White Reflection Film by Photopolymerization of Reactive Mesogen in Cholesteric Liquid Crystal Layer

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Abstract

We proposed a white reflection film (WRF) with the broadband reflection spectrum using a cholesteric liquid crystal (CLC) film mixed reactive mesogen (RM) monomers. The ultra-violet (UV) irradiation to the CLC film with RM gives rise to a gradient of the chiral pitch due to a gradient in UV intensity by UV absorption of RM monomers. Finally, the white reflection film which reflects the light with whole visible range is achieved.

1. Introduction

The reflective cholesteric liquid crystals (CLCs) have the noticeable properties due to the existence of a macroscopic helical structure [1-3]. When the helical axis is perpendicular to the substrate, selective reflection colors in an incident light are exhibited by a uniformly oriented Grandjean planar texture. The incident light beam parallel to the helical axis is split into two circularly polarized components: one of which is simply transmitted whereas the other is totally reflected. The rotation of the reflected circularly polarized light agrees with the helical sense of the structure. At normal incidence, maximum reflection occurs when the incident wavelength λ matches the Bragg law [4]. The central wavelength of the CLC is determined by $\lambda = np$, where n is the average refractive index and p is the helical pitch length [5].

Several researches on CLCs have mainly focused on making reflectors with switchable or tunable characteristics of the pitch with thermal, electric, or photo field. Meanwhile, others have taken interest in controllably influence the broadband of the CLC. The broadband CLC films can be used to enhance the brightness of direct-view LCDs by recycling and converting wrongly polarized backlight. Since the noticeable approach involved in increase the bandwidth [6, 7].

In this work, we propose the white reflection Film (WRF) investigate the broadening spectrum of CLC film with reactive mesogen (RM). It can be achieved by ultra-violet (UV) irradiation with an intensity gradient across the film thickness. When a CLC film with RM monomers is irradiated by UV light, the LC and RM molecules absorb UV light and a gradient in UV intensity can be achieved over the cell thickness. The polymerization occurs at a fast ratio toward the UV light source resulting in a faster consumption of the most RM monomers. Thus, the local depletion of these monomers was faster, generating a concentration gradient. Consequently, CLC film had the opposing concentration gradient of the pitch-tightening and the pitch-widening by local difference of polymer networks density during polymerization and we could obtain a WRF which reflects the light with whole visible range.

2. Experiment

Figure 1 shows a schematic diagram of our WRF. In our LC cell, the helical pitch length was sequentially modulated from a short pitch length near the top substrate (facing the UV source) to long pitch length near the bottom substrate. The WRF was fabricated by UV exposure to the CLC mixture of host nematic LC (87 wt.%, E48, E. Merck), RM monomer with chirality producing a right-handed helical structure (12 wt.%, RMM703, E. Merck), and photoinitiator (1 wt.%, Igacure651, Ciba Speciality Chemicals).

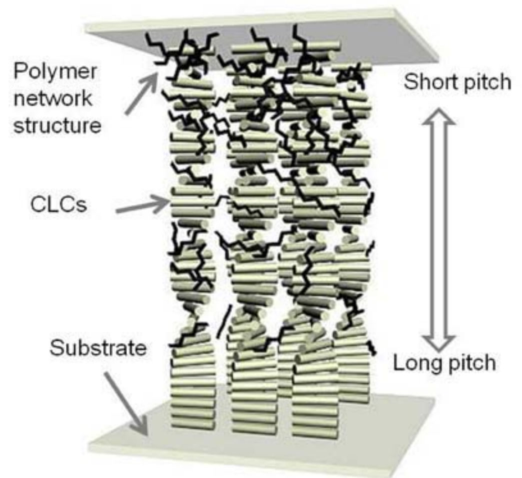

Fig. 1 The schematic diagram of our WRF.

The ChLC mixture was stirred in an isotropic phase for 24 h and injected between sandwiched glass substrates with a cell gap of 6 μm by capillary action in the isotropic phase. The inner surfaces of the sandwiched substrates were coated with polyimide alignment layer (RN1199, Nissan Chemical) and rubbed antiparallelly for planar alignment with the excellent reflectivity. After injection of the CLC mixture, we cooled slowly down to room temperature for obtaining a stabilized planar texture and exposed UV light (0.12 mW/cm^2), wavelength ~365 nm) for 4 min to produce broadband spectrum covering entire visible range.

3. Result and Discussion

The microscopic textures and measured spectrum in the reflectance, nonirradiated and irradiated, are shown in Fig. 2. The broadband spectra in the BCLCF were produced by the stable pitch gradient of the CLC though the photo-polymerization of the RMs. When UV light was irradiated to the CLC mixture with the chiral RMs, the UV intensity gradient was induced according to the direction perpendicular to the substrates. The UV intensity gradient generates the anisotropic phase separation normal to the substrates due to the diffusion of the chiral RM monomers driven by a concentration difference [8].

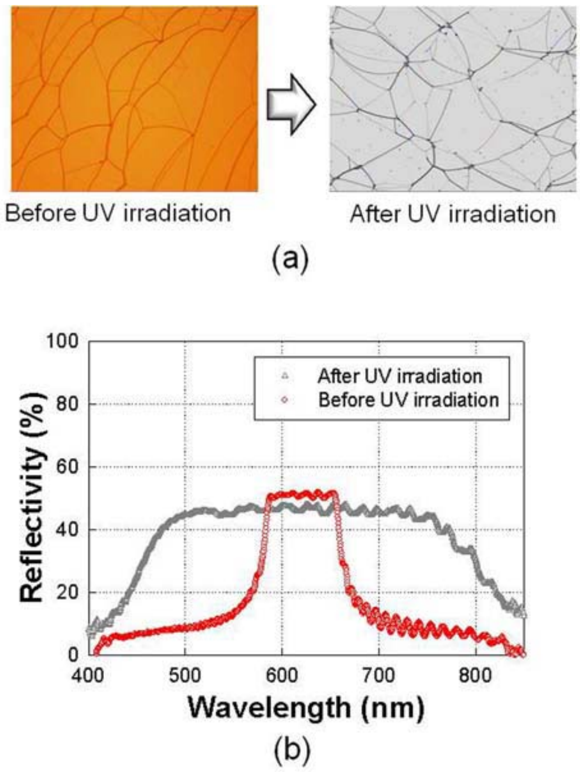

Fig. 2 Reflection characteristics of our CLC film before and after UV irradiation: (a) microscopic textures and (b) measured reflection spectra.

As a result, based on the spectral broadening characteristics by the different polymer density, the broadening of the cured CLC film was about three times of uncured bandwidth (from 500 to 750 nm). Due to the selective reflection of the circular polarized light coinciding with the cholesteric pitch and the helical sense of the CLC, the wide pitch gradient of the CLC gives rise to the broadband reflective spectrum and the complementary transmitted spectrum covering entire visible range as shown in Fig. 2.

4. Summary

In this paper, we demonstrated the WRF with the broadband reflection spectrum using a CLC film mixed RM monomers. It can be achieved by the UV irradiation with an intensity gradient across the film thickness. When a CLC film with RM monomers is irradiated by UV light, the LC molecules absorb UV light and a gradient in UV intensity can be achieved over the cell thickness, which generating a continuous gradient of the RM concentration and CLC chiral pitch. Based on the spectral broadening characteristics, we could obtain a WRF which is broadened about times of uncured bandwidth (from 500 to 750 nm). It was also expected that our WRF film with the pitch gradient covering entire visible range could find several applications for optical devices.

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