Recommendations and Predictions on the Future of Crossed-Field Devices

John M. Osepchuk, Ph. D.
Full Spectrum Consulting
248 Deacon Haynes Road
Concord, MAO 1742
Tel/Fax: 508 287-5849
E-Mail: 75754.3663@COMPUSERVE.COM

Crossed-field devices have enjoyed longevity and growth which has confounded many experts in the past who predicted their demise, especially because of their "excess noise" feature. This ubiquitous phenomenon in akin to that of "multipactor", a wide-spread phenomenon in microwave tubes, though its acknowledgment is avoided in the same fashion that people are averse to admitting the presence of "fleas" in their domiciles [1]. A half-century after the development of the modem magnetron, the crossed-field devices now includes the CFA, a key element in military radar, as well as beacon magnetrons, magnetrons for marine radar, diathermy and most importantly the "cooker magnetron", the heart of the microwave oven.

My recommendations on how to stimulate growth in this field can be characterized in three parts with differing overtones.

Altruistic View

I believe that the cooker magnetron affords modem researchers the ideal vehicle for assessing the validity and usefulness of modem compute codes now being developed for study of crossed-field interaction. The detailed substantiation of my position is in the paper I presented at this Workshop. Here, I'll stress only the key points. The cooker magnetron is now the only entity that resembles a universal standard for crossed-field research. It is inexpensive, stable in design, easily procured world-wide, and exhibits a crisp definitive and reproducible pattern of noise, spurious oscillation and quietness, not observed in any other crossed-field tube.

A computer code, if valid, must be able to predict these features. Beyond that, if the model yields verifiable predictions of the influence of various design parameters, then it will accrue credence as being appropriate for use in the more complicated CFA. The other side of the coin is: Can a computer code be valid if it doesn't predict the crisp features found in the cooker tube?

This exercise, if carried out, will not only help the military but will also help the microwave-oven industry (a "dual use") to find ways of mitigating the excess noise. International groups (e.g. CISPR) are already preparing interim specifications on out-of-band noise with the eventual goal of reducing microwave-oven noise which many fear threatens the many emerging "wireless" technologies which will operate in the 1 to 3 GHz microwave region (e.g. PCS, digital audio, broadcast, etc.).

National View

The ability and facility for large quantity manufacture of high-power efficient crossed-field devices exists only for one application, the cooker magnetron, and only in several Far East countries, principally Japan and Korea. This reality points to a significant void in the national treasures of the U.S. Long-range planners should look for opportunities to establish such a facility in the U.S. with potential applications to future military applications as well as commercial and consumer applications.

Proprietary Advances

I believe that a national goal should be the development of more low-cost magnetrons for different frequencies and different power levels. We have proposed this to NIST without any response or comment. We believe there are proprietary novel advances yet to come which will eventually stimulate economic forces to make available the wider supply of frequencies and powers at low cost.

Predictions

With respect to predictions, my view has been [2] and continues to be that there are many surprises to come. The history of this field exhibits this theme very well [2]--especially the fact that the magnetron survives despite expert predictions of its demise in the 50's and 60's. At a recent conference, one expert predicted that in 10 years the microwave oven will be pretty much the same--with no significant advances. I disagreed. I am not certain of which changes will occur but there will be surprises!

Where? As a possible hint, consider the recent report [3] of the development of a 600 Volt, 67% efficient multi-beam klystron for microwave-oven application. Why was not this breakthrough accomplished in the U.S.? Is the U.S. no longer the leader in tube development, but just users--a "service economy"? Will there be a future in microwave weapons (new pulsed sources), microwave lighting and a host of other promising applications? Will the klystron, TWT or solid-state take over from the maggie because of the noise problem?

Answers to these questions in the next 25 years will be surprising. We in IMPI (e.g. the July '96 Microwave Power Symposium in Boston) will explore some of these questions from the broader view of all types of applications and devices. In future Crossed-Field Device Workshops, I hope we'll see the eventual resolution of the crossed-field noise dilemma—with a definitive recognizable understanding as well as beneficial spinoffs from the new understanding.

References:

1. D. Priest and R. C. Talcott, "On the Heating of Output Windows of Microwave Tubes by Electron Bombardment", Trans. IRE PGED. July, 1961
2. J. M. Osepchuk, "A History of Microwave Heating Applications", IEEE Trans. MTT-32. No. 9, pp. 1200-1224, Sept. 1984
3. G. J. Kim, et al., "The Development of Multi-Beam Klystron for a Microwave Oven", Proc. 30th Microwave Power Symposium, pp. 73-74, IMPI, Manassas, VA; August 1995