UNIVERSITA' DEGLI STUDI DI ROMA Tor Vergata

Key-Holes Magnetron Design and Multiphysics Simulation

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Introduction: This paper describes the design and the characterization of an eight key holes resonant cavities X-Band Magnetron, operating in π mode, which undergoes the thermal-structural effects due to the cathode heating.

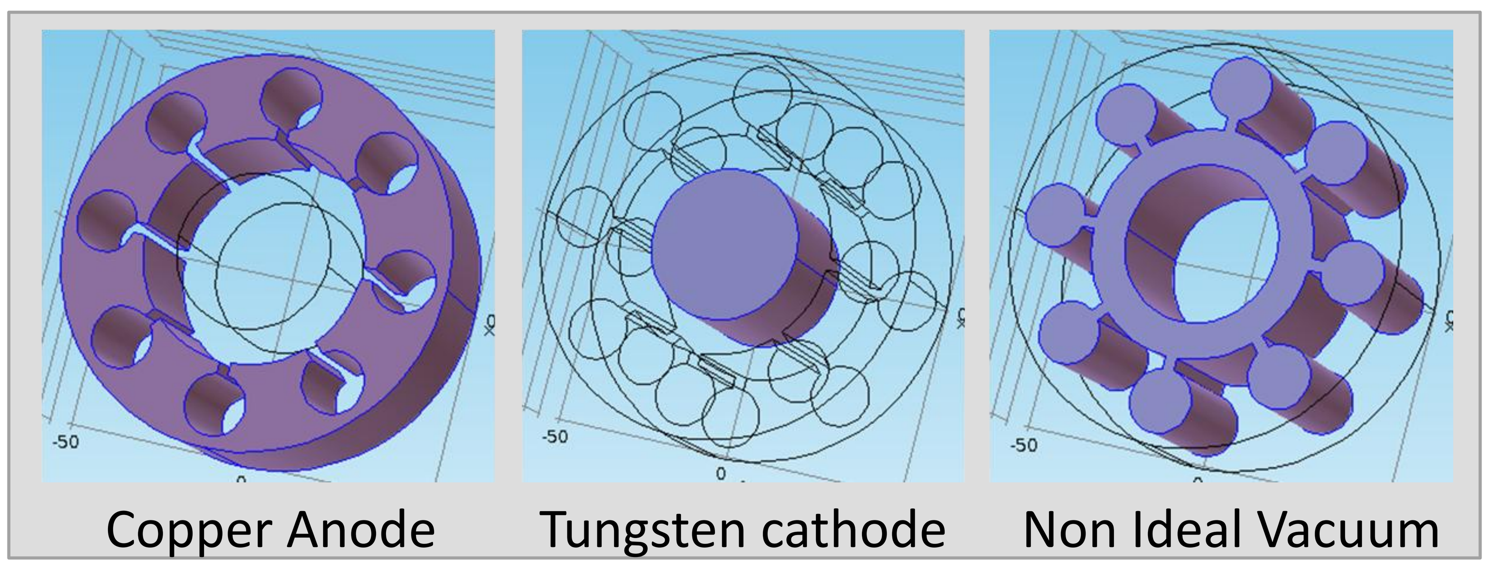

Figure 1. Magnetron geometry and materials.

Computational Methods: Thermal Stress (TS), Eigen-frequency (EF) and Particle Tracing (PT) analysis are coupled by Moving Mesh (MM) interface and by storing temperature information.

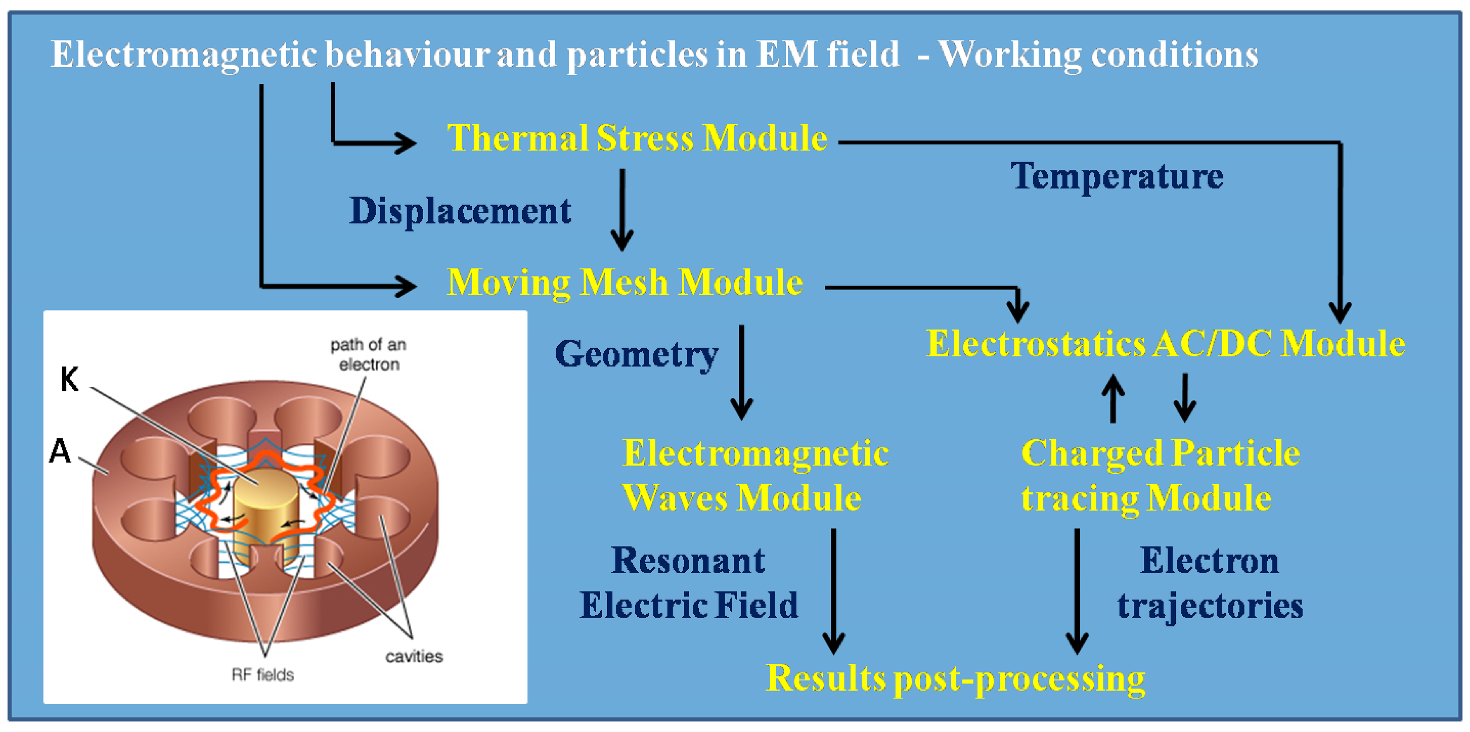

Figure 2. Computation Logical Diagram.

Critical field of the designed device can be described by (1) and (2) with $r_m=(r_a^2 - r_k^2)/(2r_a)$, where r_k and r_a are respectively the cathode and anode radii, *B* is the Magnetic induction field applied along the axial direction, *d* the anode cathode distance and *f* the operative frequency. A charge release discretization is given by (3), where *I* is the cathode current and *Δt* the time interval between releases.

$$B_C = \sqrt{\frac{2mV}{ed^2}} \quad (1), \quad V_C = \frac{1}{2}\pi B r_m df \quad (2), \quad N = \frac{I\Delta t}{e} \quad (3)$$

In order to decrease computational cost, the number of particle per release *N* has been reduced and a charge multiplication factor *n* has been introduced.

Results: Electromagnetic behavior and particle motion have been computed in Thermo mechanical operative conditions. By the superposition of resonant field and electron trajectories, operating working points have been individuated.

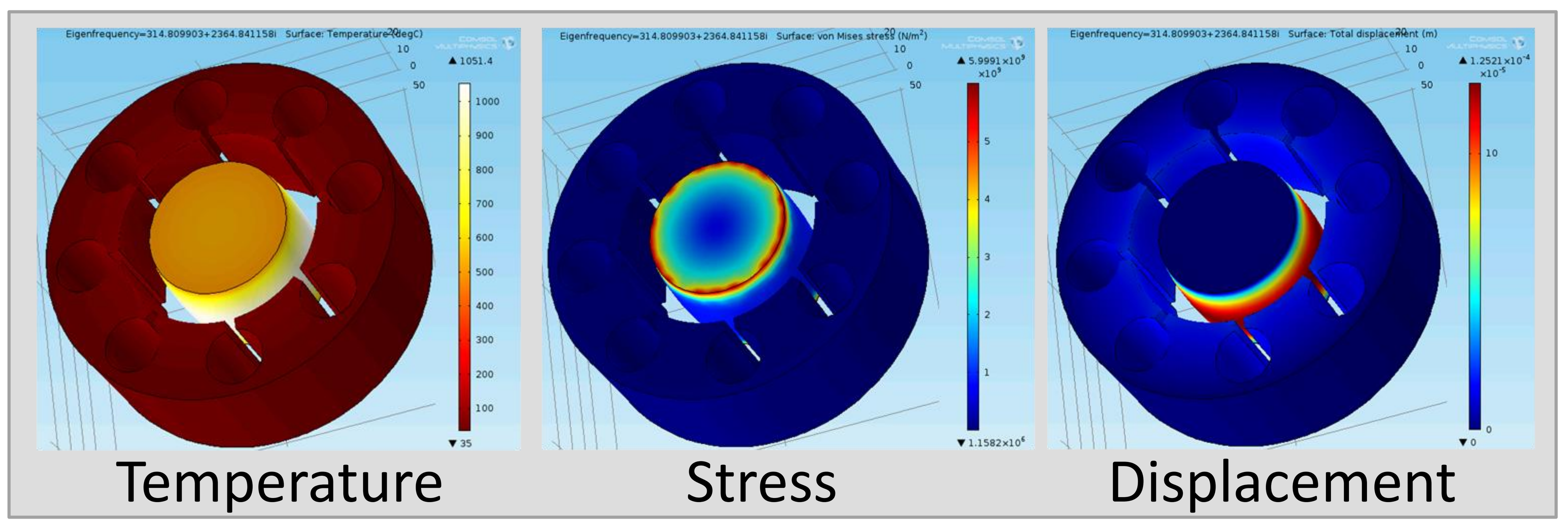

Figure 3. Cathode heating effects.

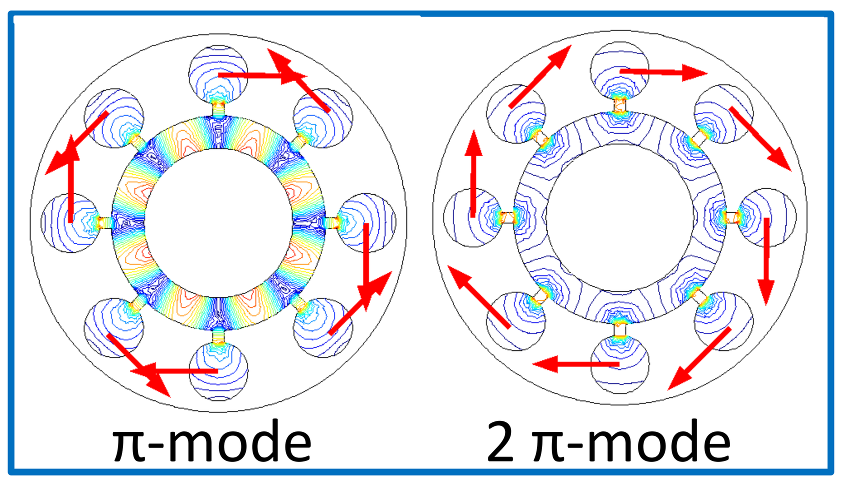

Figure 4. Resonant E-fields in working conditions.

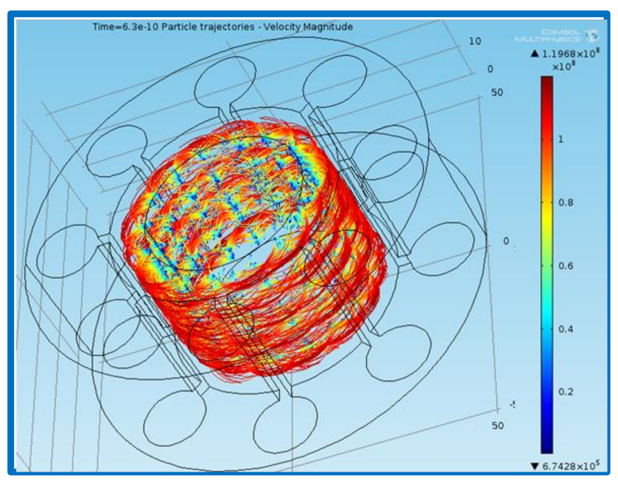

Figure 5. Velocity in working conditions.

	π mode	2π mode
Cold conditions	f_π = 9.061 GHz Q_π = 8300.	$f_{2\pi}$ = 3.673 GHz $Q_{2\pi}$ = 1000
Working conditions	f_π = 9.042 GHz Q_π = 8250	$f_{2\pi}$ = 3.663 GHz $Q_{2\pi}$ = 950

Table 1. Eigen-frequencies and Quality Factors.

Cold conditions	v_{Max} = 1.196·10[8] m/s E_{Max} = 7.94 MV/m
Working conditions	v_{Max} = 1.227·10[8] m/s E_{Max} = 8.03 MV/m

Table 2. Maximum velocity and Es fields.

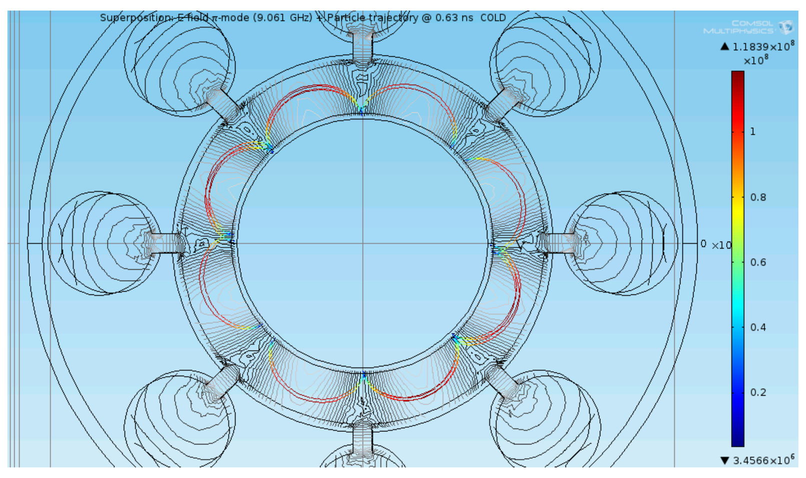

Figure 6. Resonant E-fields and particle trajectories.

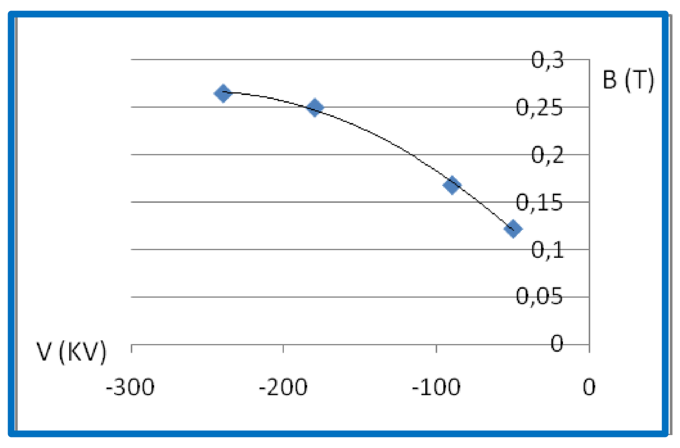

Figure 7. Magnetron working points.

Conclusions: By applying the design condition: *V*=60KV, *B*=1330G in order to have *I* =110A; this device, with a typical efficiency of 40%, can produce a pulsed microwave peak power of 2.64 MW.

References:

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