Institute of Applied Electronics
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PHYSICAL DESIGN OF AN S-BAND COLD CATHODE RF GUN

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Abstract

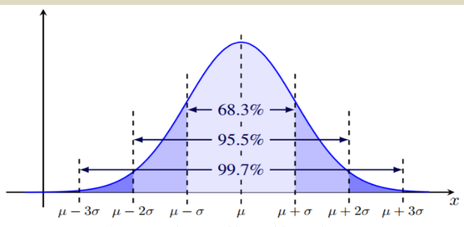
In recent years, the properties of new field emission materials have been gradually improved with the advancement of materials research fields, which have provided the possibility for the research and realization of cold cathode microwave electron guns. A 0.32+1 cell S-band microwave electron gun was designed based on the emission properties of carbon nanotube films and ultra nano diamond films. This article mainly introduces the selection of electron gun cavity, RF design and corresponding thermal analysis. The physical design results basically meet the design requirements.

Cavity type selection

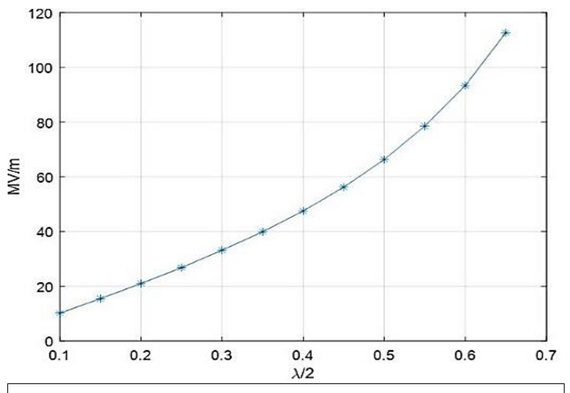
The distribution of field-induced emission current density in the microwave field.

$$J(t) = J_0 e^{-C\frac{\phi^{3/2}(\omega t-\pi/2)^2}{\beta E_0}{}^{2}}$$

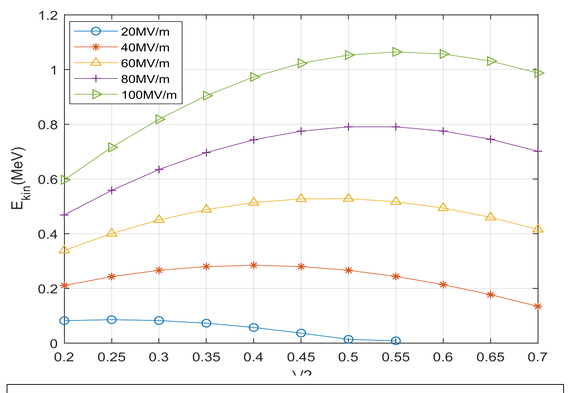
$$\sigma = \sqrt{\beta E_0/(C\phi^{3/2})}$$



Gaussian distribution



The relationship between the minimum field strength of the cathode plane required for the end electron overflow the first cavity and the length of the first cavity.

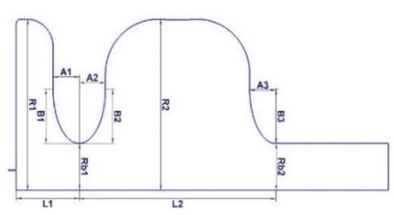


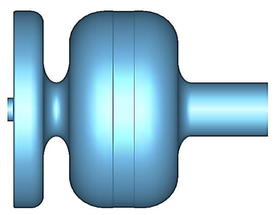
The kinetic energy obtained by electrons emitted at 90° phase vs. the length of the first cavity at different field strengths.

The cavity type is 0.32 cell + 1.0 cell .

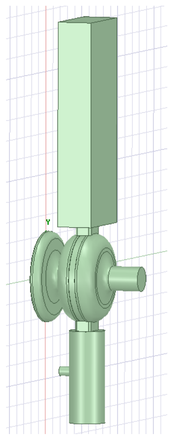
RF design

Cavity structure

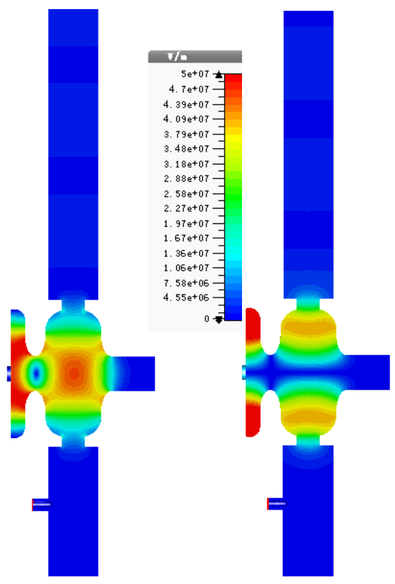


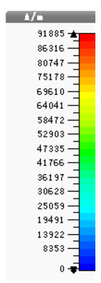


Basic structure of electron gun.

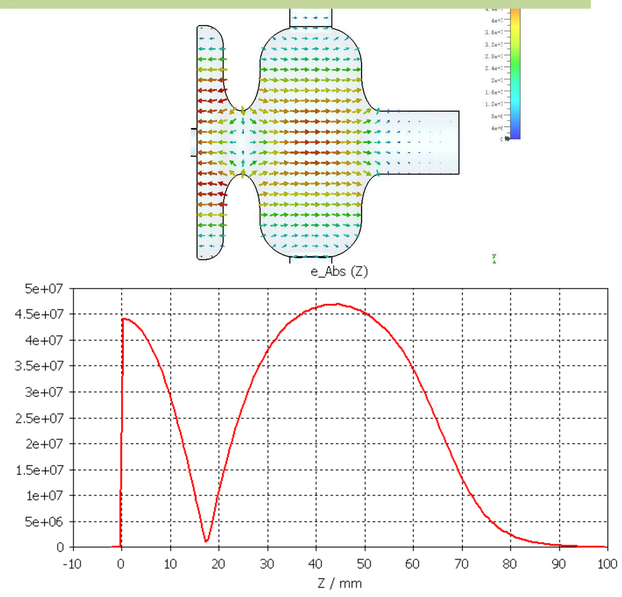


Eigenmode design and optimization





The electromagnetic field distribution.



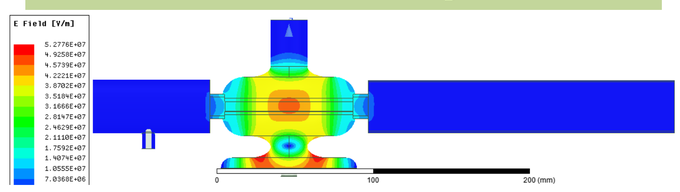
The axial electric field distribution of RF gun.

RF design

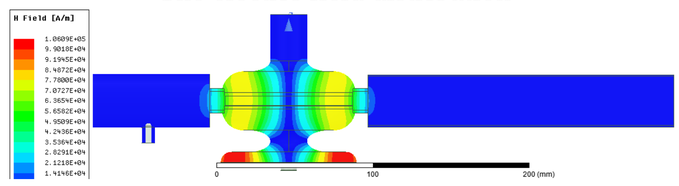
Optimization Results

Parameters	Value	*Unit*
f_0	2840.0139	MHz
f_π	2856.0492	MHz
E_2/E_1	1.0624	
β	1.0353	
R/Q	111.6220	MΩ/m
Q_0	11867.32	
Q_e	11462.89	

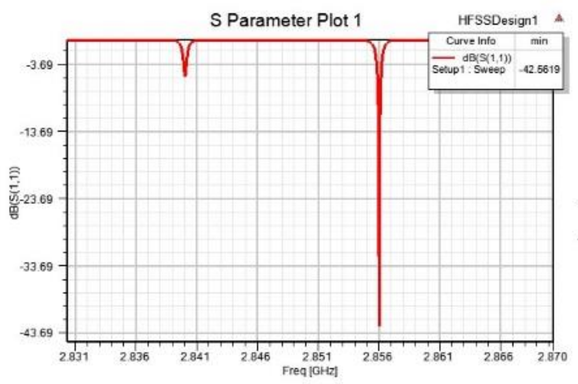
Drive mode verification

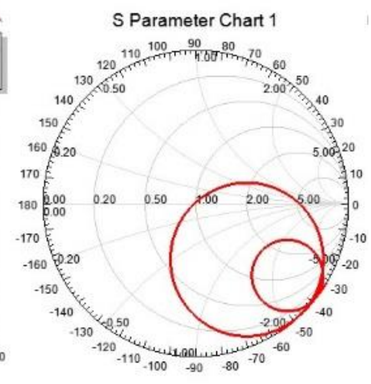


The electric field distribution



The magnetic field distribution.

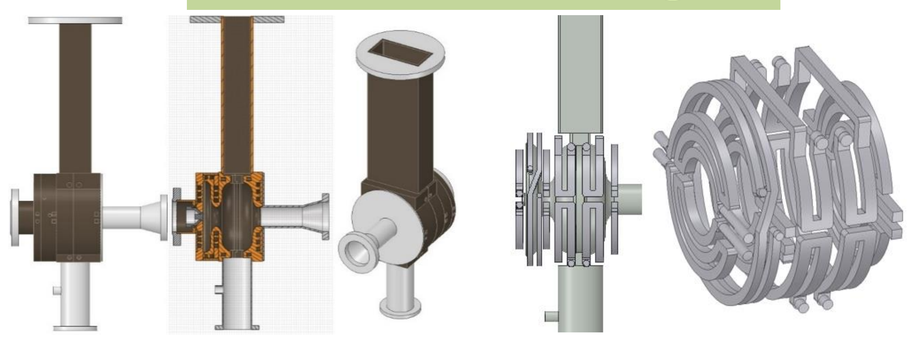




S_{11} parameter plot and SMITH chart.

Thermal analysis

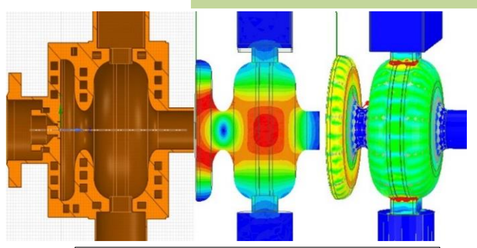
Mechanical design



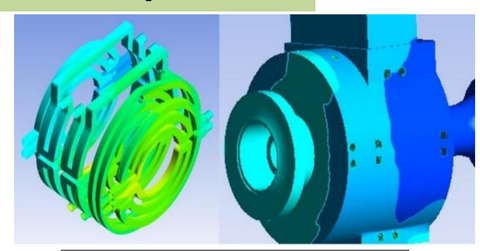
Mechanical design drawing

Waterway design drawing

Thermal analysis



The Rf gun cavity shape, electric field distribution and surface heat loss.



Temperature distribution of cooling water channel and chamber.

Conclusion

Completed the physical design of the S-band cold cathode RF gun.