§12. Absorption Characteristics of EC Beam Target Materials

Takahashi, H., Kubo, S., Shimozuma, T., Yoshimura, Y., Nishiura, M., Igami, H., Ito, S., Kobayashi, S., Mizuno, Y., Okada, K., Kamio, S., Mutoh, T., Osakabe, M., Makino, R., Ogasawara, S. (Nagoya Univ.), Nagasaki, K. (Kyoto Univ.)

In the Large Helical Device (LHD), direct measurement of transmitting electron cyclotron (EC) beam using the target plate has been planned in order to measure the absorption power of an electron cyclotron resonance heating (ECRH) into the plasmas and to deepen the physical understanding of EC beam refraction due to the presence of plasmas. Good thermal property and enough absorption of EC beam are necessary for absorber material to measure the transmitting beam profile with enough S/N of temperature rise of the target. The characteristics of beam absorber materials for EC beam target were examined before the installation into the LHD.

The examination was carried out using a set of ECRH system consisting of an 82.7-GHz gyrotron, a matching optics unit, a waveguide, a miter bend and a dummy load. The plates of the candidate materials were set instead of the miter bend and the temperature rise of the back surface was measured using an IR camera. In the examination, three kinds of material, such as TiO_2-coated Al (TiO_2 thickness: 0.2 mm, Al thickness: 5 mm), stainless steel (SUS304, thickness: 5 mm) and isotropic graphite (IG, thickness: 15 mm) has been used. In order to increase the infrared emissivity, the Al plate was coated by TiO_2 not only the EC-beam-irradiated surface but also the back surface, and for SUS304 and IG plate, a black-body tape was pasted on the view plane from the IR camera.

Figure 1 shows the temperature profiles of back surface of (a) TiO_2-Al, (b) SUS304 and (c) IG plate in the case of the ECH condition of 205 kW/20 ms. Clear temperature profiles corresponding to the power density profile of EC beam were observed with enough S/N in all cases. The highest temperature rise was obtained in TiO_2-Al case among the three materials. The peak-temperature rise of IG was 4 degree and was slightly higher than that of SUS304. Note that the thickness of IG plate was 15 mm and was three times larger than the others and the temperature rise of IG became smaller in same EC beam condition.

Figure 2 shows the dependence of EC beam absorption fraction α on PT_p. Here α is defined as the absorption power of the target P_{abs} divided by P, P is the EC beam power measured using dummy load with the usual miter bend and T_p is the pulse duration. The data of the open symbols are evaluated from the IR camera measurement, where $P_{abs} = \rho c \Delta T_{ave} St$, ρ is mas density, c is specific heat capacity, S is the EC-beam-irradiated area and t is the thickness of the plate. The data of the closed symbols are evaluated as $(P-P_{target})/P$, where P_{target} is the measured ECH power using the dummy load when the target plate was set at the corner of the transmission line. The experimentally obtained α were 28%, 6.5% and 2.3% for TiO_2-Al, IG and SUS304, respectively. In the TiO_2-Al case, the highest α was obtained among the three materials, however, the TiO_2 coating was found to be partially stripped out after the examination. This is considered due to the local arcing on the irradiated surface by the EC beam. Thus it is concluded that the TiO_2-Al cannot be used continuously. In the IG case, α was smaller than that of TiO_2-Al, however high temperature rise is expected due to the smaller heat capacity of 1.57×10^6 J/m^3/K. Also IG has good heat resistance with the high subliming temperature of 3900 degree. From these examination results, IG was adopted for the EC-beam-target plate for LHD experiments.

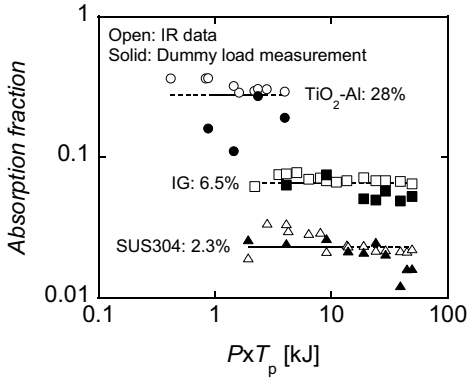
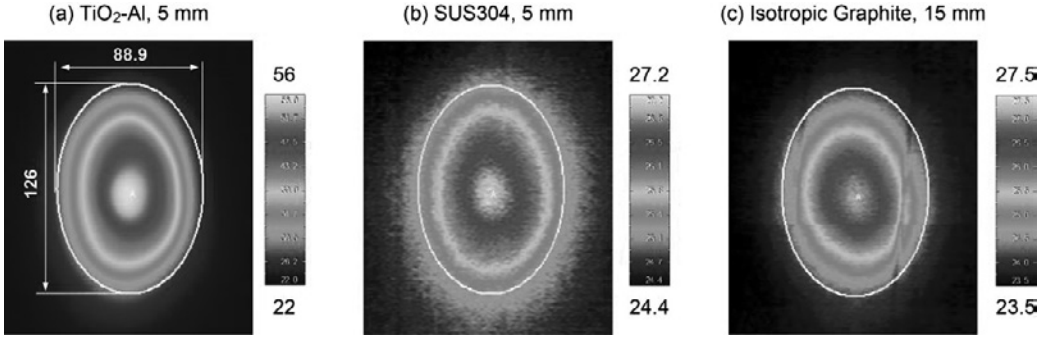


Figure 2. The dependence of the EC beam absorption fraction α on PT_p.



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