The advent of topological microlasers

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Topological photonics offers a novel paradigm for engineering new optical functionalities and devices with robust performance. Equally important, such devices serve as a fertile platform for testing topological physics in a controlled environment where many-body interactions and nonlinearities can be tuned with high precision, beyond that achieved in electronic materials. Originally investigated in Hermitian systems in which particle number is conserved, topological features have been recently predicted and demonstrated under non-Hermitian conditions represented by gain and loss. Despite this rapid progress, the possibility of achieving laser emission in topologically protected states had remained an open question.

Over the past year, lasing action of symmetry-protected edge states in one-dimensional photonic lattices was reported by our groups in two independent studies [1,2] and also in [3]. Using different semiconductor platforms, these works demonstrated the topological protection afforded by the chiral symmetry of Su-Schrieffer-Heeger (SSH) arrays made of coupled photonic microresonators with alternating weak and strong side coupling. In [1], the array was made of circular polariton micropillars coupled together in a zig-zag geometry. The required coupling profile of the SSH array was implemented by taking advantage of the asymmetric spatial profile of the first excited modes of each micropillar leading to the emergence of a gapped edge state. Lasing in this topological state was achieved by optimizing the polariton relaxation conditions, and its topological robustness was demonstrated by making use of excitonic nonlinearities. The work in [2] employed ring microcavities supporting whispering gallery-type modes, and introduced the weak-strong coupling distribution by varying the distances between the microcavities.

These arrays were forced to lase in the topological mode by exploiting the anomalous chiral profile of the topological state that makes it immune to deliberate losses on every second site. The robustness of the state was demonstrated by structural deformations of the resonator array.

These works demonstrate the versatility of topological lasers in terms of material platforms. Particularly, the GaAs-based micropillars employed in [1] open the way to the exploration of driven-dissipative polariton condensates in topological lattices, while the work developed in Ref. [2] employed a hybrid silicon platform, thus opening the door for integrating topological lasers in silicon-based photonic chips.

These works which pioneered the advent of topological microlasers [1-3], have been recently complemented by remarkable breakthroughs in two-dimensional geometries [4,5], where 1D propagation of the lasing mode reveals genuinely novel assets.

References

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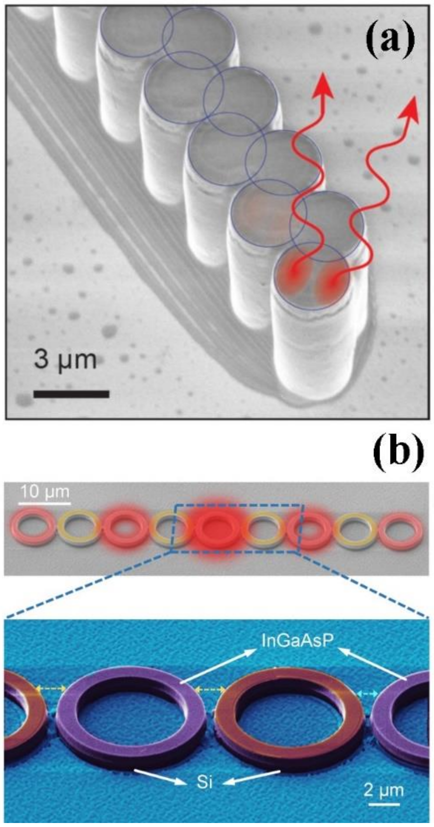

Fig. 1. Experimental demonstration of topological lasing in (a) exciton polariton microcavity array; and (b) coupled hybrid silicon microring resonators.