Homogeneous cholesteric structure exhibiting narrow band gap selective reflection for switchable optical filters

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Cholesteric liquid crystals (N*) exhibiting a selective reflection of light have been studied almost 40 years [1], however their applications are scarce. There are numerous obstacles of a basis physical and structural nature hampering their use at display and photonic technologies. Most of cholesterics exhibit a positive dielectric anisotropy $\Delta \varepsilon > 0$. When driven by electric field a transition to nematic homeotropic structure with homeotropic director orientation is induced and selective reflection of light on a helical structure is suppressed. A relaxation from such electric field driven director configuration to the final helical stable structure at zero electric field is usually driven by elastic forces and proceeds via metastable transient configurations. This process usually leads to a structures being strongly scattering due to a induction of numerous local heterogeneities of the molecular director and helix. Moreover, a single LC slab at N* phase exhibits a selective reflection at a band gap of order of 40 nm which is strongly temperature dependent and reflect up to 50% only of the incident unpolarized light.

Here we demonstrate mesogenic, structural and physical properties of a new cholesteric liquid crystals made at the Military University of Technology, Warsaw, Poland. Studied materials exhibit a broad temperature range of the cholesteric phase (~50 K) with the room temperature in the middle as well as a near temperature independent selective reflection band gap which is order of 30 nm. Such a mixtures have been obtained in result of a custom designed strategy of mixture composition with using of chiral compounds demonstrating different temperature dependence of the helical pitch.

A study of an electrooptical transducer utilising mentioned cholesteric for a narrow band gap switchable filter is presented. A filer utilising two stacked slabs of custom made cholesteric of opposite helical twist sense is electric field driven with an optical contrast ratio CR > 50 at the specific band gap. The optical uniformity obtained at the near defect-less structure at both selective reflecting as well as induced nematic structures, preserve scattering-less operation of the transducer which can be regarded as a new category at this class of liquid crystalline photonic devices. The dynamic parameters of the transducers are studied and presented. A specific electric field driving schemes are presented and examined. Application potential is considered in context of material and optical properties of studied mesogens and optical design.

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References: