New concept of terahertz sensing based on higher-order topological phase

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The topological photonic crystals are introduced in this contribution to design for the performance of the refractive index sensor, so that the device is least affected by processing defects achieving accurate measurement of refractive index sensor even under noisy detection conditions.

We proposed a 2D valley photonic crystal structure, the unit cell of which is composed of six identical dielectric cylinders embedded in air. By rotating the angle of the dielectric column [without introducing complex electromagnetic field regulation, the topological phase transition process is realized. Moreover, the structure we designed is of higher-order topological insulator (HOTI) different from the traditional bulk-boundary correspondence [1,2] Therefore, the structure has the existence of topological corner states with a very narrow spectral width. Through the innovative combination of boundary state and corner state, we design a terahertz topological refractive index sensor. By changing the refractive index of the background, the resonant point frequency can be changed. As shown in Fig. 1(a), the topological sensor is composed of two photonic crystals with different topological phase. The resonant point is located at 5.023THz as shown in the Fig.1(c), when the refractive index of the background is 1.12. The electric distribution of the sensor at 5.023THz is shown in the Fig .1(b), and the corner states in the topological cavity is excited. Furthermore, we change the refractive index of the background, so the frequency position of the resonant point also changes. The Q value of the refractive index sensor is $3.2*10^5$, and the sensing sensitivity is 1.882THz/RIU. Then we introduced the defect into a straight waveguide. The results show that the modes of the topological waveguides based on valley photonic crystals are almost unaffected and only slightly disturbance occurs. The structure has topological protection, which works against local disturbance and processing defects. Meanwhile, the resonance effect is good, which is convenient for the output monitor to detect the transmitted light, and can be suitable for the actual experimental processing and preparation.

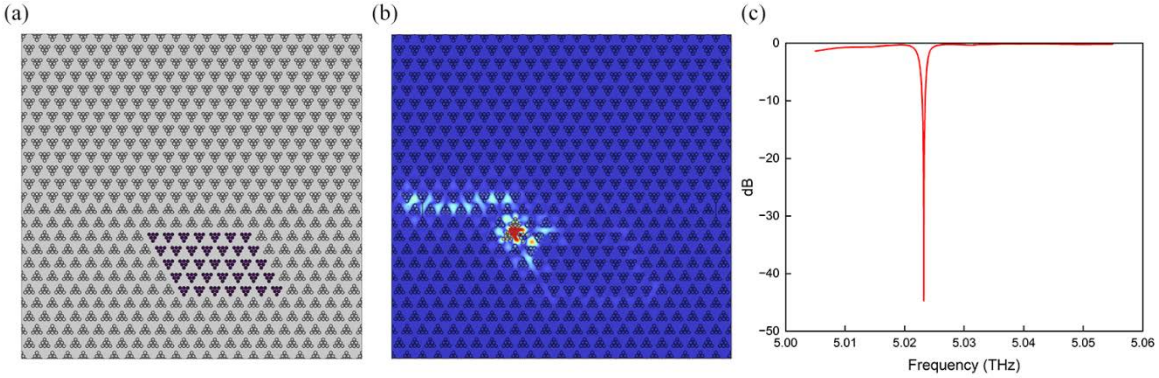

Figure 1. The structure our terahertz sensor. (a) The structure of the sensor is composed of two photonic crystal structures of different topological phases. The dark color represents the structure of the topological cavity. (b) The electric field distribution at 5.023THz. (c) The transmission of topological sensor. The resonant point is located at 5.023THz.

References

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