Temperature tunable liquid crystal mirror for the construction of optical cavities

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Optical cavities constitute an important component of modern optoelectronic devices as they lead to strengthening of light emission and provide an opportunity to observe strong light-matter coupling [1]. In this paper we concentrate on a novel construction of a tunable optical cavity based on a liquid crystal mirror. Liquid crystals are chemical compounds with a significant spatial anisotropy, which preserve both crystal and liquid properties. The materials used in this work are chiral nematics with a helical structure. Depending on the pitch of the helix, these structures exhibit a selective light reflection at different wavelengths with the spectra similar to those observed for dielectric mirrors. Interesting from the perspective of construction of tunable optical cavities, is the possibility to change the stopband position by varying the temperature. While changing the temperature, a number of phase transitions can be observed (from highly ordered structure of liquid crystal to isotropic liquid). We demonstrate that our compounds exhibit a selective reflection that changes within the range from about 800 nm to above 2000 nm. The band gap shifts with temperature at different rates, depending on the type of compound, or content of the chiral dopant. It is a prospect for further research on the construction of temperature tunable mirrors and, at a later technological stage, of optical cavities for the observation of light-matter interaction. As an emitter, which will be placed inside the cavity, we propose monolayers of semiconducting transition metal dichalcogenides such as $MoSe_2$, MoS_2, WSe_2 or WS_2. In recent years, these two-dimensional materials have attracted a great interest in the field of solid state physics [2,3]. Graphene paved the way for research on an entire class of compounds which exhibit a layered structure. In this work we measured the photoluminescence spectra for exfoliated $MoSe_2$ monolayer flakes deposited on a dielectric mirror. The experiment were performed at high temperatures ranging from 290 K to 340 K at which the changes of the phase transition in liquid crystals are observed. We observed that the transition energy shifts from 1.575 eV at 290 K to 1.545 eV at 340 K. The maximum intensity of the photoluminescence does not significantly vary with temperature while its full width at half maximum slightly decreases. These properties make the $MoSe_2$ monolayers a good candidate for the construction of novel optoelecronic devices incorporating optical cavities based on liquid crystals mirrors.

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