Transmission of a surface plasmon polariton through a slit of a finite length on a planar metal surface

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We study the propagation of a surface plasmon polariton through a slit of finite length fabricated on a planar metal surface. The system we consider consists of vacuum in the region $x_3 > 0$. The region $x_3 < 0$ is filled with a metal characterized by a dielectric function $\epsilon_1(\omega)$, except in the regions $|x_1| < L/2$, $|x_2| > d$, which are filled with a metal characterized by a dielectric function $\epsilon_2(\omega)$. For simplicity both $\epsilon_1(\omega)$ and $\epsilon_2(\omega)$ are assumed to be real. Thus the region $|x_1| < L/2$, $|x_2| < d$ represents a slit of length L and width $2d$ on the surface $x_3 = 0$. The dielectric function $\epsilon_2(\omega)$ is chosen such that the slit acts as a waveguide that supports one or more guided surface plasmon polaritons, depending on its width $2d$. A surface plasmon polariton beam of frequency ω and $1/e$ half width w, propagating in the x_1 direction, is incident on the slit from the region $x_1 < -L/2$ on the surface $x_3 = 0$. The field of the surface plasmon polariton emerging from the slit into the region $x_1 > L/2$ is calculated, and from it the transmissivity of the slit as a function of its width. These calculations are carried out by the use of an impedance boundary condition on the surface $x_3 = 0$. The singular integral equations that arise in these calculations are solved by the Wiener-Hopf method. It is found that as the width of the slit is increased the transmissivity increases in a step-wise fashion at each width at which an additional guided wave can be supported by the slit.