§11. Development of the Monitoring System for Divertor Heat Flux Distributions

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In the GAMMA 10/PDX tandem mirror, high heat-flux generation experiments (E-divertor) with high-power plasma heating systems have been conducted. Heat flux from the end-mirror exit is estimated with calorimetric method. In 2011FY experiment, plasma heat flux was estimated with the method based on Lumped-Heat-Capacity system approximation. From this results obtained with movable calorimeter, a clear prospect of generating the ITER-grade high heat flux under the good controllability was confirmed[1]. But this method can not give us information on time evolution of heat flux. Moreover, large noises are found in the movable calorimeter signal at the beginning of sampling[2].

There are other 13 calorimeters which installed on the lower V-shaped target of divertor simulation experimental module (D-module). The calorimeters on V-shaped target consist of stainless steel substrate (10mm in diameter and 0.2mm in thickness) which is connected to thermocouple (K-type). Figure 1 shows the spatial setting of these calorimeters on the lower target plate. Figure 2 shows example of thermocouple signal of these calorimeters. Plasma discharge starts at 50 ms and ends at 250 ms. The signal increment in this period is not due to temperature variation, but due to RF noise. A small hump around 800 ms also comes from confinement magnetic field termination, which was the same noise observed in movable calorimeter signal[2].

Optical fiber thermometer is often used for temperature monitor of MRI or RF source. Its sensor consists of Gallium arsenide (GaAs) and emit excited light, whose spectra depends on temperature. So the sensor and recorder are connected only with a optical fiber and electro magnetic noise has little effect on the measured signal. In Fig. 2, test result of a thermometer (Nomad, Neoptix Ltd.) is also plotted. This temperature signal indicates room temperature without such noises. Although this data shows the optical fiber thermometer is very promising, construction of small size calorimeter arrays with it has still many technical problems to be overcome and another method was tried. Figure 3 shows the noise reduction effect of insulative thermoelectric converter (MS3701, MTT corporation). Channel 3 is normal thermocouple signal and shows similar noise as Fig. 2. By using MS3701, signal noise during plasma discharge is effectively suppressed. So we will prepare similar convertors for all channels of Fig.1 in the next experimental campaign.

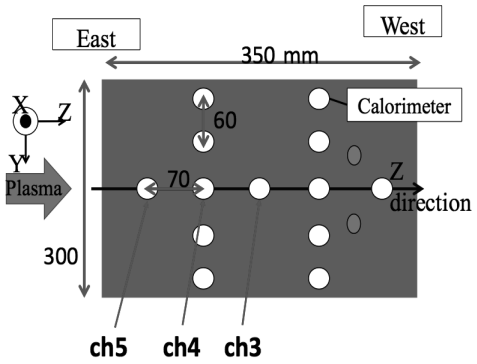

Fig. 1: Calorimeter channels of the lower V-shaped target. Distance of each cahnnel is 7 cm.

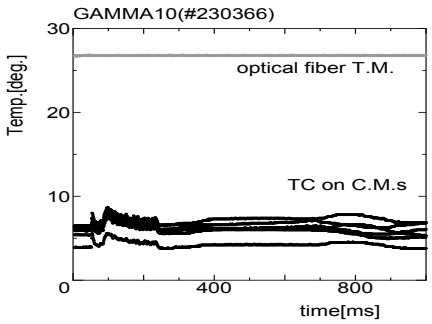

Fig. 2: Examples of thermocouple signal of V-shape target calorimeters. Test signal of optical fiber thermometer set near the west end of GAMMA 10/PDX.

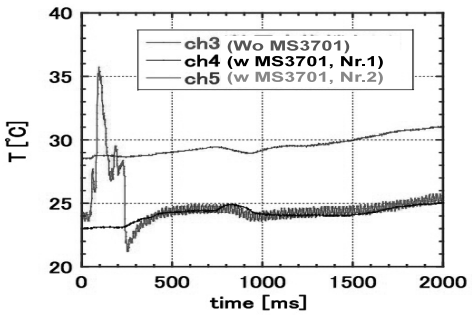

Fig. 3: Effect of Insulative convertor MS3701 on thermocouple signal noise of V-shape target calorimeters.

1) M.Iwamoto et al.: Plasma and Fusion Research, 9(2014)3402121.

2) H.Matsuura et al.: Fusion Science and Technology, 63(2013)180-183.