§16. High Power Test Result of a Millimeter-wave Beam Position and Profile Monitor

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In a high-power Electron Cyclotron Resonance Heating (ECRH) system for plasma heating, a long-distance and low-loss transmission system of the millimeter-wave is required. A real-time monitor of the millimeter-wave beam position and its intensity profile, which can be used in a high-power, evacuated, and cooled transmission line, is proposed, designed, manufactured, and tested. The beam-position and profile monitor (BPM) consists of a reflector, Peltier-device array, and a heat-sink, which is installed in the reflector-plate of a miterbend. The BPM was tested using both simulated electric heater power[1)] and high-power gyrotron output power[2)]. The profile obtained from the monitor using the gyrotron output was well agreed with the burn patter on a thermal sensitive paper.

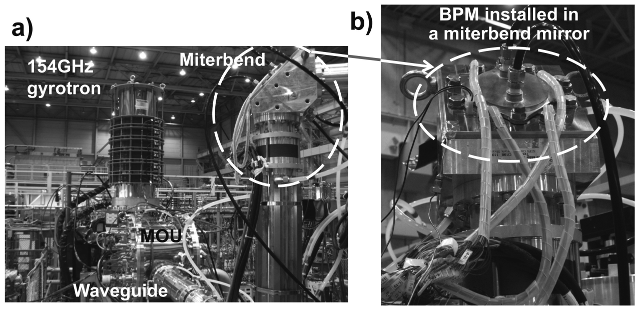

Fig. 1: High-power test configuration using gyrotron output. The BPM was installed at the second miterbend from the matching optics unit (MOU) and the power reflected by the BPM was completely absorbed by the water dummy-load.

High power test was conducted using the Mega-Watt millimeter-wave power of a 154 GHz gyrotron in the LHD ECH system. The test configuration is shown in Fig. 1. First, the constant current was started to flow to the serially connected Peltier-devices at $t = 0$. Then, the gyrotron power was turned on with 0.5 s pulse-width every 20 s. The temporal evolution of the voltages of the typical Peltier-devices, U01(edge), U16(nearest center), U30(near center), and U48(edge) are plotted in Fig. 2 a). The timing and the pulse width of the gyrotron pulses are also indicated as V_A (gyrotron anode voltage) in the figure. Immediately after the gyrotron turn-on, the voltage of each Peltier-device decreases quickly and gradually recovers after the gyrotron turn-off. The waveform of the voltage is shown particularly for U30 in the expanded Fig. 2 b) in detail. The time derivative of the smoothed Peltier voltage and S-value for U30 are shown in Fig. 2 c), where $S = -\delta(\Delta V_{\mathrm{smooth}}/\Delta t)/V_{\mathrm{smooth}}$. At the earliest timing among the timings when the value, S, for all Peltier-devices reach the maximum after the gyrotron-on timing, the values, S, of all Peltier-devices were mapped on the each Peltier-device position. The mapped data are shown in Fig. 3 b) together with the burn pattern taken by a thermal sensitive paper in a). Good agreement between the mapping of S and the burn pattern was obtained. In this case, the maximum intensity position was slightly off-axis. The peak area and the shape of the intensity profile are quite similar to those of the burn pattern[2)].

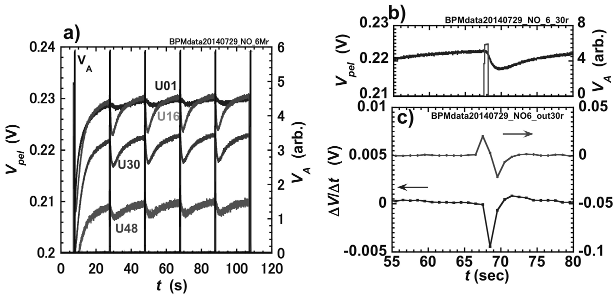

Fig. 2: a) Temporal evolution of the typical Peltier-devices, such as U01, U16, U30, and U48. The timing and pulse width of the gyrotron turn-on is also plotted as the anode voltage V_A of the gyrotron. b) The expanded time trace of Peltier-device voltage and V_A for U30 from t =55 sec to 80 sec. c) The time deference of the smoothed Peltier voltage and S-value for U30, where the suffix "smooth" is abbreviated.

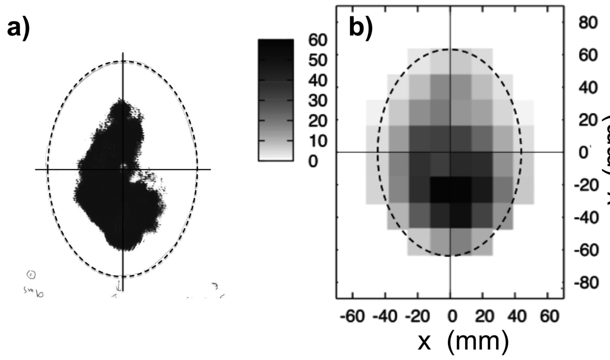

Fig. 3: Pattern of the temperature increase of the reflector. a) Burn-pattern obtained using a thermal sensitive paper. b) A mapping of S-values on the Peltier-device positions. The black dashed-line ellipse indicates the wave-guide boundary.

1) T. Shimozuma, et al., EC18 2014, April. 22-25, Nara, Japan. EPJ Web of Conferences 87, 04011 (2015)

2) T. Shimozuma, et al., Plasma Conference 2014, Nov. 18-21, Niigata, Japan, 18PB016.