Polarized Terahertz Waves for Enhancing the Imaging Contrast of Excised Breast Cancer Tissues

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Terahertz (THz) imaging has shown potential in differentiating between excised malignant and normal breast tumor tissues. In particular, THz reflection imaging of tumors fixed in formalin and embedded in paraffin (FFPE) has shown more than 90% success rate when statistically compared with histopathology images for both human and mice tumors (T. Bowman, K. Alhallak, T. Esparza, M. K. Khan, D. Lee, N. Rajaram, J. Wu, A. Chakraborty, K. Bailey, and M. El-Shenawee, 42nd International Conference on Infrared, Millimeter and Terahertz Waves, 2017). However, when imaging freshly excised breast tumors, the technique showed less success rate, especially for human tissue. This is due to several factors such as blood or fluids floating over the tissue, air bubbles formed between the tissue and the polystyrene slide holder, and the comparison was conducted with histopathology images taken at different surface level from the bulk tissue.

In this work, we will use polarized THz waves to develop images based on the sixteen elements of the Mueller Matrix. Published work using computer simulation demonstrated the potential of these elements in the detection of buried objects (M. El-Shenawee, JOSA A, 20, 183-194, 2003). Mueller Matrix polarimetry using a light source with a center wavelength of 650 nm was successful in differentiating characteristic features of cancerous tissues of fixed human skin basal cell carcinoma and papillary thyroid carcinoma (E Du, Honghui He, Nan Zeng, Minghao Sun, Yihong Guo, Jian Wu, Shaoxiong Liu, Hui Ma, J. Biomedical Optics, 19, 7, 076013 1-8, 2014). Other work used CW THz polarization imaging for colon cancer detection (P. Doradla, K. Alavi, C. S. Joseph, R. H. Giles, Proc. Terahertz, RF, Millimeter, and Submillimeter-Wave Technology and Applications VII, 8985, 89850K, SPIE, 2014).

In this work, we will collect experimental THz data in the reflection mode to develop images based on the Mueller Matrix elements. We will implement data acquisition upon installing two polarizers in the current pulsed THz TPS system (TeraView, Ltd.) available at the University of Arkansas. Fixed and freshly excised breast tumor tissue will be utilized in this work. Free-standing wire grid polarizer G50 x 20-S" from MicroTech will be used. The two polarizers, one for the emitter and one for the detector, will collect all polarimetry THz signals (VV, HH, VH, and HV). The THz images will be compared with histopathology images to determine the contrast enhancement between malignant and normal tissue using polarization.