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Investigations of microwave absorption of surface modified CVD diamond disks for fusion applications

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This paper addresses the influence of the structure and the impurities of CVD diamond to its high frequency (microwaves and THz-radiation) transmission and absorption properties. The application is the Electron Cyclotron Resonance Heating and Current Drive System (ECRH&CD) for future plasma fusion reactors like ITER and DEMO. The vacuum and tritium barrier to the ITER vacuum vessel is realized by a CVD diamond disk window assembly transmitting up to 2 MW microwave power via waveguides at a frequency of 170 GHz. The typical dimensions of the diamond disk are 75 mm diameter and 1.11 mm thickness. Diamond has an extremely high thermal conductivity of about 2100 W/Km and a very low loss tangent of tan $\delta < 10^{-5}$ for this frequency and shows therefore a very small microwave absorption, characterized by the effective loss tangent tan δ. Typically, each mm thickness of diamond absorbs 100 W per 1 MW microwave power transmitted through the CVD diamond window when the effective loss tangent is $\tan\delta = 10^{-5}$. The optimized microwave assisted CVD process of IAF/Diamond Materials Freiburg/Germany allows to fabricate disks with a loss tangent of $4 \cdot 10^{-6}$. After brazing the diamond disk into a copper cuff/SS housing only a small influence by impurities increases the loss tangent to $6 \cdot 10^{-6}$. That microwave absorption is outstanding low in comparison to former available CVD qualities. Theoretical predictions result in loss tangent values of about 10^{-8}. By special surface treatment in plasma processes, especially the surface microwave losses could be reduced by two orders of magnitude. A comparison of the theoretical models for the absorption loss mechanisms with the high frequency measurements in a Fabry-Perot resonator setup will be discussed. Additionally, first experiments by using methods of surface passivation with thin hetero-layers will be presented.

Keywords: CVD Diamond, dielectric loss tangent, loss mechanisms, microvaves