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Tamm states in two-dimensional photonic crystals

S. A. Dyakov[1], A. Baldycheva[1], T. S. Perova[1], G. V. Li[2], E. V. Astrova[2], V. S. Sivolgin[3], N. A. Gippius[3] and *S. G. Tikhodeev*[3]

[1] Department of Electronic and Electrical Engineering, Trinity College Dublin, Dublin 2, Ireland
[2] Ioffe Physico-Technical Institute, St Petersburg, Russia
[3] A. M. Prokhorov General Physics Institute, RAS, Vavilova 38, Moscow, Russia

Optical properties of photonic crystals depend on geometry of their interfaces. This is the result of breakdown of translation symmetry of spatial distribution of dielectric permittivity, a primary characteristic of photonic crystals. The presence of the interface leads to the appearance of the surface states. The Tamm surface states of photonic crystals are well known, see, e.g., in a review [1].

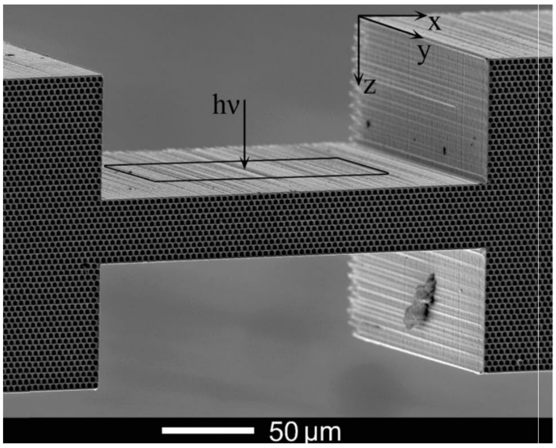

Fig. 1. Scanning electron microscopy image of a two-dimensional photonic crystal slab. The arrow show the geometry of light incidence.

In this paper we will describe our recent experimental and theoretical findings on the Tamm surface states in a two-dimensional photonic crystal slabs (PCS) fabricated by photoelectrochemical etching of deep macropores and trenches in Si [2], see the microscopy image of a manufactured structure in Fig. 1.

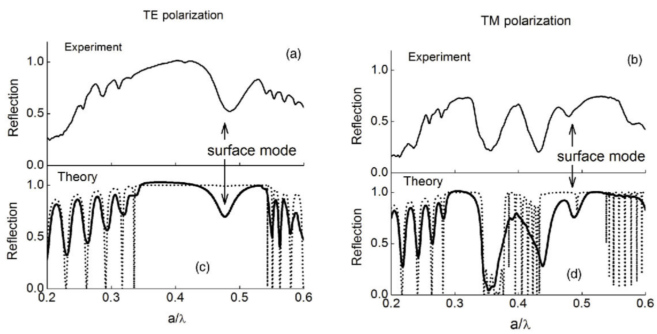

Fig. 2. (a, b) Experimental and (c, d) calculated reflection spectra of a 2D PCS for TE and TM polarizations (magnetic and electric field parallel to pores respectively). The PCS period is $a = 4\ \mu$m, pore radius $r = 0.45a$, and interfacial layer thickness $w = 0.62a$.

The Tamm states show themselves as dips in the reflection spectra inside the PCS stopbands as shown in Fig. 2.

Additionally, we will report our results on the theoretical calculation of the near field distributions and dispersion of the Tamm surface states in such structures showing that they may demonstrate a negative dispersion, as illustrated in Fig. 3.

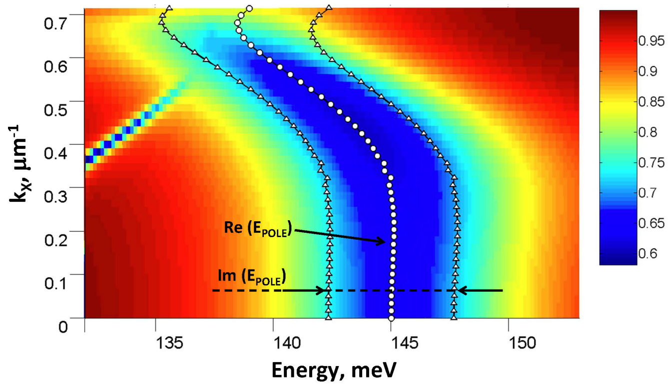

Fig. 3. The calculated dependence of the reflection coefficient of a PCS as a function of photon energy $E = h\nu$ and horizontal momentum $k_x = \frac{\nu}{c}\sin\vartheta$ (where ϑ is the angle of light incidence) for TE polarization. The color scheme is explained in the bar in the right. White circles show the calculated dispersion of the Tamm surface state $\mathrm{Re}E_{\mathrm{pole}}(k_x)$; the triangles are $\mathrm{Re}E_{\mathrm{pole}}(k_x) \pm \mathrm{Im}E_{\mathrm{pole}}(k_x)/2$

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References

[1] A. P. Vinogradov *et al*, *Physics-Uspekhi* **53**, 243 (2010).
[2] S. A. Dyakov *et al*, *Phys. Rev. B* **86**, 115126 (2012).