Plasma Conditions in Short-Pulse-Heated Buried Tracer Layers from Fine-Structure X-ray Emission

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A quartet of high-resolution x-ray Bragg crystal spectrometers was deployed at the Titan laser to measure x-ray self-emission from laser-heated Ti and Mn layers in Al foils. Targets were produced via sputtering with thin (0.1–1 μm) layers of mid-Z tracer elements sandwiched between 15 μm Al foil and a thin Al tamp (0–4 μm). When exposed to the relativistic-intensity laser pulse, the target heats comparably to an undoped Al foil if the tracer layer is sufficiently thin. It is only this thin layer that emits fine structure x-rays within the bandwidth of the crystal spectrometers. By shooting a set of targets with varied tracer element (Ti, MnAl, or both), tracer thickness, and tamp thickness, the time-integrated x-ray flux can be measured at many localized depths in the target. These high-resolution fine structure spectra of He- and Li-like Ti and Mn are observable due to focusing spherical crystal forms that enhance signal-to-noise ratio on time-integrating detectors [1]. The dispersed x-ray spectra are compared to collisional-radiative (CR) codes [2,3], implying plasma conditions within each emitting layer. The spatially-resolved, emissivity-weighted plasma parameters provide important benchmarks for hydrodynamic and fast-electron energy transport codes. In addition, the x-ray spectra challenge CR calculations to match line intensities, ratios, widths and shapes, and to explain discrepancies between codes and data [4].

References

[1] H. Chen et al., Rev. Sci. Instrum. **85**, 11E606 (2014).
[2] S. B. Hansen et al., High Energy Density Phys. **3**, 109 (2007).
[3] H. A. Scott, J. Quant. Spect. Rad. Transf. **71**, 689 (2001).
[4] R. Piron et al., High Energy Density Phys. **23**, 38 (2017).