INFRARED MONITORING OF 110 GHz GYROTRON WINDOWS AT DIII–D*

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The temperature evolution of the gyrotron windows is one of the vital factors in high power (near 1 MW) and long pulse (few seconds) operation. The ECH system on the DIII–D tokamak is built up from three Gycom (0.8 MW each) and three CPI (1 MW each) gyrotrons. Total power injected into tokamak has been greater than 2 MW for pulse lengths of 2.0 s using four gyrotrons. The pulse duration of the Gycom gyrotrons is limited by heating of their boron nitride (BN) ceramic windows. After a 2 s pulse with 800 kW generated power, the temperature of the BN window increases up to about 930°C. Synthetic CVD diamond shows considerable promise as a material for high power gyrotron windows due to low absorption of rf and high thermal conductivity. However, there have been failures of diamond windows during the first attempts to use this material. This motivated detailed infrared (IR) measurements of the window temperature during gyrotron operation. Infrared monitoring has made it possible to detect local hot spots of the diamond as well as the overall temperature distribution. Some of these hot spots were due to a graphite contamination on the surface of the window, that was confirmed by Raman scattering. Although the total number of local hot spots decreased after surface cleaning by grit blasting of a window already mounted on a gyrotron, some of these spots remained. The remaining hot spots can be explained by local graphite impurities present in the bulk or by surface contamination on the inaccessible inside surface of the diamond disk. The peak temperature of the diamond disk reaches 120°C for pulse lengths up to 5.0 s with 870 kW of rf power passing through the window. The temperature of the local hot spots of the diamond did not exceed 140°C for the same parameters of the gyrotron pulse.

Slow oscillations near 4 Hz of the apparent temperature of the diamond IR image were observed. The frequency of these oscillations is in good agreement with the sweeping frequency of the collector coil. It is apparent that local heating of components inside the gyrotron can contribute to the observed IR image due to the high infrared transparency of the diamond. Changes in the interior infrared emission, which are seen through the diamond window, can compromise the empirical calibration of the measurements. The fluctuating temperature measurements indicates that this could be a 10% effect on the accuracy of the window measurement.

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