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

B. F. Kraus\textsuperscript{1,2}, Lan Gao\textsuperscript{2}, A. Chien\textsuperscript{1,2}, K. W. Hill\textsuperscript{2}, M. Bitter\textsuperscript{2}, P. Efthimion\textsuperscript{2}, M. B. Schneider\textsuperscript{3}, R. Shepherd\textsuperscript{3} and Hui Chen\textsuperscript{3}

\textsuperscript{1}Department of Astrophysics, Princeton University, Princeton, NJ
\textsuperscript{2}Princeton Plasma Physics Laboratory, Princeton, NJ
\textsuperscript{3}Lawrence Livermore National Laboratory, Livermore, CA

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 \( \mu \)m) layers of mid-Z tracer elements sandwiched between 15 \( \mu \)m Al foil and a thin Al tamp (0–4 \( \mu \)m). 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