Nanoplasmonics and surface enhanced spectroscopy

Plasmon-polariton excitations on surfaces with fluctuating impedance: Localization, scattering, and instability against dissipation

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We study the surface plasmon-polariton (SPP) scattering by a finite domain of metal-vacuum interface with randomly fluctuating surface impedance for arbitrary strength of the fluctuations and Ohmic loss in the metal. As a measure of SPP scattering, the Hilbert norm of the integral scattering operator is used, which can take arbitrary value from zero to infinity. The strength of the scattering is shown to be controlled not only by the parameters of the fluctuating impedance (dispersion, correlation radius, the length of inhomogeneity region) but also crucially depends on the conductivity of the metal. If the scattering operator norm is small as compared to unity (weak scattering limit), the incident SPP is mainly scattered into the vacuum, thus losing its energy for excitation of non-isotropic bulk quasi-Norton waves. The scattered field intensity is expressed in terms of the random impedance pair correlation function, whose dependence on the incoming and scattered wavenumbers demonstrates the possibility to observe in random-impedance-induced scattering the effect analogous to Wood anomalies characteristic of waves scattered by periodic gratings. Under condition of strong scattering, when the integral operator norm becomes large as compared to unity, the radiation of waves into the free space is highly suppressed, and the incoming SPP is almost ideally backward-reflected from the inhomogeneous part of the interface. Our theory predicts inversely proportional dependence of the scattering operator norm on the dissipative part of the surface impedance, so within the widely used model of dissipation-free conducting medium the SPP is unstable against arbitrary small fluctuations of the medium polarizability. We interpret the SPP mirroring under strong fluctuations of the impedance in terms of the interference-induced Anderson localization arisen in the system which is open and formally non-Hermitian.