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OLED emission zone and internal quantum efficiency by varying the OLED microcavity thickness & measuring the detailed distribution of the electroluminescence emitter dipole orientation, not just the ensemble average

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Knowledge of OLED emitter molecule optical properties such as emission zone profile, intrinsic quantum efficiency and emitter orientation are essential in developing and understanding state-of-the-art organic light emitting diodes.
(i) The emission zone profile (EZP) is a crucial aspect to understanding the complex workings of an OLED. Knowledge of the EZP can give information on charge transport, exciton diffusion, efficiency roll-off, material degradation and device lifetime. The microcavity inverse light outcoupling approach will be presented which gives EZP spatial resolution of a quadratic function within the EML. The electron transport layer thickness (~the cathode-emitter distance) is adjusted to yield a microcavity interference minimum in the emission spectra (dark OLED). Interference is sensitive to small changes in the position of the emission source, thus creating large changes in the emission spectrum.
(ii) Emitter emission lifetime depends on the emitter's optical environment as described by the Purcell effect. Since this is an optical effect, the magnitude of the emission lifetime change depends directly on the internal quantum efficiency. By manufacturing a series of OLEDs of varying microcavity thickness, one can simulate and fit the internal quantum efficiency.
(iii) Non-isotropic alignment of emitter molecules can increase the outcoupling of light by 50%. Unfortunately, established approaches only determine an average orientation because emission patterns solely depend on this average. In order to resolve further details of such a distribution, additional differences in the emission characteristics of parallel and perpendicularly oriented emitters need to be introduced. A thin metal layer in the hole transport layer introduces plasmon mediated losses mostly for perpendicular emitters. Then emission lifetimes of mostly parallel or perpendicular oriented emitters are measured. The amount of lifetime splitting observed can give the angular width of the orientation distribution. A surprisingly narrow alignment for Ir(MDQ)2(acac) in an α-NPD host is presented.

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