Computer Experiments on Magnetrons with 3D Electromagnetic Particle Code

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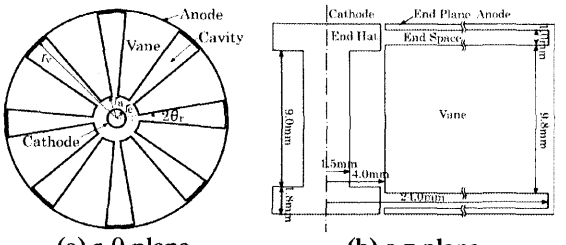
The objectives of the current study are to analyze the electromagnetic interactions with the electrons drifting around the cathode in magnetrons [1] by performing 3D electromagnetic particle simulations [2]. It is very difficult to analyze theoretically the electron resonance with the electromagnetic field in the internal space bounded by complex shaped conductors of magnetrons. Therefore, we newly developed a 3D simulation code with electromagnetic particle model for the magnetron analysis. The simulation model is shown in Fig.1.

We analyzed the effects of the complex 3D internal structure of a magnetron on the microwave enhancement and electron behavior. We particularly examined the effects of end-hats and end-spaces attached on each side in the z-axis direction. We discussed the relations between the resonance frequencies and the axial structures of magnetrons by using an equivalent circuit. Fig.2 shows the temporal evolution of the spatial distribution of electrons in the interaction space. Just after we begin the emission of electrons from the cathode, emitted electrons gather around the cathode and form Brillouin flow. The density fluctuation of electrons gradually occurs in the θ direction, and the fluctuation of electrons grows and forms electron spoke. When the electron spoke is achieving the anode, the shape of the spoke starts to change. Electrons are gathered around the center of the z-direction and there is a space which no electrons exist around the each edge of the z-direction.



(a) r-θ plane (b) r-z plane

Figure1: 3D simulation model

We also performed computer experiments with inhomogeneous magnetic field applied along the axis direction in the internal magnetron. Finally, we investigated the effects of the electron emission from the cathode on the microwave enhancement. We hired two models of electron emission from the cathode. One is the model in which a limited region for the electron emission is assumed on the cathode, and the other has emission shields around the cathode. In the first case, we observe the same microwave emission as observed in the case of uniform electron emission, although some electrons are diffused along the axis direction. In the second case, we could see the initial phase of electron bunching. However, it turned out that no intense microwave was enhanced. We conclude that the microwave emission can depend on the manner of electron emission from the cathode, which has to be examined by different parameters of electron emission as a future work.

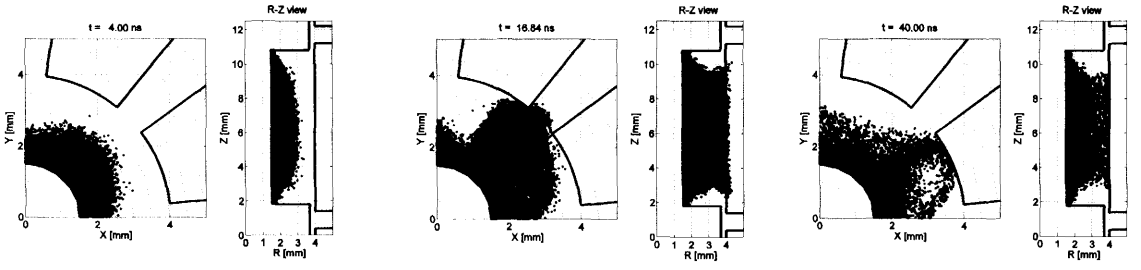


Figure 2: Electron distribution at different times

ACKNOWLEDGMENTS

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