Ultralong-range plasmon-polaritons on photonic crystal surfaces

Valery N. Konopsky and Elena V. Alieva
Institute of Spectroscopy, Russian Academy of Sciences,
Troitsk, Moscow region, 142190, Russia.
konopsky@isan.troitsk.ru

We present experimental results on ultralong-range surface plasmon-polaritons, propagating in a thin metal film on a one-dimensional photonic crystal (1D PC) surface over a distance of several millimeters. We show that a long-range surface plasmon-polaritons propagation may take place not only in a (quasi-)symmetrical scheme, where a thin metal film is located between two media with (approximately) the same refraction index, but also in a scheme where the thin metal film is located between an appropriate 1D PC and an arbitrary (air, water, etc.) medium.

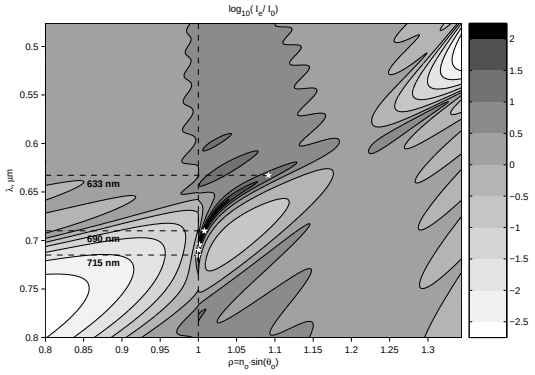

Fig. 1: The calculated dispersion of the test 1D PC structure and measured experimental points (white pentagrams) at different wavelengths. The PC band gap is clearly seen as light areas with an enhancement $\ll 1$. The PC band gap vanishes near Brewster's angle ($\rho_{Br} \simeq 1.2$), where no reflection of the TM wave takes place from the SiO_2/Ta_2O_5 interface. The optical surface mode is seen as a dark curve with an enhancement ≥ 100 inside the band gap.

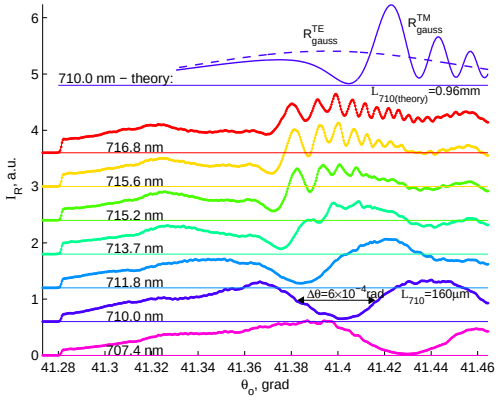

Fig. 2: Angular resonance curves at different wavelengths. Each curve is up-shifted by 0.6 a.u. from the previous one for good visibility. The diode array was shaded at $\theta_0 \leq 41.28$ to mark the zero level. The interference near the plasmon resonance curves at $\lambda > 714$ nm is a new distinguishing feature of ultralong-range SPPs in the Kretschmann-like configuration (see [1] for details).

Figures 1 and 2 show our experimental and theoretical results. The propagation length at $\lambda = 715.2$ nm is estimated to be $L_{715} \simeq 0.8$ mm. This propagation length is about two orders of magnitude higher than the one in the ordinary Kretschmann configuration at the same optical frequency. The ultralong-range surface plasmon-polaritons are potentially important for biosensors, plasmonics, and other applications.

References

1. V.N. Konopsky and E.V. Alieva, "Long-range propagation of plasmon polaritons in a thin metal film on a one-dimensional photonic crystal surface," Phys.Rev.Lett. **97** 253904 (2006).