agrees with both the euv and the x-ray streak data. Computed spectra for the n=2 to n=1 transitions in He- and H-like Mg XI and XII and Al XII and XIII, respectively, are plotted on the same time scale in Fig. 3. Shown here is the sequence of initially burning through He-like to H-like Mg from the outer layer as the temperature rises, followed by He-like and then H-like Al from the sealant layer beneath, as observed experimentally. The very early peak in Mg line emission may be an artifact of the triangular pulse shape assumed, since a slower rise was indicated in the measured spectrum, as well as in earlier modeling of another case (with a CH overcoating) for a pure Gaussian pulse shown in Fig. 4 and described in the next paragraph. This is currently being verified. One may note also in Fig. 3 the prediction of enhanced emission from these species following the collapse, as observed spectroscopically. This is most likely from recombination during the expansion period indicated in Fig. 2, and not necessarily associated with compression as indicated by the narrowing of x-ray lines whose widths depend on the source size.

In Fig. 4(b) are shown first some LLE spectral modeling of n=2 to n=1 x-ray lines for an earlier target design consisting of 2000 Å of Mg over 2000 Å of Al adjacent to the CH microballoon plus 1 μm of CH as an overcoating. Accompanying this in Fig. 4(a) is a Gaussian pulse on the same time scale. Partial results from some preliminary 1-D LASNEX calculations for this case by Dr. J. Moreno of LLNL for n=3 to n=2 transitions radiating in the euv region are included for comparison in Fig. 4(b), where the time scale has been adjusted to show the similarity. This data is scaled down in intensity so as not to overlap the results of the LLE x-ray modeling.

REFERENCE

1. T. Harada and T. Kita, Appl. Optics **19**, 3987 (1980); T. Kita, T. Harada, N. Nakano and H . Kuroda, Appl. Optics **22**, 512 (1983); and N. Nakano, H. Kuroda, T. Kita and T. Harada, Appl. Optics **23**, 2386 (1984).

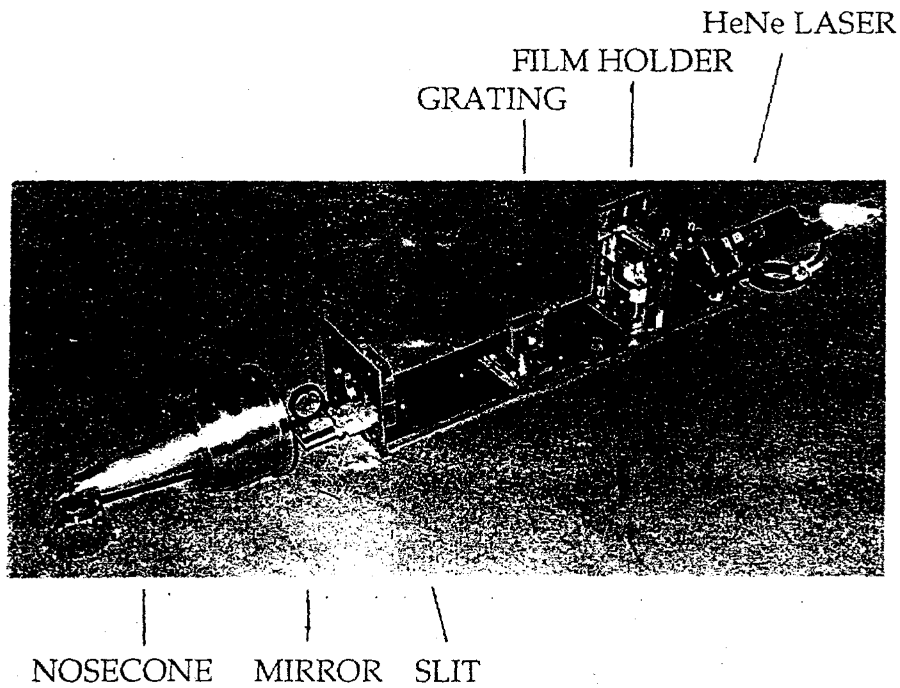

Fig. 1. Photograph of our new TIM-mounted euv spectrograph, with the nosecone and cover plates removed.

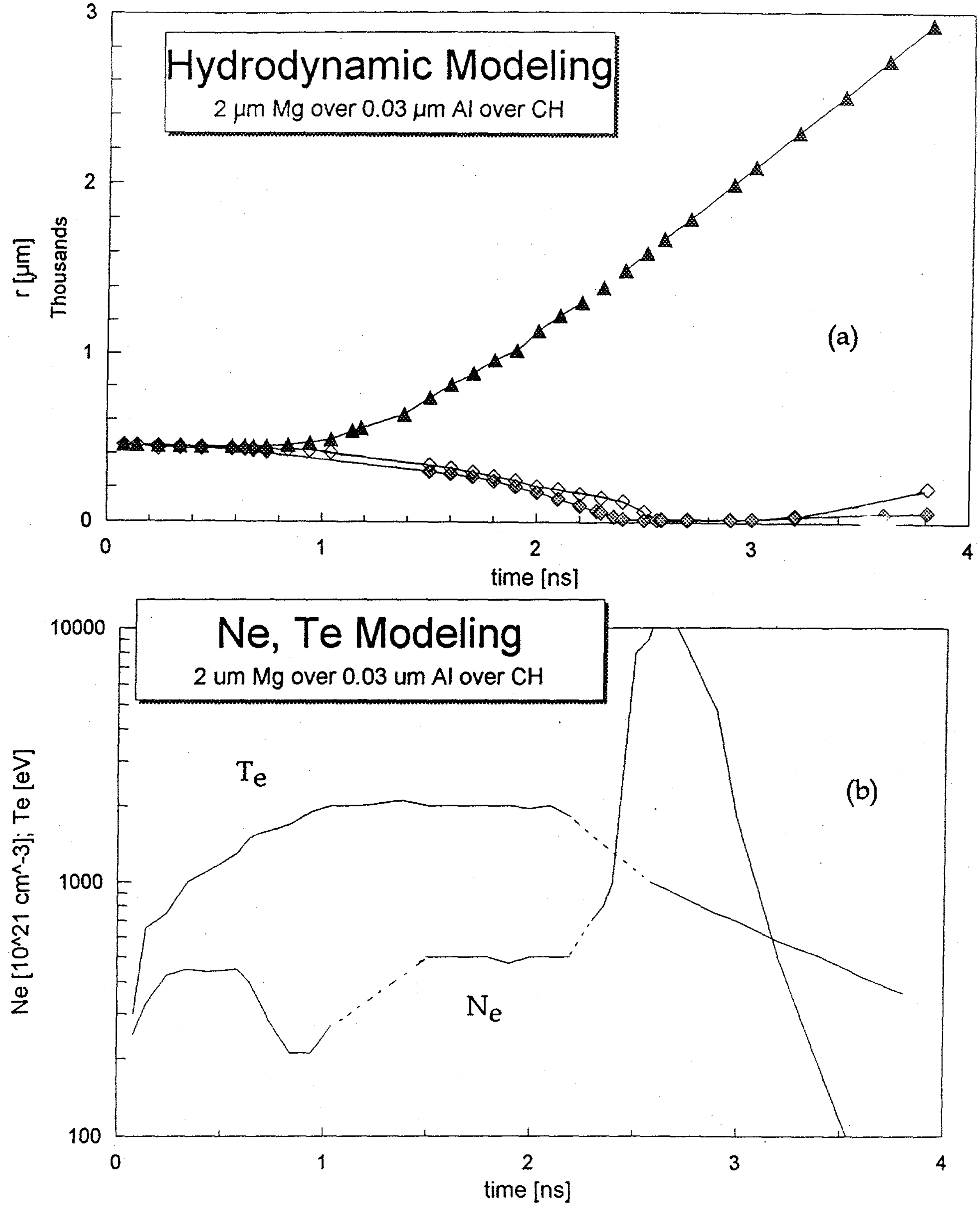

Fig. 2. Hydrodynamic modeling (a) of the expanding (radially up to 3 mm) 2000-Å thick Mg (and 300-Å thick Al) coatings (closed triangles), the collapsing shell (closed diamonds), and the closely-following peak electron density (open diamonds), for a 0-2 ns "Gaussian" drive pulse peaking at 1 ns. Shown in (b) versus time is the peak electron density in units of 10^{21} cm^{-3} and the peak coronal temperature in eV.

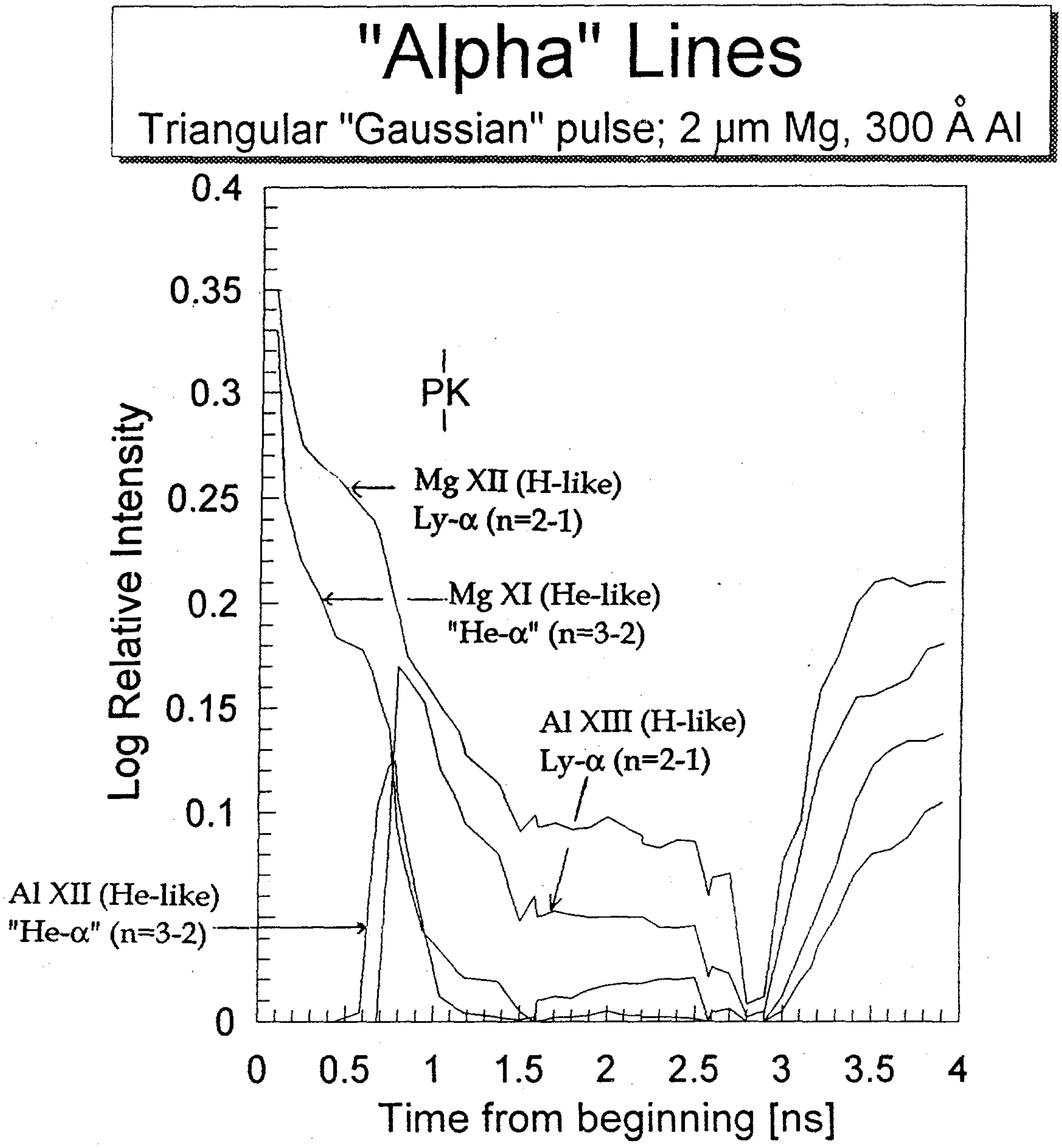

Fig. 3. Spectroscopic modeling of resonance line emission from H- and He-like ions in the Mg and Al coatings, corresponding to Fig. 2. "PK" refers to the time at which the "Gaussian" (triangular approximation) drive pulse peaks.

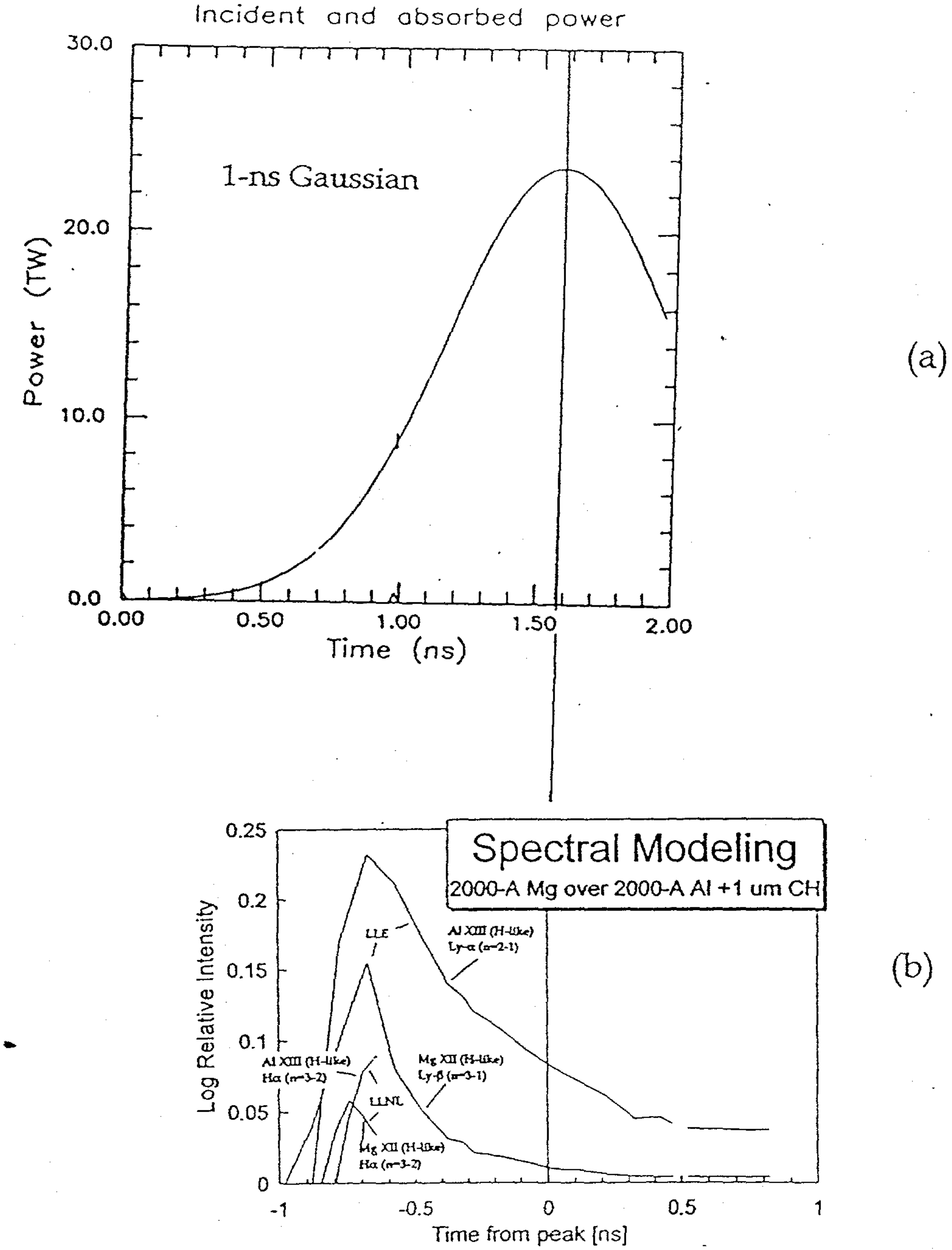

Fig. 4. Modeling (b) by LLE for an earlier case of a 2000-Å Mg coating over a 2000-Å Al coating for the Gaussian pulse shown in (a). Also shown in the lower two traces are some partial LLNL (LASNEX) modeling results for the same case, scaled down so as not to overlap the LLE results.