Evaluation of the Optical Properties of Fibrous SiO_2 Materials

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High-speed aircraft require radio communication with the ground. Of the greatest interest is silica (SiO_2) in the form of fibers, 1–10 μm in diameter, applied as a raw stock to produce either a material such as the cotton wool, or to make bundles, 0.5–1.5 mm in diameter: their 2- or 3-dimensional weaving with the silica aerosol space impregnation between them (and between the fibers) forms the lightweight, high-temperature, heat-resistant, one-component structural material. For the considered problem of thermal protection, a one-dimensional consideration is sufficient (the thickness of the coating is much smaller than its dimensions). This means that it is possible to limit ourselves to a one-dimensional consideration of the transfer of radiation energy with a given wavelength through an infinitely large plate, i.e. not to consider the actual mechanisms of light scattering and limit ourselves to determining only the normal hemispherical spectral values of reflection — $\varepsilon(\text{refl})$ and transmission — $\varepsilon(\text{transm})$, which greatly simplifies the task. In this case, $\varepsilon(\text{rad})_\lambda = \varepsilon(\text{absorption})_\lambda = 1 - \varepsilon(\text{refl})_\lambda - \varepsilon(\text{transm})_\lambda$.

As the first approximation, we might determine the integral (over the wavelength) material characteristics as $\varepsilon = \int \varepsilon_\lambda I(\lambda) d\lambda / \Delta\lambda \sigma T^4$ where $I(\lambda) = (2\pi hc/\lambda^5)/[\exp(hc/kT\lambda) - 1])$ is the blackbody radiation. With that approach, to assess the material behavior at high temperatures, it is sufficient to obtain the spectral dependences of the standard hemispheric reflectance and transmittance under the normal conditions (without performing high-temperature studies); and we did it using the standard measuring instruments. The obtained results of experimental evaluation of optical properties of 5 mm thick samples with two-dimensional weaving to harnesses (diameter 0.5–1.5 mm) of a fibrous silica material (average fiber diameter about 6–7 μm) structure are presented.