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TAMM PLASMON POLARITONS IN AN ELECTRICALLY TUNABLE DIELECTRIC BRAGG REFLECTOR – BLACK PHOSPHORUS – NEMATIC LIQUID CRYSTAL STRUCTURE UNDER LINEARLY POLARIZED INCIDENCE

Abstract. Terahertz Tamm plasmon polaritons excited by a linearly polarized electromagnetic wave incident on an electrically tunable hybrid structure are investigated theoretically. The structure comprises a two-dimensional black phosphorus layer and a dielectric Bragg reflector formed by alternating layers of a nematic liquid crystal and a polymer. Spectral dependences of the reflection, transmission, and absorption coefficients are calculated within the photonic band gaps of the dielectric Bragg reflector. The influence of the surface-electron concentration in the black phosphorus layer and an external electric field applied to the nematic liquid crystal on the excitation conditions and spectral characteristics of Tamm plasmon polaritons is analyzed. The possibility of efficient electro-optical tuning of Tamm plasmon polariton resonances in the terahertz range is demonstrated.
Keywords: Tamm plasmon polaritons; black phosphorus; dielectric Bragg reflector; nematic liquid crystal; terahertz range; linearly polarized excitation.

Tamm plasmon polaritons [1] localized at the interface between a photonic crystal and a conducting medium are of considerable interest for tunable terahertz photonic devices due to their strong field confinement and high sensitivity to material parameters [2,3]. In this work, we theoretically investigate the excitation and spectral properties of Tamm plasmon polaritons under linearly polarized electromagnetic-wave incidence on an electrically tunable hybrid structure. The structure consists of a two-dimensional black phosphorus layer [4] and a dielectric Bragg reflector [5] made of alternating nematic liquid crystal and polymer layers.

The spectral dependences of the reflection, transmission, and absorption coefficients are calculated in the terahertz frequency range within the photonic band gaps

of the Bragg reflector. The influence of the surface-electron concentration in the black phosphorus layer and an external electric field applied to the nematic liquid crystal is analyzed for the first, second, and fourth Bragg resonances. The applied electric field induces a reorientation of the liquid-crystal molecules [6], thereby changing the optical properties of the Bragg reflector and enabling spectral tuning of the resonances.

It is shown that Tamm plasmon polariton modes appear as narrow resonant features within the photonic band gaps. Increasing the surface-electron concentration shifts the Tamm plasmon polariton resonances toward shorter wavelengths and modifies their excitation efficiency and spectral linewidth. The applied electric field enables continuous spectral tuning of both the photonic band gaps and the Tamm plasmon polariton resonances. The magnitude of the spectral shift and the changes in resonance characteristics depend on the Bragg order.

The obtained results demonstrate that control of the black phosphorus surface conductivity and electric-field-induced reorientation of the nematic liquid crystal enable efficient tuning of Tamm plasmon polariton characteristics in the terahertz range. The proposed approach may be useful for the development of tunable terahertz filters, modulators, sensors, and other integrated photonic devices.

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