Transmission of Light through a Thin Metal Film with Periodically and Randomly Corrugated Surfaces

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We calculate the transmission of p- and s-polarized light, incident normally from vacuum, through a thin metal film deposited on a semi-infinite dielectric substrate. The vacuum-metal and metaldielectric interfaces are one-dimensional rough interfaces defined by $x_3 = -\zeta(x_1)$ and $x_3 = -H + \zeta(x_1)$, respectively, where the function $\zeta(x_1)$ has the form $\zeta(x_1) = d \sum_{n=-\infty}^{\infty} \exp[-(x_1 - nb - d_n b)^2/a^2]$, with $0 \leq d \leq H/2$. In this expression the $\{d_n\}$ are independent, identically distributed random deviates drawn from a uniform distribution. By means of a rigorous numerical approach the transmissivity of a single realization of the film is calculated as a function of the wavelength of the incident light, the amplitude d, and the width of the distribution from which the $\{d_n\}$ are drawn. Results for silver and gold films show that in comparison with the transmissivity of a film with planar surfaces ($d = 0$), the transmissivity is strongly enhanced in the case of a film with a periodically modulated thickness ($d_n \equiv 0$) for light of both p and s polarization even for moderate values of $d\,(= 0.2\,\mathrm{H})$. In the case of p polarization the transmissivity is further enhanced at the wavelengths of the surface plasmon polaritons supported by the scattering system. The enhancement of the transmissivity for both polarizations of the incident light is further increased as the amplitude d is increased up to $d = 0.4\,\mathrm{H}$. In the presence of nonzero randomness in the function $\zeta(x_1)$ the enhancement of the transmissivity in both polarizations is decreased for a given value of d from its value in the absence of the randomness, but a significant enhancement remains even when d_n is allowed to take values in the interval $(-0.2, 0.2)$. Thus, periodicity is sufficient to produce a significantly enhanced transmissivity, but it is not necessary.