X-RAY YIELDS AND LASER-DRIVEN HEAT-FRONT PROPAGATION IN ULTRA-LOW-DENSITY COPPER-DOPED AND PURE COPPER FOAMS

K. B. Fournier[1], F. Pérez[1,A], J. D. Colvin[1], E. C. Burks[2], T. Felter[3], M. J. May[1], S. Charnvanichborikarn[1], M.A. Barrios[1], S. A. Gammon[1], S. O. Kucheyev[1] & K. Liu[2]

[1] Lawrence Livermore National Laboratory, 7000 East Ave., Livermore, CA 94550, USA
[A] LULI, Ecole Polytechnique, CNRS, CEA, UPMC, 91128 Palaiseau, FRANCE
[2] University of California, Davis, CA 95616 USA
[3] Sandia National Laboratories, Livermore, CA 94550 USA
fournier2@llnl.gov

A high-power laser beam (several kJ, 10^{15} W/cm^2) can propagate inside an underdense target over ranges of millimeters. This creates a large volume of hot plasma (several keV temperature) at an electron density in the range of 10^{21} cm^{-3}. When a high-Z element is included in the target material, its K-shell transitions can produce bright, multi-keV x-ray sources that have important applications in laser-interaction studies, such as a source for x-ray ablation or x-ray radiography.

In the past years, several teams have investigated the laser interaction and resulting x-ray generation in gases (Ar, Xe, etc.), with metals (Ti, Fe, Cu, etc.) and in metal-doped foams (Ti, Fe, Zn, Ge, etc.). [1-8] The optimization and predictability of the x-ray sources rely on the understanding of the laser deposition heat-front propagation. Foams are particularly interesting because they provide a larger volumetric emission than solids, and they are more flexible than gases in terms of x-ray output from available dopants. Furthermore, they can be fabricated across a range of densities and dopant concentrations. We present here experimental results from Cu-loaded carbon nanotube foams and pure metal copper foams. The targets were irradiated at both the OMEGA laser (Laboratory for Laser Energetics, University of Rochester) and the National Ignition Facility (NIF). The pure Cu targets were approximately spherical, 2 mm in diameter at OMEGA and 4 mm in diameter at NIF. Targets were driven with ≈20 kJ of laser energy at OMEGA and ≈500 kJ of laser energy at NIF. Target power densities were similar between the two facilities. The novel foam fabrication techniques that we describe allowed for a wide range of foam densities, from 5 to 50 mg/cm^3, which results in plasmas with electron densities between 5 and 50% of the critical density for the lasers. Heat-front propagation velocities, two-dimensional imaging of the laser-heated volume, and absolute Cu K-shell x-ray yields were measured. These measurements, across the range of foam densities and metal concentrations, provide strong constraints on simulation benchmarks. We also present comparisons to 2D radiation-hydrodynamics simulations incorporating an atomic kinetics model. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

[1] C. A. Back *et al.*, Phys. Rev. Lett. **87**, 275003 (2001)
[2] K. B. Fournier *et al.*, Phys. Plasmas **17**, 073111 (2010)
[3] J. Workman and G. A. Kyrala, Rev. Sci. Instrum. **72**, 678 (2001)
[4] D. Babonneau *et al.*, Phys. Plasmas **15**, 092702 (2008)
[5] F. Girard *et al.*, Phys. Plasmas **16**, 052704 (2009)
[6] K. B. Fournier *et al.*, Phys. Plasmas 16, 052703 (2009)
[7] F. Pérez *et al.*, Phys. Plasmas **19**, 083101 (2012)
[8] F. Pérez *et al.*, Phys. Plasmas **21**, 023102 (2014)