Dielectric Spectroscopy of Breast Reduction Tissue Specimens at Microwave Frequencies: Conclusions from a Large-Scale Multi-Institutional Study

Mariya Lazebnik[(1)], Cynthia B. Watkins[(1)], Susan C. Hagness[(1)], and John H. Booske[(1)]
(1) Department of Electrical and Computer Engineering,
University of Wisconsin, Madison, WI

Leah McCartney[(2)], Dijana Popovic[(2)], and Michal Okoniewski[(2)]
(2) Department of Electrical and Computer Engineering,
University of Calgary, Calgary N.W., Alberta

Mary J. Lindstrom[(3)], Josephine Harter[(4)], Sarah Sewall[(4)], and Anthony Magliocco[(5)]
Departments of (3) Biostatistics and Medical Informatics and (4) Pathology,
University of Wisconsin, Madison, WI
(5) Department of Pathology, University of Calgary, Calgary N.W., Alberta

Published data in the literature suggesting a dielectric properties contrast between normal and diseased breast tissue at RF frequencies has served as motivation for the development of ultrawideband (UWB) breast cancer detection and treatment techniques in the microwave frequency range. However, the existing literature does not cover all of the different normal, benign, and cancerous breast tissue types, nor microwave frequencies over 3 GHz. Furthermore the different data sets are not all in agreement. To address these issues, we have conducted a large-scale NIH-funded investigation to determine the UWB dielectric properties of excised normal and malignant breast tissue in the microwave frequency range (0.5 to 20 GHz).

Accurate characterization of normal breast tissue is important for establishing baseline properties. In this talk, we will present our results on the dielectric properties of freshly excised normal tissue samples obtained from mammoplasty surgeries at the University of Wisconsin-Madison (UW) and University of Calgary (UC). We obtained 177 measurements from 50 patients at UW, and 313 measurements from 43 patients at UC. The measurements were performed using a precision open-ended coaxial probe technique (D. Popovic, *et al*, IEEE Trans. Microwave Theory Tech., 53:1713—1722, 2005). The measurement site was marked with ink, and the tissue composition in the probe sensing volume was categorized as a percentage of fat, glandular, loose connective, and dense fibrous tissues by a pathologist. The wideband data was parameterized using a multi-pole Cole-Cole model. The obtained Cole-Cole parameters were statistically analyzed and correlated to the pathology results.

We will discuss how the dielectric properties are correlated with tissue composition (the primary factor) as well as other "physical" factors such as patient age, time between excision and measurement, and tissue temperature (all secondary factors). Our results indicate that the impact of the heterogeneity of normal breast tissue on dielectric properties is more significant than the variability suggested by previous small-scale studies published in the literature. This heterogeneity may create a more challenging tumor detection problem than previously thought.