Barrier immune microwave propagation in topological ring resonator

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The existence of robust topological edge states (TESs) at the interface of two topologically distinct photonic crystals (TPCs) enables the construction of functional photonics devices showing superior performance to their conventional counterparts [1-3]. This work focuses on the study of metal-based TPC to investigate the topological robustness in a zigzag shaped topological channel subjected to sharply turned structural bending and an added external Si perturbation.

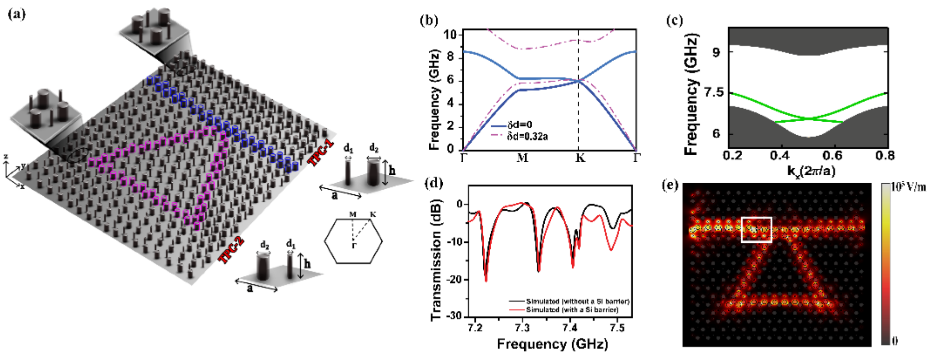

Figure 1. (a) Schematic of our metal based TPC with the right panel showing Brillouin zone and the rhomboid unit cells of TPC1 and TPC2 (b) Bulk band structure for $\delta d\ (= d_2 - d_1) = 0$ and $\delta d = 0.32a$ (c) Projected band diagram of the TPC (d) Simulated transmission spectra with and without the Si barrier (e) Simulated electric field distribution at $f = 7.364$ GHz with white rectangle indicating the added Si barrier.

The schematic of our considered structure is illustrated in Fig. 1(a), which consists of a ring shaped resonator being coupled to a straight topological waveguide. As shown in Fig. 1(b), the degeneracy at the K (K') point of the unperturbed TPC ($\delta d = 0$) can be lifted by introducing a geometrical perturbation in the rod diameters ($\delta d = 0.32a$), which leads to opening up a photonic band gap of $\sim 2.65 GHz$. The coupling of TPC-1 and TPC-2 through the zigzag domain boundary leads to the excitation of TESs, as evident from the green solid lines of Fig. 1(c). The robust propagation of TESs through the sharply turned ring resonator channel is depicted in Fig. 1(d), wherein the black solid line indicates a high microwave transmission of ~ 0 dB, except the transmission dips corresponding to the ring resonance phenomena. In addition, the red solid line of Fig. 1(d) indicates a minimal transmission loss (< 5 dB) in the presence of the external Si barrier, depicting a barrier immune propagation of the propagating TESs. The robust propagation can also be interfered with from Fig. 1(e), which indicates a strong electric field confinement along the entire topological channel with a negligible scattering loss around the corners of the ring resonator channel. This study provides a promising platform for realizing various potential microwave devices, including slow light waveguides, lossless devices, and efficient sensors.

References

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