Development of High Fluence X-Ray Sources Using Laser Heated Novel Nano-Wire Metal Foams

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High fluence multi-keV x-ray sources (E_{photon} = 1 - 20 keV) are needed for a variety of high energy density (HED) research applications. Laser heated free standing metallic nano-wire foams have been found to be a promising x-ray source candidate and have been in development for the past few years. The targets are fabricated by casting the metal nano-wires in a mold of the appropriate shape and size. Nano-wire foams of Cu (Z = 28; $E_{K\text{-}shell}$ ~8.5 keV) and Ag (Z = 47; $E_{K\text{-}shell}$ ~23 keV) have been successfully fabricated into cylindrical targets having densities of 6–20 mg/cc. These densities put the plasma electron densities below the critical density for laser absorption making the targets underdense. Therefore, the laser light can be fully absorbed by the bulk material of the target and produces a volumetric radiator.

Obtaining these high fluences at the higher K-shell photon energies ($E_{K\text{-}shell}$) is challenging. The higher $E_{K\text{-}shell}$ emission requires higher atomic number materials. The electron temperatures needed to create the K-shell emission increases with atomic number. For example, electron temperatures greater than 10 keV are needed for the silver nano-wire foams. Achieving the required electron temperature for a given atomic number requires an increasing amount of laser power and energy.

Therefore, 192 laser beams from the National Ignition Facility (NIF) laser are used to heat the nano-wire foams with ~400 TW of 351 nm laser light in a 2.5 ns square pulse in time depositing ~950 kJ into each nano-wire foam. The NIF targets consist of Ag nano-wires in the shape of cylinders nominally 4 mm in diameter and 4 mm tall. Metrology has found that the nano-wire foams consist of 51% silver by atomic fraction. The remaining mass are various hydrocarbon compounds.

The K-shell x-ray emission and the resulting x-ray environments are characterized by using the x-ray diagnostics at NIF. X-ray conversion efficiency from these laser heated underdense Ag nano-wire foams have been measured to be ~0.6% which is about twice that observed in more conventional laser heated cavity x-ray sources. Measured high resolution spectra indicate that a significant amount of the K-shell emission is from the He-like charge state. Experimental results and comparisons with simulations will be presented.

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