High performance organic light-emitting devices based on light-emitting polymers and ionic liquids

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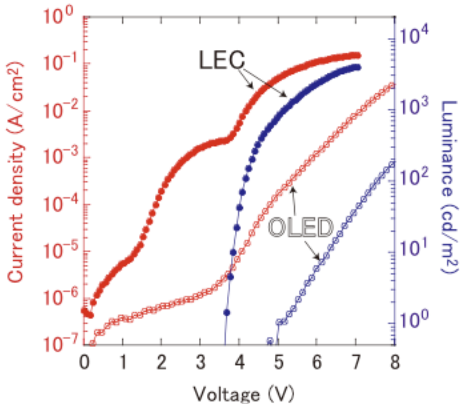
Organic light-emitting diodes (OLEDs) have successfully been applied to small-size displays and they are now expected for a much wider application. A crucial challenge for OLEDs is fabrication of high-performance devices with low-cost energy-saving processes. Another big challenge is a demonstration of electrically-pumped organic lasers. In order to challenge these issues, we are studying a potential use of light-emitting electrochemical cells (LECs) by using their flexibility of device designing.

LECs are the light-emitting devices whose active layers are composed of single layer blends of light-emitting polymers and electrolytes. When a voltage is applied to the active layer, p- and n-type electrochemical doping occur simultaneously and form highly conducting light-emitting *p-i-n* junction, which enables efficient emission with low voltage application. In this work, we adopted ionic liquids for the electrolyte of LECs. The newly designed ionic liquid dissolved light-emitting polymer, which gave a smooth and uniform active layer without phase separation, enabled us to fabricate a high performance blue-emitting LECs that shows lower driving voltage and higher efficiency than an OLED using the same polymers (Fig.1a).

For laser application, the highly-doped light-emitting *p-i-n* junction in LECs is attractive for high current injection, which is necessary for achieving high exciton density. We adopted a planar LEC structure for minimizing the optical losses by metallic electrodes. At room temperature, the device started to show the line-shaped emission in between two electrodes at 2.5 V, which is close to the bandgap of light-emitting polymer (F8T2, 2.4 eV), indicating a very efficient charge injection and transport was achieved [2] (Fig.1b). A pulse-driving technique achieved significantly high current density over 1,000 A cm^{-2}. Furthermore, small efficiency roll-off characteristics indicated our LEC is promising for the platform device for demonstrating organic semiconductor lasers.

(a)



(b)

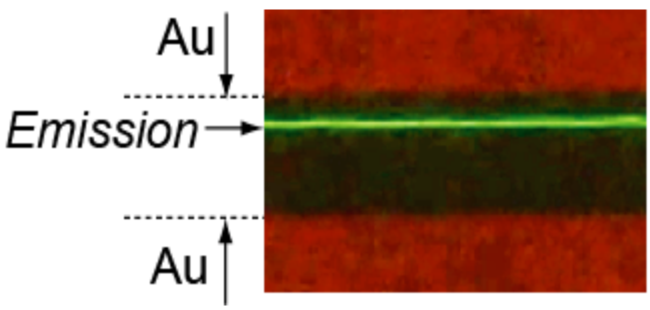


Fig. 1. (a) Current density-voltage-luminance characteristics of blue LEC and OLED using the same polymer. (b) Microscope image of light emission in planar LEC. The gap between two Au contacts is 10 µm.

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References

1. Q. Pei, G. Yu, C. Zhang, Y. Yang, A. J. Heeger, Science **269**, 1085 (1995).
2. T. Sakanoue, K. Sawabe, Y. Yomogida, T. Taishi, S. Seki and S. Ono, *Appl. Phys. Lett.* **100**, 263301 (2012).