Supporting Information

Polarization-independent Optical Broadband Angular Selectivity

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S1. The schematic of our design and the p-polarized transmission spectrum for such structure containing 5 layers of half wave plates.

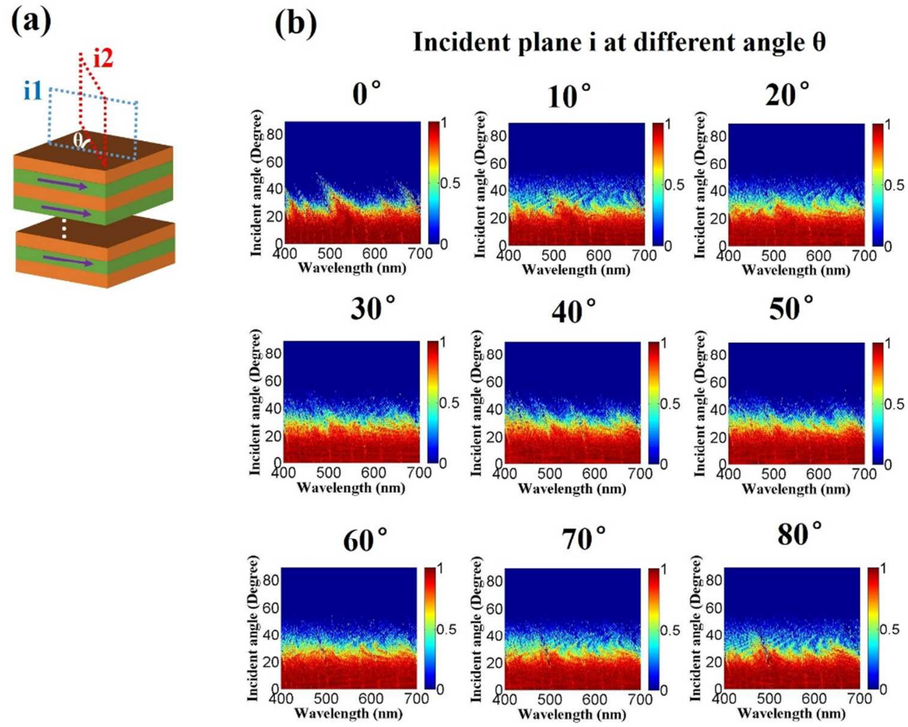

Figure S1. (a) Schematic of our design containing half wave plates with different thicknesses whose birefringent axes are in the same direction. (b) p-polarized transmission spectrum for such structure containing 5 layers of half wave plates.

S2. s-polarized transmission spectrum for a structure illustrated in Fig. S1 (a).

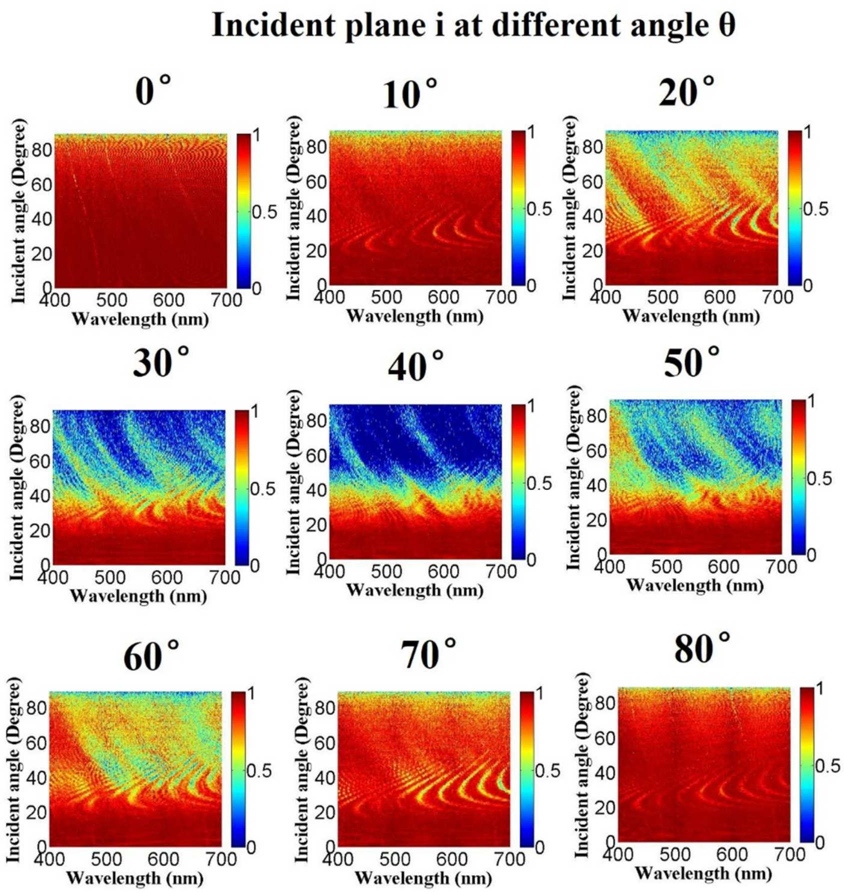

Figure S2. s-polarized transmission spectrum for a structure illustrated in Fig. S1 (a).

S3: The selective angle range can be controlled based on 1D PhC structures.

The material system we designed has a large flexibility of the selective angle range. By controlling the number of PhC stacks and bilayers in each stack, we can design any selective angle range as we want. The selective angle range is from -30° to 30° for structure with 1D PhC consisting of 80 stacks, each stack consisting of 100 isotropic-anisotropic bilayers, and the period of the ith stack is $1.01^{(i-1)}a_1$. The selective angle range is optimized to be from -20° to 20° for 1D PhC consisting of 160 stacks, each stack consisting of 300 isotropic-anisotropic bilayers, and the period is $1.005^{(i-1)}a_1$. The selective angle range can be further reduced to be less than 10° for 1D PhC consisting of 400 stacks, each stack consisting of 500 isotropic-anisotropic bilayers, and the period is $1.002^{(i-1)}a_1$.

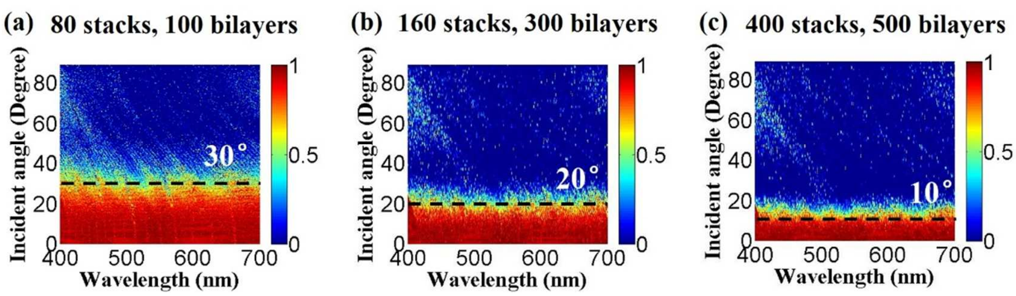

Figure S3. s-polarized transmission spectrum for the material system containing 5 layers of alternating one-dimensional photonic crystal (1D PhC) stacks and half wave plates. (a) 1D PhC consists of 80 stacks, each stack consisting of 100 isotropic-anisotropic bilayers. The period of the *i*th stack should be $1.01^{(i-1)}\mathbf{a_1}$. (b) 1D PhC consists of 160 stacks, each stack consisting of 300 isotropic-anisotropic bilayers. The period of the *i*th stack should be $1.005^{(i-1)}\mathbf{a_1}$. (c) 1D PhC consists of 400 stacks, each stack consisting of 500 isotropic-anisotropic bilayers. The period of the *i*th stack should be $1.002^{(i-1)}\mathbf{a_1}$.

S4: Comparison of transmission spectrum of the material system without loss and with loss

The suitable materials for this angular selectivity structure are the optical grade polymers with very low loss such as polyethylene terephthalate (PET), polycarbonate (PC), polystyrene (PS), and OKP. These polymer materials still have around 90% transmission even if their thickness is 3 mm.[1,2] The imaginary part of the refractive index can be calculated to be less than 5×10^{-6}, which is used for the simualtion. We compare the transmission spectrum of the material system with loss and without loss, as shown in Fig. S4. Figure (a) and (b) has 1D PhC consisting of 80 stacks, each stack consisting of 100 isotropic-anisotropic bilayers. The average transmission is 90% if the material has no loss and 60% if the material has loss. The transmission with loss can be made higher by optimizing the number of stacks and the periods of bilayers. We design a structure with 1D PhC consisting of 40 stacks, each stack consisting of 100 isotropic-anisotropic bilayers, and the period of the ith stack $1.02^{(i-1)}a_1$ (Fig. S4 (c) and (d)). The transparent window is also less than 30° and the average transmission in the transparent window is around 75%. The transmission with loss can be further increased to 80% if we use 40 stacks, each stack consisting of 50 isotropic-anisotropic bilayers. The transparent window increases a little but is still less than 40°, which can be used for most privacy applications.

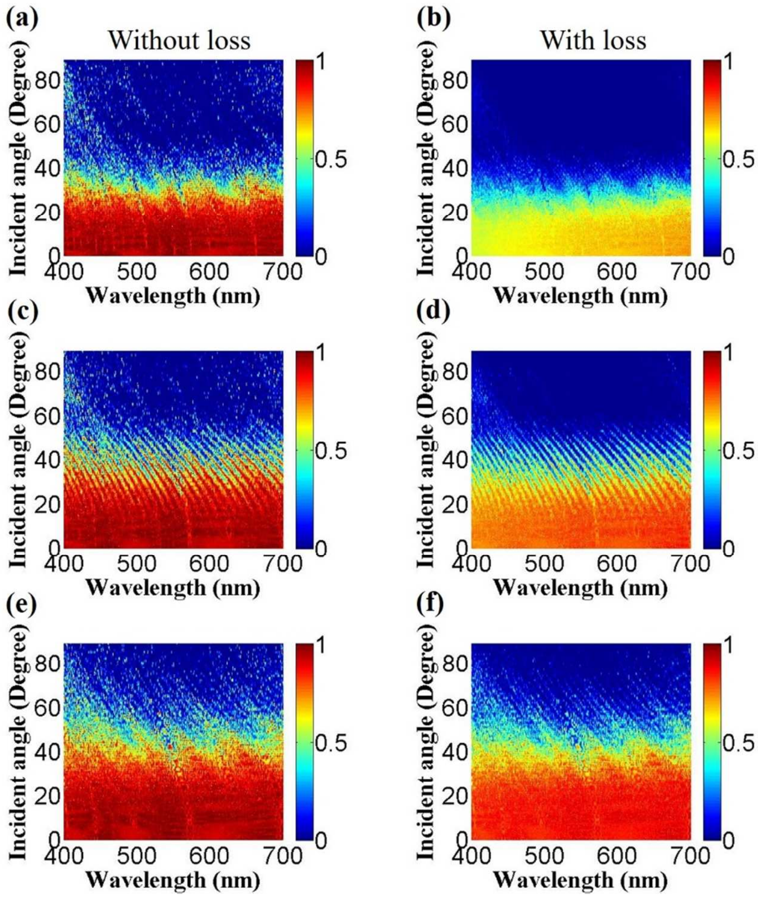

Figure S4. s-polarized transmission spectrum for the material system (a, c, e) with loss and (b, d, f) without loss containing 5 layers of alternating one-dimensional photonic crystal (1D PhC) stacks and half wave plates. (a) and (b) are 1D PhC consisting of 80 stacks, each stack consisting of 100 isotropic-anisotropic bilayers. The period of the *i*th stack is $1.01^{(i-1)}a_1$. (c) and (d) are 1D PhC consisting of 40 stacks, each stack consisting of 100 isotropic-anisotropic bilayers. The period of the *i*th stack is $1.02^{(i-1)}a_1$. (e) and (f) are 1D PhC consisting of 40 stacks, each stack consisting of 50 isotropic-anisotropic bilayers. The period of the *i*th stack is $1.02^{(i-1)}a_1$.

References

[1]http://diverseoptics.com/wpcontent/uploads/2012/02/Specifications_of_Optical_Grade_Polymers_and_Glass.pdf

[2]http://focenter.com/wp-content/uploads/docs/AngstromLink-OKP4_OKP4HT_OKP-1.pdf