# Initial Microwave Imaging Experiments in Ex-Vivo Breast Tissue

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**Abstract:** Breast cancer is a significant worldwide health problem. In the United States it is the most common non-skin malignancy in women and the second leading cause of female cancer mortality. Detection of breast cancer at an early stage increases the likelihood of successful treatment and long term survival. While screen film mammography is currently the most effective method of detecting asymptomatic breast cancer, there is considerable room for improvement in the areas of sensitivity and specificity, especially in cases of pre-menopausal women where increased breast density can obscure clinically relevant abnormalities.

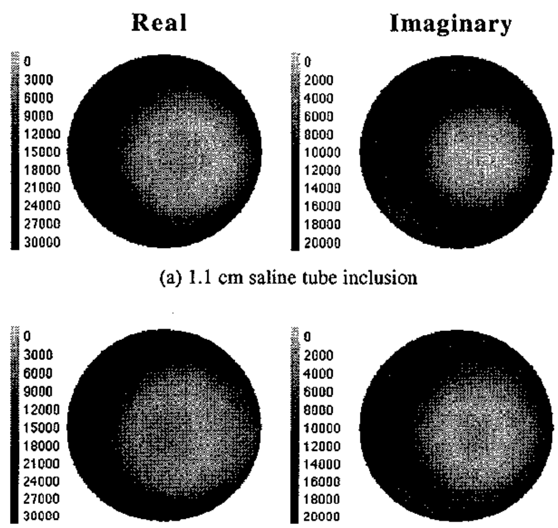
Tissue sample data suggests that malignant mammary tumors have electrical properties mimicking those of high-water content tissues such as muscle whereas the surrounding normal breast is more representative of low-water content fatty tissues, with the overall contrast between the two approaching an order of magnitude. This impressive contrast mechanism along with advances in model-based microwave imaging techniques provides a compelling rationale for near-field microwave breast imaging. The results presented here demonstrate that high contrast, tumor-like objects can be detected in ex-vivo breast tissue utilizing our fixed array, liquid-based microwave imaging system.

### Methods:

We have developed a fixed array (utilizing up to 32 elements), liquid-based microwave imaging system operating in the frequency range of 300 to 1000 MHz for target region diameters up to 26 cm [1]. For the experiments described here, we employed a 14 cm diameter array of 16 monopole antennas suspended in 0.9% saline. The tissue sample was comprised of freshly excised breast tissue recovered from reduction surgery and placed in a 8.2 cm diameter, thin-walled plastic container. The sample was roughly 5 cm in height and placed off-center in the antenna array. Small saline tubes of 1.1 and 2.5 cm in diameter were embedded in the tissue to simulate inclusions. Images were recovered at 900 MHz with a data acquisition time of roughly 1 second and the image reconstruction requiring 24 minutes (total of 4 iterations).

### Results and Discussion:

The images shown in Figure 1 are the real and imaginary components of the squared electromagnetic wavenumber for the cases of a 1.1 and 2.5 cm 1.2% saline tube in the breast tissue, respectively. For this discussion, the real component is proportional to the relative dielectric constant, $\varepsilon_r$, and the imaginary component to the electrical conductivity, $\sigma$. The contour of the breast tissue is clearly defined and the saline tube objects are discernible in the real part of both images. In the case of the 2.5 cm diameter saline tube, the presence of a high conductivity object in the imaginary component is also evident. This set of experiments presents a number of interesting and difficult problems for microwave imaging. The breast itself is a large, high contrast object with respect to the background medium and it has been demonstrated previously that recovery of electrically large, high contrast objects is difficult in the microwave regime. However, even with this high contrast interface between the breast and background medium, our technique still allows for the detection of the saline tube in the breast tissue interior. These results are exciting and motivate further studies into a number of system issues along with variations in the reconstruction algorithm as we progress in the development of a clinical microwave imaging prototype for the breast [2].




(a) 1.1 cm saline tube inclusion

(b) 2.5 cm saline tube inclusion

Figure 1. Reconstructed $k^2$ images of an 8.2 cm diameter breast tissue sample with saline tube inclusions at 900 MHz: (a) 1.1 cm diameter saline tube, and (b) 2.5 cm diameter tube.

### References:

[1] P.M. Meaney, K.D. Paulsen, J.T. Chang, "Near-field microwave imaging of biologically-based materials using a monopole system," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-46, pp. 878-890, 1998.

[2] P.M. Meaney, K.D. Paulsen, J.T. Chang, M.W. Fanning, A. Hartov, "Nonactive antenna compensation for fixed array microwave imaging: Part II imaging results," *IEEE Trans. Med. Imaging*, 1999 (accepted).

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