Directional lasing emission based on self-organized photonic crystals with helical nanostructures

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Photonic crystal (PC) lasers that enable the arbitrary control of the beam direction have attracted interest for various potential applications such as optical communications and holography [1]. Here, we present a self-organized PC band-edge laser that ena bles manipulation of the beam direction, based on a photo-patterned cholesteric liquid crystal (ChLC). A ChLC in which molecules are self-assembled into a periodic anisotropic structure with a helical modulation is regarded as a one-dimensional PC structure, giving a photonic band gap [2, 3]. In experiment, we artificially introduced a periodic modulation of the dielectric constant in the Γ–X direction with a periodicity of Λ as shown in Fig. 1 (a). The PC structure enables the photonic band-edge [indicated by red circle in Fig. 1 (b)] to be moved away from the Γ point, causing the direction of the output beam to be shifted from the surface normal. Figure 1 (c) shows a photograph of the lasing emission from the device, where the red lasing beam is observed at a distance of 5.8 cm from the zero-order pump light, corresponding to an emission angle of 30°. In addition, because the PC structure can be easily modulated by exploiting the external-stimulus responsivity of LCs, we show that the device can also steer the output beam angle by controlling the helical pitch of the ChLC. The device proposed here will provide a new frontier in compact PC lasers without any complex fabrication process.

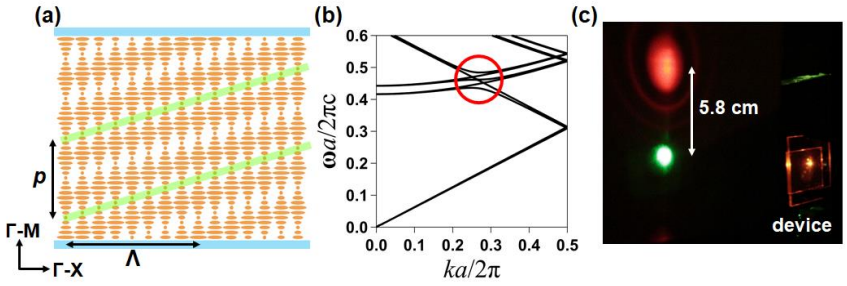

Fig. 1. Directional lasing emission from the device. (a) A schematic of the orientation of the ChLC molecules in the device. (b) Photonic band structure of the proposed device, where Λ is 1.5*p*. (c) A photograph of the laser emission from the device. The distance from the sample to the screen is 10 cm.

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