On the use of Doubly Conformal Electrodes in Vacuum Diodes for High Power Microwave Applications

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Abstract**—** This paper evaluates the use of double conformal electrodes in Vacuum Diodes for High-Power Microwave applications. It was found that having both conformal cathode and anode, produces a more uniform electric field distribution, resulting in higher emitted current. This is illustrated by comparing the beam current emitted by a traditional planar geometry and the proposed double conformal geometry. The results were obtained by particle in cell simulation.

Keywords- Conformal Electrodes, High Power Microwaves sources, Field emission.

I. CONFORMAL VS PLANAR ELECTRODES

In a vacuum diode, parameters such as the emitted current, the electron diffusion and the beam current density distribution [1] have a large impact on the performance of quality of the beam. Moreover, those parameters are highly influenced by the electrostatic field, defined by the boundary conditions imposed by the surface of the electrodes.

It has been demonstrated that Conformal Electrodes produces uniform electric field distribution over the emitting surface [2]. This characteristic allows increasing the effective emitting cathode surface and the uniformity of the current distribution. Another advantage is the capacity to reduce the electron diffusion resulting in the improvement of the beam efficiency.

As example, Figure 1 compares the electric field of the diode presented in [3] with a proposed conformal diode designed to have an equivalent emitting area and gap. Magnitude of the electric field is shown using colormap, direction using arrows.

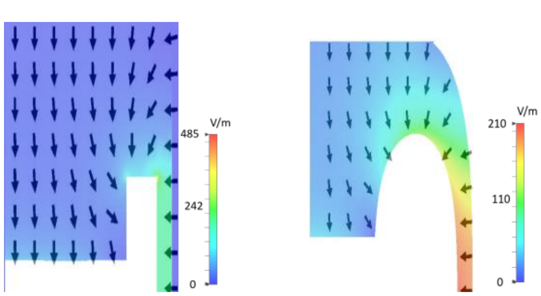

Figure 1. Electric field for planar [2] (left-hand) and conformal electrode (right-hand)

II. RESULTING BEAM

The planar diode reported in [3] produced a peak diode current of 21 kA, with a diffusion of 30 %, for an effective current of 14.7 kA. This geometry was simulated in CST-Particles in cell simulations with Explosive Electron Emission, obtaining a current of 22.5kA. The electron diffusion obtained from the simulation was 38% resulting on a beam current of 14 kA.

The same kind of simulation was performed on a conformal diode, obtaining a current equal to 26.3kA. The electron diffusion was 22 %, resulting on a higher beam current of 20.5 kA.

Simulations were performed for a double exponential signal of 290 kV peak. The diodes charge distribution is shown in Fig. 2. For the planar diode, charge concentrates in the border and center, being this the reason for the high electron diffusion. Whereas for the conformal, the charge presents high uniformity.

III. CONCLUSIONS

This example illustrates that diodes with double conformal electrodes improve the concentration of electrons in the beam when compared to planar profiles. This type of geometry is a promising idea that might be considered in HPM. In future works, electrodes will be experimentally compared in terms of effective emission area.

REFERENCES

[1] V. G. Baryshevsky et al., “Generation of High-Current Electron Beams in Diodes With Large-Area Explosive Emission Cathodes,” IEEE Trans. Plasma Sci., vol. 44, no. 7, pp. 1103–1111, Jul. 2016, doi: 10.1109/TPS.2016.2572043.

[2] R. Schinzinger, and P. A. A. Laura, “Conformal Mapping, Methods and applications”, Dover publications, Inc. New York, 2000

[3] E. H. Choi, M. C. Choi, Y. Jung, M. W. Choug, J. J. Ko, Y. Seo, G. Cho, H. S. Uhm, and H. Suk, “High-power microwave generation from an axially extracted virtual cathode oscillator,” IEEE Transactions on Plasma Science, vol. 28, no. 6, pp. 2128–2134, Dec 2000.

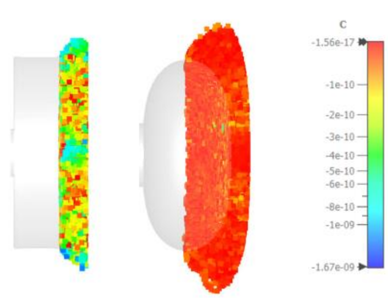

Figure 2. Charge distribution in the diodes. Left hand: planar diode. Right hand: conformal electrodes.