Numerical optimisation and development of magnetron for WPT applications

N. Faure*, P. Leveque*, D. Dumont**

**** IRCOM, UMR CNRS 6615, Faculté des Sciences et Techniques, 87060 Limoges, France.***
*****COVIMAG, Av. du 4 juillet 1776, Z.I. La Marquisie – BP25, 19101 Brive Cedex, France***
Email: nicolas.faure@etu.unilim.fr , leveque@unilim.fr

OBJECTIVE:

The originality of this work comes from the study of microwave tube with complete 3D code which take into account the physical phenomena related to the operation of the magnetron (static, electromagnetic, electromagnetic with space charge and thermics). This software makes possible to design the anode, cathode as well as other elements like the straps, the polar parts, the permanent magnets or the transition between cavity and output port. The objective of our work consists to improve and develop magnetron (2.45 GHz and 5.8 GHz) but also to study the stability and the spectral purity of the tube for synchronisation.

INTRODUCTION:

For wireless power transportation, several problems arise concerning the system of emission and reception. Indeed, it is possible to transport energy by electromagnetic wave, at the frequency 2.45 GHz for example. In order to generate this electromagnetic wave, a high power microwave tube like magnetron can be used. The magnetron is still one of the most important microwave tubes. It belongs to the group of electronics devices, which is also called cross-field devices.

METHOD AND RESULTS:

We determine, initially, the distributions of the electrostatic and magnetostatic fields within the structures to be analysed. The magnetostatic simulations allowing to design the polar parts and to determine the characteristics of the permanent magnets.

Then, we study the cavity without space charge. This study allows to identify the various modes present in the cavity and to appreciate the influence of various parameters such as the dimension of the elementary cavities, their number, the presence of straps etc. This knowledge is essential for the design of the cavity and a stable operation on the π mode[1].

The electron dynamics in a crossed-field cylindrical diode are analysed by using a tree dimensional code, which is a finite difference time domain program (FDTD) using the Particle In Cell (PIC) technique for simulating space charge effect[2],[3],[4]. The interaction between the electron beam and the field HF in the cavity is done via the force of Lorentz. In order to develop or optimise a source, it is necessary to produce a tool for simulate the physical phenomena inherent in the magnetron. That is why we developed, in parallel with the PIC code, a thermal software allowing to take account of the dissipation of heat in the anode. We are thus able to carry out total power assessments. The results on π mode operation (resonant frequency, efficiency, output power) are compared with the experimental results for two CW magnetrons at 2.45 GHz and 5.8 GHz with output power of 6 kW and 2.25 kW.

CONCLUSION:

Simulation allows to optimize, to develop microwave tube and to study the stability and the spectral purity of the sources according to various parameters like the supply voltage. We study the association of magnetron by phase locking, which is a technique planned to generate high power waves in much WPT application.

REFERENCES :

[1] G.B. Collins, " Microwave magnetrons ", McGraw-Hill, New York, 1948
Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955.
[2] C.K.Birdsall, A.B. Langdon, "Plasma physics via computer simulation" , McGraw-Hill Inc., New York, 1985.
[3] P.J. Mardahl, J.P. Verboncoeur, "Charge conservation in electromagnetic particle-in-cell codes", Comp. Phys. Comm., vol. 106, pp 219-229, November 1997.
[4] T.Umeda, Y. Omura, T Tominaga, H. Matsumoto, "A new charge conservation method in electromagnetic particle-in-cell simulation", Comp. Phys. Comm, August 11, 2003.