§19. Development of a Millimeter-Wave Beam Profile Monitor in Mega-Watt CW ECH Transmission Line

Shimozuma, T., Kobayashi, S., Ito, S., Ito, Y., Kubo, S., Yoshimura, Y., Igami, H., Takahashi, H., Nishiura, M., Mizuno, Y., Okada, K., Takita, Y., Mutoh, T.

We have been developing and installing three high-power 77 GHz gyrotrons under collaboration with University of Tsukuba. The output power of each gyrotron has been improved from 1 MW to 1.5 MW step by step, and the gyrotrons also achieved 0.3MW CW operation [1]. It is important to precisely align a propagating millimeter-wave(mmw) beam to a transmission line to avoid mode conversion to the other higher-order modes. We have been developing a real-time beam-position and profile monitor (BPM) to measure the intensity profile of a high power (Megawatt level) mmw propagating even in an evacuated corrugated waveguide without any disturbances. It was improved to obtain higher spatial resolution [2].

In a high power ECH system with long-distance transmission lines, the reliable gyrotron operation can be much improved by the evacuation, sufficient cooling and precise alignment of the system. A real-time beam-position and -profile monitor is required to evaluate the position and profile of a high power (Megawatt level) mmw propagating even in the evacuated corrugated waveguide. The idea of the BPM is as follows. 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. The voltage of each Peltier device is approximately expressed as a following equation.

$$V = IR + S(T_H - T_C), \quad (1)$$

where I, R and S are a current, resistance and Seebeck coefficient of the Peltier device, respectively. T_H and T_C represent hot- and cold-side temperature of the Peltier device. 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 cooled 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 miterbend reflector can give the real-time information of the position and profile of the mmw beam.

For higher spatial resolution, 52 Peltier devices with 10 mm square size are now aligned on a circuit board shown in Figs. 1, 2 and the voltage of each Peltier device can be measured at the same moment. A heat sink is cooled by water to remove the heat generated by megawatt, CW millimeter-waves. The Peltier-device array install in the miter-bend reflector with water-cooled heat sink is shown in Fig. 3. This device will be installed in the high power transmission line of ECH system and will be tested.

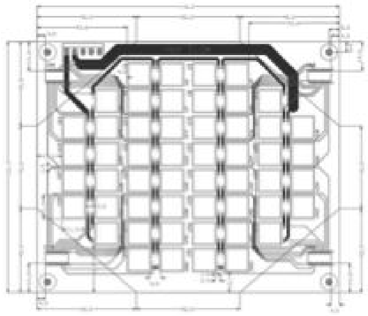

Fig. 1: Circuit board pattern of a Peltier-device array

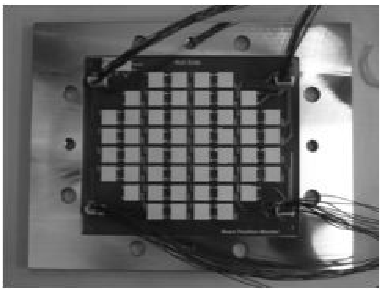

Fig. 2: Hot side of Peltier-device (52 devices) array on a backside of a reflector.

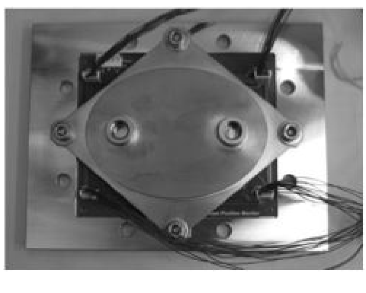

Fig. 3: Water-cooled heat sink for cooling a Pelter-device array

1) T. Shimozuma, S. Kubo, *et al.*, Journal of Microwave Power & Electromagnetic Energy, 43(2009) pp.60 - 70.

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