3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Towards higher resolution X-ray radiography using lithium fluoride detectors

P. Mabey[1], B. Albertazzi[1], G. Rigon[1], Th. Michel[1], T. Pikuz[2,3], N. Ozaki[2], S. Pikuz[3], S. Makarov[3], T. Matsuoka[2], A. Casner[4], M. Koenig[1,2]

[1]LULI, France, [2]Osaka University, Japan, [3]Joint Institute for High Temperature RAS, Russia, [4]CELIA, France

e-mail (speaker): paul.mabey@polytechnique.edu

As an AAPPS-DPP standard, we do not need to add your postal address.

High resolution X-ray imaging is crucial for many high energy density physics (HEDP) experiments. Recently developed techniques to improve resolution have, however, come at the cost of a decreased field of view. Here, an innovative experimental detector for X-ray imaging in HEDP experiments with unprecedented spatial resolution, as well as a large field of view, is presented. The detectors are based on Lithium Fluoride (LiF) crystals, characterized by their large dynamic range. The imaging properties of LiF are based on the photoluminescence of F-type color centers (CCs) which are generated under irradiation by photons with energy greater than 14 eV. CCs are very stable at room temperature and may be read out any time after irradiation using a conventional fluorescent microscope.

The response and resolution of the detector was measured as a function of incident photon flux and photon energy at the SOLEIL synchrotron [1]. By considering absolute photon numbers, we estimate that these detectors are suitable for use at moderate to large laser facilities or XFELs. The results also show that using a lower energy backlighter is generally advantageous due to the shorter attenuation length of the photons, while the electron cascade effect, predicted to limit resolution at higher photon energies, is not seen.

The LiF detctors were benchmarked with both the X-ray free electron laser at SACLA, Japan and an X-ray source produced by the short pulse laser at LULI2000, France [2] as well as at LFEX, Japan. Under optimal conditions, a spatial resolution of 2 μm over a field of view greater than 2 mm^2 is observed. This represents a significant advance over previous techniques. For example, using LiF detectors one could vastly increase the resolution available for imaging the small-scale structures, instabilities and turbulence within the imploding fusion core in ICF experiments, thus paving the way to better understand the dynamics of the system and enabling the validation of various theoretical models [3].

[1] Mabey, P., et al. “Photometric study of LiF detectors.” Review of Scientific Instruments 90, 063702 (2019)

[2] Faenov, A. Y., et al. "Advanced high resolution x-ray diagnostic for HEDP experiments." Scientific reports 8.1 (2018): 16407

[3] Casner, A., et al. "Turbulent hydrodynamics experiments in high energy density plasmas: scientific case and preliminary results of the TurboHEDP project." High Power Laser Science and Engineering 6 (2018)