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Light absorption by layered structure of silicon particles

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Photovoltaic (solar) cells are the object of intensive theoretical and experimental investigations in the last decades. One of the ways to increase efficiency of the solar cells is to reduce optical losses. To attain this end different approaches allowing one to decrease reflection, increase the path length of radiation in the structure, and, as a result, increase the light absorption, are developed.

Another way is creation of the cell structure that absorbs light more effectively from a standpoint of the photo-electromotive force (photo-emf). To increase absorption of light by a homogeneous silicon layer, it is necessary to increase its volume. This reduces the efficiency of solar cell (SC) due to the diffusion length limitation. Instead of increasing the volume of the homogeneous silicon layer, the creation of layered particulate structure (multilayer) of active layer was proposed [1]. Such a layer consists of a number of plane-parallel monolayers of spherical silicon particles with sizes of the order of the diffusion length.

In this presentation absorption of light by an ordered monolayer and a multilayer of submicron spherical silicon particles is investigated. The single scattering approximation, quasicrystalline approximation, and the transfer matrix method are used. It is shown that the spectral and integral over the solar spectral irradiance absorption coefficients of monolayer and multilayer grows with the particle size. Effect of spatial ordering of particles on the absorption coefficient is studied. It is shown that absorption by particulate structure increases with the disorder. The multilayers with variable concentration and size of particles in monolayer sequences are considered. Absorption coefficient of such "gradient" multilayers can be much greater than the one of the non-gradient multilayers.

Comparison of the absorption by the particulate layers and the homogeneous plane-parallel plates with the equivalent volume of material (equivalent plate) is carried out. The absorption coefficient of particulate monolayer can be 20 times greater than the one of equivalent plate in the range of small absorption index of material.

[1] Miskevich AA, Loiko VA. Light absorption by a layered structure of silicon particles as applied to the solar cells: Theoretical study. J. Quant. Spectr. & Rad. Transfer 2014;146: 355–64.