Orthonormal Complex Hybrid Guided Mode Coupling over a Discontinuity in a Plasmonic Waveguide

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We generalized an expression for expansion coefficients to determine the orthonormal complex hybrid guided mode coupling over a small step discontinuity which allowing prediction of the localised surface intensity on a plasmonic waveguide for design of devices for integrated surface-enhanced spectroscopy.

Introduction

Waveguide surface sensing measurements require maximization of surface optical intensity. Plasmonic waveguides (PWGs) formed from a dielectric waveguide with an absorptive overlayer of a noble metal can exhibit high surface localization and therefore high surface intensity. PWGs are usually illuminated from the uncoated input waveguide as shown in the schematic in Fig 1a. The transmittance of such a device has been modelled previously for the slab waveguide case [1]. In this study, we extend a predication of transmittance through the structures with 2D confinement of a guiding layer reported elsewhere [2] using a more general expression for the expansion coefficients describing the coupling between transmitted orthonormal complex hybrid guided mode (OCHGM) amplitudes and a distribution of a surface intensity which is superimposed in Fig 1a.

Results

Fig. 1b and Fig 1c show the calculated transmittance at 633 nm through the PWG as a function of refractive index of an ambient and power carried by the three guided modes, respectively, within gold region, neglecting backscattering and a multiple reflections. The mapped surface intensity is detailed in Fig. 1d. The guided mode intensity distributions $|E_y(x,y)|^2$ at z=0 μm for a gold-coated waveguide region, calculated using FEM at a wavelength of 620 nm are shown in Fig. 1e.

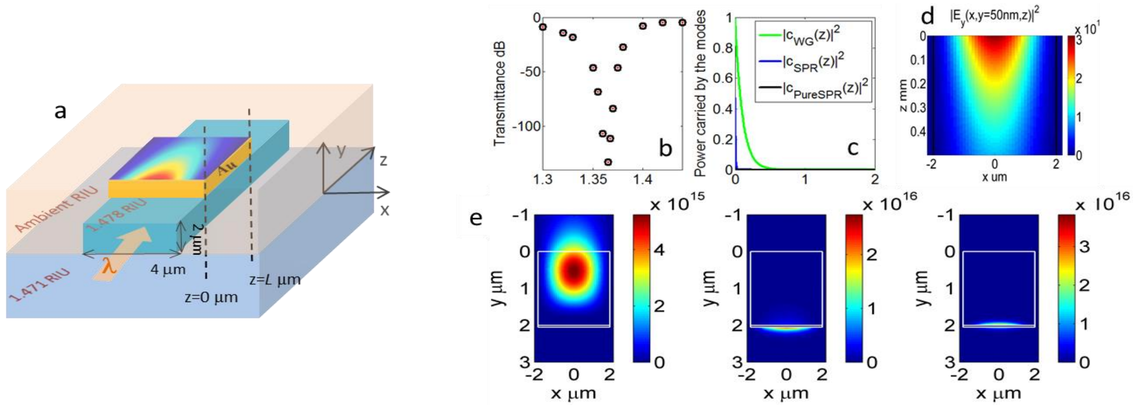

Fig. 1. (a) Schematic of a waveguide with calculated surface intensity distribution $|E_y(x,y=50nm,z)|^2$ enlarged in **(d)**; **(b)** calculated transmittance; **c)** calculated powers carried by the modes within the Au-coated region, **(e)** $|E_y(x,y)|^2$ of the three guided modes obtained using FEM for a Au-coated region.

Conclusion

We have introduced a general expression for the expansion coefficient of any two OCHGM at a step of discontinuity and applied this to the introduction of a thin absorptive overlayer to predict device transmittance and surface intensity on PWGs. This model provides the basis for designing high-sensitivity refractometers and integrated optical devices for surface-enhanced spectroscopies.

References

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