FY21 Sandia National Laboratories Progress Report on Omega Laser Facility Experiments

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The Energetic Neutrons Campaign led by Sandia National Laboratories (SNL) had a successful year testing electronic devices and printed circuit boards (PCB's) under 14-MeV neutron irradiation at the Omega Laser Facility. During FY21 Sandia's neutron effects diagnostics (NED's) and data acquisition systems were upgraded to test novel commercial off-the-shelf and Sandia-fabricated electronic components that support SNL's National Security mission. The upgrades to the Sandia platform consisted of new cable chains, sample mount fixtures, and a new fiber optics platform for testing optoelectronic devices.

The new cable chains improved data quality and reduced the time required by LLE and Sandia to identify and solve issues with the electronic circuits under test. A variety of sample fixtures were designed and fabricated to mount new shapes and sizes of PCB's closer to the neutron source without interfering with other components fielded simultaneously. PCB's fielded in FY21

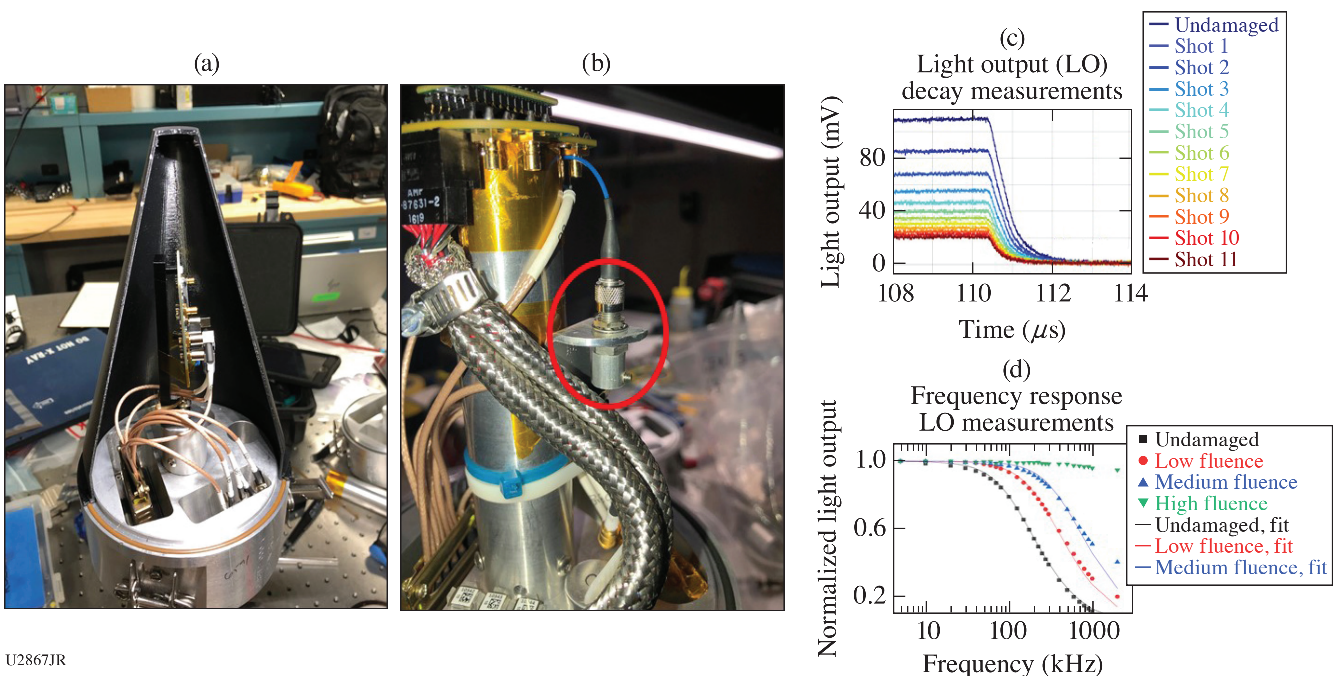

Figure 1
(a) A PCB mounted in one of the Sandia NED's used to study single-event effects; (b) an example of the setup used to test optoelectronic devices in the Sandia NED's; and (c) an example of the light output data measured after each shot during one of the Energetic Neutrons Campaigns.

contained a variety of components ranging from low to high voltage and from discrete devices to small integrated circuits as shown in Figs. 1(a) and 1(b).

The new fiber optics platform consisted of fiber optic cables, sample mount fixtures, and data acquisition systems that allowed Sandia to measure high-quality optical signals for the first time on OMEGA. Optical data will be used to calculate carrier lifetime degradation in semiconductor devices exposed to 14-MeV neutron irradiation using light output decay and frequency response measurements as shown in Fig. 1(c).

A SNL graduate student intern participated for the first time in one of the experiments on OMEGA performing *in-situ* testing of optoelectronic devices. The student developed software, connected hardware, acquired data, and performed data analysis during one of the energetic neutrons campaign in FY21; he will be participating again in FY22.

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Investigating the Effects of Magnetization on Laser–Plasma Instability Backscatter in MagLIF Preheat
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The magnetized liner inertial fusion[1] (MagLIF) concept requires coupling energy from a multikilojoule laser to preheat magnetized D_2 before compression with a pulsed-power generator. The laser preheat process is sensitive to laser–plasma instabilities (LPI's) and filamentation, which affect energy coupling and can lead to beam spray that introduces mix into the target. The LPI processes are affected by magnetic fields that affect plasma temperatures by suppressing thermal conduction but can exacerbate thermal self-focusing and filamentation and breakup of the beam. These effects have not been studied at conditions relevant to MagLIF.

To address the effect of magnetic fields on LPI in MagLIF preheat, magnetized D_2-filled gas tube experiments were conducted on OMEGA as part of the MiniMagLIF-21a shot day. Figure 2(a) shows the target geometry, wherein a single OMEGA beam (B30) heated a 650-nm polyimide window and D_2 gas inside a polyimide tube. The heating beam delivered a total of ~450 J in a 1-ns

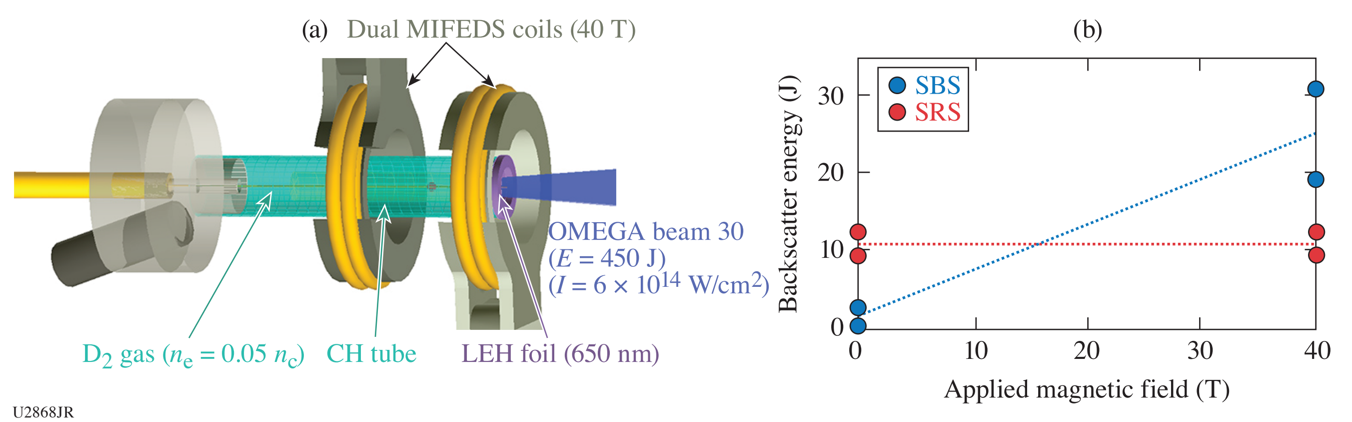

Figure 2
(a) Target geometry of magnetized preheat experiments on OMEGA, showing a polyimide gas tube filled with D_2 and sealed with a 650-nm LEH window. The dual MIFEDS coils magnetized the target to peak fields ~40 T. (b) SBS and SRS direct backscatter energies as a function of applied magnetic field.

pulse with 300-μm spot, resulting in intensities ~6×10^{14} W/cm^2. Dual MIFEDS (magneto-inertial fusion electrical discharge system) coils imposed an ~40-T magnetic field oriented along the tube axis. Five shots were conducted in total, including one calibration shot for the full-aperture backscatter system (FABS) and four target shots: two with and two without a magnetic field.

FABS systems monitored direct backscattered and sidescattered light from stimulated Raman (SRS) and stimulated Brillouin scattering (SBS), and an x-ray framing camera diagnosed time-gated emission to evaluate beam propagation. Preliminary data collected by the FABS calorimeters are shown in Fig. 2(b). SBS levels increased nearly 5× when the magnetic field was increased from 0 to 40 T, whereas virtually no change in the amount of SRS was observed. SBS streaked spectra from magnetized targets showed an additional feature at the laser wavelength not present in the spectra from the unmagnetized targets. Hard x rays, as recorded by the HERIE, decreased by a factor of ~2 in the magnetized targets compared to unmagnetized targets. While the increased SBS levels and decreased hard x rays in magnetized targets may have resulted from magnetization effects in the preheated gas and laser entrance hole (LEH) window, additional experiments are needed to rule out other causes. The preliminary data set from these experiments is helping to inform target modifications and diagnostic configurations for similar experiments set for January 2022.

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1. S. A. Slutz *et al.*, Physics of Plasmas **17**, 056303 (2010).