Fast electro-optic effect in polymer/cholesteric liquid crystal nanocomposite formed by low-temperature polymerization

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Cholesteric liquid crystals (ChLCs) are known to self-organize into helical structures with periodicities of a few hundred nanometers and thus possess a selective reflection (SR) band, which blocks off circularly polarized light of the same handedness as the cholesteric helix. By utilizing this property of selective reflection, ChLCs can potentially be used in switchable optical devices such as polarizers, shutters, diffraction gratings, reflective displays, and tunable lasers. However, almost all ChLC devices have slow responsive characteristics on the order of ~ms, which is disadvantageous for practical applications. In this study, we demonstrate fast (20 μs) and reversible tuning of selective reflection band in a polymer/cholesteric liquid crystal composite fabricated by low-temperature polymerization.

The sample was fabricated by photopolymerizing a ChLC mixture doped with mesogenic acrylate monomer of 4.7 wt% at a low temperature (-20 °C). Figure 1 shows the electro-optic effect of the polymer/LC composite measured at room temperature. When an electric field was applied along the helical axis, the longer band edge blue-shifted, while the shorter band edge remained constant. Furthermore, upon removing the field, the SR band returned to the original state in a short decay time of ~20 μs. The change of the SR band can be attributed to the decrease of ne while keeping p constant, on the basis of the equations of \( \lambda_{\text{short}} = n_o p \) and \( \lambda_{\text{long}} = n_e p \), where \( \lambda_{\text{short}}, \lambda_{\text{long}}, n_o, n_e, \) and \( p \) are shorter and longer band edge wavelengths, ordinary and extraordinary refractive indices, and the helical pitch, respectively. Hence, we believe that this tuning mode is based on the effective medium effect in which reorientation of non-polymerized LC molecules occur within nano-sized domains that exist between polymer networks that strongly fixes the helical structure. In our presentation, the mechanism will be illustrated in detail through scanning electron microscopy.

![Fig. 1 Electric field dependence of selective reflection band in the composite polymerized at -20 °C](image)

References:

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