The modeling of local distribution of the temperature photo-induced by ensemble of nanoparticles

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***Abstract*—In this paper we consider the laser irradiation of the ensemble of absorbing nanoparticles localized in macroscopically-sized area of the tissue sample. The simple formula for estimation of distribution of the local temperature is presented.**

***Keywords*— photoabsorbing nanoparticles; laser irradiation; local temperature field**

I. Introduction

For applications related to cell optoporation and cancer cell killing, a localized overheating of biological tissue around the nanoparticles heated by laser radiation should be analyzed [1]. Using experimental data on the temperature field in a medium with absorbing nanoparticles (see, e.g. [2]) it is difficult to extract information about the small-scale inhomogeneity of this field (temperature drops ΔT within the nanoparticles themselves and their surroundings, see Fig. 1). In this regard, the numerically-analytical and analytical methods based on the developed two-scale approach to the solution of the problem [3] were considered. Thus we have estimate of the characteristic values of temperature drops ΔT.

II. Results of modeling

For nanoparticles in the form of homogeneous nanospheres with a coefficient of thermal conductivity much greater than this value for the environment the desired characteristic has the simplest form:

$$\Delta T \sim \frac{< T >}{D^2 d N_0} \ . \qquad (1)$$

Here D is the characteristic size of irradiated macroregion the shape of which is close to spherical and containing nanospheres of diameter d at a concentration N_0, <T> is the macroscopically averaged value of the temperature field in the center of the macro-region. Expression (1) is valid for both stationary and quasi-stationary exposure modes of laser irradiation.

As an example, Fig. 2 shows the corresponding result, depending on the size of the irradiated macro-region D for three different concentrations N_0 of nano-spheres with diameter d = 10 nm.

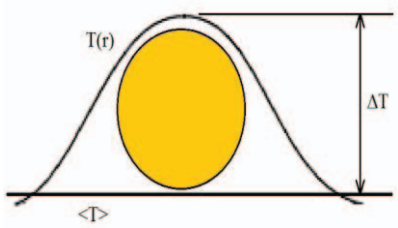

Fig. 1. T(r) is the local value of the temperature field at the point r, <T> is the value of macroscopically averaged temperature, ΔT is the temperature drop.

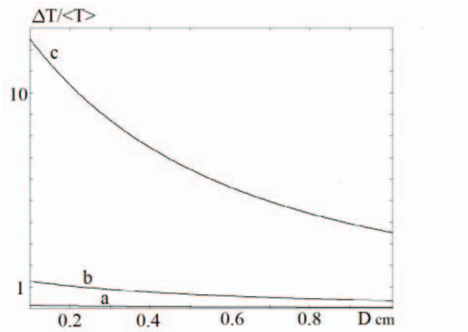

Fig. 2. The relative value of temperature drops $\Delta T/<T>$ at a concentration of nanospheres $N_0 = 10^9$, 10^8 and 10^7 1/cm^3 (curves a, b and c, respectively).

III. Conclution

With decrease of each of the following parameters *D*, N_0, *d,* temperature drop ΔT, which takes place during the heat transition from nanoparticles to the environment is growing and could significantly exceed the average temperature <*T*>. The proposed approach is applicable for both CW and quasi-stationary regimes of laser irradiation.

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References

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