Radiative Properties of Gold Surfaces with One-Dimensional Microscale Gaussian Random Roughness

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The radiative properties of engineering surfaces with microscale surface textures (patterned or random roughness and coating) are of fundamental importance and practical interest. These properties depend on the incident wavelength, optical properties and temperature as well as the topography of the reflective surface. In the case of slightly rough surfaces, the traditional Kirchhoff theory may be applicable. In recent years, several rigorous theoretical treatments have been developed to understand the light scattering from very rough surfaces, for example, the ray tracing method, integral equation formulation and rigorous coupled wave analysis (RCWA) method of solving the Maxwell's equations. In this study, a direct numerical solution of Maxwell's equations was implemented. The method is the finite difference time domain method (FDTD). The problem of interest is a set of gold surfaces with Gaussian random roughness distributions. Highly accurate experimental data is available from the work of Knotts and O'Donnell [1994]. Because of the negative real component of the complex dielectric constant at the infrared wavelengths of 1.152 and 3.392 μm, the convolute integral was used to convert the frequency domain permittivity to time domain permittivity in order to obtain converged solutions.

The FDTD method produced highly accurate solutions to understand the light scattering process of the metallic surfaces. The bi-directional reflectivities in both normal and parallel polarizations were obtained and compared with the experimental data. The predictions and experimental results are in good agreement. The highly specular peak in the reflectivity was reproduced in the numerical simulations. The effects on the surface radiative properties due to the microscale surface topography were discussed in detail.