Compact AutoEdge X-ray System to Measure HED Target Areal Density to 1% Precision and Accuracy

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Accurate and precise knowledge of the areal density is of central importance to HED experiments. In these experiments, targets of very precise thickness and composition are used to create materials under extreme conditions, and x-ray filters are deployed for diagnostic purposes. Any error in the areal density affects the data interpretation and undermines the science under study. Whereas 5-10% certification are routine, 1-2% level areal density certification had been an unobtainable goal, until now.

The problem came in two fronts. (1) With the shutdown of the Brookhaven beamline in 2014, the US program lost its domestic synchrotron access to x-ray transmission measurement. For example, the end users no longer certify critical components such as Dante filters, which would affect the diagnosis of hohlraum x-ray drive. (2) Conversion from x-ray transmission to areal density requires the use of x-ray mass attenuation (cold opacity) databases, which are only accurate to 5-10%. For example, synchrotron measurements, even when available, give different areal values for the same metal foil below and above the x-ray absorption edge, and such targets can be certified to high precision, without high accuracy. Further improvements require both access to new x-ray equipment and an ability to refine the x-ray database.

We have constructed an automated "AutoEdge" system in-house to push the limits of x-ray absorption measurements: (1) Precision is controlled by photon statistics, 1 hour data acquisition is adequate to measure 0.5um thick foils to 1% precision. (2) Accuracy is controlled by x-ray database used in data fitting. We have compiled five x-ray databases, namely NIST X-COM, NIST XFFAST, LBNL Henkie, LLNL, and SNL, into a single program for direct comparison, - this process revealed the 5-10% difference among them for every element. (3) We developed methodology to refine x-ray database to 1% accuracy. Our measurement on Ni agrees with recent European synchrotron measurement to within ~1%.

In summary, General Atomics is supporting the US HED program with in-house measurement to fill the hole left by Brookhaven. All Opacity targets for NIF/Z are now non-destructively characterized by AutoEdge. GA has joined the X-ray Fundamental Parameters Workgroup coordinated by CEA, PTB and NIST in an international effort to push the frontier of x-ray research. We are planning further equipment upgrades to allow x-ray opacity calibration on gaseous elements.

This material is based upon work supported by General Atomics internal R&D funding.