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The Use of Metal Oxide Semiconductors for THz Spectroscopy of Biological Applications

Hans Hartnagel[1] and Vadim Sirkeli[1,2]
[1]*Institute of Microwave Engineering and Photonics, Technische Universität Darmstadt, Darmstadt, Germany*
[2]*Department of Applied Physics and Computer Science, Moldova State University, Chisinau, Moldova*

Terahertz (THz) waves refer to the electromagnetic radiation in the frequency range from 0.1 to 10 THz, which corresponds to the wavelengths from 3 mm to 30 μm, respectively. This spectral region, called also as "T-gap", is important for many practical applications, including THz imaging, chemical and biological sensing, high-speed telecommunication, security and medical applications. THz waves have low photon energies (~ 4.1 meV for 1 THz), which is about 1 million times weaker than the energy of X-ray photons. They do neither ignite any explosive materials at typical power levels nor cause any harmful ionization in biological tissues. The terahertz radiation is strongly attenuated by water and is very sensitive to water content. Unique THz absorption spectra caused by intermolecular vibrations in this spectral region have been found in different biological materials and tissues. Thus, Terahertz spectroscopy provides a powerful tool for characterization of a great many bio molecules and tissues. All these applications require relatively high power terahertz sources with milliwatt-level output power, which could operate at room temperature. Despite great progress, made in the last few years of design, fabrication and demonstration, THz devices based on GaAs/AlGaAs materials, there are some limits of bandgap engineering due to the relatively low (0.72 eV for GaAs/AlAs) conduction band offset, and most terahertz sources with one milliwatt-power like quantum cascade lasers (QCLs) require cryogenic cooling down to less than 200 K. To overcome the issue the new material systems such as metal oxide materials are considered as promising for room-temperature THz sources. The interest in terahertz imaging and spectroscopy of biologically related applications is increasing more and more within the last few years. This paper provides a review and current status of using metal oxide materials for THz spectroscopy, and recent advances in terahertz spectroscopy techniques in biological and medical applications.