Terahertz Image Processing for the Skin Cancer Diagnostic

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Abstract - The results of the study of THz imaging of soft (skin) and hard tissues (teeth and nail sections) are presented. THz images of tissue specimens and the results of various image-processing technologies are discussed.

I. INTRODUCTION

In the last decade there have been a large number of basic and applied researches on the generation and application of radiation in the wavelength range of 0.1-10 THz. Interest to terahertz radiation in biology and medicine is caused by its non-ionizing nature (photon energy 0.04 - 0.004 eV); low scattering in turbid media as scattering intensity is $\sim \frac{1}{\lambda^2}$, n=1-4; spectral range corresponding to rotational spectra of molecules and oscillations of biologically important collective modes of DNA and proteins, hydrogen bonds and intermolecular forces of Van der Waals.

The intensive research in the field of THz wave generation and detection was made possible to carry out measurements of THz spectral response of different materials including biotissues. This technique has a subpicosecond resolution, provides information on the phase of the reflected signals by measuring short pulse reflectance from the interfaces. It can be used for broadband spectroscopy and tissue imaging [1]. The goal of this study is to provide new informative technology for the THz imaging.

II. RESULTS

We used the method of pulsed terahertz radiation generation and detection for the TDS.

In the course of the experiments we registered the radiation reflected from the object. The result was either the image of the entire surface of the sample, or the spectrum obtained by the detection of a signal from one point of the sample and then averaged to reduce noise.

**Multiband Method:** Temporal response of cancer and normal tissue are shown in Figure 1. Three Gaussian filters ("red", "green" and "blue") were applied to the absolute value of the temporal THz profiles (shown in Figure 2). For each filter, the scalar product $\int S(t) F(t) \, dt$, where $S(t)$ is the temporal response and $F(t)$ is the filter profile, was calculated. For each pixel, 3 numbers corresponding to red, green and blue color were obtained. These numbers were normalized to be represented in an 8-bit color scheme and formed a colored image. Cancer tissue should appear in yellow color due to the position of the filters and the normalization method chosen.

Example images of skin samples are compared to respective histopathology in Figures 3 and 4. Both methods indicated that sample presented in Figure 4 contained cancer and sample presented in Figure 4 was normal. These results were confirmed by histopathology.

III. SUMMARY

We suggest the method of the visualization and the substance analysis of the THz tissue imaging based on the "multiband color method". We show this method as efficient for the analysis and of the skin cancer diagnostics.