Modelling of Skin Tissue for Body-Centric Communications at Terahertz Frequencies

Max Munoz, Ke Yang, Akram Alomainy, Yang Hao

School of Electronic Engineering and Computer Science, Queen Mary, University of London,
Mile End Road, London, E1 4NS, UK.
y.hao@qmul.ac.uk

Abstract

In the recent years, there has been a significant amount of interest in body-centric applications. The in/on/off-body radio communications have been extensively studied and characterized at microwave frequencies for a wide range of applications, which include healthcare, military and lifestyle. The next generation of wearable technology will be operating at higher frequencies (millimeter wave and terahertz frequencies) and will offer a new set of applications not only for imaging, but also for sensing and communicating.

The development of wearable terahertz-based devices that can automatically detect abnormal physiological parameters, such as skin cancer cells or track glucose changes, is a continuous challenge for research. It has been shown that the interconnection of nano-machines can support short-range communication between micro and nano-devices [1]. In order to understand and properly characterize the effects of electromagnetic wave propagation and the body, the design and simulation at terahertz frequencies will require the use of highly detailed 3D-tissue models which need to include the effects of the inhomogeneous anisotropic media, thus suitable radio propagation models can be derived. High-resolution and three-dimensional images of the human tissues can be acquired using optical coherence tomography which records the magnitude and relative location of the backscattered wave produced by microstructures of the tissue. In [2, 3], 3D images of the skin and finger-pad ridges were created from cross-sectional images depicting the different layers of the skin, namely dermis, epidermis, stratum corneum and the spiraling sweat ducts. Recently, the reported images were used in [4] to create a detailed simulation model of the skin and to understand the electromagnetic properties in the frequency range of 100-450 GHz. The results have shown that the morphological features of the skin and the structure of the sweat ducts play an important role in the reflectance spectrum.

Feasibility studies for nano-communications and analytical models for path loss have been proposed in [5] and [6], respectively. Implanted miniature terahertz units could operate as sensing units (e.g., continuous glucose monitoring within the subcutaneous layer) and communicate with on-body devices; however, the radiation performance of such devices will significantly depend on the tissue models being used. In addition, tissue models considering effective dielectric properties would only deliver misleading results not only on the radiation performance of in-body antennas, but also on the design of future terahertz applications.

References

1. I. F. Akyildiz, F. Brunetti, and C. Blázquez, "Nanonetworks: A new communication paradigm," *Computer Networks,* vol. 52, pp. 2260-2279, 2008.
2. P.-L. Hsiung, Y. Chen, T. Ko, J. Fujimoto, C. de Matos, S. Popov, J. Taylor, and V. Gapontsev, "Optical coherence tomography using a continuous-wave, high-power, Raman continuum light source," *Optics Express,* vol. 12, pp. 5287-5295, 2004/11/01 2004.
3. P. Cimalla, J. Walther, M. Mehner, M. Cuevas, and E. Koch, "Simultaneous dual-band optical coherence tomography in the spectral domain for high resolution in vivo imaging," *Optics Express,* vol. 17, pp. 19486-19500, 2009/10/26 2009.
4. I. Hayut, A. Puzenko, P. Ben Ishai, A. Polsman, A. J. Agranat, and Y. Feldman, "The Helical Structure of Sweat Ducts: Their Influence on the Electromagnetic Reflection Spectrum of the Skin," *Terahertz Science and Technology, IEEE Transactions on,* vol. 3, pp. 207-215, 2013.
5. J. M. Jornet and I. F. Akyildiz, "Channel Capacity of Electromagnetic Nanonetworks in the Terahertz Band," in *Communications (ICC), 2010 IEEE International Conference on*, 2010, pp. 1-6.
6. Y. Ke, A. Alomainy, and Y. Hao, "In-vivo characterisation and numerical analysis of the THz radio channel for nanoscale body-centric wireless networks," in *Radio Science Meeting (Joint with AP-S Symposium), 2013 USNC-URSI*, 2013, pp. 218-219.

978-1-4673-5225-3/14/$31.00 ©2014 IEEE