§53. Measurement of Electrical Conductivity for Diamond-like-carbon Plasma toward Efficient Energy Coupling in Fast Ignition

Sasaki, T., Kikuchi, T., Takahashi, K., Harada, N. (Nagaoka Univ. Tech.), Horioka, K. (Tokyo Tech.), Fujioka, S., Siraga, H. (Osaka Univ.), Koga, M. (Univ. Hyogo)

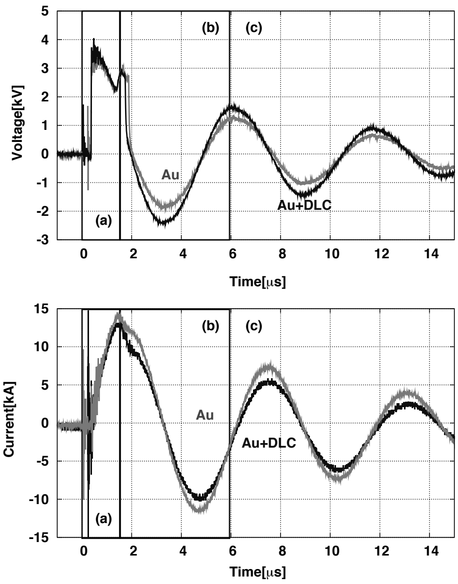
Critical to fast ignition [1)] is the transport of the laser-generated fast electrons and their associated heating of compressed DT fuel. The coupling efficiency of laser energy to these fast electrons and the energy deposited in the fuel should be improved the cone materials. From the numerical results, the low-Z cone is expected to be the improvement of coupling efficiency, because the fast electrons are scattered by the large Coulomb potential of highly charged ions in high-Z cone wall [2)]. On the other hand, the transport of fast electrons in the cone depends on the electrical conductivity in warm dense matter (WDM) state [3)].

From above evaluations, the diamond-like-carbon (DLC)[4)] cone, which is one of the low-Z cone, is promised to increase the coupling efficiency due to the redaction of stopping power in cone compared to the high-Z cone. The properties of DLC respects the diamond and the graphite, however, materials in WDM state are in a complex area.

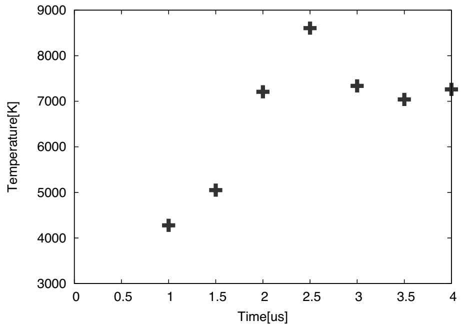
To evaluate the electrical conductivity in DLC WDM, we propose a concept to investigate the WDM properties of insulator by using pulsed-power discharges. The concept of the evaluation of electrical conductivity for DLC WDM is a shock compression driven by an exploding wire discharge with confined by a rigid capillary.

The WDM generation by using pulsed-power discharge is qualitatively evaluation of the electrical conductivity and the other plasma parameters. However, the pulsed-power discharge is difficult to make the WDM for insulator. To evaluate the electrical conductivity for DLC WDM, the shock compression driven by an exploding wire discharge with confined by a rigid capillary is considered. The exploding wire has a huge ablation pressure approximately a few GPa. Thus, the pressure of exploding wire drives the shock heating for the insulator as the DLC membrane which is coated on the wire. The heated DLC membrane state is observed by the emission spectrum for the temperature. The DLC membrane coated on the wire for gold was fabricated using RF plasma CVD.

Figure fig:Fig1 shows a time-evolution of voltage, current and DLC temperature. As shown in Fig. fig:Fig1 (a), observed voltage and current waveforms are same at the region (a). The region (a) means that the wire is heated up to vaporization. After the region (a), we can see that the voltage and current waveforms between Au wire and Au wire + DLC is difference because of the difference of the resistance. After the region (c), the capillary was broken by the expansion pressure and the wire/plasma behaves free expansion. As shown in Fig. fig:Fig1 (b), the DLC temperature estimated by the absorption spectrum is up to 9000 K. It means that the warm dense DLC is generated by using proposed method. The electrical conductivity of DLC plasma is roughly estimated to be 10^6 S/m incorporating hydrodynamic simulation. To determine the correct electrical conductivity of DLC plasma, we should measure the DLC or the wire/plasma size.



(a) Typical voltage and current waveforms for Au wire and Au wire +DLC



(b) DLC temperature

Fig. 1: Time-evolution of voltage, current and DLC temperature

1) R. Kodama, *et. al., Nature*, **412**, 798 (2001).
2) T. Johzaki, *et. al., Nuclear Fusion*, **51**, 073022 (2011).
3) P. McKenna, *et. al., Physical Review Letters*, **106**, 185004 (2011)
4) S. Fujioka, *et. al., Plasma Physics and Controlled Fusion*, **54**, 124042 (2012).