Development Of The Technique Of Terahertz Pulse Spectroscopy For Diagnostic Malignant Tumors During Gastrointestinal Surgeries

Anna A. Goryachuk, and Mikhail K. Khodzitsky, *Member, IEEE*

***Abstract*— Samples of fresh excised tissues obtained from patients who had undergone gastric cancer have been investigated. Samples were consisted of cancer zone, normal zone and pathologically changed zone. Their optical properties and spectral features were investigated by terahertz time-domain spectroscopy (THz-TDS) in reflection mode. It was found that and waveforms of reflected signals from normal and cancer tissues and their optical properties were well distinguished so it can be concluded that it is easy to discriminate gastric cancer tissue from normal by using THz-TDS.**

***Index Terms*— biological objects; biophotonics; oncology.**

I. Introduction

Advanced gastric cancers have shown poor prognosis [1] because of spread of metastasis which could not be detected with white light. For successful detection of malignant tumors an operator-independent technique is needed. At the present day, the most convenient method of diagnosis for such kind of disease is terahertz time-domain spectroscopy (THz TDS).

The main features of THz radiation which make it very suitable for medical applications are following: the characteristic energies of molecule's rotational and vibrational motions lay in THz frequency region, therefore, various biological molecules can be identified by their characteristic resonant peaks; THz radiation is very sensitive to water so in case of cancer investigations it could provide a great contrast of samples because tumors have higher water content then normal tissues.

II. Sample Preparation

Six patients were enrolled in the study. Samples of tumors were put into opaque box for fixation. Tissue samples were excised during surgeries on the operating table. Samples consisted tumor tissue, not visually altered tissue and normal tissue. Samples volume were about 3 x 3.5 x 1 cm^3. Specimens were carried in sterile containers filled with a solution of 0.9 % NaCl. Experiments were held within 4 hours after samples were excised.

III. Experimental Setup

Samples were investigated by THz - TD spectrometer in the reflection mode (Fig. 2). The characteristics of the spectrometer are following: the spectral resolution of 15GHz, the sensitivity of lock-in amplifier of 1mV, the lock-in amplifier time constant of 1s. The THz broadband pulsed radiation had the following parameters: the spectral range of 0.1–1.5THz, the pulse duration of 2.7ps, the average power of 30 μW, the average power density 60 μW/cm^2, THz radiation was generated by femtosecond laser (Yb:KYW) irradiation of undoped indium arsenide crystal. The femtosecond laser parameters are following: the wavelength of 1040nm, the pulse duration of 120fs, the pulse repetition rate of 75MHz, the power of 1W.

First, the reference signal of silica window was acquired. Silica window have well-known optical properties, so it is a good material for normalizing of object signal. Then samples were placed under the silica window to acquire the object signal. Waveforms of reference and object reflected signals with both amplitude and phase information were recorded by balanced photodiodes and pictured at PC. So at the stage of waveforms acquisition, the reflected signals amplitudes altered in accordance to the water content.

IV. Results

In this study, optical properties and spectral features of oncological, normal and mixed of oncological and normal epithelium (transitional) tissues were calculated and averaged between 6 specimens. Waveforms of reflected signals from oncological, mixed and normal tissues as well as from distilled water were compared and it was shown that amplitude of reflected signals of oncological, mixed and normal tissue are different The amplitude of signal of oncological tissue is substantially lower than that of the normal tissue and similar to reflected signal from water. This effect appeared due to strong absorption of THz radiation by water molecules. Such result approves the theory [2] that the more advanced a tumor becomes the more bodily fluids it contains.

For more accurate discrimination of these three tissues, it is necessary to compare the basic optical properties of tissues such as refractive indices, permittivities and absorption coefficients.

Anna Goryachuk, Mikhail Khodzitskiy, ITMO University, Saint Petersburg, Russia (goryachuk-anna; khodzitskiy@yandex.ru).

The refractive index dispersion is about 1.7 – 1.8 for normal tissues, 2.4 – 2.5 for cancer tissues, 1.8 – 2.2 for mixed tissues and 2.5 – 2.6 for water in the frequency range of 0.4 – 0.5 THz (Fig. 1). Therefore, the comparison of refractive indices could be an additional approach in the diagnostics of gastrointestinal cancer.

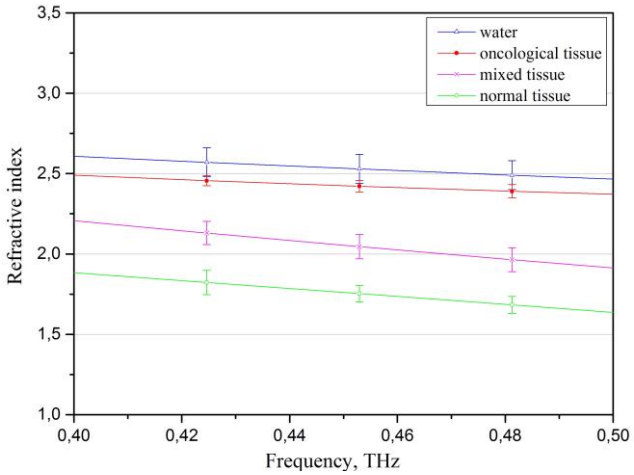

Fig. 1. The dispersion of real part of refractive indices of water, cancer, mixed and normal tissues in frequency range of 0.4 – 0.5 THz

V. Conclusion

Features of THz radiation allow THz reflectometry to easily detect malignant tissues and due to the fact of high sensitivity of terahertz radiation to water it is enough to get waveforms of reflected signals from different tissues for its diagnostics and use optical properties of these tissues as additional parameter for more accurate investigations.

References

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