Morphological Feature Extraction in Biomedical Samples using Polarimetric Terahertz Imaging

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Elongated morphological features in biological tissues, such as axon bundles in the brain, nerve fibers in the muscle, and blood/lymph veins within organs often exhibit quasi-periodic arrangements whose resonant characteristics fall in the high millimeter and terahertz (THz) bands (100GHz-2THz). Such features have been studied for reflectometric THz imaging using commercially available time-domain spectroscopy instrumentation. However, to date, such features have been studied using incident signals whose polarization is not precisely controlled. Moreover, cross polarization response cannot be measured using available systems. A fully-polarimetric THz imaging system is badly needed for the study of biological tissues in mmW and THz bands.

We present a fully-polarimetric THz imaging system using full-duplex frequency extenders driven by a conventional vector network analyzer (VNA). Using a polarizer, the co-polarized and cross-polarized reflected beams are separated onto the 2 ports of the VNA, respectively. Through raster scanning, the fully-polarimetric images of tissue samples are studied for identifying their morphological characteristics. In particular, we show that the axon bundles in brain tissues can be resolved using THz waves, leading to automated classification of white and gray matter regions. Moreover, axon demyelination effects due to neurodegenerative diseases is studied in detail using fully-polarimetic THz imaging.