SAR Value Distribution in an Electromagnetic Reverberation Chamber

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Exposing biological tissue to electromagnetic (EM) fields may result in many effects; yet the only reproducible effect known in the RF range is the thermal one related to heating of the tissue [1]. It is quantified by the specific absorption rate (SAR). Differing thermal and non-thermal effects requires suitable tissue samples under well-defined environmental parameters (e.g. temperature and humidity) and an exposure setup providing defined deterministic or probabilistic EM fields. Multiple test setups exist, e.g. open area test sites, (semi-)anechoic chambers or EM reverberation chambers (ERCs). In contrast to the first two, in which a well-defined EM field is generated, the fields of an ERC vary statistically. For a small ERC, e.g. of the size of a cabinet, the exposed sample (Device Under Test, DUT) must be electrically sufficiently small. In order to exploit the advantage of a small and inexpensive ERC for the investigation of EM compatibility (EMC), an accurate knowledge of the field magnitude distribution is mandatory. Investigations of the effect of EM fields on biological systems ranges from cell cultures suspended in nutrient solutions to animal experiments. Such samples often occupy a relatively large volume, where a spatially homogeneous distribution of the EM field cannot a priori be guaranteed [2]. Dosimetry for thermal or non-thermal effects of EM fields can be achieved indirectly by determining field magnitudes [3] or directly via the effect on the DUT. In the latter case, the spatial distribution of the SAR can be deduced from the temperature profile of some material at the spatial positions of interest during exposure via identification of the balance of all energy fluxes related to heat transport. However, the number of probes available for recording temperature profiles is limited, and a thermographic determination of the DUT's surface temperature may be inaccurate. In this paper, precise determination of the spatial and stochastical distribution of the SAR is achieved by an accurate, spatially resolved measurement process, identification of increasingly refined physical models for heat transfer inside the ERC, and by an enhanced estimation of statistical observables via bootstrapping [4], allowing for a higher level of significance. Identified SAR distributions are related to those of other observables, e.g. field strength. To also enhance the empirical data base, a new method to access the spatial distribution of the SAR of cell and tissue solutions is implemented: Patterns of a large number of nearly adiabatic droplets of a liquid, electrically equivalent to that of the solvent (e.g. salted water), are exposed in a polystyrene matrix. Their temperature profiles are simultaneously recorded by thermography. From measured temperature gradients, the SAR homogeneity can directly be evaluated. Measurement results are compared with simulated data. Finally, conclusions for the construction of a "BIO-ERC" are derived.

1. vander Vorst, A., Rosen, A., Kotsuka, Y., "RF/Microwave Interaction with Biological Tissue", IEEE Press, John Wiley & Sons Inc, Hoboken, 2006.
2. Fichte, L.O., Grutza, K., Stiemer, M., "On the Use of Electromagnetic Reverberation Chambers for Exposiure Tests of Cell Tissue", *Proc. CEEM'2012,* Shanghai, 2011.
3. Barbary, I., Schiffner, J., Rozgic, M., Hollan, R., Schlie, C., Storjohann, J., Hagel, M., Fichte, L.O., Potthast, S., Schaarschmidt, M., Lange, S., Stiemer, M., „Simulation based analysis of electric field distributions in small reverberation chambers", *Proc. EMC Europe,* 2017.
4. Kasmi, C, et. al., "Stochastic EMC/EMI Experiments Optimization Using Resampling Techniques", *IEEE Transactions on Electromagnetic Compatibility*, vol. 58, no. 4, 2016.