FY20 Sandia National Laboratories Progress Report on Omega Laser Facility Experiments

Energetic Neutrons Experiments on OMEGA-60
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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 FY20 the Energetic Neutrons Campaign increased the number and complexity of experiments, continued collaborations with external organizations, and generated knowledge that supports SNL's national security mission.

During FY20 the Energetic Neutrons Campaign was executed by an early career team led by a new principal investigator (PI). The SNL team members were trained to take over new responsibilities during the shot day to increase the number and complexity of experiments in the campaigns. Also, in FY20 for the first time the Energetic Neutrons Campaign had a graduate student at SNL contributing with pre- and post-irradiation characterizations of the semiconductor devices irradiated on OMEGA.

In FY20 SNL collaborated with the Air Force Nuclear Weapons Center and supported experiments related to radiation effects in semiconductor devices. SNL also gave the opportunity to multiple scientists from Los Alamos National Laboratory, MIT, and LLE for the ride-along diagnostics tests.

SNL continued to use the last two generations of the neutron effects diagnostics (NED's) to field active and passive experiments but also redesigned the latest generation of the NED's to accommodate larger components and improve the vacuum sealing as shown in Fig. 1(a). The redesigned NED's allowed SNL to perform active tests of a high-voltage (HV) PCB for the first

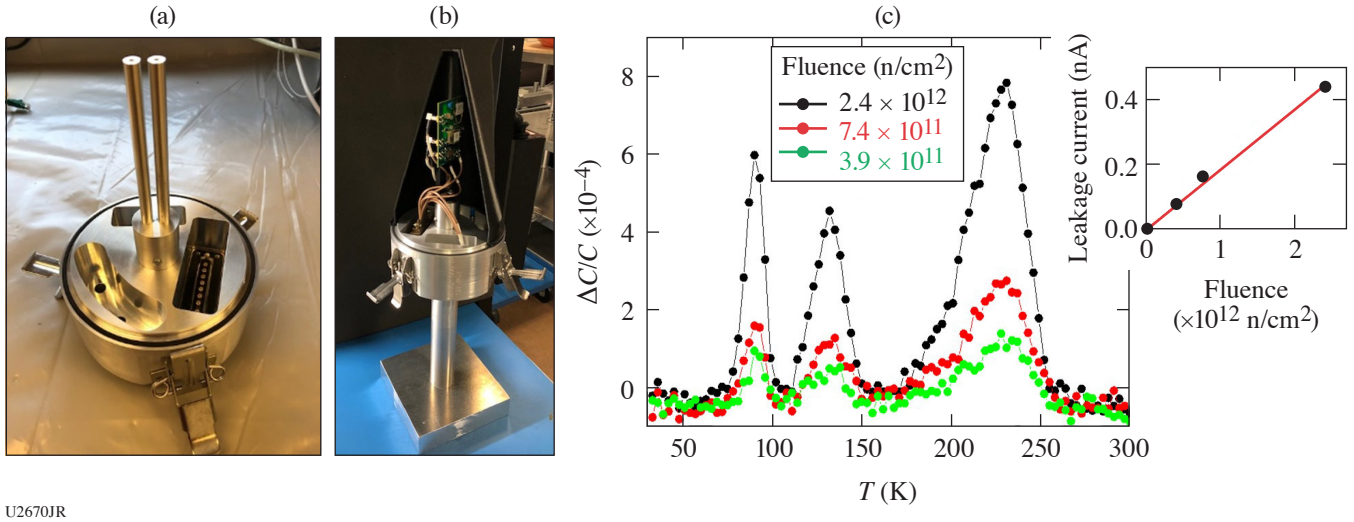

Figure 1
(a) The redesigned Gen 3 NED used on OMEGA; (b) a HV PCB mounted in one of the redesigned Gen 3 NED's; and (c) the radiation-induced defects and leakage current for different 14-MeV neutron fluences.

time on OMEGA, where signals before, during, and after the irradiation were recorded. The HV PCB installed in one of the SNL NED's is shown in Fig. 1(b), where a 3-D–printed nose cone was used to check for mechanical and electrical interference. Passive irradiations of multiple components were followed up with leakage current, gain measurements, and radiation-induced defect characterization at SNL as shown in Fig. 1(c).

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Dynamic Materials Experiments at the Omega Laser Facility
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Two dynamic materials campaigns were carried out by SNL scientists during FY20. In addition, a third campaign scheduled for FY20 was postponed to early FY21 due to COVID-related shutdowns. The completed campaigns provided data to support ongoing experiments at the Sandia Z Pulsed-Power Facility geared toward constraining the reshock Hugoniot of α-quartz and the sapphire release isentrope. In addition, data from FY19 OMEGA and OMEGA EP experiments were included in a manuscript detailing the Hugoniot of TiO_2 rutile, which was published in Physical Review B.[1]

The QuartzSapphireEP Campaign on OMEGA EP in FY20Q1 successfully completed 15 shots to meet two experimental objectives: measurement of the reshock Hugoniot of quartz into sapphire and the release of sapphire into quartz, TPX, and 200-mg/cm^3 silica aerogel. The results have been paired with sapphire Hugoniot data from the Z facility to generate an independent constraint of the quartz reshock from initial states ranging between 350 and 1200 GPa. Sapphire release data were taken from 600 to 1500 GPa and will be used to support ongoing experiments on the Z precompression platform.

A combination of two half-day campaigns was completed on OMEGA in FY20Q4: SapphireCryo and HiZEOS. The SapphireCryo Campaign was a companion campaign to QuartzSapphireEP, where the primary measurement was the sapphire release isentrope. Liquid deuterium was used as the release standard to provide a deep release measurement into a well-constrained standard. Four planar cryogenic experiments were completed as part of this campaign. As interleaved experiments during warming and cooldown of targets in the cryogenic targets, the HiZEOS Campaign investigated the Hugoniot and release of hafnium. As a high-Z material, hafnium has higher shock impedance than most standards and limited data exist above 500 GPa. This campaign provided the first measurement of the Hugoniot above 1000 GPa and provides initial results to develop hafnium as a high-impedance shock standard.

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REFERENCES

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