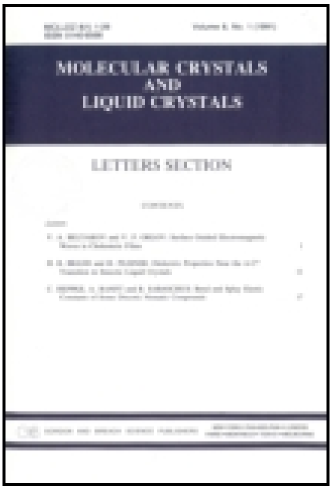

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Enhanced Reflectance of Cholesteric Liquid Crystal Device with Quantum Dots

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Enhanced Reflectance of Cholesteric Liquid Crystal Device with Quantum Dots

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Cholesteric liquid crystal (CLC) has a helical structure with either of left-handedness or right-handedness. Due to the helical structure, the selective reflection occurs depending on the chrial pitch. However, the reflectance of the CLC layer is theoretically limited to 50% because only one of right- or left-handed circularly polarized light is reflected. In this paper, we demonstrate high reflectance of CLC layer with quantum dots for the color reflector application.

Keywords Liquid crystals; cholesteric; reflective mode; high reflectance

1. Introduction

Cholesteric liquid crystal (CLC) has a helical structure with either of left-handedness or right-handedness. Due to the helical structure, the selective reflection occurs depending on the chiral pitch. This feature enables to CLC device to display the images with vivid color without the aid of a polarizer or color filter [1–4]. Generally, when an unpolarized light is incident into a cholesteric LC layer with the right-handedness, the left-handed circularly polarized light within the bandwidth is reflected only, so the reflectance is limited to 50% [5,6].

On the other hand, Quantum dots (QDs) absorb photons at a certain wavelength and emit photons at a different wavelength [4,7]. Spectral overlap between the reflectance of

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CLC device due to the selective reflection and the photoluminescence (PL) spectrum of QDs should improve the reflectance of the CLC device. In this paper, we will discuss the energy conversion by QDs and will demonstrate the enhanced reflectance of the CLC layer with nanocrystals for the color reflector application.

2. Synthesis of QDs

Cadmium oxide CdO 99.99%, zinc acetate (99.9%, powder), selenium powder (Se, 99.99%), sulfur powder (S, 99.9%), oleic acid (OA, 90%), trioctylphosphine (TOP, 90%), 1-octadecene ODE, 90% were purchased from Aldrich. Acetone (analytical reagent), methanol (analytical reagent), toluene (analytical reagent) were purchased from Sinopharm (Shanghai) Chemical Reagent Co. Ltd. As a typical synthetic procedure, 0.4 mmol of cadmium oxide (CdO), 4 mmol of the zinc acetate, 17.6 mmol of oleic acid (OA) and 20 mL of 1-octadecne (ODE) were placed in the 100mL round flask. The mixture was degassed under 100 mTorr pressure for 15 min, then filled with N_2 gas, and further heated to 310°C to form a clear solution of $Cd(OA)_2$ and $Zn(OA)_2$. At this temperature, 3 mL of trioctylphosphine (TOP), in which both 0.4 mmol of selenium powder and 4 mmol of sulfur powder were dissolved, were quickly injected into the reaction flask. After the injection, the temperature of the reaction flask was set to 280°C to promote the growth of QDs for 10 min, and it was then cooled down to room temperature to stop the growth. QDs were purified by adding 20 mL of chloroform and an excess amount of acetone (3 times), they were then dispersed in toluene.

The PL spectrum of the fabricated QDs was measured by the ultraviolet-visible spectrophotometer (HITACHI U-3900) and the transient and steady state fluorescence spectrometer (FLSP920) at room temperature. Figure 1 shows the measured absorption spectrum and PL spectrum of fabricated QD. The peak of PL spectrum is between 500 nm and 600 nm.

2. Fabrication of CLC Device with QDs

We fabricated the CLC cells. Cholesteric phase of liquid crystals can be obtained by mixing chiral dopant into nematic phase of liquid crystals. We mixed 0.365 g of the chiral dopant,

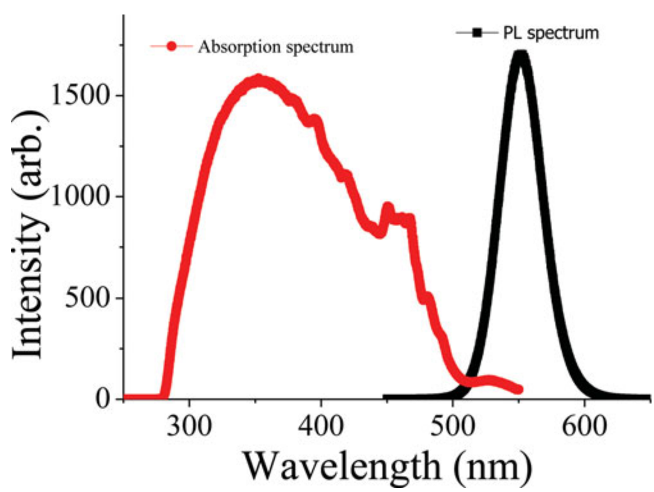

Figure 1. Absorption spectrum and PL spectrum of the fabricated quantum dot material.

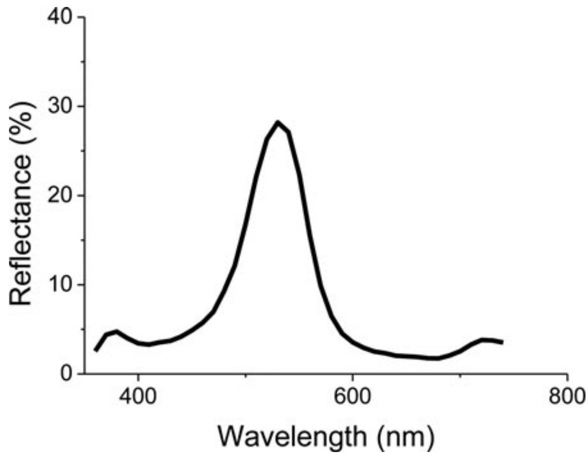

Figure 2. Reflectance of CLC device.

S-811, into the 1g of the nematic liquid crystal material, HSG44700-100. Refractive indices for extraordinary and ordinary are 1.701 and 1.502, respectively.

This mixture was injected into the empty cell, whose thickness is 9 um. The reflectance of fabricated CLC device was measured by CM-2600d (Konica Minolta co.). Figure 2 shows the measured reflectance. The fabricated CLC device reflects the light, whose wavelength is between 450 nm to 600 nm. The spectrum of the reflected light overlaps the entire range of the PL spectrum of the fabricated QDs as shown in Fig. 1. The maximum reflectance is 28% at 530 nm.

To clarify the energy conversion effect of QDs, we also fabricated CLC device with QDs. 0.05g of the fabricated quantum dot material is mixed into the 0.95 g of CLC mixture. This mixture was also injected into the empty cell with 9 um thickness. The fabricated

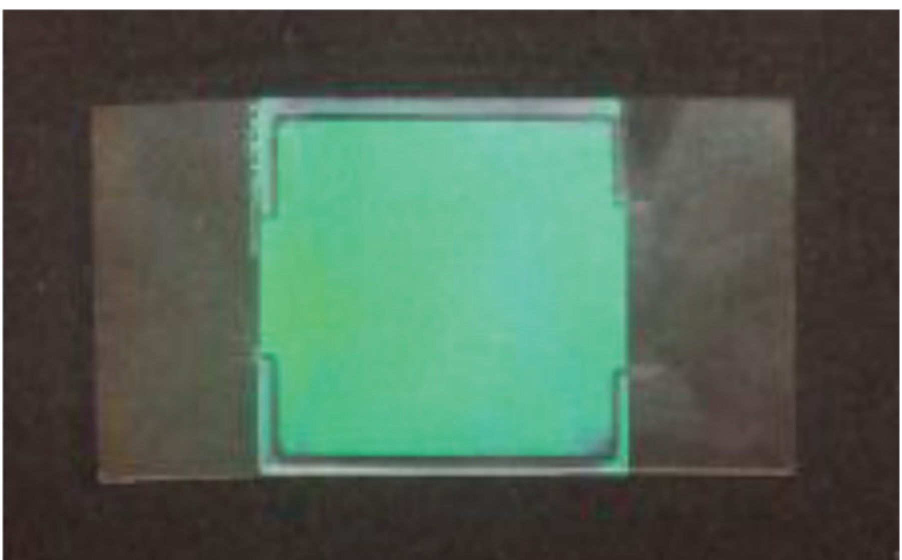

Figure 3. The fabricated CLC device with QDs.

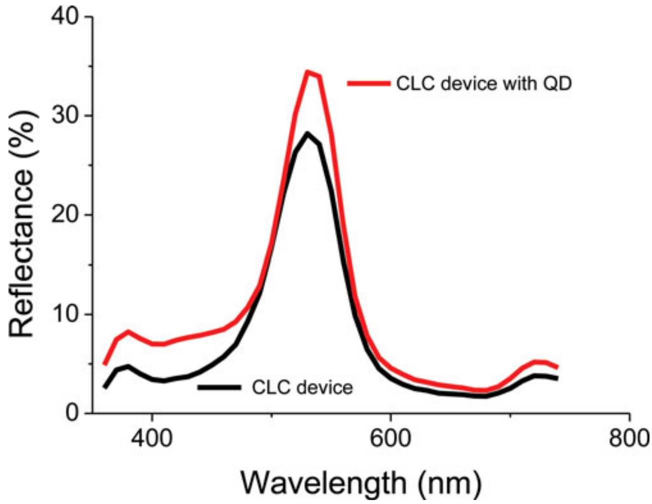

Figure 4. Reflectance of CLC device and CLC device with QDs.

cell is shown in Fig. 3. The measured reflectance of the CLC device with the quantum dot material are improved from 28% to 34%.

4. Summary

The reflectance in the single cholesteric liquid crystal layer is theoretically limited to 50% because with the right-hand CLC layer, Left-handed circularly polarized light is reflected and vice versa. We propose a CLC device with QDs to improve the reflectance by the energy conversion. We have improved the reflectance of about 34% from 28%.

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