Realization of exciton-mediated optical spin-orbit interaction in organic microcrystalline resonators for circularly polarized electroluminescence

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The ability to control the spin-orbit interaction (SOI) of light in optical microresonators is of fundamental importance for future photonics. Organic microcrystals, due to their giant optical anisotropy, play a crucial role in spin-optics and topological photonics. We demonstrated controllable and wavelength-dependent Rashba–Dresselhaus (RD) SOI, ascribed to the anisotropic excitonic response in an optical microcavity filled with an organic microcrystalline. We investigated the transition of the spin-splitting from twice winding caused by the splitting of the transverse-electric (TE) and transverse-magnetic (TM) modes to once winding caused by the RD effect. The interplay of the two allows engineering of the SOI of light in organic microcavities toward exploiting nonmagnetic and low-cost spin-photonic devices.

Circularly polarized (CP) electroluminescence from organic light-emitting diodes (OLEDs) has aroused considerable attention for their potential in future display and photonic technologies. Currently, the development of CP-OLEDs relies largely on chiral-emitters, which not only remain rare owing to difficulties in design and synthesis but also limit the performance of electroluminescence. Here, we demonstrate a chiral-emitter-free microcavity CP-OLED with a high dissymmetry factor (g_{EL}) and high luminance by embedding a thin two-dimensional organic single crystal (2D-OSC) between two silver layers which serve as two metallic mirrors forming a microcavity and meanwhile also as two electrodes in an OLED architecture. In the presence of the RD effect, the SOIs in the birefringent 2D-OSC microcavity result in a controllable spin-splitting with CP dispersions. Thanks to the high emission efficiency and high carrier mobility of the OSC, chiral-emitter-free CP-OLEDs have been demonstrated exhibiting a high g_{EL} of 1.1 and a maximum luminance of about 60000 cd/m^2, which places our device among the best performing CP-OLEDs.

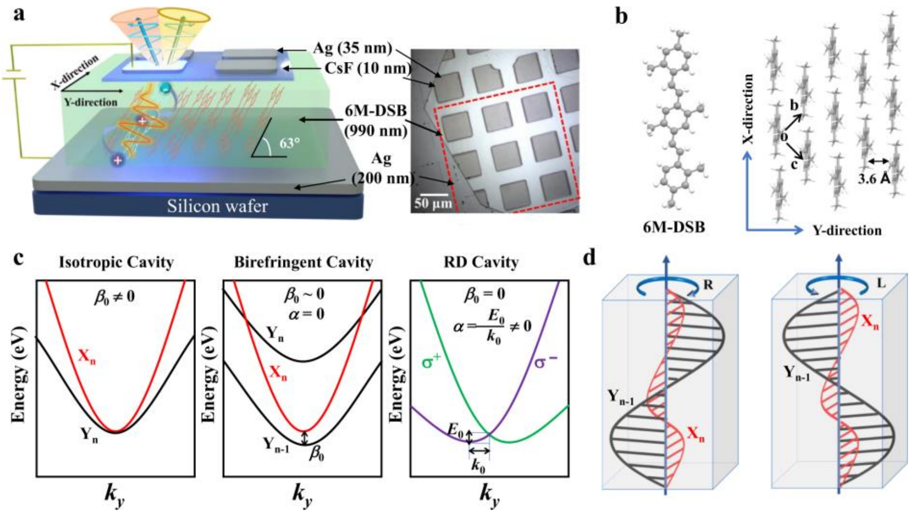

Figure 1. a, Schematic diagram of the microcavity CP-OLED device structure. **b** Left: Molecular structure of 6M-DSB. Right: brickwork molecular packing arrangement within the (001) crystal plane, viewed perpendicular to the microribbon top-facet. **c** Left: two orthogonally linearly polarized modes with the same parity in an isotropic microcavity. Middle: the dispersion of two orthogonally linearly polarized modes in an anisotropic microcavity. Right: RD SOI emerges when two orthogonally linearly polarized modes with opposite parity are resonant. **d** The resonant X- and Y-polarized cavity modes of opposite polarity. The 6M-DSB crystal in the microcavity hence acts as a half-wave plate, and the intrinsic mode polarization of the light-emitting side of the mirror turns into a circle, corresponding to left-handed and right-handed circular polarizations, respectively..

References

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