Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2008**	2. REPORT TYPE	3. DATES COVERED **00-00-2008 to 00-00-2008**
4. TITLE AND SUBTITLE **Effects of Perturbing B-Field Orientation on Magnetic Priming of a Relativistic Magnetron**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Plasma, Pulsed Power, and Microwave Laboratory,Department of Nuclear Engineering and Radiological Sciences,University of Michigan,Ann Arbor,MI,48109**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM002087. Proceedings of the 2008 IEEE International Vacuum Electronic Conference (9th) (IVEC 2008) Held in Monterey, CA on April 22-24, 2008. U.S. Government or Federal Rights License**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**2**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

P2.34: Effects of Perturbing B-Field Orientation on Magnetic Priming of a Relativistic Magnetron

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ABSTRACT

Experiments have been performed testing magnetic-priming [1, 2] at the cathode of a relativistic magnetron to study the effects on high power microwave performance [3]. Magnetic perturbations were imposed utilizing three, high-permeability nickel-iron wires embedded beneath the emission region of a 1.27 cm diameter cathode, spaced 120 degrees apart (for N/2 symmetry in an N (6) cavity magnetron). These three, high-permeability wires perturb both the axial and radial magnetic fields near the emission region of the cathode. Magnetic priming was demonstrated at UM to increase the percentage of π-mode shots by 15% over the baseline case in the relativistic magnetron. Improvements in microwave power, pulse width and start-oscillaion time were also observed.

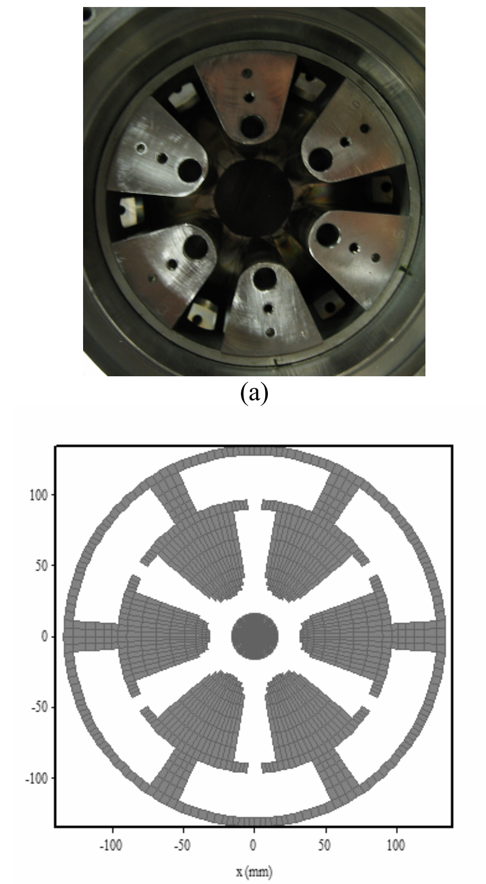
Earlier experimental research by Neculaes [2] and recent simulation work suggest that using permanent magnets with radially-directed remanence fields centered under the cathode emission region instead of high permeability wires can yield improved magnetron performance.

I. INTRODUCTION AND MODELING

The magnetic priming simulations used in this study were constructed using a combination of the Field Precision Magnum magnetostatics code and MAGIC PIC. The anode vanes of the simulation magnetron were designed to approximate the rounded vanes in the University of Michigan/L-3 relativistic magnetron anode block, as shown in Figures 1(a) and 1(b).

The simulation magnetron uses a larger diameter cathode (3.18 cm) than the previous cathodes employed in the experiment. This was done both to reduce simulation run time and to allow for comparison with larger cathode experiments planned in the future.

Priming magnets were modeled in the cathode as described previously and as shown in Figure 2. The magnetic field data for the cathode priming magnets were calculated using the Magnum code for remanent fields that are achievable in commercially available permanent magnets (0.5T). For these initial, idealized calculations, the magnetic permeability of the permanent magnets was assumed to be equal to that of free space. B Field data were calculated for two axial orientations (+z, -z) and two radial orientations (+r, -r).



(a)

(b)

Figure 1: (a) UM/L-3 magnetron anode block (coupling cavities not shown), (b) Simulation magnetron anode block and coupling cavities.

The final magnetic priming fields used in the PIC simulations, the magnetic field calculated by Magnum was then superposed on the global, uniform +z magnetic field imposed in the Magic PIC code.

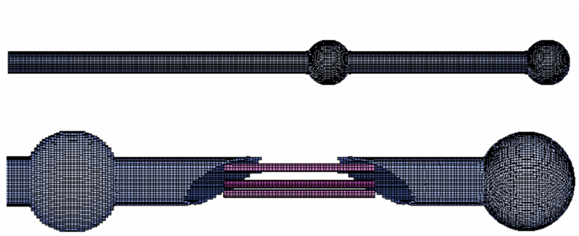
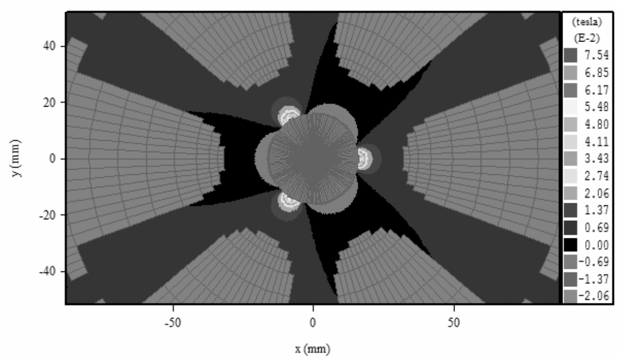
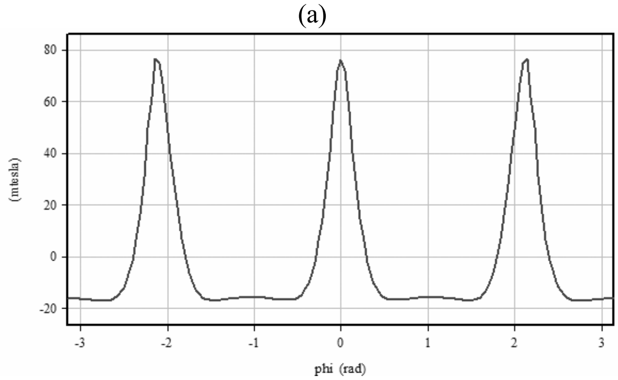


Figure 2: Wire frame schematic of the modeled magnetic priming cathode, showing magnet placement.



(a)



(b)

Figure 3: (a) Calculated contour plot of the radial component of the magnetic field near the cathode for the +r case. (b) Plot of the radial magnetic field component at the cathode surface for the +r case.

Figures 3(a) and 3(b) illustrate a contour plot of the radial component of the magnetic field and a plot of the radial component of the magnetic field close to the cathode surface for the +r remanent magnetic field orientation case.

III. RESULTS AND CONCLUSIONS

Figure 4 presents simulated RF electric fields for each of the five magnetic-priming cases explored. Magnetically primed magnetron performance in the case utilizing permanent magnets with +r directed remanence B fields was observed to perform better than either of the simulated, axially-directed remanent field cases (+z, -z).

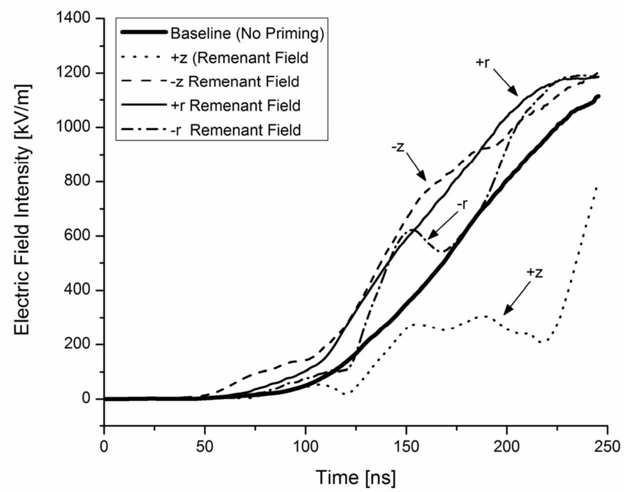


Figure 4: Simulated RF electric field for the four magnetically primed cases versus the baseline (no magnetic priming) case.

The +r directed remanence field case exhibited the fastest microwave startup, reaching saturation before the baseline case or either of the two axial-perturbation cases. Additionally, the +r case showed the least mode competition of the studied cases.

Experimental work is currently in progress to test the simulation results using magnetically-primed cathodes of various diameters. Both simulation and experimental results will be presented for these magnetic priming configurations.

ACKNOWLEDGEMENTS

This research was supported by the Air Force Office of Scientific Research, Air Force Research Laboratory and AFOSR MURI on Cathodes and RF Window Breakdown.

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