In Vivo Dielectric Characterization of Normal Breast Tissue: A Pilot Study

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A number of microwave technologies are currently under development for breast cancer detection and treatment. Examples include microwave beamforming (see, for example, E. Bond, X. Li, S. C. Hagness, and B. D. Van Veen, *IEEE Trans. Antennas and Propagation*, April 2003, in press), microwave tomography (e.g. P. Meaney, M. Fanning, D. Li, S. Poplack, and K. Paulsen, *IEEE Trans. Microwave Theory Tech.*, 48:1841-1853, Nov. 2000), microwave-induced thermoacoustic tomography (e.g. M. Xu and L. Wang, *Medical Physics*, 29:1661-1669, Aug. 2002), and microwave phased-array hyperthermia (e.g. R. Gardner, H. Vargas, J. Block, C. Vogel, A. Fenn, G. Kuehl, and M. Doval, *Annals of Surgical. Oncology*, 9:326-332, May 2002). The physical basis for these technologies is the dielectric properties contrast between malignant and normal breast tissue, as suggested by relatively sparse amounts of published data.

The engineering of these non-invasive, non-ionizing microwave technologies can be greatly facilitated by a complete understanding of the dielectric properties of malignant, benign, and normal breast tissue. For this reason, the University of Wisconsin in collaboration with the University of Calgary is conducting a comprehensive NIH-funded experimental study of the dielectric properties of malignant, benign, and normal breast tissue at microwave frequencies (100 MHz – 20 GHz). The majority of these measurements are being conducted on freshly excised breast biopsy, mastectomy, lumpectomy, and reduction mammoplasty specimens. Our research protocol has been designed to preserve as much as possible the physiological temperatures and moisture content of the *ex vivo* tissue. Nonetheless, it is of interest to establish the extent to which the measured dielectric properties of excised breast tissue differ from those *in vivo*.

In this paper, we present preliminary results from a pilot study of the dielectric properties of normal breast tissue *in vivo*. This study has been approved by the institutional review board at the University of Wisconsin and all subjects undergo an informed consent process. During an excisional biopsy, the dielectric properties of normal tissue surrounding the suspicious breast lesion are measured using an open-ended coaxial probe technique with an Agilent 8720ES vector network analyzer. The special-purpose probe is manufactured from stainless steel and borosilicate glass with a hermetically sealed tip. (Further discussion of the calibration procedures developed for this probe will be presented at this conference by the Univ. of Calgary.) After the tissue is excised, measurements are repeated *ex vivo* until the tissue has reached room temperature. Afterwards, the measured dielectric properties are correlated with the results from the histopathology, yielding *in vivo* and *ex vivo* dielectric-properties data as a function of normal breast tissue composition and temperature. These results provide the baseline data needed to accurately interpret *ex vivo* measurements.