2D Azobenzene Liquid-crystalline Polymer-based Switchable Photonic Crystals via Nanoimprint

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Organic polymers have been considered to be the leading candidates for future integrated photonic devices because of their outstanding advantages over inorganic materials. Among these polymers, Crosslinked liquid-crystalline polymers (CLCPs) have gained attention because they are unique materials that possess the properties of both LCs and elastomers. By incorporating azobenzene moieties into CLCPs, larger deformations can be induced by the photochemical reactions of these azobenzene chromophores. Thus, novel switchable photonic crystals (PCs) can be realized in term of the photoinduced deformation effect of azobenzene-containing CLCPs by controlling the disruption of photonic crystal order. [1,2] A large number of works has already been done to demonstrate the fabrication feasibility of PCs in different dimensionalities and with different materials.[3] However, how to fabricate a 2-D PCs structure within the visible region still presents practical challenges, not to mention the fabrication of CLCPs PCs. Here a novel optical switching with high switch efficiency based on photoinduced deformation of the photonic crystals (PCs) is realized. Nanoimprinting approach is implemented to create a robust CLCPs PC structure.

Azobenzenes have two isomeric states: a thermally stable *trans* configuration, and a meta-stable *cis* form. The light-sensitive CLCPs can undergo large reversible shape changes when stimulated by UV and visible light (Fig. 1). Fig. 2 shows the surface morphology of the photonic crystals composed of CLCPs. When irradiated under UV light, the *trans* isomer transforms into the *cis* form, causing the rods deformation such as expansion or bending. As illustrated in Fig. 3, the diameter of the rod with period of 1μm changes from 670 nm to 754 nm. Under the irradiation of ultraviolet light (UV light, 365 nm) with a intensity of 20 mW/cm^2, the reflection peak at 596 nm decreased rapidly (Fig. 4). The curve of the transmission spectrum becomes almost a line with a transmissivity of 18%, indicating that the PCs are on the "off" state. The observed change can also be reversed to the original state, that is, from the "off" state to the "on" one, with visible light replacing UV light. Therefore, very high transmittance contrast of more than 75% was realized. This indicates that it is possible to reversibly switch the spectral properties between the pass-band and stop band. A test on the circle of the intensity of the reflection peak by irradiating UV and visible light alternately shows the reversibility is stability and reproducibility (Fig. 4).

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[1] M. Kamenjicki, I. K. Lednev, and S. A. Asher, J Phys. Chem. B **108,** 12637-12639 (2004)

[2] M. C. Carreno, I.l Garcıa, I. Nunez, E. Merino, M. Ribagorda, S. Pieraccini, and G. P. Spada, J. Am. Chem. Soc. **129**, 7089-7100 (2007)

[3] G. Z. Han, Z. Y. Xie, D. Zheng, L. G. Sun, Z. Z. Gu, Appl. Phys. Lett. **91**, 141114 (2007).

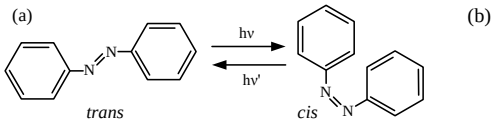


Figure 1. The operation mechanism of the CLCPs: (a) Structures of azobenzene. (b) schematic illustration of the mechanism of the bending

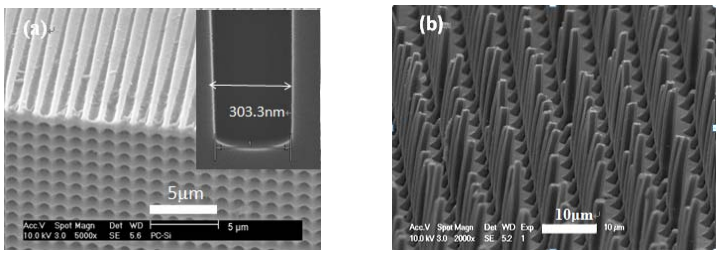


Figure 2. one of SEM images of template for nanoimprinting: (a). Cross section of the microarray silicon template with a period of 1 μm. (b). SEM images of the microstructure photonic crystals with a period of 8 μm.

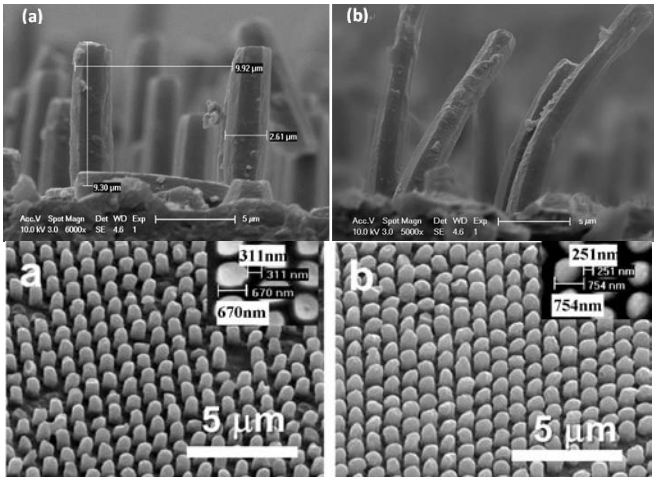
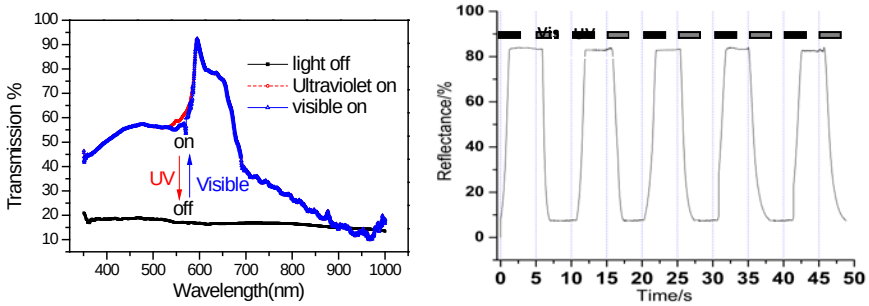


Figure 3. SEM images of the microstructure photonic crystals and their response to light: the periods are 8 μm (top) and 1 μm (bottom), respectively: (a). before irradiation with UV light. (b). after irradiation.



F*igure 4. Transmisson spectra of the CLCP PCs (left) and response time of the reversibly switching photonic crystals in the "off" and "on" state (right).*