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Hop Funnel and Field Emitter Array Interaction

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Abstract

Investigate the use of hop funnels with field emitter arrays (FEAs) as a method to improve FEA performance for use in various microwave vacuum electron devices (MVEDs).

Disciplines

Electrical and Computer Engineering

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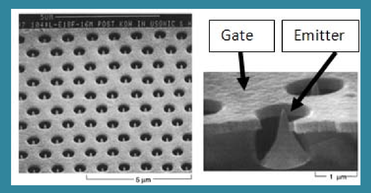
Objective:

Investigate the use of hop funnels with field emitter arrays (FEAs) as a method to improve FEA performance for use in various microwave vacuum electron devices (MVEDs).

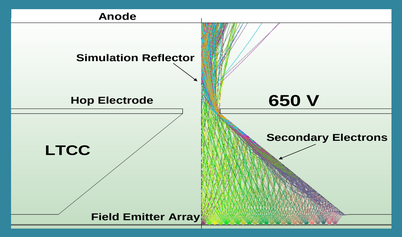
Background:

• MVEDs such as magnetrons, crossed field devices, flat panel x-ray sources, etc. all require an electron source
•Field emitters could replace thermionic electron sources and can be spatially and temporally controlled



Spindt-type field emitters (D.Temple)

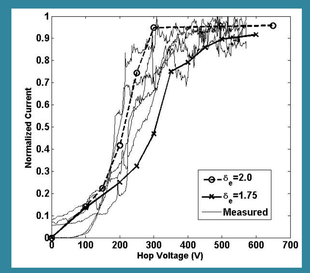
•Hop funnels can improve FEAs by increasing emission uniformity and electron current density
•Hop funnels use secondary electron emission from a dielectric surface to cause electrons to “hop” across the surface
•The funnel is sloped to enable hopping, concentrate electron emission, and protect the FEAs
•An electrode is placed at the hop exit to create an electric field to pull the electrons out of the hop funnel



Lorentz simulation showing electron emission from a hop funnel

Experiment:

•Previous work shows that hop funnels can be used with FEAs

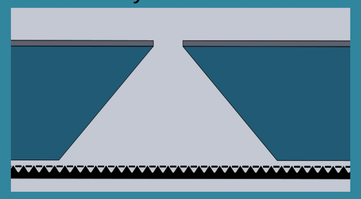


I-V Characteristics (Browning)

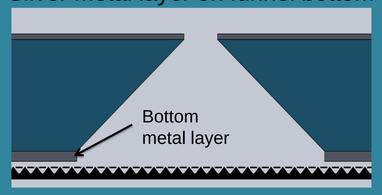
•Previous work included both simulation and experimental data
•Simulation was done using Lorentz2E with different dielectric parameters
•This graph shows the results of both the simulation and experimental work preformed

•Unknown if charging on the underside of the hop funnel structure affects the funnel characteristics
•Measure I-V characteristics of two funnel types:

No metal layer on funnel bottom

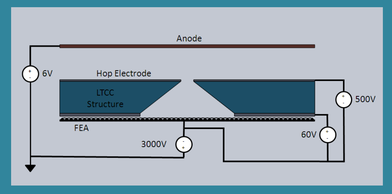


Silver metal layer on funnel bottom

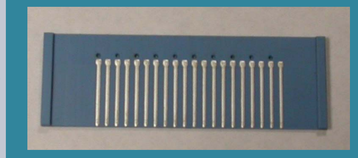


Test Structure:

• Fabricated at Boise State University using a Low Temperature Co-Fired Ceramic and thick film metal electrodes
•This test structure has 10 hop funnel holes and was used to make measurements
•An anode was placed above the funnel to measure I-V characteristics (anode current vs. hop voltage)



Test Setup

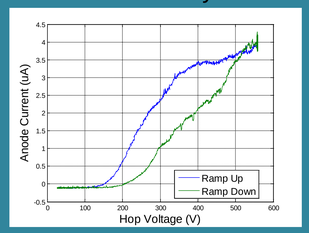


Physical Hop Structure

Data:

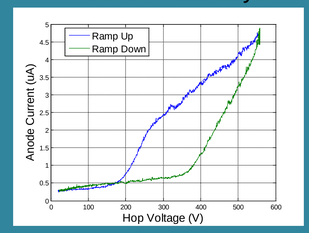
•The I-V characteristic of each hop funnel was measured for
✓two different ANODE electric fields
✓with and without metal layer on funnel bottom
•Two important aspects of IV
✓Voltage at which current reaches saturation
✓Voltage at which current begins to leave the hop funnel

No Metal Layer



Field at Hop Exit= 50V/mm

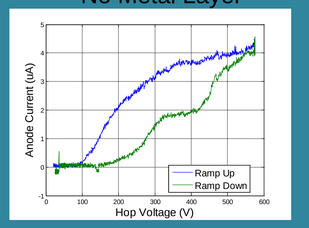
Silver Metal Layer



Field at Hop Exit= 50V/mm

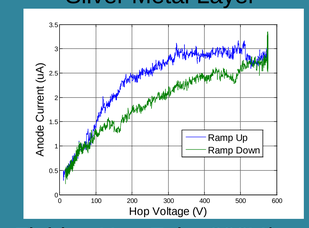
•At 50V/mm the I-V curves never reach saturation
•No significant difference from bottom metal layer
•No effect on hysteresis

No Metal Layer



Field at Hop Exit= 200V/mm

Silver Metal Layer



Field at Hop Exit= 200V/mm

•At 200V/mm the I-V curve shows strong difference with and without bottom metal layer
•Current reaches saturation
•Current does not go to zero with bottom metal layer

Future Work:

•Use three electrode energy analyzer to measure energy distribution of exiting electrons
•Conduct additional experimental and simulation work to determine the cause of hysteresis in the curves
•Run additional simulations to discover why I-V curves vary with different electric fields at the hop funnel exit

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