§3. A Forced Gas-Cooled Single Disk Window for High Power CW Millimeter Waves

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A vacuum barrier window is one of the most critical components needed to realize high power CW (Continuous Wave) gyrotrons. Many efforts to make 1 MW CW windows have been made all over the world. Single-disk windows have the merit of being simple structures which assure higher reliability than complicated multiple-disk designs. By means of gas-cooling, a surface-cooled single-disk window with a low loss and tough material might be possible to succeed in CW power transmission.

Using the low loss silicon nitride composite, we assembled a forced gas-cooled single-disk window with edge-water cooling. Figure 1 shows the structure of the gas-cooled single-disk window for high power testing. A circular disk of the silicon nitride composite with a diameter of 150mm and a thickness of about 2mm is held between two stainless steel flanges and sealed by O-rings. In this window structure, the whole surface of one side is forced gas-cooled by means of gas erupting nozzles drilled on the inner wall of the flange. The disk edge of the other side is water-cooled. The typical diameter of the holes is 1mm and the number is 24. The nozzle section is exchangeable to check the effect of the size, the number of the holes, and its configuration. The effective diameter of the window is 88.9mm and can be connected to a corrugated waveguide with the same inner diameter. Working gases used for the tests were dry nitrogen and dry air.

In order to demonstrate the possibility of high power CW transmission, we performed 30 seconds injection with 130kW power. Figure 2 shows the time evolution of the peak temperature on the disk with and without gas-cooling. Without gas-cooling, the temperature continued to increase during the pulse, because of the insufficient removal of the heat generated. At the end of the 30sec. pulse the maximum temperature reached as high as 323 °C. On the other hand, with forced gas-surface-cooling of 465 liter/min., the peak temperature completely saturated during the pulse at 123.6°C. This fact means that this type of window can withstand a 130kW CW power transmission of HE_{11} mode through the waveguide with 88.9mm in diameter.

The local heat transfer coefficient of the forced gas-cooling can be estimated by evaluating the decay time of the peak temperature on the disk after turning off of the millimeter-wave injection. The maximum value of the heat transfer coefficient is 0.1 W/cm^2K for a gas flow rate of about 400l/min.

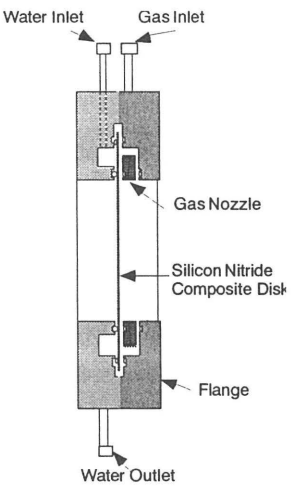

Figure 1 Structure of the forced gas-cooled single-disk window of silicon nitride composite

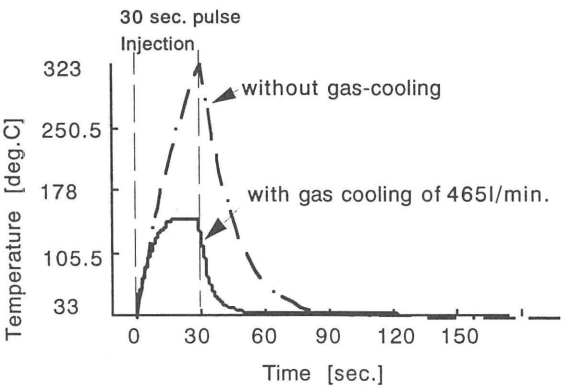

Figure 2 Time evolution of the peak temperature on the disk during 130kW, 30sec. injection without and with gas-cooling.