Investigation On The Role Of Aperture Wall Thickness for The Generation Of Sheet Electron Beam Using COMSOL Multiphysics®

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INTRODUCTION:

- With increase of operational frequency of the microwave devices, the dimensions of the beam-wave interaction region gets reduced
- In THz frequencies, the dimensions are in sub millimeter ranges for which high current density electron beam is required
- For planar interaction structure, the sheet beam is required for the maximum beam-wave interaction
- Dimensions of hollow cathode aperture wall plays a major role in efficient sheet electron beam generation
- The role of the hollow cathode aperture wall thickness for high current density sheet electron beam has been reported

COMPUTATIONAL MODEL:

A 2D hollow cathode geometry has been modeled with different aperture wall thickness in COMSOL®.

UTILIZED MODULE :

The present work is carried out using the Plasma Module of COMSOL Multiphysics®. Argon is used as the inert gas in the model. The electronically excited states can be lumped into a single species, which results in a chemical mechanism consisting of only 3 species and 7 reactions.

Reaction	Formula	Type	Δε(eV)
1	e+Ar=>e+Ar	Elastic	0
2	e+Ar=>e+Ars	Excitation	11.5
3	e+Ars=>e+Ar	Super elastic	-11.5
4	e+Ar=>2e+Ar+	Ionization	15.8
5	e+Ars=>2e+Ar+	Ionization	4.24
6	Ars+Ars=>e+Ar+Ar+	Penning ionization	-----
7	Ars+Ar=>Ar+Ar	Metastable quenching	-----

Table 1. List of volumetric plasma chemical reactions considered

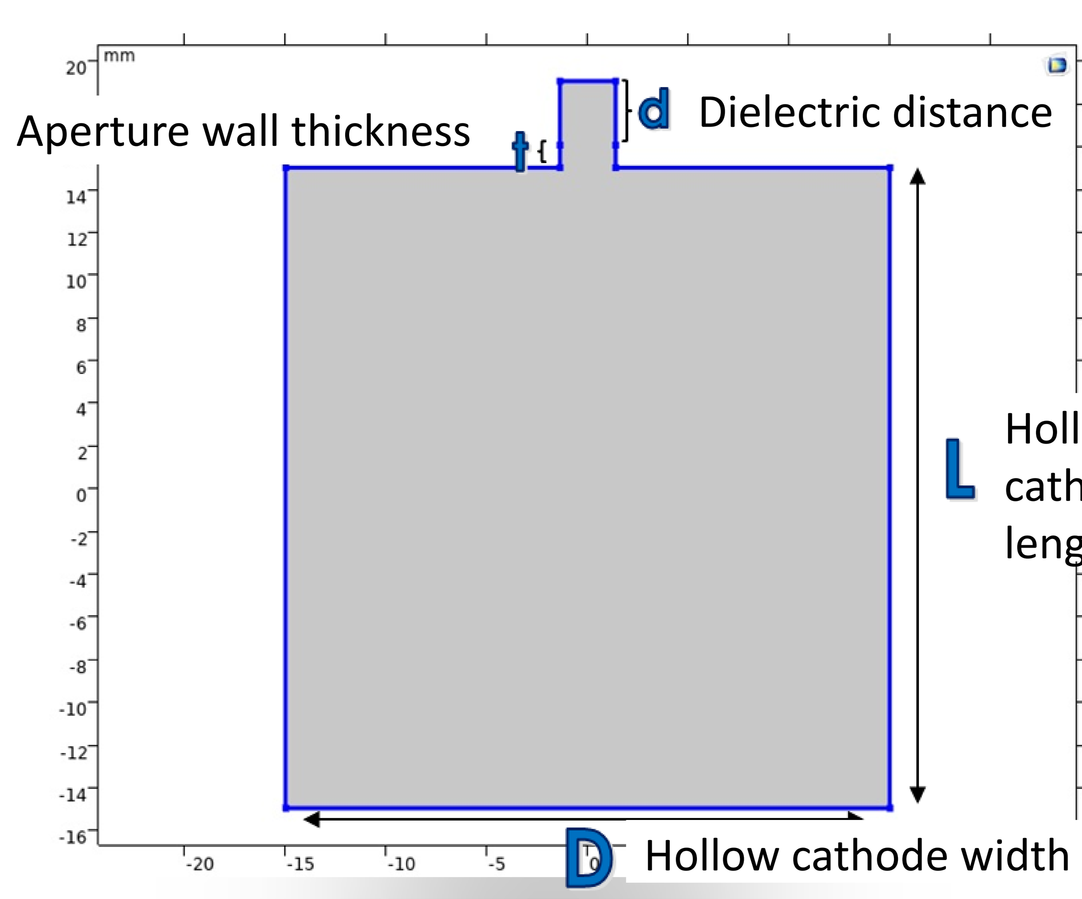

Figure 1. simulation model of hollow cathode in single gap Pseudospark configuration

RESULTS: It is observed that :

- With the change in aperture wall thickness, the change in field penetration inside the hollow cathode (at T= 51 ns) is as shown in figure 2 and 3.

RESULTS:

- The change the electron beam current and the hollow cathode phase with respect to the change in aperture wall thickness (ranging from 1.05 mm- 3.65mm) has been shown in figure 4.

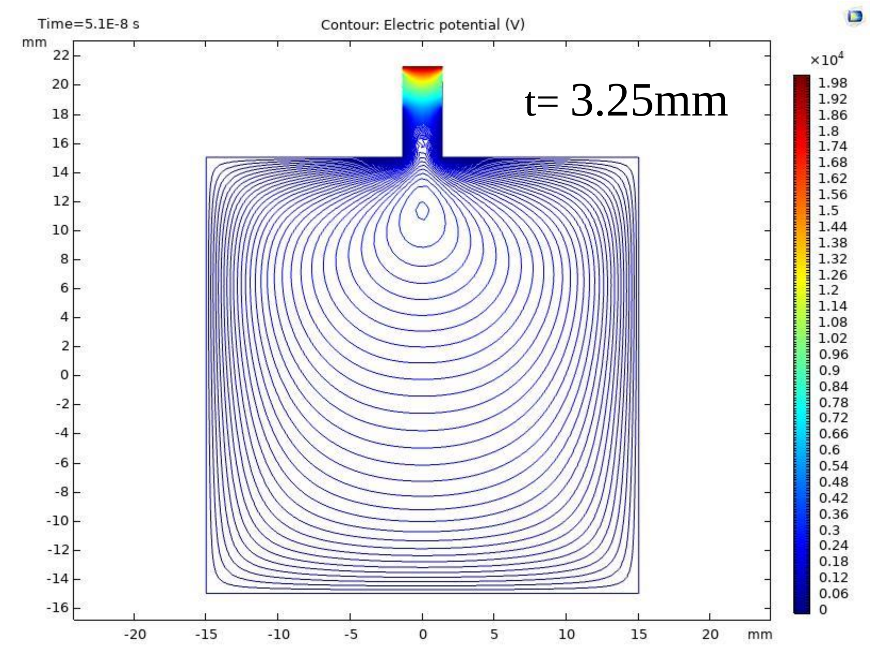

Figure 2. Electric field contour at 51ns for wall thickness of 3.25mm.

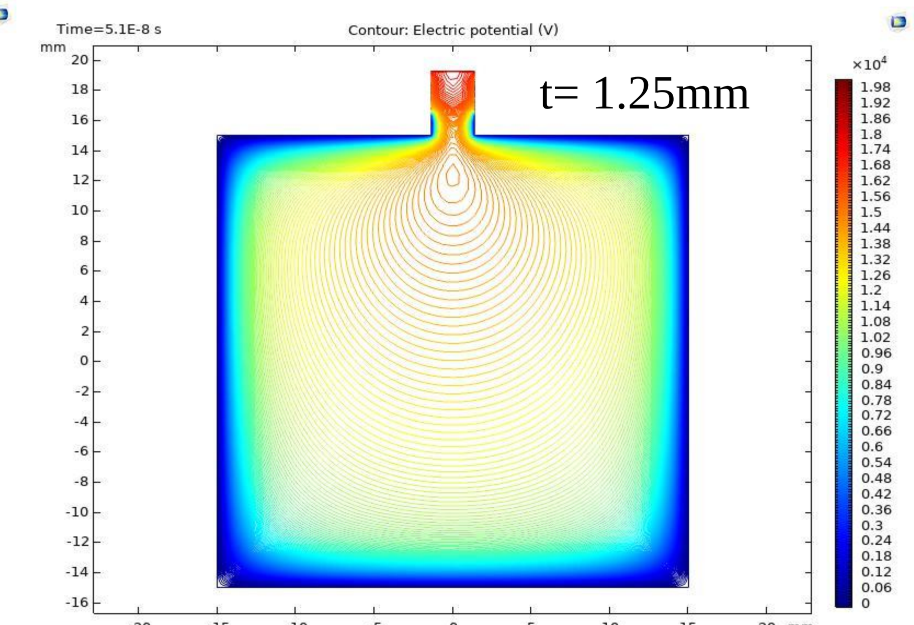

Figure 3.Electric field contour at 51ns for wall thickness of 1.25mm.

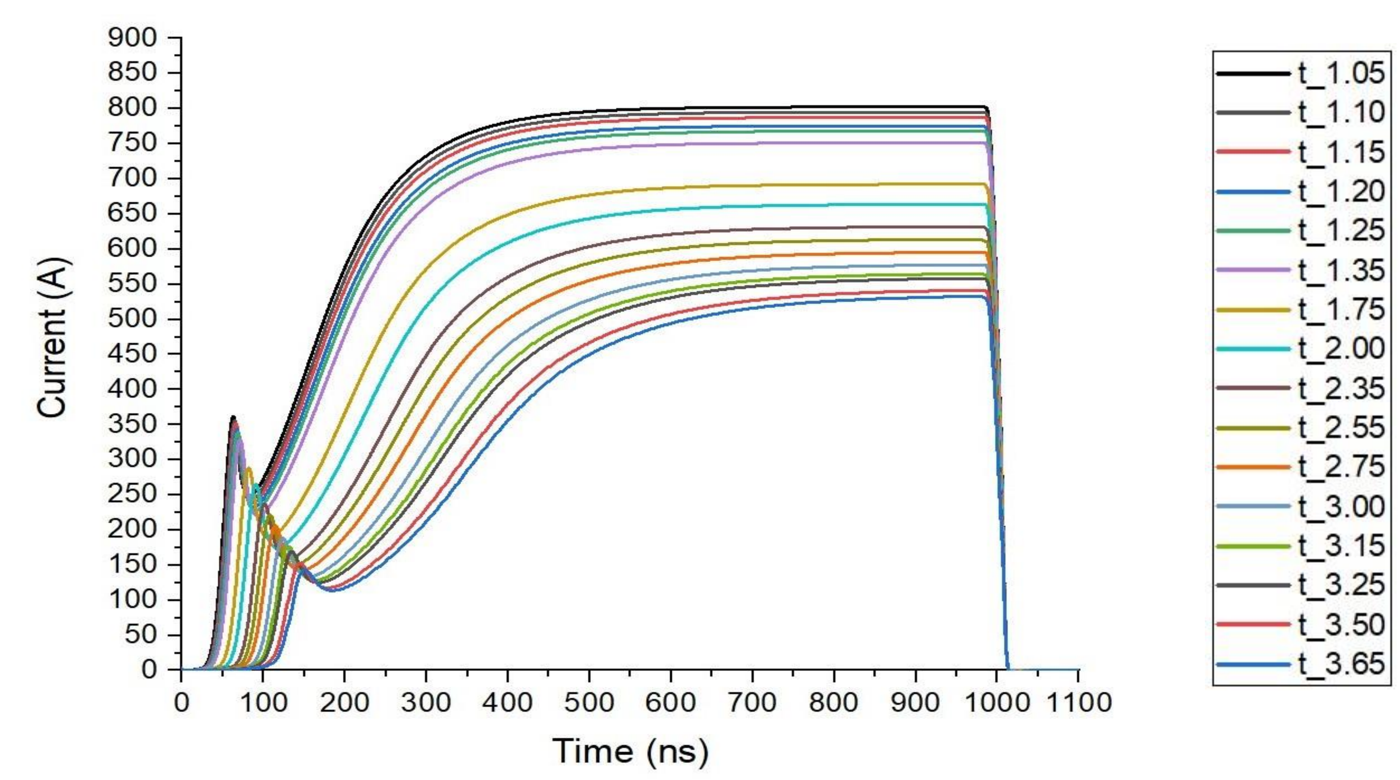

Figure 4. plot of beam current vs time for different wall thickness 't' that varies from 1.05mm to 3.65mm

DEVELOPMENT WORK: Based on the simulation results, hollow cathode has been fabricated with optimized aperture wall thickness and other geometrical parameters.

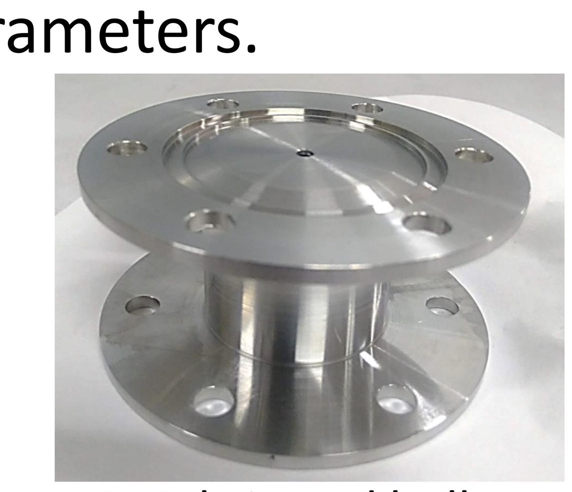

Figure 5. Fabricated hollow cathode isometric view

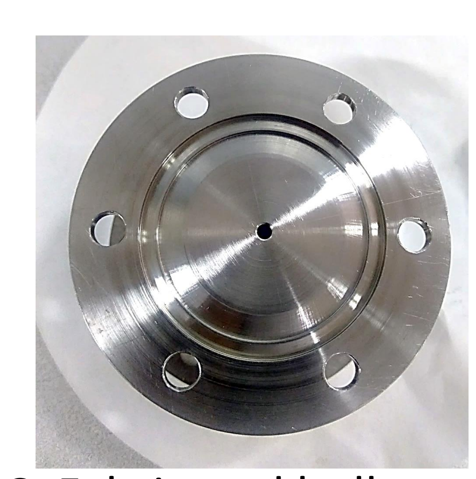

Figure 6. Fabricated hollow cathode top view

CONCLUSIONS:

- With increase in wall thickness from 1.05mm to 3.65mm the hollow cathode phase gets delayed by 58% while the value of peak current in Hollow cathode phase reduced by 60%.
- The duration of Hollow cathode phase increases by 55% and the maximum beam current reduced by 33%.
- The hollow cathode with optimized parameter, capable of producing high current density and suitable for sub-THz generation has been fabricated.

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