Refraction of Surface Polaritons by a Surface Lens

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The scattering of surface plasmon polaritons by spatially localized surface defects has been studied both theoretically [1, 2] and experimentally [3]. Such scattering processes lead not only to a reflected surface plasmon polariton but also to radiation of electromagnetic waves into the vacuum above the metal surface on which the surface plasmon polariton propagates. When a surface plasmon polariton propagating along a metal surface impinges at oblique incidence on an extended linear surface defect such as a linear groove or a ridge on an otherwise planar surface, the translational invariance along the surface structure imposes a conservation law on the tangential components of the wave vectors of all waves excited by the interaction of the surface plasmon polariton with the structure, namely the reflected and transmitted surface plasmon polaritons as well as the radiated bulk waves. This is Snells law for surface plasmon polaritons. When the surface defect is formed from a different material, e.g., a dielectric film, so that in the region of the defect the surface plasmon polariton has a different wavenumber, the surface polariton is refracted at the boundary of the defect. In the present work we consider the transformation of surface plasmon polaritons at surface structures that are formed by a film on a planar (or corrugated) metal surface. In particular we are interested in the case where the boundary between the clean metal surface and the film is a parabola, for which the surface profile function is given by $\zeta(x_1, x_2) = d\theta(x_1 - ax_2^2)\theta(x_1)$, where $\theta(z)$ is the Heaviside unit step function, and d is the thickness of the film, and the case where the film has an elliptic shape for which $\zeta(x_1, x_2) = d\theta(1 - (x_1/a)^2 - (x_2/b)^2)$. The refraction of surface polaritons at the boundary of such structures on a metal surface leads to a focusing of the transmitted surface waves. The reduced Rayleigh equations for a vacuum/film/metal system with two two-dimensional rough interfaces are derived and solved numerically. The parameters of surface defects allowing an efficient focusing of surface plasmon polaritons are determined.

REFERENCES

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