§17. Setup and Preliminary Test Results of a High Resolution Millimeter-Wave Beam Profile Monitor

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In a high power Electron Cyclotron resonance Heating (ECH) system with long-distance transmission lines, the reliable millimeter-wave (mmw) transmission can be much improved by the evacuation, sufficient cooling and precise alignment of the whole transmission system. A real-time beam-position and -profile monitor (BPM) is required to evaluate the position and profile of a high power (Megawatt level) mmw propagation even in the evacuated corrugated waveguide. The idea of the BPM [1] is shown in Fig. 1. Two-dimensional array of Peltier devices is installed and aligned on the atmospheric side of a thin miter-bend reflector. A mmw-beam propagating in the corrugated waveguide is reflected on the mirror surface of the miter-bend and partly absorbed in the reflector plate. The generated heat by Ohmic loss diffuses to the outside of the reflector and removed by the Peltier devices. When these devices are connected serially and driven by the constant current control ($I =$ constant), the voltage change of each device is almost linearly proportional to the temperature change of the cold-side of the device, if the temperature at the hot-side of the Peltier device is kept constant. The information of the two-dimensional temperature profile of the miter-bend reflector can give the real-time information of the position and profile of the mmw beam. If two BPMs are installed apart from about one beat wavelength of the HE_{11} main mode and the HE_{21} lowest converted mode in the transmission line, mode contents included could be determined from two beam profile informations [2].

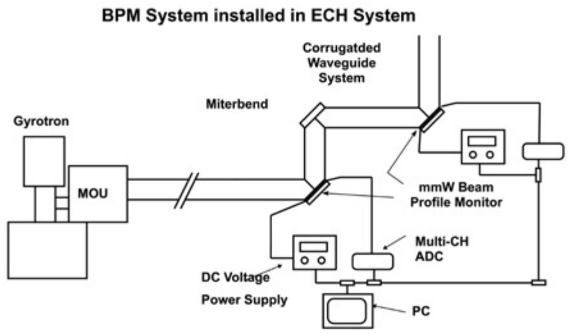

Fig. 1: Schematic of the beam position monitor installed in ECH system

At first, we tested the BPM using a circular heater with 40mm diameter as a heat source. Figure 2 (a) shows a wave form of the voltage of a Peltier device which located around the center of BPM, when the heater was turned on. Because the temperature difference between hot and cold sides of the Peltier device decreases during the heater-on, the voltage of the device decreases. Probably, it will saturate in the steady-state operation.

We tried a transient analysis of the variation of the Peltier device voltage. In order to find the start timing of the voltage decrease, the smoothed voltage signals are linearly fitted partly, and the difference of their gradients, $S = \delta(\Delta V_{\rm smooth}/\Delta t)/V_{\rm smooth}$, is calculated as shown in Fig. 2 (b). At the timing at which the value S becomes maximum after heater-on timing, the values S of all Peltier devices were mapped in Fig. 3 (b). The area with big S value well corresponds to the heater position indicated by a white dashed circle. The method of the analysis, however, should be improved considering the heat conduction in the copper reflector plate.

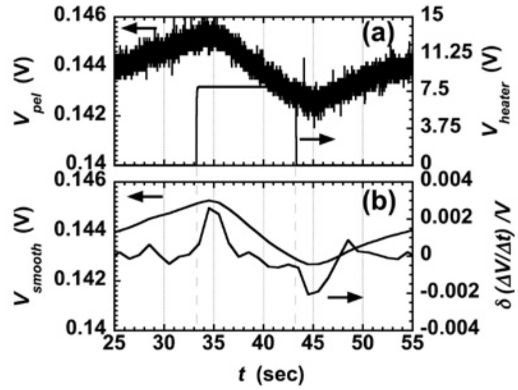

Fig. 2: (a) raw voltage signal of a Peltier device and voltage of a test heater. (b) Smoothed Peltier voltage and $\delta(\Delta V_{\rm smooth}/\Delta t)/V_{\rm smooth}$

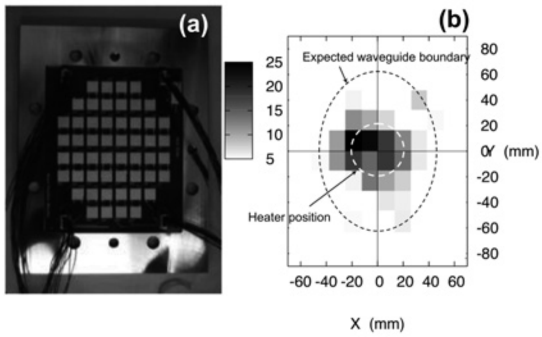

Fig. 3: (a) Back-side of the beam position monitor with 52 Peltier devices. (b) Mapped profile of the Peltier voltage variation. Black dashed line denotes expected corrugated wave-guide wall position and white dashed line shows the position of a test heater.

1) T. Shimozuma, H. Takahashi, S. Ito, *at al.*, Proceedings on 36th International Conference on Infrared, Millimeter, and Terahertz Waves, 2011, W2A-1.

2) T. Shimozuma, S. Kobayashi, S. Ito, *at al.*, Plasma Conference 2011, Nov. 22-25, Kanazawa, Japan, 22P146-P