§20. Development of In-situ Calibration of Infrared Camera Measurement

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i) Introduction

The infrared (IR) camera has a capability to measure surface temperature in the wide areas as an image compared with the thermocouple, so that the IR camera is a main diagnostics for surface temperature measurement of the plasma facing components. However, the accuracy of the temperature measurement with the IR camera is affected by the emissivity change of the surface due to the erosion and impurity deposition on the surface. In the fusion devices such as LHD and ITER, it becomes difficult to calibrate the optics for measurements and to evaluate the emissivities of the plasma facing components by removing the IR camera system and the plasma facing components from the devices for calibration. The main objective of this research is to develop the in-situ calibration technique for the IR camera including the transmission of the optics and the emissivities of the plasma facing components.

ii) Research results and experimental plan

The proof-of-principle experiment for the in-situ calibration method to evaluate the emissivity change of the object surface was performed by irradiating an IR laser on the surface. Figure 1 shows the experimental setup. A tungsten sample mounted on the rotating optical stage was irradiated by an IR laser (wavelength was selectable between 3.08 - 3.34μm) and the scattered light on the surface was measured by an IR camera (FLIR SC5200) which was calibrated by a plane blackbody source with the emissivity of 0.94. The angle between the axis of the IR camera and the irradiating axis of the IR laser was 20 degrees. Tungsten samples with the different surface conditions were used. One had a sandblasted surface and another had a mirror surface. Each sample was heated by a ceramic heater put on the back in the temperature range from room temperature to 280˚C. The angle dependences of the scattered light were obtained by rotating the sample with the rotation optical stage at the different temperatures. The surface temperatures of the sample were measured with a thermocouple at several points of the surface. Figure 2 shows the images of the IR camera with a filter of the central wavelength of 3.35 μm for different tungsten samples; a) with the sandblasted surface at the surface temperature or 277˚C and b) with the mirror surface at that of 272 ˚C. In the cases of Fig.2, the normal of the each surface was just on the axis of the IR camera. The integrated times of the camera were 200 μs for a) and 800 μs for b) respectively.

Moreover, the similar experiments were carried out to obtain the wavelength dependences of the surface emissivities by changing the filter of the camera at the central wavelength of 2.95, 3.35, 3.65, 4.07, 4.26, 4.44 and 4.67 μm without laser irradiation.

Similar experiments at higher temperatures (up to 1100˚C) are planned by installing samples in the vacuum vessel to prevent surface oxidation. The IR laser irradiation on the samples and the measurement of the scattered light on the surfaces will be made through a sapphire window. Experiments using samples with different surface-roughnesses (Ra=0.01 – 32 μm) and experiments using IR lasers with different wavelengths are also planned. In addition, experiments on LHD are planned to confirm the availably of this method using an IR laser on the large fusion device.

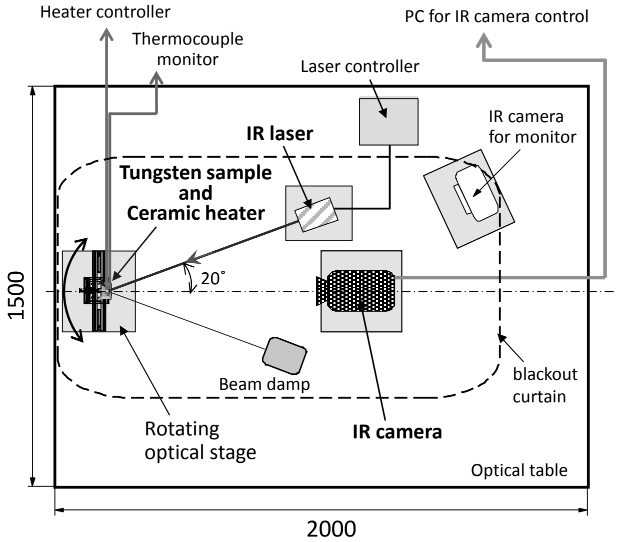

Fig. 1 Experimental setup: Tungsten sample mounted on the rotating optical stage is heated by a ceramic header put on the back of the sample. The sample is irradiated by an IR laser and the scattered light on the surface is measured by an IR camera.

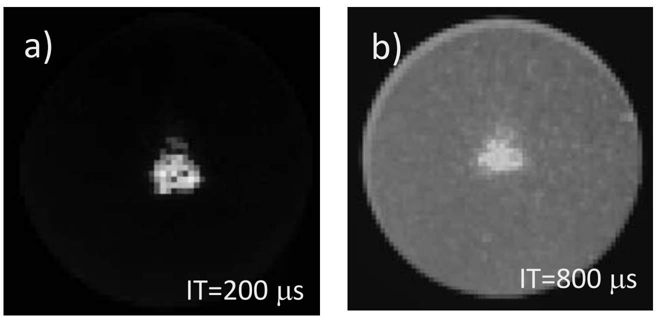

Fig.2 Images of IR camera for tungsten samples with a) a sandblasted surface and b) a mirror surface. Surface temperatures and the integrated times are 277˚C and 200 μs for a), and 272˚C and 800 μs for b) respectively.