Ultra-Directive Palm Tree Vivaldi Antenna with 3D Substrate Lens for μ-biological Near-Field Microwave Reduction Applications

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***Abstract*— We present a new Palm Tree Antipodal Vivaldi Antenna with an Exponential Slot Edge and 3D polylactide printed Substrate Lens presents an unprecedented directive radiation pattern, and simultaneously mitigates the Side Lobe Level, increases the Main Lobe gain, and reduces the angular width, for μ-biological Near-Field Microwave Reduction Applications.**

***Index Terms*—Ultra-wideband antenna, antipodal Vivaldi antenna, μ-biological Near-Field Microwave Reduction, 3D printed lens.**

I. INTRODUCTION

Autoclaving and ionizing radiation techniques have widespread applications for microbiological reduction and sterilization, especially in health and pharmaceutical fields, for virus, fungus, and bacterium inactivation. In food industry, reducing microorganisms may extend food expiration dates, requiring less chemical preservatives. Despite being very popular, those techniques can compromise the polymer packages, causing degradation, which can generate the migration of plasticizers or benzenes to the medium to be sterilized. In contrast, microwave reduction and sterilization techniques are as efficient as those traditional methods, but they do not compromise polymer packaging, and can be applied even with the medium [1], [2].

Microwave-related techniques have received great attention over the last decade, [3], [4], [5], [6], [7], [8],[9], [10], [11], [12]. In the microwave technique, microorganisms undergo non-ionizing electromagnetic radiation, with frequency spectrum ranging from 300 MHz to 300 GHz, respectively with wavelengths from 1 km to 1 mm and energies from 1.24μeV to 1.24 meV [4], [13], [14], [15].

The microwave reduction and sterilization is specified by the ratio of power and time of exposure to electromagnetic radiation through thermal and non-thermal effects. The first one is related to the dielectric properties of the molecular dipoles (dipole polarization and ion conduction) of the irradiated medium, leading to energy transfer in the form of thermal effects (causes molecular internal friction). The second one is related to energy transfer in the form of polar electrostatic effects due to interactions between the molecular dipoles and the electric fields of the microwave signal. This may, in addition to reducing or even sterilizing, lead to microbial inactivation through cleavage of chemical bonds or molecular synthesis, which compromises the basic metabolism, e.g. hydrogen peroxide synthesis [1], [5], [6], [7], [8], [16].

Exposure of micro-organism contaminated medium to microwaves is usually performed with an electromagnetic cavity fed by a TE10 mode waveguide in a few hundred watts of power at 2.45 GHz. However, this setup is neither portable nor directional, and cannot be implemented in continuous or open chemical processes (pharmaceutical or food industrial production). Additionally, it leads to a temperature increase in the irradiated medium, mainly due to the high power involved[1], [2], [3], [4], [5], [6], [8], [10], [16], [17].

In order to address limitations of the resonant cavity technique, but still taking advantage of the microwave sterilization, this investigation proposes a sterilization system with ultra-low power, portability and ultra-directionality. This system could be implemented at any stage of a supply chain, industrial production line, logistic distribution, transport and storage, or even at the