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NEWS AND VIEWS

Exciton–polaritons in semiconductors

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In 1951, Huang firstly proposed the concept of polariton and derived its dispersion relation by combing lattice vibration in ionic crystals with electromagnetic waves using classic electromagnetic theory, which was primarily aimed to explain light retardation effect (see Fig. 1)[1]. Hopfield *et al.* extended Huang's theory to exciton–photon interaction in crystals, experimentally demonstrated Raman scattering by phonon polaritons and formally proposed the name of "polariton" from "polarization" and "photon"[2, 3]. Since then, polariton has been widely studied in fundamental and application research fields.

Polariton is half-matter, half-light quasi-particle that forms when the energy transfer rate between polarized particles in matter (e.g. exciton, phonon, plasmon, magneton) and photons is faster than their dissipative rate. Inheriting from the matter which is massive and controllable as well as the photon which is massless and inactive, polariton exhibits a light mass and interactive behavior, and hence creates an idea platform to explore quantum electromagnetic dynamics in solid-state matters and develop high-speed, low-loss devices.

With revolution and rapid advances in semiconductor and microfabrication technologies, exciton–polariton (EP) has aroused great attentions from worldwide scientists in particular when Bose–Einstein condensation (BEC) of EP was realized in GaAs and CdTe quantum wells under optical pump in 2000s[4, 5]. Researchers consider that the EP–BECs make photons controllable by slowing their velocity, and hence could be applicable to develop optical chips with higher computing speed and lower energy consumption in comparison to electronic devices. Considerable efforts have been made, and till so far room temperature EPs have been realized in a variety of inorganic and organic semiconductors[6–9]. Moreover, electrically-driven BECs from InGaAs and EPs from organic semiconductors compound, such as 9,10-bis(phenylethynyl) anthracene, have been achieved at room temperature[10, 11]. Very recently, photo-transistors applying EP–BECs have been established, and new concepts such as parity-time-symmetry are introduced to extend the capability of light manipulation as well as lower threshold of semiconductor lasers[12–14].

To date, on the one hand, the research in EPs of these well-established semiconductors is still blooming, and continuous efforts are devoted to push laboratory devices to industry-friendly products. The central issues include low consumption, reliability and mass fabrication, *etc.* On the other hand, this area grows rapidly with the emergence of new materials including two dimensional semiconductors and metallic halide perovskites, *etc.*[15–21]. The perovskites combine the advantages of inorganic and organic semiconductors, exhibiting high exciton oscillator strength, long-range bipolar carrier transport, high defect tolerance, easy-tuning of band gap as well as low-cost fabrication processes[22–24]. In the last few years, several groups from Singapore, China and U.S.A. have reported EPs and EP–BEC effects at room temperature as well as continuous wave pumped EP lasing from the perovskite family[15–18, 25]. Despite of structure instability, perovskite raises the possibility to develop flexible, low cost, and low energy consumption EP devices.

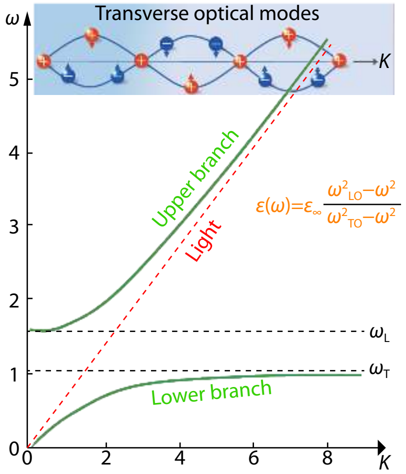

Fig. 1. The principle of the interaction between photons and lattice vibration.

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