Compression of Solid CD Sphere by Multiple Laser Beams in 100-T Magnetic Field for Magnetically-Assisted Fast Ignition Research

K. Matsuo [1], H. Sawada [2], H. Nagatomo[1], T. Shiroto[3], S. Lee[1], S. Sakata[1], S. Kojima[1], K. Law[1], H. Morita[1], Y. Iwasa[1], Y. Arikawa[1], T. Johzaki[4], Y.Sentoku[1], M.Hata[1], A.Sunahara[5], H.Sakagami[6], A.Morace[1], A.Yogo[1], LFEX・GEKKO-XII team[1], K.Yamanoi[1], T.Norimatsu[1], T.Shimizu[1], Y.Nakata[1], J.Kawanaka[1], S.Tokita[1], N.Miyanaga[1], M.Murakami[1], M.Nakai[1], H.Nishimura[1], H.Shiraga[1], K.Mima[1], H. Azechi[1], R.Kodama[1] and S. Fujioka [1]

1) Institute of Laser Engineering Osaka University

E-mail: matsuo-k@ile.osaka-u.ac.jp

2) University of Nevada, Reno, 3) Tohoku University, 4) Hiroshima University, 5) Purdue University, 6) National Institute for Fusion Science

Magnetically-assisted Fast Ignition (MFI) [1] is a new approach of FI, in which kilo tesla-level magnetic field is applied externally to a fusion fuel for guiding an energetic electron beam to a compressed fusion fuel core. Proof-of-principle experiment of this scheme has been conducted at Institute of Laser Engineering, Osaka University [2]. A capacitor-coil target is used to generate a strong magnetic field required for the MFI [3]. Diffusion of the magnetic field into a highly conductive plasma takes much longer time than the duration of the magnetic field pulse, the external magnetic field must be applied to a fuel before irradiating compression laser beams. A two-dimensional radiation magneto-hydrodynamic simulation with PINOCO-MHD code revealed that significant deformation of an imploding fusion fuel shell is driven by non-uniform pressure distribution caused by anisotropic thermal conduction in a strong magnetic field [4]. We introduce a solid spherical fuel as an alternative of the fuel shell. Both inflight aspect ratio and magnetic Reynolds number of the solid sphere are smaller than those of the shell, therefore the solid sphere has larger tolerance to hydrodynamic instability initiated by the external magnetic field.

We carried out experiments to measure temporal evolution of directly-driven solid deuterated polystyrene (CD) sphere that were attached to a gold cone. A solid CD sphere was compressed by nine beams of GEKKO-XII laser facility, whose pulse was a Gaussian shape having 1.3 ns of full-width-at-half-maximum (FWHM). A capacitor-coil target was irradiated by other three beams of GEKKO-XII to generate a magnetic field. From previous research [3], it was estimated 100-T magnetic field was generated at the center of solid CD sphere. X-ray shadows of compressed sphere were imaged on imaging plates by a spherically bent quartz crystal imager. The backlight was Ti K_α (4.51 keV) X-ray ps-flash produced by LFEX laser beams having 1 kJ in total and 1.6 ps of FWHM [5]. Temporal evolution of the compressed sphere was obtained by changing the delay between the compression and backlight laser beams. The compressed density reached its maximum around 250 ps after the peak of the compression laser pulse and it expanded after the maximum compression. Detectable deformation caused by the anisotropic electron thermal conduction was not observed in the experiment. The details of the experiment will be presented at the conference.

References: [1] D. Strozzi et al., Phys. Plasmas 19, 072711(2012)., [2] S. Fujioka et al., Phys. Plasmas 23, 56308(2016)., [3] K.F.F.Law et al., Appl. Phys. Lett. 108, 1(2016)., [4] H. Nagatomo et al., Nucl. Fusion 55, 93028(2015)., [5] H. Sawada., Appl. Phys. Lett. 108, 254101(2016).