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# Phase Effect on the Microwave-Induced Temperature Field: Computational and Experimental Evidence

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*Abstract*— Simulations of microwave processing of lossy loads in a dual-source 2.4GHz 70-W low-volume (or 1.4L) cylindrical chamber demonstrate the effect of relative phase on heating patterns. Experiments carried out with full cavity loading typical for microwave heating of waste show consistent results revealing a strong dependence of the loss factor of the processed material on relative phase between solid-state sources.

***Keywords*— microwave processing of waste, multiphysics simulation, phase shift, solid-state power amplifiers, temperature.**

## I. Introduction

The rapidly growing technology of generation of microwave energy by solid-state generators makes a transformative impact on the entire field of microwave power engineering [1]. Specific mechanisms of control over the heating process are thus of particular interest [2], [3]. In their development, the role played by computer simulation may be crucial [4]. Frequency control over the patterns of dissipated power was computationally studied in [2]. In this paper, we present multi-physics modeling results showing the effect of relative phase shift between sources on the temperature field in a solid-state dual-source cylindrical chamber. Computational results appear to be consistent with experiments carried out with the cavity filled with various food waste loads. This work shows in both simulations and measurements that phase shift can be used to control the microwave heating patterns inside a loaded cavity.

## II. Microwave Reactor: Computational and Experimental Results

A computer model is developed for a cylindrical 1.4 L chamber fed by two WR284 waveguides with either aligned or orthogonal orientations (Figure 1). Two loads different in their dielectric properties and typical for microwave processing scenarios in waste management are considered. The loads completely fill the chamber and are characterized by material properties of shredded paper and bread. The output power is fixed at 70 W at 2.45 GHz, produced by 70 W GaN PAs with PAE > 60%. The system is reproduced in a 3D fully parameterized model for the full-wave conformal FDTD simulator *QuickWave*.

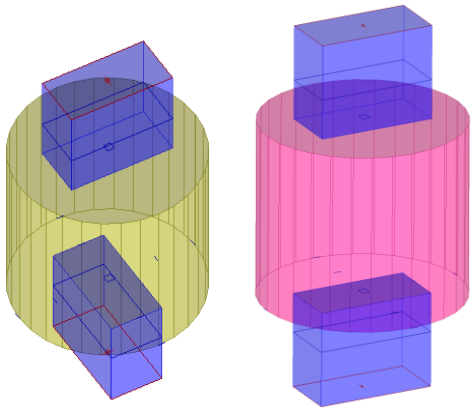

Figure. 1. Geometry of the cylindrical chamber with the aligned and orthogonal orientation of the feeding waveguides.

Simulations show that if the cavity with the waveguides of the aligned orientation is filled with the material with a low/high loss factor, the magnitude of the electric field in the center of the cavity is 1.5-2/8-10 times lower than in the output of waveguides. The phase shift decreases the magnitude in the center and brings it down to zero with the shift of 180º. Computation of the temperature field in the electromagnetic-thermal simulation shows alternation of time evolution of the temperature field with the phase shift increasing up to 180º. A measurement in the system with two 70 W GaN solid-state sources confirms that the temperature distribution is similarly dependent on relative phase control.

## References

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