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

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i) Introduction

The measurement of the heat load on the plasma facing components, such as first wall and divertor plate, is indispensable for thermonuclear devices to understand particle and energy transports physics in the plasma peripheral region, and to maintain the integrity of plasma facing components. The infrared (IR) camera, which is different from thermocouple, has a capability to measure surface temperature in the wide areas as an image, so that the IR camera is a main diagnostics for surface temperature measurement of the plasma facing components. However, the measurement accuracy of the IR camera is affected by the emissivity change of the surface due to the erosion and impurity deposition on the surface. In LHD and the superconductive devices such as ITER in the future, it becomes difficult to calibrate the measurement optics and to evaluate the emissivities of the plasma facing components by removing the IR camera system from the devices for calibration. The main objective is to develop the in-situ calibration technique for the IR camera including the measurements of the optical transmission and the emissivities of the plasma facing components.

ii) Calibration methods and experimental plan

The calibration methods using the data of the thermocouples installed on the objects to be measured, installing a blackbody light source in the vacuum vessel during the maintenance phase of the device, inserting a small light source in front of the IR camera to evaluate the transmission of the optics and applying lasers on the object to be measured have been investigated for LHD and ITER.

In this development, the method of applying a laser on the surface of the object from outside the vacuum vessel in order to evaluate the emissivity change of the surface and inserting a small IR light source in front of the optics remotely in order to measure the transmission change of the optics and the sensitivity change of the IR detector (camera) is selected. Fig. 1 shows the conceptual diagram of the planed experimental arrangement for the proof-of-principle. The pulse oscillated IR laser with a capability of tunable wavelength is introduced in the measurement optics by a half mirror and applied on the surfaces of the samples (tungsten, etc.). The reflected light on the surface goes through the same measurement optics and measured by an IR detector in order to evaluate the emissivity change of the surface. The temperature dependence of the emissivity is measured by heating the sample with monitoring the temperature by thermocouples. The angle dependence of the reflectivity is measured by rotating the sample. The transmission change of the optics including the sensitivity change of the detector is measured by locating a plane heater, as an IR light source, in front of the optics. The two-color pyroreflectometry technique[1)] will be tested for temperature measurement.

In addition, it has been indicated in LHD that the large error is observed for the heat flux on the surface derived from the measured surface temperature because of the change of the heat conduction parameters of the object due to the erosion and the formation of redeposition layer of the first wall and the divertor target materials. However, the error becomes small by investigating the heat conduction parameters of the object taking out to the outside the vacuum vessel.[2)] It will be necessary to develop an in-situ investigating technique of the heat conduction parameters of the object for the future thermonuclear devices such as ITER, in which it is difficult to take out the object to the outside the vacuum vessel.

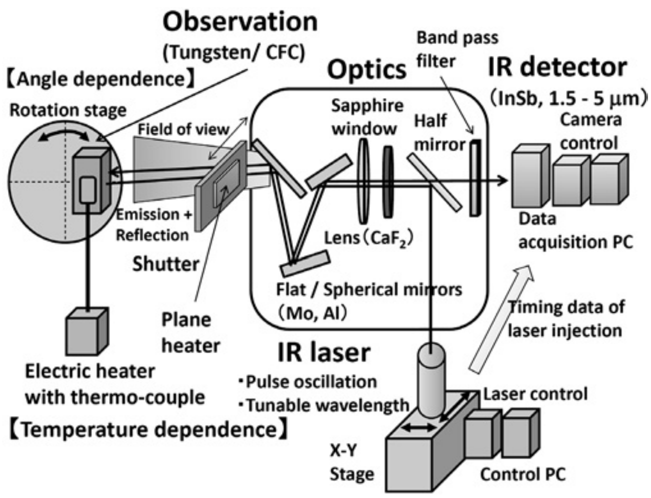

Fig. 1 Conceptual diagram of proof-of-principle experiment for in-situ calibration technique of infrared camera measurement

1) Hernandeza, D. et al.: Fusion Engineering and Design **83** (2008) 672.
2) Drewelow, P. et al.: “Comparison of Modelled Divertor Heat Flux and Experiments at LHD”, to be appeared in Plasma and Fusion Research.