§23. Development of Electron Density and Temperature Measurements for Plasmoid Using Laser Thomson Scattering

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In ITER, control of transient heat and particle loads due to ELMs and its impact to divertor materials will be an important issue. For the assessment of the transients, it is necessary to characterize the high density plasmoid, and it is thought that laser Thomson scattering diagnostics will be the best tool for the characterization. For Thomson scattering diagnostics, laser transmission mirrors and a neodymium - doped yttrium aluminum garnet (Nd:YAG) laser at 1064 nm will be used for future fusion devices. In this study, the design of the laser Thomson scattering diagnostics was done for the plasma gun device developed in Nagoya university. Moreover, for the assessment of the metallic mirror, the multi-pulse laser induced damage threshold (LIDT) was conducted in vacuum condition for the first time.

The measurement of multi-pulse LIDT for OFHC - copper mirror were done with the set up shown in Fig. 1. A Nd:YAG (yttrium aluminum garnet) laser (Continuum, SLII-10) was used for the pulsed laser source. The wavelength, the pulse width, and the repetition frequency were 1064 nm and 5-7 ns, and 10 Hz, respectively. The multi-pulse LIDT measurement was conducted in air atomspher and vacuum condition. A turbo molecular pump was used for vacuuming, and the background pressure was approximately 5x10^{-5} Pa. Mirror sample was installed to the vacuum chamber. Since the accessibility to the mirror was less than that in the air atomospher, we simplify the measurement system. The laser beam power monitor was not used in the multi-pulse LIDT measurement in vacuum. This was because we confirmed that the laser power was stable enough to measure the LIDT without monitoring from the experiments in air condition.

Concerning the multi-pulse LIDT experiments for metallic mirrors, to our knowledge, all the experiments reported have been conducted in air atmosphere. However, in ITER, the mirrors will be irradiated by the laser pulses in vacuum condition. The difference may arise the difference in LIDT. Let us check the difference between LIDT in the air and vacuum conditions.

Figure 2 shows the multi-pulse LIDT for OFHC-Cu in air and vacuum conditions. The multi-pulse LIDT in vacuum was higher than that in air as increasing the number of pulses. The slope in the double legalistic scale plot was shallower, indicating that the LIDT should be much higher as increasing the number of pulses. In Fig 2, open square markers show the experimental data where the damage was not formed on the surface for the number of pulses higher than 10^5.

In vacuum, oxidization process does not occur, and consequently, the LIDT becomes higher than that in the air. Here we extrapolate the LIDT to the expected ITER condition, i.e. 10^8 -10^9 pulses by assuming that the relation between the LIDT and the number of pulses can be expressed with the power law.

The data in Fig. 2 were fitted with power function. The obtained function was (3.76±0.32) N $^{(-0.083\pm\ 0.015)}$ for the data in air atmosphere and (3.73±0.97) N $^{(-0.049\pm 0.025)}$ for the data in vacuum. In the vacuum condition, the expected LIDT was 1.51 (+1.51, -0.80) J for 10^8 pulses and was 1.35 (+1.50,- 0.75) J for 10^9 pulses. Although the ambiguity was still large, the LIDT in vacuum could be twice higher than that in air atmosphere when the pulse number was higher than 10^8 pulses. Especially, in vacuum, the data is still not sufficient to extrapolate it to larger number of pulses expected in ITER. For future work, it is expected to obtain the data for higher number of pulses in vacuum condition, which will leads to deduce more accurate necessary values in ITER condition.

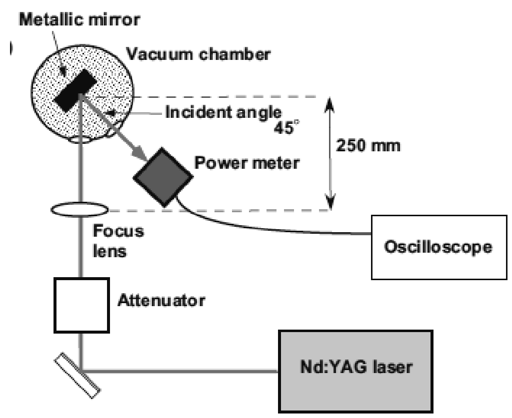

Fig. 1 Schematic of the experimental setup for the multi-pulse LIDT measurement in vacuum.

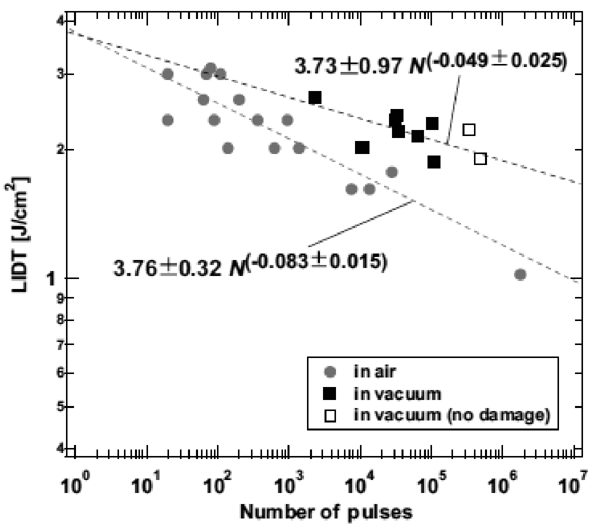

Fig. 2 Multi-pulse LIDT for OFHC Cu mirros in air atomspher and vacuum condition.