Clinical Application of Terahertz Reflectometry for Sensing of Corneal Tissue and Tear Film

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***Abstract* — Terahertz frequency-domain reflectometry is applied for sensing of human corneal tissue hydration level and dynamical control of the tear film in clinical applications.**

Keywords — terahertz radiation; corneal tissue; tear film; hydration level.

I. Introduction

Dry eye syndrome or corneal xerosis nowadays becomes one of the major problems of ophthalmologic pathology. This syndrome is appeared due to a decrease in the quality and/or amount of tear fluid that forms a tear film on the eye surface. A violation of the composition or production of the tear film can lead to sufficiently serious damage to the anterior eye surface. The middle aqueous-layer of the tear film is represented by water solution and makes up 90% of the tear film volume. Under normal conditions, the tear fluid of the ocular surface and in the aqueous humor of the anterior chamber is isotonic with the corneal stroma.

The assessment of pre-corneal tear film is a leading direction in the diagnosis of dry eye syndrome. In clinical practice the most common method for determining the stability of the tear film is Norn test. Non-invasive methods for studying the stability of a tear film include thioscopy. Confocal microscopy expands the possibilities of studying the anatomy of the cornea at the level of its microstructure.

It has been shown recently [1,2] that terahertz (THz) reflectometry might be used for *in vivo* measurements of corneal tissue hydration and tear film dynamic control. In the current study we use our frequency-domain approach and expand the proposed technique [2] for the sensing of corneal tissue hydration level and tear film control in clinical applications.

II. Experimental Technique

The proposed apparatus was based on two distributed feedback (DFB) cw diode lasers with precise resonator temperature control. The lasers generated narrow 10 kHz line in the range of 1530 - 1608 nm with average power of 22 mW each. X-type fiber optical beam splitter with the splitting ratio 50/50 combined both lasers output. The outputs of the splitter were connected to the THz emitter and receiver - low-temperature InGaAs bow-tie photoconductive antennas (PCA) from BATOP. The bias voltage for the terahertz emitter (0/6 V, 40 kHz) was provided by the function generator. The difference frequency range of DFB lasers allowed tuning of the output THz radiation within a range of 50-300 GHz. HDPE-lens with focal distance of 30 mm focused THz signal to the eye surface. The specularly reflected THz signal through second similar HDPE-lens guided into the receiver PCA module. The digital lock-in amplifier was used to measure the resulting photocurrent. Both THz emitter and receiver were fixed on the clinical ophthalmology apparatus allowed measuring the eye reflection in THz range simultaneously with using of the other standard ophthalmological methods.

For each human eye we measured the reflected signal versus time. Each measurement started at the time of eye opening. During the measurement series the testee human was requested to keep the eye open as long as possible. The same time he was able to close the eye as soon as he willing doing that. The measurements continued until the next eye closing.

III. Results

There are some well-recognized areas corresponding to the opening and closing eye in the measured graphs. The THz reflectivity of the open eye demonstrates the dehydration dynamic. Such dependency may be fitted by linear function and decreases with the time. At a time of eye closing the reflectivity decreases significantly and remains constant while the eye is closed. After the eye second opening the reflectivity restores to the value similar one of the previous cycle. Based on the results of preliminary studies, it can be possible to measure of pre-corneal tear film dynamics. The special attention is paid to the case of using drops of artificial tears. In this case the pre-corneal tear film dynamics clearly shows new tendency and might be used for characterization of artificial tears.

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