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Design aspects and RF characterization of ITER-RF-CVD-diamond windows

INTRODUCTION

For the plasma engineering of ITER, EC launchers will be used at the upper port and the equatorial port levels. Part of these studies is to verify the window design and to work out, whether a concept is available for both launchers. To this goal, first experiments with low and high power mm-waves are performed and will be presented. The high power RF behavior of torus window assemblies with corrugated waveguides is being investigated by using IR imaging technique during high power microwave loading with the intention to reach 1 MW at a frequency of 170 GHz at the JAEA gyrotron facility. Short pulse experiments up to 15 seconds pulse duration have been performed to determine the temperature distribution over the whole diamond window area and the efficiency of the indirect cooling by a copper cuff. The occurrence of arcing is being studied as part of evaluation of the assembly design. In a future step also long pulse measurements up to several hundred seconds are planned.

Characterization of CVD diamond window material

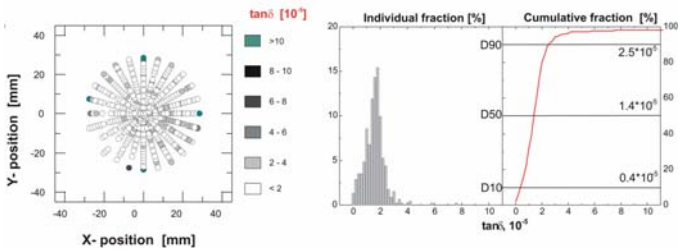

Fig. 1: Dielectric loss mapping of the bare CVD diamond window disk 70DB1 (Manufacturer: ElementSix) measured at a frequency of 100.71 GHz. The diameter of the diamond disk is 75 mm, the thickness 1.114 mm and the dielectric constant 5.67. The length of the resonator was 116.54 mm.

Configuration of the ITER torus window assembly

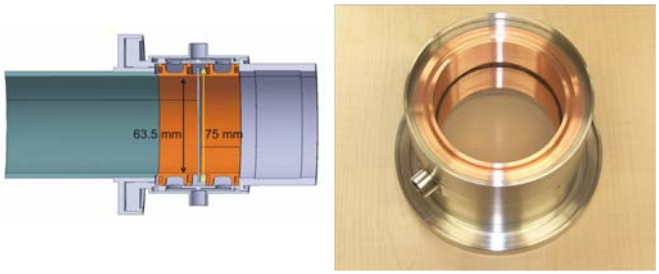

Figure 2 CAD design and photograph of the CVD diamond torus window unit with the CVD diamond disk separating the torus vacuum section from the dedicated transmission line section. The red section is formed by a copper cuff with two symmetric cooling chambers separated from a vacuum segment at the outer diamond edge. The left part is the torus side, the right part the transmission line side.

Experimental setup for high power short pulse 170 GHz measurement at JAEA

Vacuum TMP	Vacuum Window	He leak Rate	Water flow
$1.6 \cdot 10^{-4}$ Pa	10^{-3} Pa	10^{-10}Pam³/s	12.5 l/min

Table 1. Vacuum, leak rate and water flow conditions of the CVD diamond window for the high power tests..

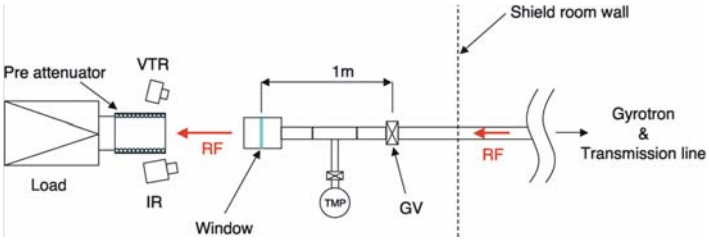

Fig. 3: Setup for short-pulse CVD diamond window testing at 170 GHz/1MW gyrotron at JAEA

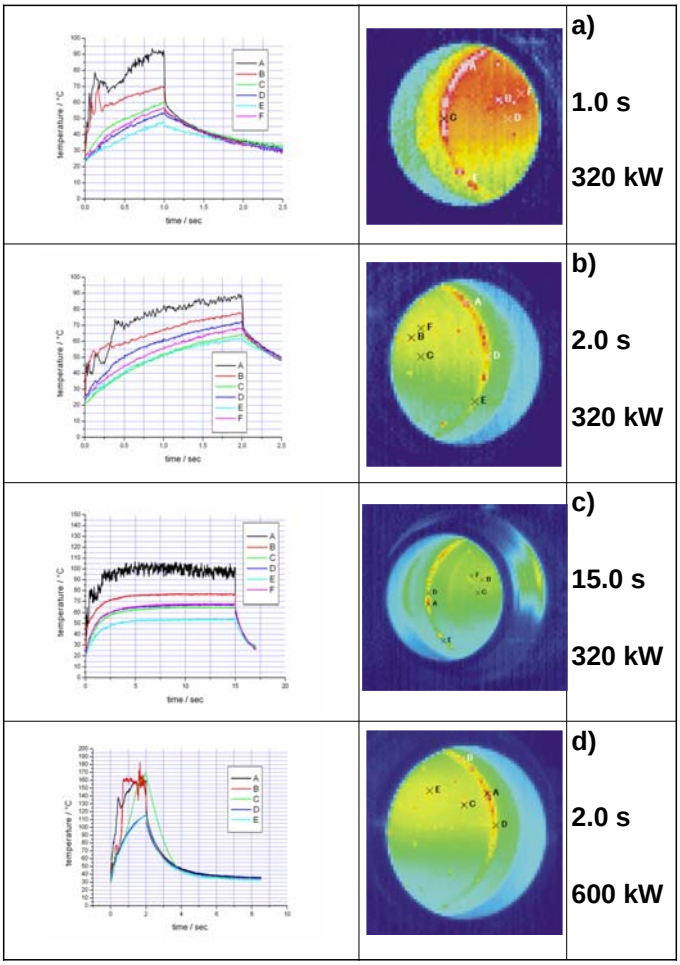

Fig. 4: IR measurements of the temperature of the CVD diamond window at different short pulse time and RF power at 170 GHz. The temperature-time dependence in the left part of the table corresponds to the indicated letters in the infrared picture. IR picture a) has an other color range in comparison to pictures b), c) and d).

SUMMARY

Short pulse high power RF measurements at 170 GHz have been performed at JAEA gyrotron facility by means of IR thermography. To understand the inhomogeneous temperature distribution over the diamond disk it is to remark, that the beam profile at the end of the waveguide after passing several miter bends is not purely Gaussian. A non radial symmetric temperature distribution was observed and is accompanied by a non radial symmetric distribution of the electrical field and therefore the electrical power. The influence of this deviation of a non-Gaussian field distribution will be subject to additional investigations. The detailed analysis of the temperature evolution as function of the absorbed mm-wave power has to await the quantification of the mode composition. In future experiments also long pulse measurements are planned.

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