Experimental and Theoretical Studies of Specular and Diffuse Scattering of Light from Randomly Rough Metal Surfaces

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We present experimental results for the reflectivity of two-dimensional randomly rough metal surfaces, as well as the contribution to the mean differential reflection coefficient from the light scattered incoherently by such surfaces. The measurements were done with s- and p-polarized light. The samples were fabricated on photoresist and coated with gold. Their surface profiles constitute good approximations to Gaussian random processes with a Gaussian surface height autocorrelation function. The measurements were done in the infrared at a wavelength of $10.6\,\mu$m. The experimental results for the reflectivity are compared with the results of small-amplitude perturbation theory, phase perturbation theory, and self-energy perturbation theory, and with results obtained on the basis of the Kirchhoff approximation. Rough surfaces with rms heights a small fraction of the wavelength of the incident light were employed, so that meaningful comparisons with the results of the perturbation theories could be made. In the case of the light scattered incoherently, the experimental results are compared with results obtained by means of the Kirchhoff approximation and with the results of small-amplitude perturbation theory and phase perturbation theory. The theoretical results for the reflectivity obtained on the basis of phase perturbation theory are closest to all the experimental results in both s and p polarization. Phase perturbation theory also produces the best overall agreement with the experimental results for the contribution to the mean differential reflection coefficient from the incoherent component of the scattered light for in-plane, co-polarized scattering, although small-amplitude perturbation theory produces better results in p polarization for samples with very small transverse correlation lengths of the surface roughness.