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MODELING AND ANALYSIS OF GENERALIZED PHOTOTHERMAL PULSE RESPONSE FOR CHARACTERIZATION OF THE MACROMOLECULAR MATERIALS

¹Galovic S., ²Reshetnyak A., D. Cevizovic¹¹University of Belgrade, Vinca Institute of Nuclear Sciences, Serbia²Institute of Strengthened Physics and Material Sciences of SB RAS, Tomsk, Russia

bobagal@vin.bg.ac.rs, reshet@ispms.tsc.ru, cevizd@vin.bg.ac.rs

Macromolecular structures have important role in the processes of functioning of the living cells. Besides, they are very sensitive to the physical state of their environment, as well as to the methods used to their investigations. For that reason, nondestructive methods of investigations always attract the great attention.

Here a generalized model of the photothermal pulse response is proposed, including thermal memory effects on a base of our previous study [1], [2]. Detailed analysis have been performed in comparison to the standard classical model. It has been shown that classical model in pulse photothermal techniques is not suitable for characterization of macro-molecular materials because in these materials the effects of thermal memory are highly pronounced. The parameters of the model have been related to thermo-elastic and optical properties of the macro-molecular sample. It has been shown that the velocity of heat propagation could be estimated from photothermal pulse response. This material property has not been estimated yet, but its understanding is very important for further fundamental investigations of heat transfer as well as for many applications of macromolecular materials [3]. We assumed that the tested sample was optically opaque, and that it is in the contact with semi-infinite layer of air. In the case when such system is irradiated by a laser beam of the certain profile and with short duration of time, the process of heat propagation can be described by the following system of differential equations

$$\left[\frac{\partial^2}{\partial t^2} - \frac{1}{D_{T_i}} \left\{ \frac{\partial}{\partial t} + \tau \frac{\partial^2}{\partial t^2} \right\} \right] \vartheta_i(x, t) = - \frac{S_0 \delta(x)}{k_i} \left\{ 1 + \tau_i \frac{\partial}{\partial t} \right\} f(t), i = a, s$$

$$\left\{ 1 + \tau_i \frac{\partial}{\partial t} \right\} q_i(x, t) = -k_i \frac{\partial}{\partial x} \vartheta_i(x, t) \quad (1)$$

where k_i, D_{T_i}, S are respectively the thermal conductivity, thermal diffusivity and the volume velocity of the thermal source generation, q is the vector of the heat flux, τ_i appears by the relaxation times, and $\vartheta_i(x, t)$ is the thermal field. We consider different regimes of heat propagation on a basis of solution for the system (1) for a model sample of. macro-molecules.

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