Guided Bloch long-range surface plasmon polaritons

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Light confinement near the surface of a photonic structure is appealing for the realization of optical sensors, in which one relies on the interaction between the electromagnetic field and an adlayer forming on the surface as analyte binds thereon. In this respect, surface plasmon polaritons (SPPs) are probably the most studied and utilized. Yet, despite their success, the use of SPPs is somewhat limited by propagation losses associated with the absorption of light in the metal. An approach to mitigate this problem makes use of symmetric structures based on a thin metal layer to support long-range SPPs (LRSPPs) [1]. The existence of the LRSPP requires that the SPPs at the upper and lower surfaces of a thin metal layer propagate at similar speeds, namely they must have similar effective indices. This condition is automatically satisfied when one works with symmetric structures, but this can be a serious constraint for some applications.

A few years ago, Konopsky showed that a one-dimensional photonic crystal (1DPC) structure can be used on one side of a thin metal layer to mimic the optical properties of the material on the other side [2]. Inspired by this approach and motivated by the use of LRSPP waveguides for biosensing, we propose and realized metal stripes on a SiO2/Ta2O5 1DPC (see Fig. 1 and 2) as waveguides supporting fully guided Bloch LRSPP [3].

The measured propagation losses of the Bloch LRSPP are between 12 and 12.8 dB/mm at 1349 nm, thus in good agreement with the theoretical values, which are expected to be between 11 and 12 dB/mm, depending on the working wavelength.

These results provide a significant advantage in terms of material flexibility for the substrate and further the attraction of metal stripe waveguides and LRSPPs for biosensing applications.

References

[1] P. Berini, Adv. Opt. Phot. 1, 484-588 (2009).
[2] V. N. Konopsky and E. V. Alieva, Phys. Rev. Lett. 97, 253904-253907 (2006).
[3] N. Fong, et al., ACS Photonics 4, 593 (2017).

Figures

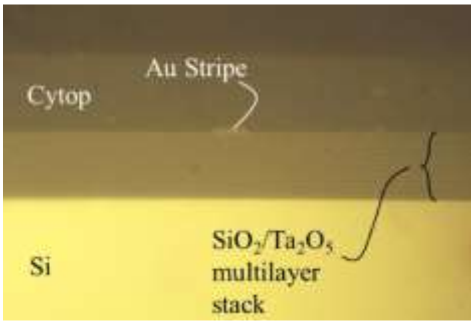

Figure 1. Microscope image of a polished end facet, revealing individual layers of the multilayer stack, the Au stripe, and Cytop upper cladding

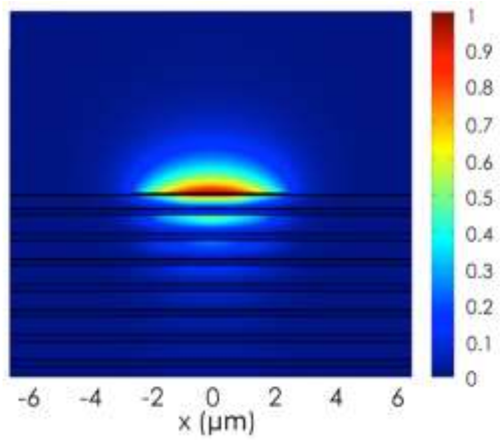

Figure 2. Calculated Field intensity for the Bloch LRSPP on an Au stripe on a 1DPC with a Cytop upper cladding.