§24. Development of a Millimeter-Wave Beam Position and Profile Monitor in an ECH Transmission Line

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In the long-distance transmission lines, the reliable gyrotron operation was much improved by the evacuation, sufficient cooling and precise alignment of the system. We have been developing an alignment method of the corrugated waveguides and the propagation mode analysis in the waveguide. Recently we are also developing a real-time beam-position monitor (BPM), which can measure the position of the high power (Megawatt level) millimeter wave (mmw) propagating even in the evacuated corrugated waveguide[1]. Two-dimensional Peltier devices are installed and aligned on the atmospheric side of a thin miter-bend reflector. The schematic diagram of the BPM is illustrated in Fig. 1. 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 the Ohmic loss diffuses to the outside of the reflector and removed by the Peltier devices. Two-dimensional Peltier-device array is installed on the outside of the reflector. When these devices are connected serially and driven by the constant current control, the voltage change of each device is almost linearly proportional to the temperature change of the cold side of the device, when the temperature at the hot side of the Peltier device is kept constant. The information of the two-dimensional temperature profile of the miterbend reflector can give the real-time information of the position and profile of the millimeter wave beam.

A prototype equipment, which consisted of a copper reflector, a 2D array of eighteen Peltier devices (20 mm square), a heat sink, a power supply, A/D convertors and a control PC, was constructed and tested. At the beginning, this equipment was tested using a circular electric heater (45 mm in diameter, heating power was about 14 W) attached on the reflector plate. The heated positions could be well distinguished. Then, the equipment was installed in one of the miterbends in the LHD transmission line, which is connected to an 82.7 GHz gyrotron. Another side of the miterbend was connected to a dummy load. High power test was performed using 82.7 GHz power with about 200 kW and 100 ms pulse every 30 s. The temperature increase of the reflector measured by an RTD was about 0.5 degree around the center. Figure 2 a) shows the voltage change normalized by the initial voltage of each Peltier device. Each quadrate in the figure corresponds to the device position. The ellipse indicated by a white dashed line shows a cross section of the corrugated waveguide at the miterbend. In this case, the maximum of the voltage change was slightly off-center. After the test, we took a thermal image by an IR camera on an absorber-coated miterbend reflector at the same setting. Figure 2 b) shows the obtained IR image. The peak temperature position well coincides with the position of the highest voltage change shown in Fig.2 a).

The system upgrade of increasing the Peltier device number for higher resolution was performed. Fifty-two Peltier devices with 10.3 mm square size were aligned on the double-sided circuit board shown in Fig. 3, because many cables were required to measure the voltage difference of each device. A reflector was made of a copper-SUS cladding material, and a heat sink is water-cooled to withstand a steady-state operation. This device will be tested soon.

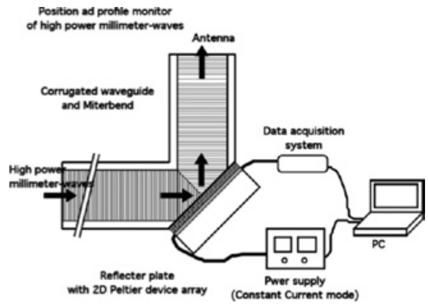

Fig. 1: Schematic diagram of a beam position monitor.

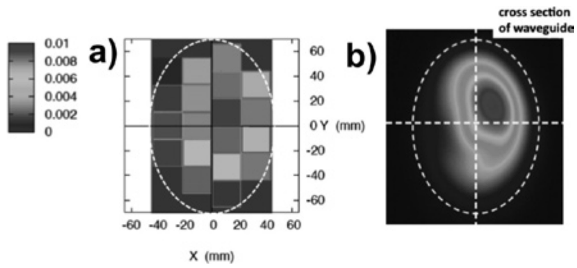

Fig. 2: High power test result of a BPM using 82.7GHz gyrotron output. a) Output voltage pattern of BPM, b) IR image of the absorber-coated reflector viewed from outside .

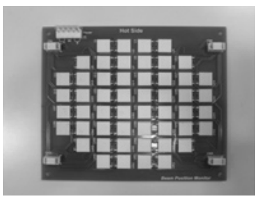

Fig. 3: A higher resolution BPM with 52 Peltier devices.

1) T. Shimozuma, *at al.*, Proceedings on 35th International Conference on Infrared, Millimeter, and Terahertz Waves, 2010, Tu-P.04.