Terahertz Imaging for Defect Identification in Liquid-Sterilizing Membrane Devices

Nathan Burford[(1)], Tyler Bowman* [(2)], Robert Beitle[(3)] and Magda El-Shenawee[(2)]
(1) Microelectronics-Photonics Program, University of Arkansas, USA
(2) Department of Electrical Engineering, University of Arkansas, USA
(3) Department of Chemical Engineering, University of Arkansas, USA

Terahertz technology has recently emerged as a promising medical imaging modality. This technology offers several favorable features, such as high sub-millimeter resolution. Unlike other imaging modalities, pulsed THz imaging detects both signal amplitude and phase, offering additional information to the resulting image. Additionally, THz waves have the property of exceptional transmittance through non-conductive material. In this work, we present THz nondestructive imaging as a method for the detection of defects inside membrane based liquid sterilization devices.

Membrane based devices for sterilization of liquids have long been utilized in the biomedical field. Quality control of such devices is of great importance, since device failure can lead to contamination of substances that may be placed inside a patient's body. Membrane punctures are one common source of defects, with defects on the order of 10 µm being capable of inducing device failure. However, detection of such defects is not a straightforward process, since many such membrane devices are packaged in such a way that visible imaging is not feasible. The nondestructive property and submillimeter resolution of THz imaging offers a promising solution to detect such membrane defects.

Preliminary results obtained using a Teraview Spectra 3000 THz imaging system have demonstrated the detection of sub-500 µm puncture holes in dry membrane filter material. In this instance, the contrast mechanism allowing for the detection of such defects was from the THz electrical property contrast between air and the membrane material. This contrast was demonstrated to be enhanced by applying water to the membrane. It is proposed that additional contrast methods can be utilized to enhance the detection sensitivity closer to the 10 µm defect goal. Microspheres of polystyrene, latex, or magnetic material are commercially available, measuring 1 – 5 µm, which have a variety of materials conjugated to their surface. These and other materials will be investigated for their potential to enhance the defect detection sensitivity. In addition to the investigation of various contrast mechanisms, image processing will be implemented to improve the resolution degrading effects of the lower frequency components of the broadband THz pulse utilized by this imaging method.