A Real Time Exposure System for Neuronal Networks in the MW Band

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INTRODUCTION

The study of possible alterations in neuronal networks functionality induced by the EM exposure is extremely relevant in understanding and defining microwave (MW) non-thermal field effects. Neurons, in fact, represent one of the favorite targets of the EM field interaction as stressed by the growing of experimental investigations [1, 2, 3]. In order to deepen such studies, a new real time exposure set-up usable in the GHz region has been designed and realized. The real time recording of the neurons action potential under exposure is detected by an integrated electrically passive microelectrode array (MEA) as an alternative approach to the common used patch clamp technique [1,3].

MATERIALS AND METHODS

The adopted EM structure is a transverse electromagnetic cell (TEM) designed for working up to the MW region (structure dimensions reported in Fig. 1(a)),[4]. In order to receive the recording chip (MEA) the bottom ground plate of the cell is opened by an hole. Two hole shapes, circular and squared, are possible allowing the positioning of the chip under or over the bottom ground plate of the cell respectively, Fig. 1 (b, c). The neurons are placed directly over the MEA surface thus the chip is surrounded by a cylindrical glass containing the culture medium, Fig. 1 (b, c). Therefore to optimize the biological sample positioning an in depth numerical analysis is carried out by FDTD methods evaluating E field and SAR distribution, reflection parameters as well as the impedance matching with the feed. First, an accurate numerical model of the chip tracks with minimal dimension of 200 μm have been considered for simulations. Since the electrodes dimensions in the central recording zone are extremely small (about 20 μm), it has been necessary to adopt a simplified numerical treatment, as shown in Fig. 2 (a, b). At the same time experimental characterization of the system is on going, involving temperature and E field measurements essential to validate numerical results and to evaluate possible EM field coupling with the recording electrodes.

RESULTS

Results of simulated scattering parameter S_{11} confirm the good transmission behavior of the structure, with a value of $|S_{11}|$ equal or less than –10 dB in the whole operating band (0.5-2 GHz). The SAR (W/kg) distributions at 1.8 GHz into the biological solution have been evaluated for the configurations of Fig. 1 (b).Values of $\varepsilon = 71$ and $\sigma = 2.1$ (S/m) for the biological medium permittivity and conductivity have been adopted respectively. As observable from Fig. 2 (c, d) the SAR homogeneity in the recording zone strongly depends on numerical modeling of the electrodes, Fig. 2 (a, b), as well as the system efficiency ((W/kg)/W). For this reason comparison with experimental measures, on going at the

moment, are useful to define correct modeling features and to validate future numerical results in the different system configurations.

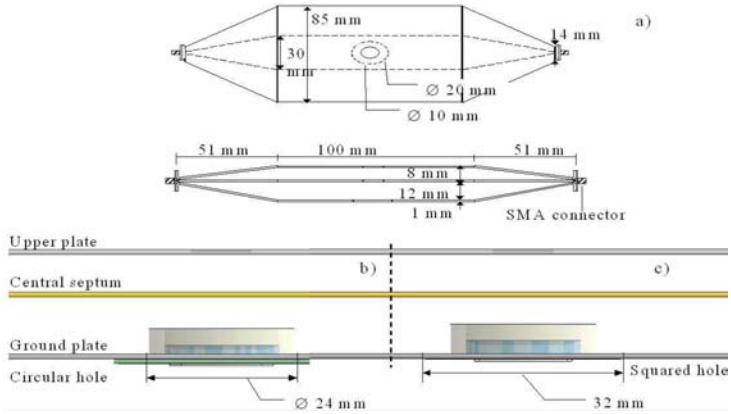

Figure 1: a) TEM cell dimensions, b) circular hole configuration the biological sample is placed under the ground plate, c) squared hole configuration the biological sample is placed on the ground plate.

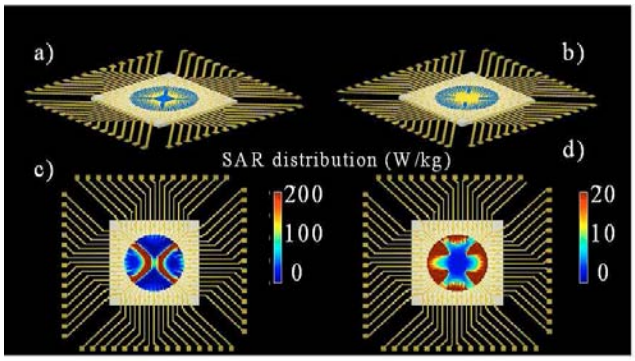

Figure 2: Two possible modeling of the chip center a) without metallizations, b) fully metallized; c) and d) SAR distribution for the two cases at the interface between the biological solution and the chip.

CONCLUSIONS

A new exposure set-up for real time recording of neuronal networks activity through MEA is presented. A numerical analysis is ongoing as well as experimental measurements on the system. First results evidence the importance of an accurate chip modeling to correctly evaluate SAR and E field distributions homogeneity in the recording zone.

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