Development of sensing platforms using free-space and on-chip terahertz spectroscopy

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Terahertz (THz) spectroscopy is used in various applications such as safety inspection, Earth-space telecommunications, and sensor technology. One of its key advantages is its ability to examine biological or chemical samples without labels, or damage. However, challenges arise with substances transparent to THz waves, lacking distinct THz spectral features, especially in small amounts or thin films. Preparing sufficient samples can be laborious or even impossible. THz waves face significant attenuation passing through water layers and polar liquids, complicating the analysis of biological or chemical samples. Moreover, when the specimen's volume is small compared to the THz wavelength, examining samples becomes complex due to the low scattering cross-section between THz waves and specimens. THz metamaterials (THz MMs) are arrays designed to interact with THz waves. They can tackle the low-scattering challenges by utilising highly localised electric fields near the resonator structures. To unlock its full potential, understanding the relationships between dielectric properties and MM resonance parameters like frequency and amplitude is essential. On the other hand, on-chip THz spectroscopy utilises planar configurations and confined THz fields, allowing examination of mesoscopic scale samples and systems. Our preliminary works indicate that THz MMs can further minimize interaction areas within on-chip THz systems. Practical platforms for diverse specimen analysis have been investigated.