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Shielded Cold Cathode Magnetron (SCCM)

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Abstract

A magnetron is a vacuum device that uses the interaction of electrons and an electric field to generate microwaves. Magnetrons are often used for radar systems. Current magnetrons create electrons by heating a tungsten wire to the point that it emits electrons. These systems waste large amounts of energy and are difficult to control. A shielded cold cathode magnetron is a new magnetron design that has the potential to greatly improve the magnetron's efficiency. These new magnetrons utilize arrays of gated field emitters to inject the electrons into the electric field. These field emitters must be protected from electron bombardment inside of the cavity, so a ceramic structure is incorporated into the design. The field emitter structure consists of emitter tips paired with gates; the electron motion is controlled by a pusher electrode. These emitter gate pair arrays can be individually addressed, thereby allowing control of electron injection. The ceramic structure is fabricated using a Low Temperature Co-Fired Ceramic and thick film metal electrodes. This structure is designed to shield the emitters from back bombardment by electrons and ions. Performance can be measured using segmented collectors and energy analyzers. The results from the design, fabrication, and testing of a shielded cold cathode test structure will be presented.

Disciplines

Engineering

Shielded Cold Cathode Magnetron (SCCM)

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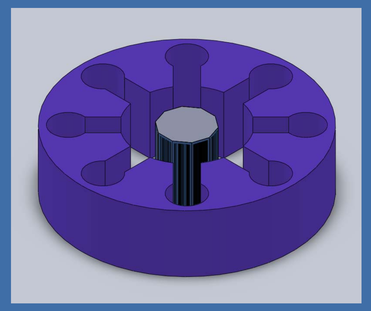
Objective:

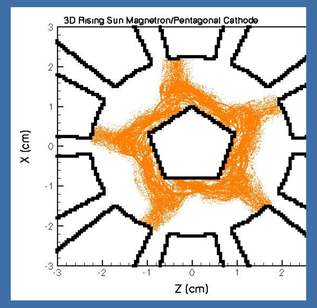
Test an experimental shield structure to allow use of field emitters in radar system magnetrons.

SCCM Design:

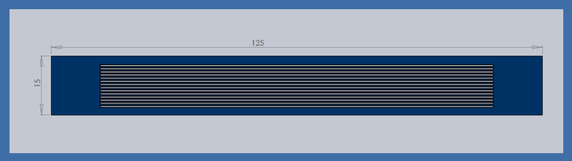
• Current Magnetron designs implement cylindrical slow wave anodes and thermionic cathodes to generate microwaves.
• A shielded cold cathode magnetron uses shielded emitters to inject electrons into the interaction space.
• A SCCM magnetron uses faceted plates with slits
•An example implementation shown below has ten facets each containing as many slits as possible



Faceted cathode design



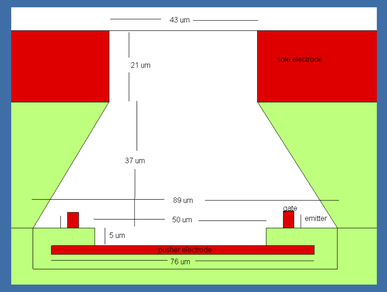
ICEPIC simulation using 5 facets (J. Watrous, NumerEx)



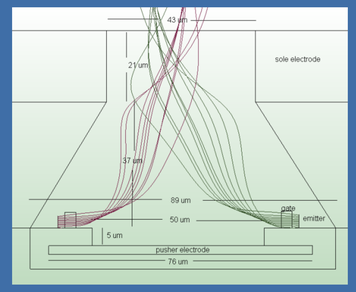
Single facet slit structure design

Shielded Structure:

•Field emitters must be protected from electron and ion bombardment
•A sloped slit structure is used
•The slope of the slit wall must be steep enough to avoid electron hopping, but shallow enough to ensure emitter protection
• Each emitter tip is paired with a gates and the electron motion is controlled by a pusher electrode
•These emitter gate pairs can be individually addressed, thereby allowing control of electron injection



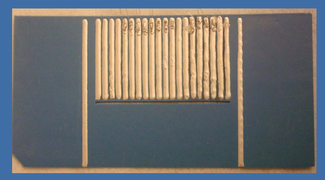
Shielded structure design



Lorentz simulation showing electron emission from slit.

Test Structure:

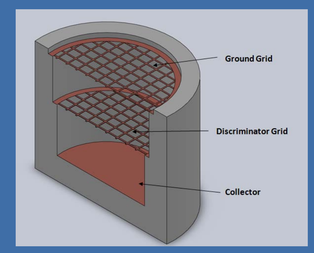
• Fabricated at Boise State University using a Low Temperature Co-Fired Ceramic and thick film metal electrodes
•This test structure has one slit and was used to measure electron emission



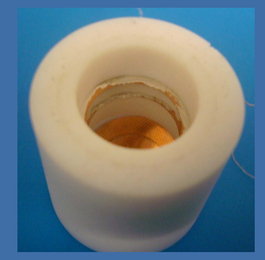
Test Structure fabricated from LTCC

Data:

•An energy analyzer was used to measure the energy of the electrons exiting the slit
•Energy measurements determine whether electrons strike the slit walls
• For magnetron performance, electrons should exit at energy of emitter

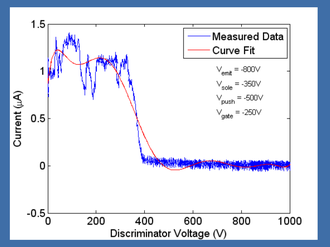


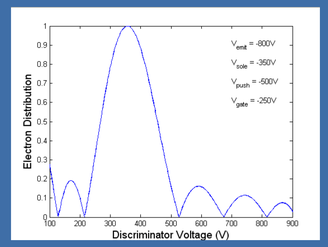
Energy analyzer design

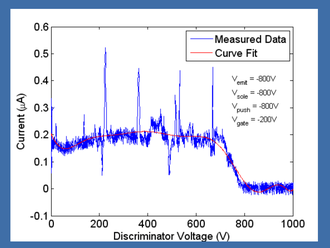


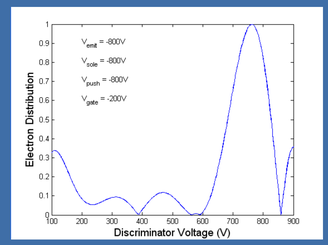
Energy analyzer fabricated using Teflon tubing

Measurements from Energy Analyzer:









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