

The CUNY Center for Advanced Technology In Photonics Applications (CUNY CAT)  
 Designated by NYSTAR, the New York State Foundation for Science, Technology and Innovation

## Optical Mammography and Tomography

Early detection and diagnosis of breast cancer is essential for effective treatment. X-ray mammography, the modality commonly used for breast cancer screening, cannot distinguish between malignant and benign tumors, and is less effective for younger women with dense fibrous breasts. If a tumor is suspected from an x-ray mammogram, a biopsy that requires invasive removal of tissue from the suspect region need be performed to determine if the tumor is benign and malignant. In a majority of the cases, the biopsy turns out to be negative, meaning the tumor is benign. Besides being subject to an invasive procedure, one has to wait an agonizing period until the biopsy results are known. A breast cancer screening modality that does not require tissue removal, and can provide diagnostic information is much desired.

We are pursuing the development of optical mammography and tomography as a noninvasive method that uses non-ionizing near-infrared (NIR) picosecond light pulses to obtain three-dimensional images of the interior of the breast. However, breast tissues scatter light strongly, so a direct shadow image of any tumor is generally blurred by scattered light. We have developed time-resolved, space-gated, and polarization sensitive imaging techniques that can differentiate between tumor and normal tissue.

Results of a time-sliced imaging measurement on *ex vivo* human breast tissue showing the difference between infiltrating ductal carcinoma and normal regions are displayed in Fig. 1.

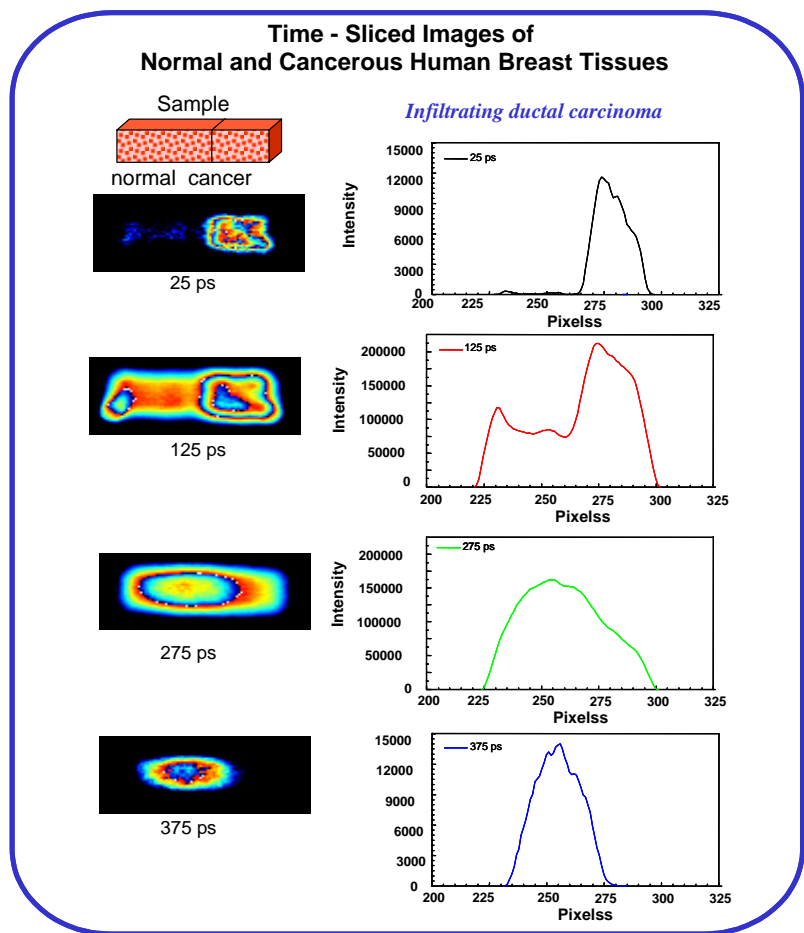


Fig. 1. Time-sliced images of a breast tissue sample with infiltrating ductal carcinoma.

This technology opportunity sheet describes continuing efforts in this area. Several patents may have been issued or are pending and which may be available for licensing.

For Details, contact Alan Doctor; email: [alan.doctor@qc.cuny.edu](mailto:alan.doctor@qc.cuny.edu); Phone: 718-997-4279 Fax: 718-997-4278  
 Queens College • Razran 314 • 65-30 Kissena Boulevard • Flushing, NY 11367 [www.cunyphotonics.com](http://www.cunyphotonics.com)

The major impetus behind development of optical breast imaging modality is its diagnostic potential through the exploitation of spectroscopic signatures. Figure 2 shows the results of a spectroscopic imaging measurement on an *ex vivo* breast tissue specimen containing adipose (fatty) and fibrous tissues. Images recorded with light near resonant with adipose absorption at 1203 nm exhibit a high contrast between the adipose and fibrous region. These results clearly demonstrate the diagnostic potential of the spectroscopic imaging.

For three-dimensional tomographic *in vivo* imaging one needs to combine time-sliced and spectroscopic imaging with inverse image reconstruction (IIR). An IIR approach uses the knowledge of the characteristics of input light,

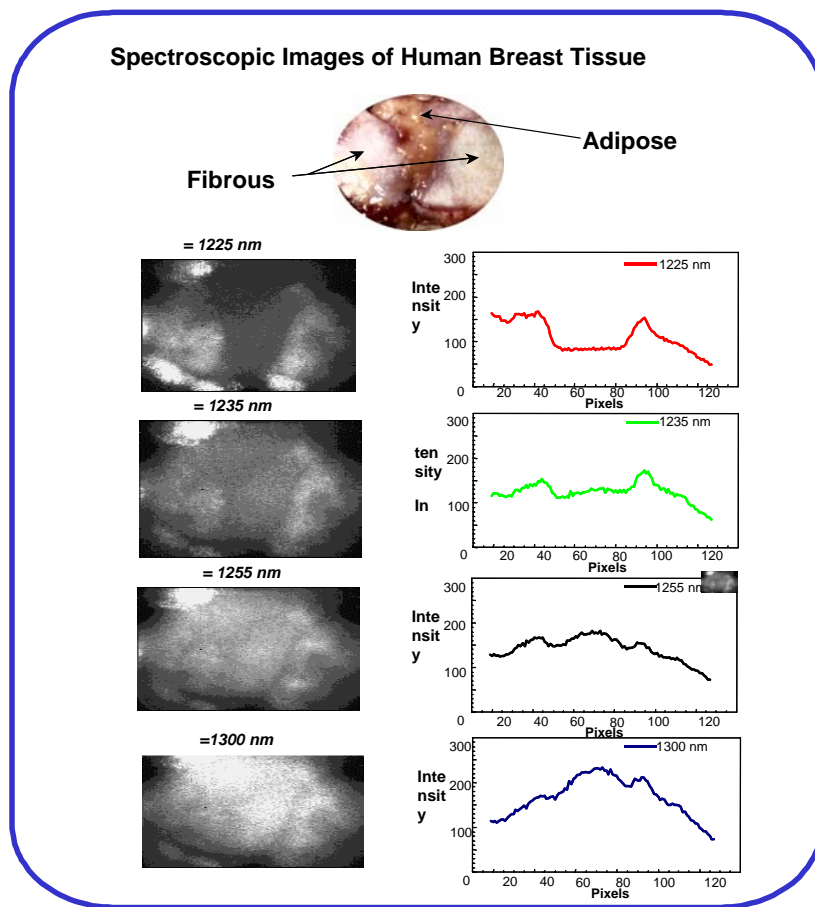


Fig. 2. Spectroscopic images of a breast tissue specimen with adipose and fibrous components. When 1225-nm light that is near resonant with the adipose absorption is used, the adipose and fibrous regions are imaged with high contrast demonstrating diagnostic potential of optical methods.

measured distribution of light intensity that emerges from the illuminated breast, and a theoretical model that describes how light propagates through breast to construct an image of the interior of breast. Although the problem has received much attention lately, that development of photonic tomography has been slow because of a paucity of suitable light sources, detectors and other instrumentation needed for accumulation of useful data in reasonable times, and an adequate theoretical formalism for inversion problem.

We are using a time-resolved imaging approach that uses an ultrafast gated intensified camera system for fast acquisition of a sequence of time-sliced two-dimensional images to be used as data for three-dimensional image reconstruction. Our theoretical model for light propagation in tissues is more exact and accurate than the commonly used model known as the diffusion approximation (DA). We are developing

inversion algorithms that provide three-dimensional images within a short computation time. We envision obtaining diagnostic information using light of different wavelengths. Our approach builds on our preliminary experimental, analytical and computational work mentioned above.