Non-Ablative Skin Tissue Treatment Using Controllable RF/Microwave Heat Deposition

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The EM field applied to the tissue causes the oscillation of biomolecules. As a result, heat is deposited. This biophysical effect is used in diverse biomedical applications. In this study, the effect is demonstrated for skin tightening and resurfacing (Procedures in Cosmetic Dermatology Series: Non-Surgical Skin Tightening and Lifting, 2008) for aesthetic medicine needs. RF was early proved as an efficient method in skin treatment with deeper penetration compared to laser and ultrasound. Normally RF skin treatment operates in lower MHz bands using several types of galvanic electrodes in mono-polar, bi-polar and multi-polar layouts by inducing only RF conductivity currents without the EM fields directly involved. This study explores directly the EM field tissue stimulus at higher operational frequencies up to microwaves because of expected (i) better controlling of heat deposition; (ii) less power needed, (iii) more compact probe possible, and (iv) frequency-selective tissue-specific absorption.

A coupled electromagnetic-thermal model was first developed to predict 3-D temperature distributions in the skin tissue by using full-wave EM and bioheat numerical solvers. The skin was represented by a planar, averaged and multi-layer structure. The simulations have been performed in 20-1000 MHz frequency band. As a primary field source, several planar conductor topologies of different shapes have been considered (Fig. 1a). As a result of such simulations, heat deposition has been predicted in the tissue model with 2-D and 3-D temperature distributions (Fig. 1b). The probe computational model (Fig. 1a) has been then optimized for better electrical performance (S11) and better heat features (uniformity of heat distribution). Such probes have been designed and fabricated in PCB (Fig. 1c) and tested with chicken and pork meat (Fig. 1d).

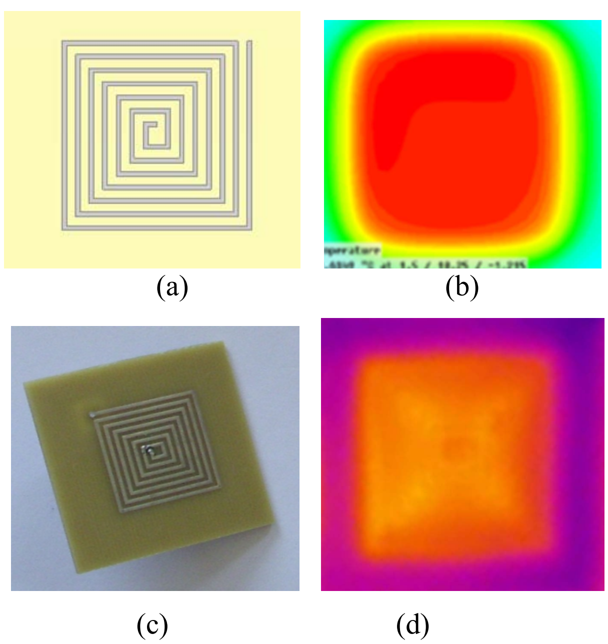

Figure 1. (a) single-arm spiral planar conductor topology of probe; (b) 2-D heat distribution slice predicted in simulations with (a); (c) designed PCB probe based on the design (a); (c) 2-D surface heat distribution measured with the probe (c) in tests with chicken and pork meat.