Recent progress in organic light-emitting devices

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The demonstration of the first laser in 1960 led to a revolution in everyday life. Today, lasers are ubiquitous and can be found in CD/DVD players, printers, supermarket scanners, and medical equipment. The development of new types of lasers with expanded applications remains a major research activity worldwide. One class of lasing materials currently attracting considerable attention is organic semiconductors. They combine the simple manufacturing of plastics with favorable optoelectronic properties such as high photoluminescence quantum yield, strong absorption/gain, and broad spectra. Therefore, there is great interest in developing an electrically-pumped organic semiconductor laser (OSL), as it would provide a new class of lasers.

Although full-color monitors of organic light-emitting diodes (OLEDs) are already available in the market, electrical pumping remains a very challenging problem for conventional OLEDs. Particularly, for electrical excitation of OSLs, extremely high current density more than 1 kA/cm^2 is required [1,2]. However, the maximum current density of OLEDs are typically limited to 1-10 A/cm^2 due to the effect of exciton quenching and photon loss processes [1,2] and, consequently, electrical excitation of OSLs has not been realized.

Recently, to address this limitation, we focus on two unique organic light-emitting devices, such as organic single-crystal light-emitting transistors [2-8] and organic electrochemical light-emitting cells [9-11]. These light-emitting devices have p-i-n homojunction with highly conductive active area owing to electro-static or electro-chemical carrier doping, which is irrealizable for OLEDs. As the results, we demonstrated the effective light emission with extremely high current density more than 1 kA/cm^2, which is the first important milestone for future electrically-pumped OSLs.

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