Spatially resolved speckle correlometry in application to media structure characterization

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***Abstract*— We propose an original speckle-correlometry method for the structural analysis through a random multiple scattering media with complex dynamics and structure. The use of a localized radiation source and spatial ring filtration of scattered field give the opportunity to select the partial components of scattered field. In this work, the dynamic process of gel formation beginning from the stage of sol to the stage of gelling are investigated and the experimental data are presented. The object under study consist of 0.28 %weight fraction of gelatin dissolved in water and 1 gram per liter (gL^{-1}) and 100 mg per liter (gL^{-1}) of TiO_2 for optical scattering.**

Keywords*— *dispersive media; scattering; laser light; speckle correlometry

I. INTRODUCTION

Speckle correlometry is successfully used in laboratory and clinical test for the monitoring of cells and organs movements in tissues (for example, the dynamics of red cells [1]), for the process of fibrous tissue thermal modification under the condition of laser heating [2], as well as for the liquid phase transfer in porous layers [3]. The evaluation of the correlation between the parameters of the intensity fluctuations of speckle-modulated images are the informative characteristics of the optical properties of the medium, so in [4] the method of speckle correlometry based on a localized light source and spatial ring filtration of scattered field were proposed for the determination of the transport scattering coefficient of polytetrafluoroethylene.

II. DISCUSSIONS OF THE RESULTS

The information about structural and optical properties of the investigated medium is contained in the intensity distribution of scattered field. The spatial filtration using the variation of the radii of the inner and outer rings of the filter allows to select the partial components of scattered radiation and to analyze the components of radiation with different depth penetration into the medium and therefore to get the information about the existence and the depth location of the movable constituent part of the medium, as well as its mobility characteristics.

Speckle correlometry method with the spatial ring filtration of scattered field and the use of a localized radiation source was used to analyze the process of gel formation. It is known, that the early stages of the process of gelling is accompanied by the solidification of surface and subsurface layers and thereby the reduction of Brownian motion mobility. In this work the dependences of correlation time on the temperature of the phantom media consisting of the gelatin with weight fraction equal to 0.28 % dissolved in water and 1 gram per liter (gL^{-1}) and 100 mg per liter (gL^{-1}) of TiO_2 were experientially obtained. The temperature of the phantom media in the process of gel formation was changed from 48-50 ^{0}C to 25 ^{0}C, at the same time the time duration of whole process was 35-40 minutes. In the case of the gelatin dissolved in water and 1 gram per liter (gL^{-1}) there are no considerable differences between the correlation times for different radii of the inner and outer rings of the filter because of the scattering properties of medium. It was shown that the big correlation time for the spatial ring filter with radii equal to 0.6 - 0.7 mm that correspond to the stationary, inactive upper layer of the investigating medium. In comparison, the correlation time for the spatial ring filter with radii equal to 1.1 - 1.3 mm is small because of the active dynamics of scatterers in the lower layers.

Thus, speckle correlometry method with the spatial ring filtration of scattered field and the use of a localized radiation source allows us to analyze not only the structural features of the medium, but the dynamic processes taking place at different depths inside the investigated medium.

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