Linear-to-Circular Polarization Conversion with Broad Polarization Angular Span using Twisted Structures

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Twisted van der Waals heterostructures have drawn great attention recently due to some extraordinary phenomena, such as moiré excitons and flat bands. As a photonic analogy, twisted bilayer photonic crystal slabs (TBPCSs) have also been intensively investigated.[1, 2] Due to the twist between two layers, both in-plane and out-plane symmetries are broken, making TBPCSs intrinsically chiral. Compared to structures based on discrete chiral unit cells, TBPCSs usually have simple intralayer configurations and are easy to achieve large-area fabrications.[3] Moreover, the chirality of TBPCS is largely dependent on the twisted angle which is convenient to manipulate. As a typical application of chiral photonic structures, linear-to-circular polarization conversion is useful in light communication and polarization imaging. However, most current polarization convertors are small-scale and can only work at a specific polarization, such as transverse electric polarization or transverse magnetic polarization, hindering practical applications.

In this research, based on TBPCSs, we successfully design a linear-to-circular polarization convertor that can work within a broad polarization angular span. Figure 1(a) shows the schematic of the polarization convertor. A SiO_2 gap layer is sandwiched by two twisted patterned layers. A modified rigorous coupled-wave analysis method proposed recently[2] for TBPCSs is applied to analyze the optical properties. Figure 1(b) shows the applied unit cell which can be created by interference lithography and etching to realize large-area fabrications. The twisted angle between two layers is set to 40° for better performance. Polarization angle ξ is considered to denote the orientation of linear polarization for incident light. Meanwhile, the polarization states of reflected light are evaluated by the axis ratio of the polarization ellipse. As shown in Figure 2, the axis ratio is smaller than 3 dB within a range of 0 – 35° and 110 – 180° at 706 nm, indicating that the reflected light is circularly polarized. If the threshold is slightly increased to 4 dB, the linear-to-circular polarization conversion can be available under arbitrary polarization angles.

[1] K. Dong, T. Zhang, J. Li, Q. Wang, F. Yang, Y. Rho, D. Wang, C.P. Grigoropoulos, J. Wu, and J. Yao, *Phys. Rev. Lett.* **126**, 223601 (**2021**).
[2] B.C. Lou, N. Zhao, M. Minkov, C. Guo, M. Orenstein, and S.H. Fan, *Phys. Rev. Lett.* **126**, 136101 (**2021**).
[3] C. Zheng, Y. Shen, M. Liu, W. Liu, S. Wu, and C. Jin, *ACS Nano* **13**, 5583 (**2019**).

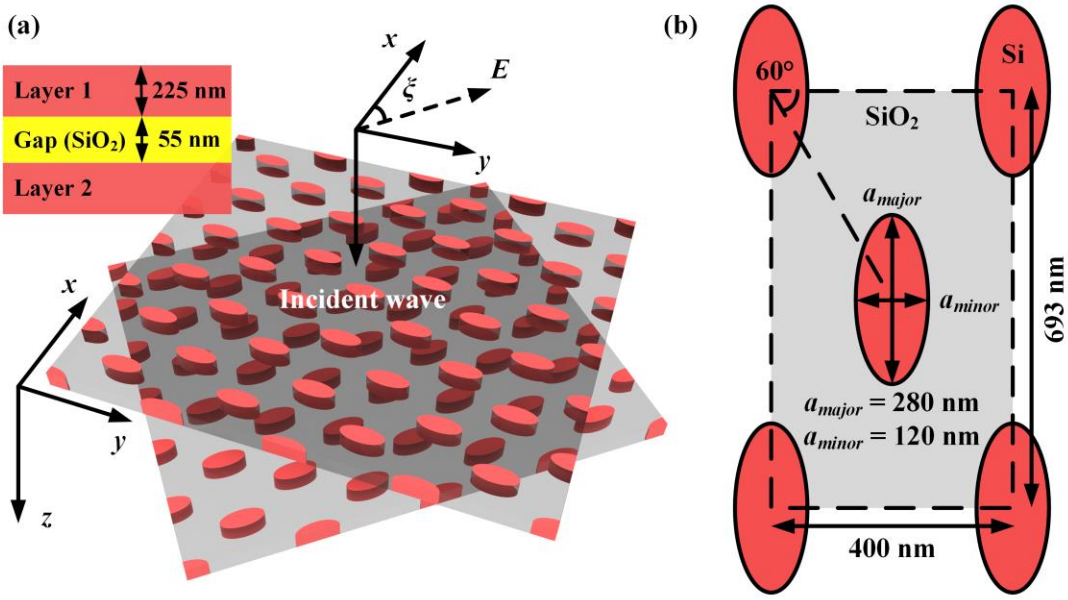

Figure 1. (a) Schematics of the polarization convertor based on twisted bilayer photonic crystal slabs. The polarization angle ξ is defined by the angle between the electric field of incident light and x-axis. (b) Unit cell used in RCWA simulations to emulate the hexagonal lattice in Cartesian coordinate system.

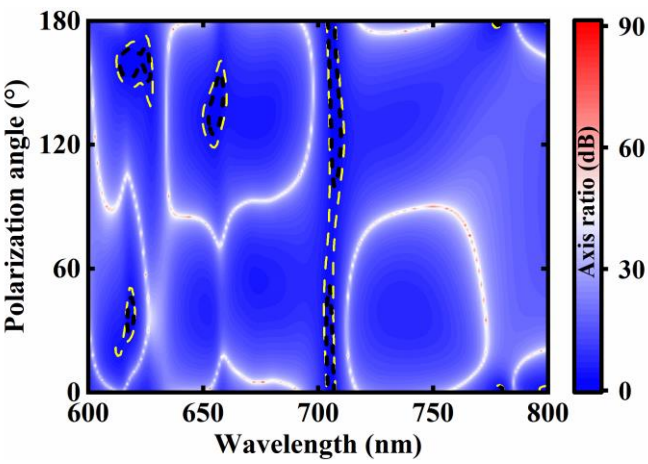

Figure 2. Simulated axis ratio with respect to wavelength and polarization angles when the twisted angle is 40°. The areas circled by black dashed lines have axis ratios smaller than 3 dB and areas circled by yellow dotted lines have axis ratios smaller than 4 dB.