§13. Studies on Cooling Performance of Vacuum Windows for High Power Millimeter Waves

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Development of vacuum window for high power millimeter wave is one of the key technical issues to realize CW ECH system . For this purpose, we proposed a forced gas-cooled single-disk window. We tested the cooling performance of a circular gas-cooled window assembly and confirmed a good cooling efficiency. The heat transfer coefficient reached to 0.1 kW/cm^2°C which was about 1/3 of the coefficient obtained with the liquid (FC-75) cooled double-disk window system. From this result, we think that the target of ~1MW and CW operation might be achieved by applying this method to an elongated elliptical window (120mm X 320mm) which is integrated to the circular wave guide (inner diameter, 88.9mm) at the Brewster angle (~70°).

In the previous experiment (circular window), the cooling gas was ejected to the disk center from the nozzles distributed on a circular aperture. For the elliptical window, however, gas might be ejected in parallel along the minor axis. In the present study, we have tested cooling performance of a rectangular window (particularly temperature uniformity) using not a microwave but a dummy heat source.

Figure 1 shows a schematic structure of the rectangular gas cooled single-disk window assembly used in the present experiment. Two alumina (A479) disks (1.6mm thick each, 120mm X 240mm) are folded and held by the rectangular frame. Between these disks a film resistor (0.12 mm thick, 110mm wide) is sandwiched and it is heated by a DC power supply (I=0~120A). The cooling gas (dry nitrogen at a pressure of several kg/cm^2) is ejected through the nozzles (1mm diameter) distributed with equal distances of 20mm along the straight manifold. The disk surface is coated with lusterless black paint. The surface temperature distribution is measured by an IR camera.

Figure 2 shows a temperature distribution measured for the same gas flow pattern as in Fig.1 (distances between nozzles in the central part =40mm, heating current=90A, total gas flow rate =60 l/min). The hotter part at right hand side is due to the current feeder. The temperature at the central part is ~50°C. If the total gas flow rate is kept constant, the cooling performance is better for smaller number of nozzles, i.e., for higher gas flow speed. This result is same as those observed for the circular window assembly. As for the temperature distribution, we observe the non uniformities of 10°C and 5°C along the vertical and horizontal lines, respectively in Fig. 2. When the distances between the nozzles are reduced to 20mm, the non uniformity is suppressed less than 3°C in both directions. We also tried to eject gas from both bottom and top manifolds and collide to each other but cooling performance was not improved.

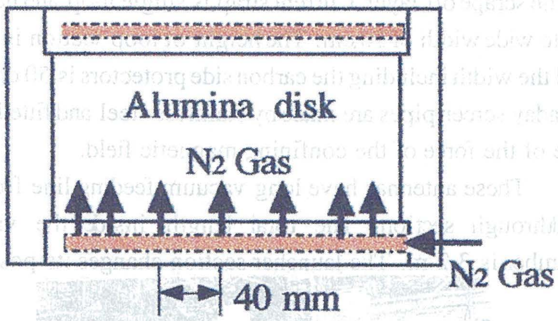

Fig. 1 Rectangular gas-cooled vacuum window assembly. The disk is heated by a film resistor (0.12mm thick).

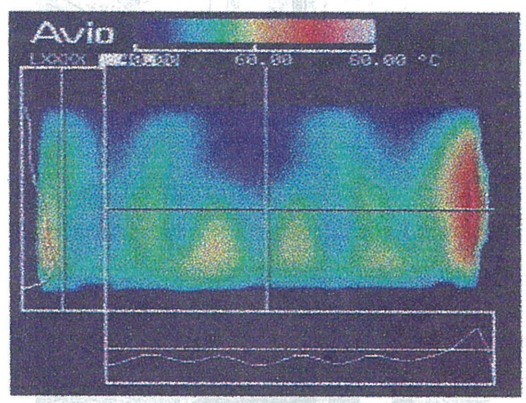

Fig.2 Temperature distribution of the disk measured with an IR camera. The gas flow pattern is same as in Fig. 1.