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

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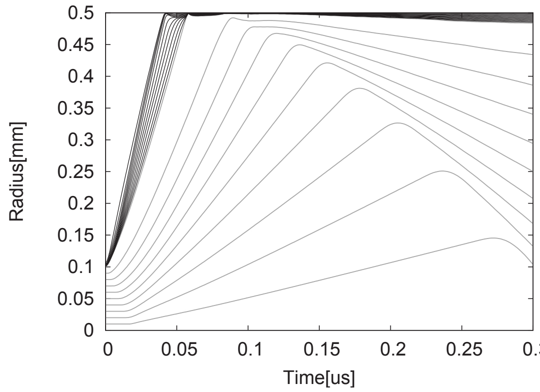
Critical to fast ignition [1] is the transport of the laser-generated fast electrons and their associated heating of compressed DT fuel. The coupling efficiency of laser energy to these fast electrons and the energy deposited in the fuel should be improved the cone materials. Improving coupling efficiency, we should consider the behaviors of unstoppable, un-ejected, and diverging fast electrons. 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. The DLC is also made by the plasma-enhanced chemical vapor deposition on the substrate. Therefore, the properties of vapor DLC is difficult to obtain the conventional method.

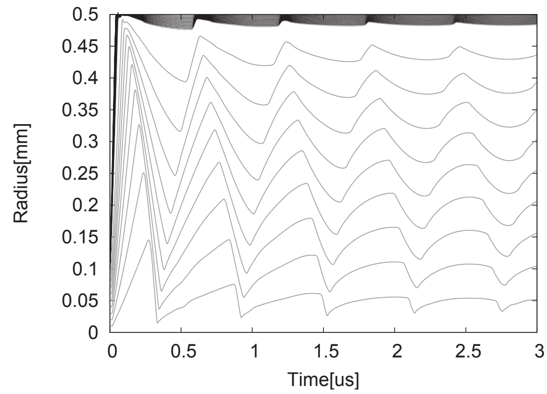
To evaluate the electrical conductivity in DLC WDM, we propose a concept to investigate the WDM properties of insulator by using pulsed-power discharges. The concept of the evaluation of electrical conductivity for DLC WDM is a shock compression driven by an exploding wire discharge with confined by 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 ruby fluorescence for the pressure and the emission spectrum for the temperature. The DLC membrane coated on the wire for gold was fabricated using RF plasma CVD.

To understand the time-evolution of hydrodynamic behavior, we have demonstrate one-dimensional hydrodynamic simulation. The initial condition is assumed 5 μm DLC membrane coated on gold wire with 100 μm in radius. Figure 1 shows the time-evolution of gold wire coated on the DLC membrane. The result indicated that the radius of WDM DLC is almost 100 μm after a few μs from beginning of discharge. From these results and theoretical estimation of DLC conductivity with the experimental observation of electrical conductivity for gold WDM, the resistance of DLC WDM is dominant. It means that the method is possible to generate WDM DLC and to measure the electrical conductivity of WDM DLC.



(a) up to 300 ns.



(b) up to 3 μs

Fig. 1: Time-evolution of gold wire coated on DLC membrane. Red lines show Lagrangian meshes of gold and blue lines are Lagrangian meshes of DLC membrane.

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).