Measuring Dopant Concentration in Graded ICF Targets through Quantitative Contact Radiography*

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Doping level must be accurate to 0.05 at. % and its radial distribution accurate to 1 µm for graded targets to perform in an ICF experiment; there had been no characterization technique capable of such measurement without destroying the sample. We developed a quantitative contact radiography method that delivers nondestructive dopant profile measurement with comparable precision to the destructive techniques, which is becoming a new enabling technology for target fabrication.

Traditional film-based contact radiograph system and scintillator-based X-radia system are not quantitative in two aspects (1) Even the best digitization lens produces image distortion of ~2 µm on a 2kx2Kimage, leading to several microns error in radius measurement that varies with the shell image location. (2) Grayscale does not automatically translate into useful dopant information. We have solved both problems on contact radiography system, and plan to extend the dopant modeling capability to the X-radia system in the near future: (1) We designed a high precision digitization system with 0.5 µm optical resolution and customized algorithm to remove the lens pincushion distortion and the CCD pixel size effect, which makes all dimensions measurement NIST traceable. Specifically, it measures the shell radius to 0.5 µm and the layer thickness to 0.2 µm accuracy. The system delivers a linear dynamic range exceeding 6.0 in optical density for film digitization purpose. (2) We developed detailed film model to convert gray scale information into X-ray absorption strength under polychromatic radiation conditions. The model is calibrated on polypropylene flats and can measure the X-ray absorption (and thereby dopant level) to ~10% in each sublayers. Our measurement results on Cu-doped Be shells and Ge-doped GDP shells agrees with those from destructive techniques.

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