

# Challenges and Opportunities in Terahertz Biomedical Imaging

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**Abstract**—Various biomedical applications utilizing terahertz technology are presented. Technical challenges in such applications are discussed in terms of limited penetration depth, blurred spectral features, and deficient contrast and the feasible solutions to the problems are also suggested.

**Keywords**—terahertz; medical imaging; cancer diagnosis; terahertz measurement depth; terahertz molecular imaging

Terahertz (THz) radiation has unique characteristics for the applications in medicine compared with those of other electromagnetic spectral regions. Most significant properties are the non-ionization due to low photon energy, the high sensitivity to water molecules, and the capability of spectroscopic analysis [1]. Except the radiation safety, these advantages are not fully utilized in the biomedical applications. The sensitivity to water molecules helps probe the dynamics of biological samples but also limits the penetration depth of THz radiation into water-abundant specimens. This difficulty can be overcome by using several techniques such as paraffin-embedding [2,3], freezing [4,5], and the use of penetration enhancing gels [6]. The spectral fingerprints of biomedical samples by the motions of biological molecules are not readily observed because of the two major reasons. One is due to the relaxational absorption of THz radiation by water molecules, which can be somehow circumvented by the techniques described above. Another comes from the inhomogeneous broadening of resonances in macromolecules. Distinct spectral peaks have been measured with nucleobases, which are components of DNAs and RNAs, but the resonant features of DNAs and RNAs are hardly discovered. However, the resonances of macromolecules can be measured during the progress of biological changes such as getting diseased. The mechanisms of showing fingerprints are to be discussed in the presentation. The contrast enhancing techniques for cancer imaging will also be explained [6-8]. In

conclusion, the author believes that there are some points where terahertz imaging can contribute to the real-world medicine [10].

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