Miniaturization of Organic Semiconductor Devices

Chih-Jen Shih
Department of Chemistry and Applied Biosciences, ETH Zürich

Miniaturization of organic semiconductor devices can enable hybrid integration with silicon photonics and three-dimensional coupling with nanocavities for advanced optoelectronics. In this talk, taking the organic light-emitting diodes (OLEDs) as a platform, we present the scalable fabrication of nanoscale patterning of organic semiconductors, which enables unprecedentedly small OLED pixels, surpassing the Abbe diffraction of emission wavelength ($< \lambda/2$). We report single-color OLED pixel arrays of the highest array density (up to 100,000 pixels per inch (ppi)) and the smallest pixel size (~150 nanometers) ever reported to date. The average external quantum efficiencies (EQEs) extracted from a nano-OLED device of more than 4 megapixels reach up to 10%, representing the highest value ever demonstrated in all nanoscale LEDs. At the subwavelength scale, individual nanopixels act as electroluminescent meta-atoms forming metasurfaces that convert electricity directly into modulated light. The diffractive coupling between nanopixels enables control over the far-field emission properties, including directionality and polarization. The results presented here lay the foundation for bright surface light sources of dimension smaller than the Abbe diffraction limit, offering new technological platforms for super-resolution imaging, spectroscopy, and hybrid integrated photonics.