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Photothermal effect in biomedical applications

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When a sample is exposed to EM radiation, part of the excitation energy is absorbed, and part of the absorbed energy is transformed into heat through non-radiative deexcitation-relaxation processes. This effect of optical heating of the sample, so so-called photothermal (PT) effect causes the spread of heat through the sample and through its environment, leading to several phenomena that can be detected in different ways: a change in temperature on the surface of the sample, a change in the spectrum of IR radiation of the sample, bending and/or stretching of the sample, the appearance of a gradient of optical refractive index within the sample (thermal lens effect) or in its environment (mirage effect). All of these phenomena depend on the morphological, thermal, optical, elastic, and other physical properties of the sample that govern the transport processes caused by the effect of an external source of EM radiation. As all these phenomena are non-destructive, the PT effect can be used in in vivo biomedical diagnostics.

The subject of our research is the development of a model for optically induced temperature variations in biological tissues, i.e. solving of direct PT problem. To this end, we take into account the fractal structure of the tissues, thermal memory effects, and blood perfusion effects on the propagation of heat through human tissues. Besides, we analyze the possibilities of tissue image reconstruction and determination of tissue characteristics when some of the PT phenomena dependent on temperature profile are experimentally detected i.e. we solve inverse PT problem. Our results could enable the development of novel non-destructive biomedical diagnostic techniques.

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