Optical properties of human jawbone, spongy bone and human bone substitute CERABONE in spectral range from 0.2 to 2.5 THz

A.S. Nikoghosyan[1] and J. Shen[2]

[a]*Yerevan State University, Armenia,* [2]*Capital Normal University, China*

The aim of recent advances in medical research is the solving of problems related to an increase in the age and the quality of human life. The developed technologies contribute to the creation of materials for artificial organs and tissues. According to the action on human organism, the transplant materials are classified as: 1) toxic (when the surrounding tissues mortify at the contact) are the most metals; 2) bioinert (non-toxic but biologically inactive) 3) bioactive (non-toxic, biologically active, inosculating with the bone tissue). The known and widely used bioactive materials are the bioglass and the materials based on the hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$. The Cerabone® bone tissue substitute is made from the mineral phase of bovine bone, which has the maximum similarity to the human bone. For effective treatment, the artificial bone should correspond by chemical and physical properties to the replaced part of the bone tissue as closely as possible.

In the present work, the method of the THz time-domain spectroscopy (TDS) is applied to study the human jawbone, spongy bone and the Cerabone® bone transplantation material in order to determine the proximity of their physical properties. It is known that the time of the vibrational motion of biological molecules is of the order of picoseconds, therefore, the frequency of the oscillation is in the THz frequency range. The THz wave is non-invasive and is non-contact in its nature, it can penetrate into the non-conductive materials and can provide additional spectroscopic data for the accurate diagnosis and analysis of the material.

To measure the optical properties Cerabone® and the human bone fiber femtosecond laser (Fx-100, IMRA) with a pulse width of 113 fs, a central wavelength of 800 nm and an average power of 120 mW was used as a laser source for pumping and detecting terahertz pulses. The method of the THz TDS allows one to determine a complex spectrum of test material with use of the fast Fourier transform by registration of temporal form pulse of THz electric field after its interaction with the sample.

By the method of the THz TDS in a wide frequency range from 0.2 to 2.5 THz in vitro, the refractive indexes and absorption coefficients of the human jawbone tissue, spongy bone and the bone tissue substitute Cerabone® are determined. As the results of studies, it was found that the refractive index of the human jawbone changes between the values of 2.075 and 2.157, for the spongy bone is between 1.09 and 0.99, and of the Cerabone® changes between the values 2.4 and 2.65. The absorption coefficient of the human jawbone increases with the frequency from 1.7 cm^{-1} to a value of 178.5 cm^{-1}, showing the several resonance absorption lines at the value greater than 1.6 THz. The Cerabone® absorption coefficient is less than the natural bone and increases from zero to 80 cm^{-1}, and shows the resonant absorption at 1.7 THz. The absorption coefficient of the human spongy bone changes with the frequency from 23.8 cm^{-1} to a value of 19.6 cm^{-1}, showing the several resonance absorption lines in low frequency range from 0.2 THz to 1.1 THz.

This is the first representation of the frequency-dependent refractive index n(f) and absorption coefficient α(f) of human jawbone, spongy bone and human bone substitute Cerabone® in spectral range from 0.2 to 2.5 THz