Determination of egg yolk optical properties at various temperatures using modified integrating spheres

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INTRODUCTION

Optical properties of biological tissues may change during laser irradiation. Quantification of these processes is important for optimisation of medical diagnostics and surgery methods [1]. In this work, a method for determining optical properties of biological tissues at various temperatures is presented; absorption, scattering and scattering anisotropy of egg yolk during laser irradiation are measured.

EXPERIMENTAL SETUP

A block-scheme of the experimental setup is shown in figure 1. The yolk sample 1.03 mm thick was sandwiched between two microscope slides and placed between two integrating spheres S_T and S_R. The distances L_T and L_R between the sample and spheres were changeable, allowing to measure total power of scattered radiation as a function of solid angle. The sample was irradiated by a modulated laser beam at 1064 nm wavelength; heating of the sample was performed with the same laser beam. When measuring properties of the sample at room temperature, average laser power was equal to 250 mW; in order to conduct measurements and heating simultaneously, radiation of 3.5 W was used. The measurement of scattered radiation was based on a lock-in detection using photodetectors D_T and D_R.

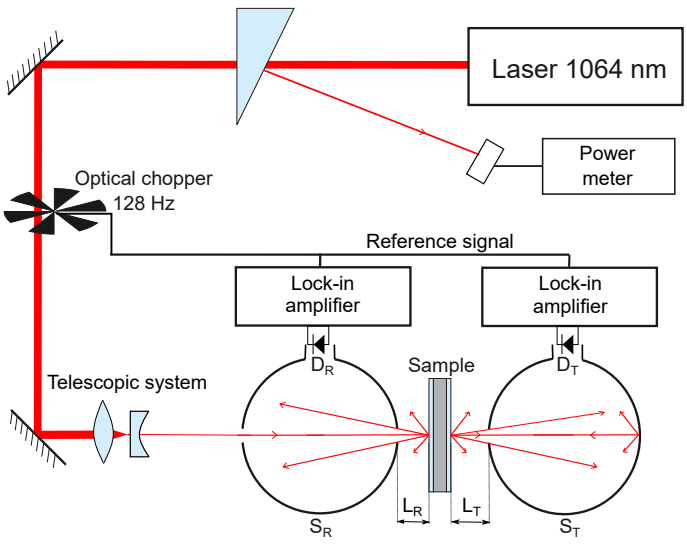

Fig. 1. Block-scheme of the experimental setup

MODELLING

Inverse adding-doubling method was used for solving the radiative transport equation. The method uses total reflection and transmission measurements to find the scattering and absorption of a slab of turbid material (scattering anisotropy is assumed). The radiative transport equation is solved repeatedly until its solution corresponds with the measured total reflection and transmission values [2, 3].

The method was modified to be used in experiment configuration. In original work, all radiation transmitted and reflected by the slab is taken into account when performing the calculations. In this experiment, only a certain amount of radiation is detected, depending on distance between the slab and integrating sphere.

RESULTS

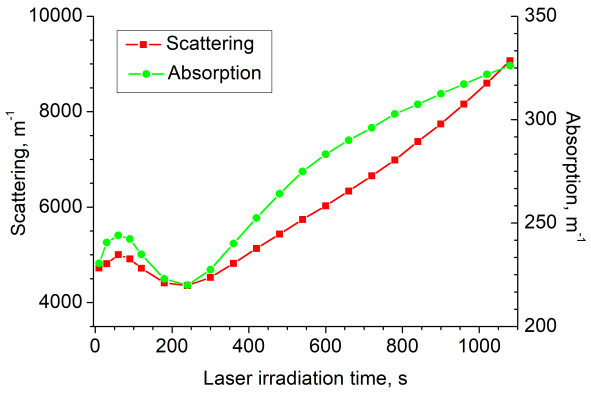

Fig. 2. Egg yolk scattering and absorption kinetics during laser irradiation at 1064 nm (g = 0.9, $L_R = L_T$ = 10 mm)

	Unheated	Heated
Scattering μ_s, м$^{-1}$	4600	8500
Absorption μ_a, м$^{-1}$	200	340
Scattering anisotropy g	0.89	0.91

Tab. 1. Egg yolk optical properties before and after laser heat treatment at 1064 nm (T = 24°C)

CONCLUSION

Experimental method for measurements of optical properties of different biological tissues during laser irradiation was presented. A mathematical model of laser-tissue interaction accounting for experimental configuration was implemented. The method was used for determining egg yolk optical properties during laser heating, and can be practical for physical and mathematical modelling of light-tissue interaction processes.

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