Supplemental Information for Unidirectional asymmetry transmission based on quasi-accidental bound states in the continuum

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1 Section 1

1.0.1 Discussion about unidirectional asymmetry transmission in periodical chiral structure composed of tilted silicon quadrangular prism

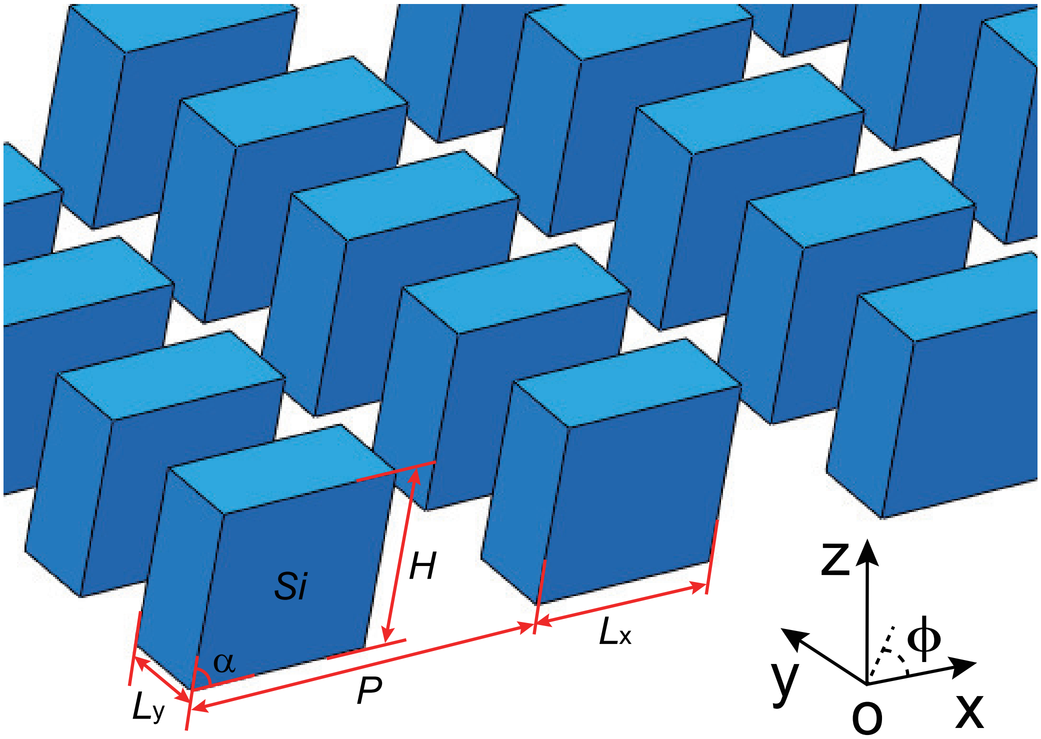

Fig. S1 Schematic illustration of designed two-dimensional periodical chiral structure.

Here, we verify the asymmetric transmission based on the accidental BICs supported by the periodical chiral structure composed of tilted silicon quadrangular prism, as shown in Fig. S1. The mirror symmetry is broken in xoz plane. By the numerical simulation, the unidirectional asymmetric transmission is verified under conditions of $P = 0.82$ μm, $H = 0.504$ μm, $L_x = 0.445$ μm, $L_y = 0.582$ μm and $\alpha = 74.9^\circ$. The refractive index settings are the same as that in the main text. The analysis method is also similar to the main text. Fig. S2 (a) shows the Q-factor and eigen-wavelength of mode at Γ point; The Q-factors of upward and downward radiation channels are calculated in Fig. S2 (b); $\mathrm{CD_{top}}$ and $\mathrm{CD_{bott}}$ spectra are shown in Fig. S2 (c-f); The transmission spectra is illustrated in Fig. S2 (g-j). The numerical simulation indicates the result is similar to that in main text. When the incident angle is 9°, the unidirectional asymmetric transmission with the $|\mathrm{CD}|$ of 0.99 and Q-factor of 470.6 occurs at $\phi = 109^\circ$, 251° (under the incidence from the top of structure) and $\phi = 71^\circ$, 289° (under the incidence from the bottom of structure).

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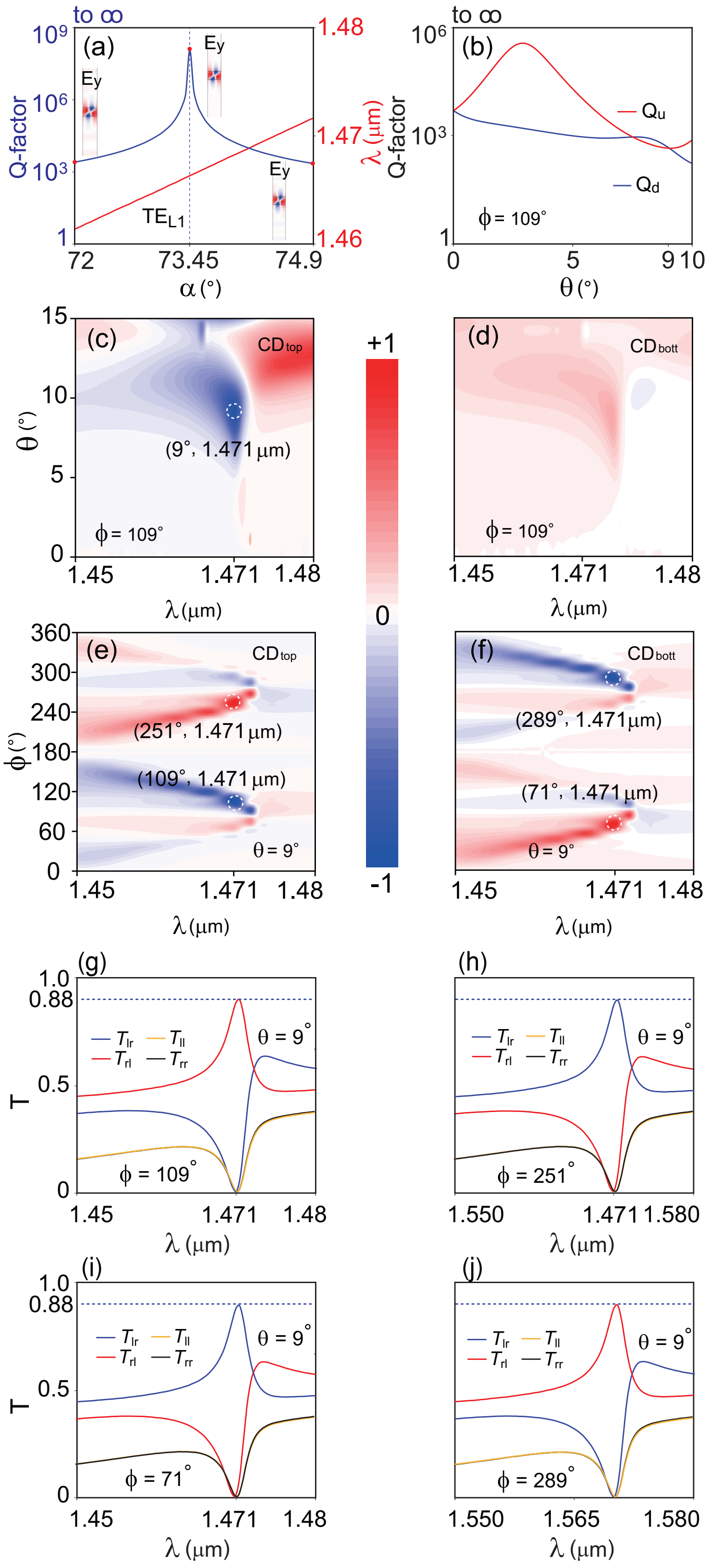

Fig. S2 (a) Band structure (red curve) and total Q-factors (blue curve) of the eigen-mode at Γ point, (b) Q-factor of upward (Q_u) and downward (Q_d)radiation as functions of incident angle θ at $\phi = 109^\circ$, (c-f) $\mathrm{CD_{top}}$ and $\mathrm{CD_{bott}}$ spectra, (g-j) transmission spectra at maximal and minimal CD.

1.0.2 Example with different lattice constant

As shown in Fig. S3, the unidirectional maximal asymmetry transmission can be also realized, when the structural parameters are set as $P = 0.861$ μm, $H = 0.551$ μm and $L = 0.446$ μm.

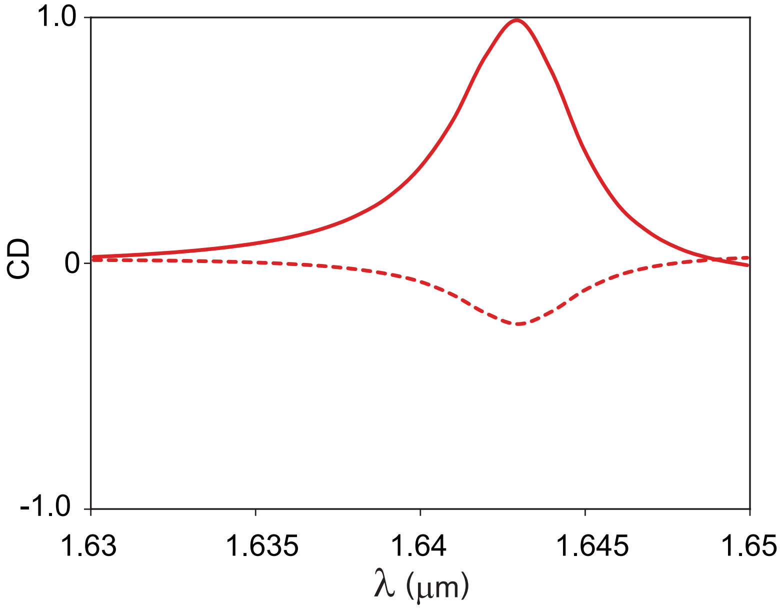

Fig. S3 $\mathrm{CD}_{\mathrm{top}}$ (solid line) and $\mathrm{CD}_{\mathrm{bott}}$ (dash line) spectra as functions of λ.

2 Section 2

2.0.1 Technical details in COMSOL Multiphysics

In the main text, we employ COMSOL Multiphysics based on the finite element method to calculate the band structure, Q-factor, far-field polarization state and transmittance. In COMSOL Multiphysics, three-dimension model is created according to "model wizard". The perfect matched layer is set at both ends along the z axis; The periodic (Floquet) boundary condition is applied in the x and y axes.

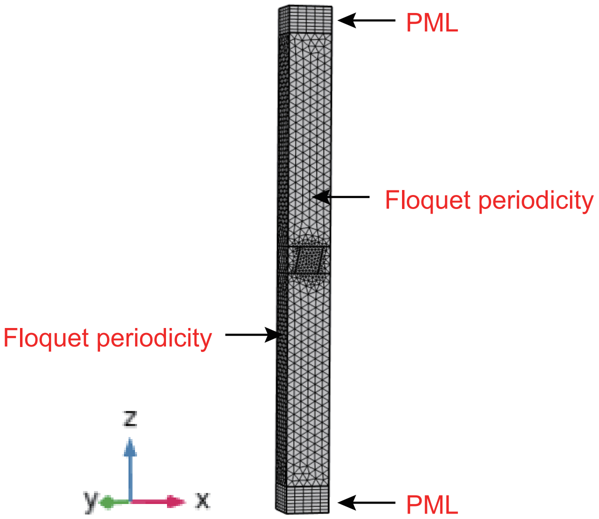

Fig. S4 Schematic illustration of CPhCs in COMSOL Multiphysics.

For the band structure, Q-factor, far-field polarization state, we use the "Eigenfrequency" solver. The expression of "ewfd.Q-factor" is used to calculate the total Q-factor. Note that the meshing resolution is related to the Q-factor of capture. Radiation losses (γ_u and γ_d) and far-field polarization state are calculated by two surface probes placed at both sides of structure. The band structure can be obtained by varying the "Floquet vector". For the transmittance, the solver is chosen as "Frequency Domain".

3 Section 3

3.0.1 Study on weakly chiral sensing

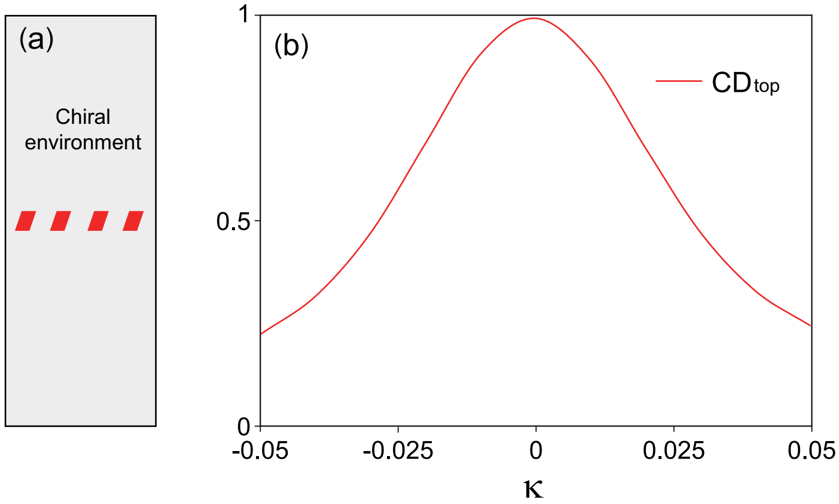

Fig. S5 (a) Schematic illustration of CPhCs in chiral environment, (b) $\mathrm{CD_{top}}$ as a function of κ.

Here, we further offer a study about weakly chiral sensing. The CPhCs in the main text is placed into the isotropic chiral environment ($n_e = 1.46$), the schematic is shown in Fig. S5 (a). The corresponding Tellegen's equivalent constitutive relations can be expressed as:

$$\begin{aligned} \mathbf{D} &= \varepsilon_0 \varepsilon_r \mathbf{E} + i\kappa\sqrt{\mu_0 \varepsilon_0}\mathbf{H}, \\ \mathbf{B} &= \mu_0 \mu_r \mathbf{H} - i\kappa\sqrt{\mu_0 \varepsilon_0}\mathbf{E}, \end{aligned} \tag{1}$$

where the dimensionless chiral parameter κ presents the strength of cross-coupling of electromagnetic fields.

We fixed $\phi = 130^\circ$, $\theta = 10^\circ$, $\lambda = 1.565$ μm, $\alpha = 78^\circ$ and and the light is illuminated from the top of structure. From Fig. S5 (b), in the research range from -0.05 to 0.05, it can be found that the maximal $\mathrm{CD_{top}}$ occurs at $\kappa = 0$ (achiral environment). As κ varying slightly (chiral environment), the $\mathrm{CD_{top}}$ decreases rapidly. Therefore, the proposed CPhCs can be applied to weakly chiral sensing with high sensitivity.