Abstract

The terahertz frequency range, sandwiched between the electronic microwave range and photonic infrared range, exhibits several unique features that have been of great scientific interest for several decades. This portion of the electromagnetic wave ranges from 0.1 – 10 THz. Owing to the unique attributes of terahertz radiations and the technological advancements in the field of ultrafast optics, terahertz spectroscopy has emerged as a non-destructive technique for numerous applications such as biomedical diagnostics, material characterization, security screening, astronomy, agri-food and process control in industries. Most of these applications are directly or indirectly related to selective sensing of chemicals and biochemicals.

In this dissertation entitled “Chemical sensing using terahertz time-domain spectroscopy”, we have employed terahertz spectroscopy and imaging techniques to study the optical response of a large variety of chemicals towards implementation in precision agriculture, industrial process control and material characterization. Different classes of chemicals investigated in this dissertation include biochemicals such as water and plant pigments (chlorophyll, carotenoid, betalain and anthocyanin) for precision agriculture application; common organic compounds such as aromatic nitro-compounds and their derivatives, solid polymer composites systems (binary, ternary and quaternary), pharmaceuticals and genetically modified plants.

The major thrust of this dissertation is the development of improved methodologies to overcome the experimental challenges, thereby demonstrating the possibility of the successful implementation of terahertz spectroscopy and imaging techniques for sensing purposes in several agri-photonics applications. We have demonstrated the application of quantum cascade laser-based laser feedback interferometry imaging technique for hydration mapping in plants and compared its feasibility and viability with the photoconductive antenna based broadband terahertz imaging towards field deployability. Additionally, the dissertation focuses on the

utilization of suitable theoretical models and signal processing tools to address the existing challenges such as dispersion in granular composites and false quality assessment of complex composite systems, such as pharmaceuticals, where a multi-variate analysis is required for accurate quality assessment and management.