Shocked Foams on OMEGA EP: An experiment to study shocked foams with imaging x-ray Thomson scattering was recently conducted on OMEGA EP. Foams are of interest in many inertial confinement fusion target designs, but have been difficult to simulate. Part of this difficulty is because shocked foams are often in the warm-dense-matter regime, where the equation of state is poorly known. Warm dense matter consists of plasmas at near-solid density and ~tens eV temperature that bridge classical plasma physics and condensed-matter theory. The goal of this experiment is to obtain density, temperature, and ionization measurements of shocked foams to validate the equation of state in the warm-dense-matter regime. This experiment used one 10-ns OMEGA EP beam to drive a shock through the foam package, as shown in Fig. 1. The target consisted of a 40-μm-thick plastic ablator layer and a 2-mm-long carbonized resorcinol foam (CRF) block with a density of 0.1 g/cm^3. The remaining three OMEGA EP UV laser beams illuminated a nickel foil with a 2-ns pulse to generate x rays to probe the shocked foam. The imaging x-ray Thomson spectrometer[1] (IXTS) spatially resolves the 90° scattering of the x-ray probe in 1-D. This experiment is in the noncollective regime, where the x rays scatter off of individual electrons. The measured x-ray spectrum is comprised of an elastic scattering peak and an inelastic peak at the lower-energy side because of scattering from the free electrons. The width of the inelastic feature in the spectrum provides a temperature measurement and the ratio of the inelastic peak to the elastic peak provides an ionization measurement. A shock profile can be obtained from the 1-D imaging aspect of the IXTS, thereby measuring compression. Scattering spectra are shown in Fig. 2(a) at different locations. The noticeable changes between the upstream scattering profile and the shocked region indicates a temperature difference. As shown in Fig. 2(b), the theoretical scattering profile of the shocked region, based on hydrodynamic simulations, is consistent with the measurement. Preliminary analysis gives a temperature of ~30 eV in the shock front. Further analysis will be conducted to determine the compression of the shock. Future experiments will be dedicated to enhancing the temperature and ionization of the shocked foam by using a re-shock configuration. The research plans in FY17 are also aimed at combining this technique with x-ray radiography and optical self-emission from the streaked optical pyrometer diagnostic, which will help to improve the precision of the inferred temperature and density.

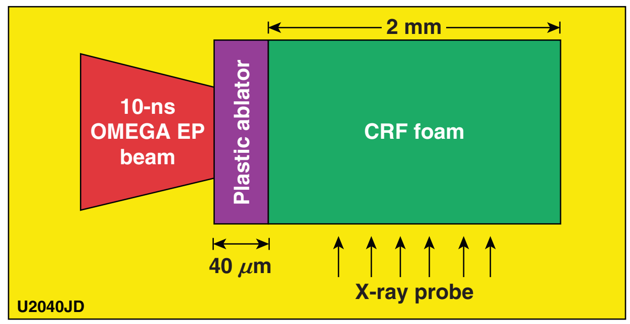

Figure 1. Schematic of the foam package and geometry of experiment. One beam (from the left) drives a shock wave into the carbonized resorcinol foam with a density of 0.1 g/cm^3. The remaining three beams generate an x-ray probe beam that penetrates the shocked foam. The imaging x-ray Thomson spectrometer diagnostic records the scattered x-ray spectrum spatially resolved along the axis of the foam.

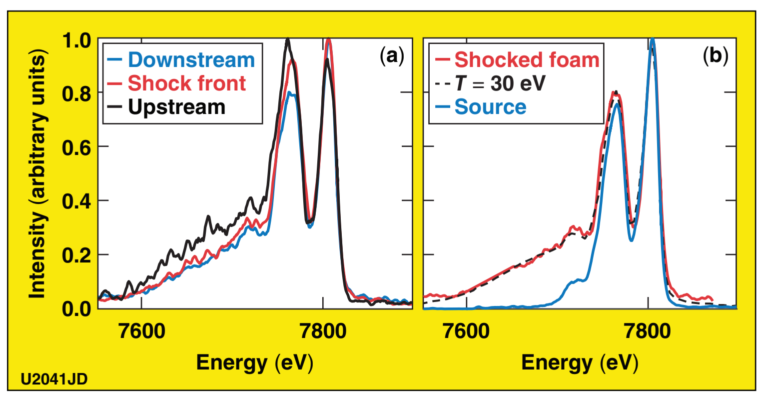

Figure 2. (a) X-ray scattering spectra at different locations along the shock profile. Differences in the inelastic scattering region (~7600 to 7700 eV) indicate different temperatures. (b) The spectrum from the shocked foam (solid red curve) is compared to a theoretical spectrum (dotted black curve) with a temperature of 30 eV and indicates excellent agreement. The spectrum of the incident x-ray probe beam (solid blue curve) that is used as input in the calculation is included for reference.

Omega Facility Operations Summary: The Omega Laser Facility conducted 215 target shots in July with an overall experimental effectiveness (EE) of 94.9% (138 shots on OMEGA with an EE of 97.1% and 77 shots on OMEGA EP with an EE of 90.9%).The ICF program accounted for 89 target shots for experiments by LLE-, NRL-, and SNL-led teams. The HED program conducted 59 shots for experiments led by LANL, LLNL, and LLE. Four NLUF campaigns from MIT and UCSD took 40 target shots, while the LBS program fielded two experiments accounting for 14 shots. One campaign led by CEA had 13 target shots.

1. E. J. Gamboa *et al.*, Rev. Sci. Instrum. **83**, 10E108 (2012).