



HAL
open science

Application the THz spectroscopy and holographic approach for diagnostics of dry pellets of human blood plasma

Olga Smolyanskaya, Maksim Kulya, Maxim Nazarov, Vladimir Vaks, Yury Kistenev, O P Cherkasova, Patrick Mounaix, Jean-Paul Guillet, Yulia Kononova, A. Shkurinov

► **To cite this version:**

Olga Smolyanskaya, Maksim Kulya, Maxim Nazarov, Vladimir Vaks, Yury Kistenev, et al.. Application the THz spectroscopy and holographic approach for diagnostics of dry pellets of human blood plasma. 9th International THz-Bio Workshop, CNR, Apr 2021, Online, Italy. hal-04561595

HAL Id: hal-04561595

<https://hal.science/hal-04561595>

Submitted on 27 Apr 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Application the THz spectroscopy and holographic approach for diagnostics of dry pellets of human blood plasma

O. Smolyanskaya¹, M. Kulya¹, M. Nazarov², V. Vaks³, Yu. Kistenev⁴, O. Cherkasova⁵, P. Mounaix⁶, J.-P. Guillet^{1,6}, Yu. Kononova⁷ and A. Shkurinov²

¹ITMO University, Saint-Petersburg 199004, Russia

²Moscow State University, Moscow 119991, Russia

³IPM RAS GSP-105, Nizhny Novgorod 603950, Russia

⁴Tomsk State University, Tomsk, 634050, Russia

⁵Institute of Laser Physics, SB RAS, Novosibirsk, 630090, Russia

⁶Bordeaux University, Talence, 33045, France

⁷Almazov National Medical Research Centre, Saint-Petersburg, 191014, Russia

Abstract—This work describes the promising approach for the diagnostic of diseases, such as diabetes, by using the THz spectroscopy and THz holography method. In this paper, dry pellets consisting of human blood plasma (normal and diabetic) were designed; these objects were analyzed in various THz laboratories in Russia, PCA-analysis of THz spectra was apply to separate the normal and diabetic groups; we proposed the holographic approach that provides sufficient information to reconstruct the spatial distribution of complex refractive index of the sample.

INTRODUCTION

Verification of the physical and mathematical models by comparing the results of numerical modeling with the results of real measurements on phantoms and biological objects is an actual problem of THz biophysics. As shown in some THz laboratories [1-2], the blood plasma is one of the most promising object of study, since changes among its composition caused by pathological processes may considerably affect the optical properties of the blood plasma of humans and animals in the THz frequency range. In this paper, firstly, dry pellets consisting of human blood plasma (normal and diabetic) were created for this work; secondly, these objects were analyzed in various THz laboratories in Russia, using THz pulsed spectroscopy and a high-resolution THz spectrometer based on a backward wave oscillator, PCA-analysis of THz spectra was apply to separate the normal and diabetic groups; third, we proposed the holographic approach for diagnostics of biological phase object, that allows to register hyperspectral holograms in the detection plane and to provide numerical wavefront propagation to the object plane.

I. MATERIAL AND METHOD

Human blood plasma samples were frozen at a temperature of -80 °C and lyophilized by freeze-drying VaCo 2 (ZirBus, Germany) at a temperature of -50 °C and a pressure of 3 Pa (Laboratory of Almazov National Medical Research Centre). The dry mixture of 200 mg blood plasma substance has been pressed into a flat pellet in a steel press-mold with a diameter of 5 mm on a Corvette 590 hand press (Enkor, Russia) at a pressure of 500 kg / cm².

In this work, the samples were studied on a pulsed terahertz setup in transmission mode in two different laboratories (ITMO University [1] and MSU [2]). A high-resolution

terahertz spectrometer based on a backward wave lamp (IPM RAS [3]) was also used.

Biochemical parameters of the human blood plasma were measured to control the results of the study in the clinical diagnostic laboratory of Almazov National Medical Research Centre (Russia). Plasma glucose concentration was increased in diabetic plasma, which is common for diabetes mellitus.

II. RESULTS AND DISCUSSION

The groups of the THz spectra have a rather compact distribution in the principal component space. Also, the groups of the THz spectra are fully spatially separated. Using a high-resolution THz spectrometer, the spectral lines of substances were detected in blood plasma samples.

We demonstrated the ability of holographic approach to reconstruct spatial properties of investigated object in terms of two-dimensional distribution of refractive index, as well as frequency-dependent refraction in each point of the pellets (see Fig).

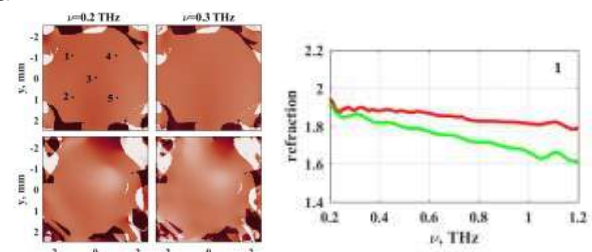


Fig. Spatial distribution of reconstructed refractive index for healthy and diabetic sample. Label 1 shows spatial point where we plotted refractive index versus frequency. Green line corresponds to healthy sample and red corresponds to the diabetic one.

III. ACKNOWLEDGMENTS

The reported study was funded by RFBR according to the research project #17-00-00275 (#17-00-00270, #17-00-00272, #17-00-00184, #17-00-00186), 18-51-16002 and by the Government of the Russian Federation (Grant 08-08).

REFERENCES

- [1] O.A. Smolyanskaya, V.N. Trukhin, et al. "Terahertz spectra of drug-laden magnetic nanoparticles," *Colloidal Nanoparticles for Biomedical Applications XIV*, vol. 10892, pp. 108920L, 2019.
- [2] O. Cherkasova, M. Nazarov, A. Shkurinov "Noninvasive blood glucose monitoring in the terahertz frequency range," *Optical and Quantum Electronics*, vol. 3, pp. 217, 2016.
- [3] V. L. Vaks, E.G. Domracheva, et al. "Exhaled breath analysis: physical methods, instruments, and medical diagnostics," *J. of Physics*, vol. 7, pp. 684, 2014.