Absorptance of densely packed particulate samples

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This presentation addresses the problem of light transport in a weakly absorbing powder medium. The individual particles of the medium are assumed to be large compared to the wavelength. Different values of the particle refractive index, in the range from 1.3 to 4.0, are used in the calculations. The results of ray tracing Monte Carlo simulations are presented for three models of absorption in the medium. We consider bulk absorption of radiation in the powder particles themselves, absorption in the spaces between the particles, and continuous absorption. The total absorptance and the depth dependence of the absorbed energy are calculated for all these cases. At rather great depths, the obtained results can be fitted by the diffusion law with appropriate values of the absorption and transport mean free path. The value of the transport mean free path is retrieved by fitting the diffusion flux attenuation curve to the data of Monte Carlo simulations for the model of continuous absorption. The dependence of the ratio of the transport mean free path to the particle size on the filling factor of the powder medium and on the particle refractive index is studied. We find that, for given absorption and transport mean free path, the value of the energy absorbed in the sample depends on the model of absorption and differs from the corresponding prediction of the radiative transfer theory. The difference between the obtained results diminishes as the filling factor of the powder medium decreases. We propose a qualitative explanation of the observed effects, based on an analysis of the path distribution of photons in the medium and a comparison of the average photon paths inside and outside the particles.

The presented results can be useful for the management of absorption in various applications such as solar cells and other photovoltaic devices, absorption spectroscopy, and random lasers. See, e.g., [1–3].

References

[1] Sgrignuoli, F., and P. Bettotti, 2016: Roughness-induced enhancement of optical absorption in random media. *J. Opt. Soc. Am. B* **33**, 915–921.
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