Enhanced orientational Kerr effect in vertically aligned deformed helix ferroelectric liquid crystals with sub-wavelength helix pitch

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A new type of orientational Kerr-effect has been discovered recently [1] in vertically aligned deformed helix ferroelectric liquid crystals (VADHFLC) with sub-wavelength helix pitch $p_0 \approx 100 - 200$ nm [2]. Though the VADHFLC Kerr constant $K_{kerr} \approx 27$ nm/V^2 [1] is already compatible with K_{kerr} of the best modern polymer stabilized blue phase liquid crystals (PSBPLC) [3] it is feasible to increase K_{kerr} of VADHFLC's further, which is important for low voltage display devices and phase modulators of light.

Based on the theoretical analysis and material optimization, we reveal now an efficient strategy to enhance the Kerr constant in VADHFLC's in order of magnitude higher, up to 250 - 300 nm/V^2. The ferroelectric liquid crystal (FLC) optimization imposes tight constrains on the selective reflection limited to UV region to prevent diffraction, light scattering and polarization plane rotation of visible light.

Under certain conditions, the phase modulation of light with ellipticity less 0.05 over the range of continuous and hysteretic free electrical adjustment of the phase shift from zero to 2π have been obtained with the developed VADHFLC cells at kilohertz frequency because of the enhanced Kerr constant. The proposed VADHFLC systems with a continuous, hysteresis-free 2π phase modulation could find applications in many modern photonic and display devices demanding fast phase only modulation with conserved ellipticity at low electric fields. These include photonic devices such as tunable lenses, focusers, wave front correctors and correlators that are in use as building blocks of optical information processors and displays.

We have proved that the FLC helical structure elastic energy $W_e \sim \mathrm{K}q_0^2$ ($q=2\pi/p_0$, and K is the effective twist elastic constant) can entirely dominate over the anchoring energy $W_A \sim \mathrm{W_R}/d_{FLC}$ (d_{FLC} is the FLC layer thickness, W_R is the Rapini potential coefficient) of the VADHFLC cell, if p_0 is sufficiently small. This condition is sufficient to solve so called "shock problem" [4], which has always been one of the main obstacles to the use of FLC in display and photonic devices because of low steadiness of FLC cells to mechanical stress.

On the basis of the above approach, we have developed shock-free VADHFLC display cells, which provide phase modulation of light by π with a contrast ratio more than 1000:1 and the response time of about 100μs at the applied field less than 1V/μm.

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