Optical Dyakonov surface plasmons at a metal-crystal interface

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Surface plasmon polaritons (SPPs) are typical electromagnetic (EM) waves that propagate along a metal-dielectric interface and whose amplitudes decay exponentially away from the interface. Because of their tighter spatial confinement and higher local field intensity, as well as high sensitivity to the permittivity function, SPPs have been used in various applications including sensing, imaging, nano-photon detectors, enhanced second harmonic generation, surface enhanced Raman scattering, and many more. Such SPPs propagate not only at the interface of an isotropic metal and an isotropic dielectric, but also at the interface between an isotropic metal and an anisotropic dielectric [1,2]. Examples include the Dyakonov surface waves (DSWs) [3] and Dyakonov surface plasmons (DSPs) [4]. The latter have properties of both the DSWs and the SPPs. The DSWs have some unique characteristics, e.g., they are weakly localized and they propagate at the interface of two media at least one of which is anisotropic and the real parts of the permittivity functions are of opposite sign. Also, they are hybridized due to polarization of both the transverse electric (TE) and the transverse magnetic (TM) fields, and they are highly directional, i.e., they can exist only under certain conditions and in specific regimes.

Extensive and potential applications of SPPs and DSPs demand proper theoretical investigations together with convenient and controllable tools and techniques for coupling of EM waves and surface plasmons [5]. Also, it has become possible to control the permittivity function of materials, and thereby enabling new approaches for the excitation of SPPs and DSPs due to the availability of non-conventional plasmonic materials such as transparent conductive materials and highly doped semiconductors.

In this study [6], the theory of DSPs propagating at optical frequencies along the interface of an isotropic metallic plasma [e.g., gold (Au)] and a uniaxial crystal [e.g., Rutile (TiO_2)] is advanced with the Drude-Lorentz (DL) model for the material permittivity to take into account the contributions of both the *intraband* transitions of free electrons and the multiple *interband* transitions of bound electrons in metals. It is found that the propagation characteristics of DSPs are significantly modified especially in the short-wavelength spectra (< or ~500 nm) and with a small deviation of the orientation of the optical axis. The excitation of such DSPs can have novel applications in transportation of EM signals in a specified direction at optical frequencies (~PHz).

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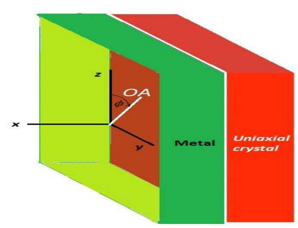

Fig.1 A schematic diagram of a planar interface (*x* = *0*) between an isotropic metal (*x* > *0*) and an anisotropic uniaxial crystal (*x* < *0*) is shown. Here, OA is the optical axis making an angle ϕ with the direction of propagation of DSPs (*z*-axis).

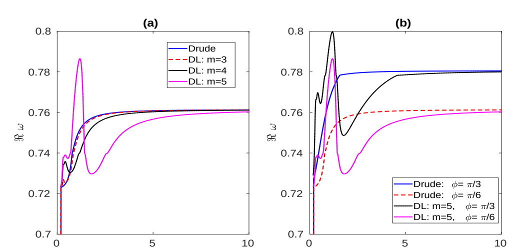

Fig. 2 Plots of the real part of the wave frequency against the wave number *q* of DSPs to show the effects of (a) the multiple interband transitions for a fixed $\phi = \pi/6$ and (b) the angle of propagation.