Magnetic field effect on electron beam from a ferroelectric electron gun

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1. Abstract
The influence of magnetic field on electron emission from a ferroelectric electron gun is experimentally examined and presented. Annular ferroelectric (FE) electron gun with ~4A electron beam current, suitable for gyrotron tubes, was experimentally tested. The electron current was measured with different magnetic fields. It was found that increasing the magnetic field extends the emitted current until a maximal working point is reached. Magnetic field above this point reduces the emission. A 20% enhancement in the emitted current relative to the emission in the absence of a magnetic field is obtained. CST simulations were made to describe the electron beam propagation under the influence of the magnetic field. Another observation relates to the gap closure and breakdown effects. The influence of the magnetic field on these effects is also reported. A suitable working point for an electron tube is chosen according to these observations.

2. Experimental Setup.
The experimental was base on a FE electron gun containing a FE cathode with a 12mm diameter annular front electrode. The cathode was placed inside an insulating ceramic cylinder forming the electron gun as shown in Fig. 1. An axial magnetic field was induced by a 20 cm long and 16.5 cm diameter gun solenoid placed around the electron gun. The cathode was located in the center of the solenoid. The gun solenoid was operated with DC current or pulsed current supplies.

3. Experimental results.

![Figure 1. The gun schematic.](image)

![Figure 2. Electron current as a function of the gun solenoid magnetic field for the pulsed (green marks) and the DC (blue marks) power supplies.](image)

4. Simulation results

![Figure 3. Electron current measurements: (A) without magnetic field, (B) magnetic field of 80 G, (C) magnetic field of 100 G with a 'tail' at the pulse end started, (D) magnetic field of 250 G, it can be seen that the current 'tail' last for longer duration in the last two measurements.](image)

![Figure 4. CST simulation of electron trajectories for varies magnetic field, (a)B=0 G, (b)B=90 G, (c)B=150 G, (d)B=800 G.](image)

5. Conclusion.
From the presented results, it can be seen that the magnetic field is an important factor in the FE electron emission behavior. Two observations are seen. (A) There is a dependence of the emitted current on the magnetic field. An increase of the emitted current related to the increment of the magnetic field is seen, up to a maximum of about 20% enhancement in the emitted current relative to the emission in the absence of a magnetic field. The maximal current obtained in this specific configuration was ~5.4 A. Variations of the configuration such as radius of the electrodes, operative voltage, and longer excitation triple point line, can increase the maximal emitted current. Simplified model of the electron beam with a hollow rigid cylindrical cross-section was used for calculation of the space charge limiting current without a magnetic field. A result of 5 A was obtained for the limiting current. This result is close to the experimentally measured maximal current. Also, the current in the presence of an infinite magnetic field was calculated. A result of 0.3 A was obtained, that resembles the experimental result obtained for 800 G. (B) A second observation is related to the pulse ending behavior. It is seen that when the magnetic field is above a certain value (90 G in our setup) the electron pulse does not end sharply together with the trigger pulse as it does for lower magnetic fields. When the magnetic field is strong enough, it influences the behavior of the plasma after the high voltage pulse. It restricts the plasma expansion and decay. The plasma continues to serve as an electron source while it exists. Therefore a current is obtained after the high voltage pulse is finished.


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