Parity-time reversal Symmetric Polaritonic System with a Single Hexagonal Microrod Cavity on a Loss-controlled Substrate

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Exciton-polaritons are quasi-particles having both excitonic and photonic properties and can be condensed into a coherent ground state in a strongly coupled microcavity system. GaN-based semiconductor microcavity system is an excellent platform for investigating room-temperature polaritonics with a large Rabi splitting energy caused by its high oscillator strength and large exciton binding energy [1]. Recently, there has been a lot of attention on non-Hermitian physics with parity-time symmetry (PT symmetry) in photonic systems with complementary gain and loss profiles. In many cases, near-field-assisted indirect coupling has been utilized to mediate interaction between two or more identical photonic components. Here, we present non-Hermitian polaritonic system with a single GaN hexagonal microcavity on a loss-modulated substrate, based on the room-temperature polariton condensates within the microcavity. First, by using a high-quality GaN hexagonal microrod, we observed whispering gallery polariton condensates at room temperature together with ballistic transport phenomenon depending on the excitation size-related potential gradient [2]. The natural six-fold symmetry of the hexagonal GaN microrod with wurtzite crystal structure provides degenerate modes between two quasi-whispering gallery modes, having upward and downward triangular paths. We achieved direct polariton coupling between the upward and downward triangular-whispering gallery polaritons within a single hexagonal microcavity by virtue of the excitonic nature of polaritons. By integrating the single GaN microrod into a bowtie-shaped, loss-controlled substrate, we realized a polariton-based PT-symmetric system at room temperature within a single microcavity [3]. As a result, we found that a phase transition from an unbroken to a broken phase and the decrease in polariton condensates threshold despite increasing loss. This polaritonic PT-symmetric system can be used to study non-Hermitian physics and to develop a variety of polaritonic applications operating at room temperature.

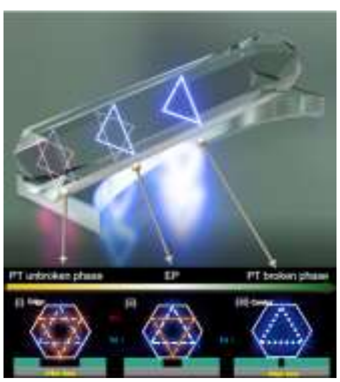

Figure 1: PT-symmetric polaritonic system with upward and downward triangular whispering gallery polaritons formed in a GaN hexagonal microcavity on a loss-modulated substrate. Different modes and intensities depending on the different loss conditions for downward triangular polaritons are shown. Lower images show the cross-sectional intracavity field intensities of the hexagonal microcavity in (i) the unbroken phase at the edge, (ii) the exceptional point (EP), and (iii) the broken phase at the center. [Ref. 3]

References

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[3] H. G. Song, M. Choi, K. Y. Woo, C. H. Park, and Y. H. Cho*, ***Nature Photonics*** 15, 582 (2021).