- IFSA2025 –

Experimental and numerical characterization of high-energy point-like X-ray sources for radiography applications at the LMJ-PETAL laser facility

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We report on the generation of high-energy pointlike X-ray backlighters with the high-intensity, sub-picosecond PETAL laser for radiographic purposes. Silver wire backlighters with 25 μm diameter were used to image 100 μm thick gold slabs. Three backlighter configurations were investigated in which the wire was either fixed on a substrate or left free-standing, and irradiated either at maximum ($5.6 \times 10^{18}\ \mathrm{W/cm^2}$) or reduced laser intensity ($1.6 \times 10^{18}\ \mathrm{W/cm^2}$). The best spatial resolution (~ 26 μm) and contrast (~ 0.29) were obtained close to the radiography axis of the free-standing wire backlighter.

A simulation tool chain, combining a radiative hydrodynamics code, a particle-in-cell code and a Monte-Carlo code, has been developed to model the radiography experiment, from the interaction of the PETAL beam with the backlighter and the emission of X-rays to the generation of the radiography image. The synthetic X-ray spectrum includes emission from the Ag K-lines and a two-temperature Bremsstrahlung background (~ 0.1 MeV and 3 MeV). To reproduce the experimental data, the simulations must take into account the laser-accelerated electrons (from a few hundred keV to a few MeV) hitting the detector. These fast electrons can contribute up to 75 % of the measured signal for the high-intensity shot, and thus appear to be the main cause of degradation of the radiography contrast compared to predictions based on X-rays only.

Acknowledgment

The PETAL project has been performed by the CEA (“maître d’oeuvre”) under the financial auspices of the New Aquitaine Region in France (“maître d’ouvrage”, project owner), the French Government and the European Union.