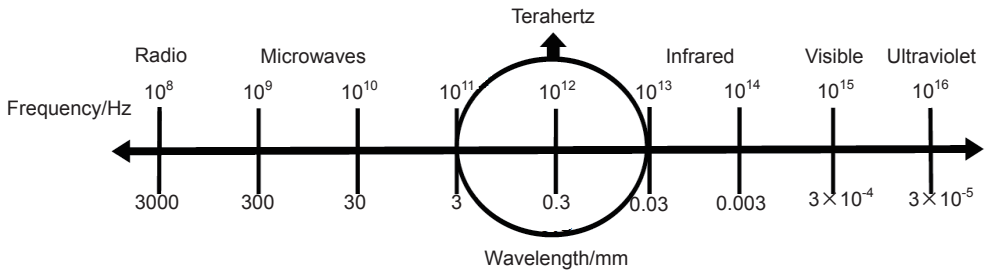
Applications of terahertz technology in medical science and research progress

Ye Hui[1], Xi Mingrong[1,2], Cao Hanyu[1], Lan Feng[3,4], Hou Minmin[1,3*]

[1]Department of Obstetrics and Gynecology, West China Second University Hospital, Sichuan University, Chengdu, Sichuan 610041, China; [2]Key Laboratory of Birth Defects and Related Diseases of Women and Children, Sichuan University, Ministry of Education, Chengdu, Sichuan 610041, China; [3]Terahertz Science and Technology Key Laboratory of Sichuan Province, Chengdu, Sichuan 610054, China; [4]Terahertz Research Centre, School of Electronic Science and Engineering, University of Electronic Science and Technology of China, Chengdu, Sichuan 610054, China



Terahertz in the electromagnetic spectrum

Overview: Terahertz radiation has attracted extensive attention of researchers recently, because of its prominent detecting ability and its noninvasive and non-ionization properties. The frequency band of terahertz radiation spans from 0.1 THz to 10 THz, which locates in the infrared regions and the microwave of electromagnetic spectrum. Terahertz technologies can be categorized into terahertz imaging and terahertz spectroscopy according to the manner of detection and signal processing. It is a typical interdisciplinary subject which combines electronics and photonics. With the rapid development of terahertz technology, it can be promisingly applied in the fields, such as biomedicine, quality control, security, national defense, environmental monitoring and astronomy. We introduce the current medical application of terahertz imaging and spectroscopy, ranging from vivo to vitro, from animals to human beings, from biomolecules to cells and tissues. Differences of water content and variations of structure or component are essential mechanisms of terahertz biomedical imaging. Setting pathological biopsy as gold standard for comparison, terahertz imaging has been widely used in identifying differences between normal tissues and abnormal tissues, including a variety of solid tumors, diabetic foots and flaps transplantation, etc. Compared with ultrasound, X-ray, computed tomography and magnetic resonance imaging, the comprehensive advantages of terahertz imaging are non-ionization and rapidness with acceptable sensitivity. Additionally, artificial contrast enhancement has been applied in terahertz imaging, such as gold nano-rods. In recent years, terahertz spectroscopy attracts a great deal of attention in probing and identifying various biomaterials. It is an edge technology for recognizing biomolecules, cells and tissues, based on their individual terahertz spectral fingerprints. Because the majority of low-frequency biomolecular motions lies in the terahertz spectrum, like rotation and vibration of the molecular skeleton. Time-domain spectroscopy and time resolved spectroscopy are common terahertz spectroscopy technologies, which analysis the differences of absorption coefficient or refraction index to probe and recognize a variety of biomolecules, cells or tissues. At present, terahertz medical application has achieved impressive progresses in discrimination, such as the detection of macromolecule and the imaging of tissues. Based on its properties, terahertz technology has great potential ability for clinical application, especially for real-time and label-free identification combined with or without pathology biopsy. However, this technology needs to overcome several difficulties, like biological safety, sample processing, detection performance and cost-efficient management. In this review, we introduce the application of terahertz imaging, spectroscopy in medical science and medical research progress, and also discuss the difficulties of terahertz technology and potential biological safety.

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* E-mail: mayvenhou@126.com