Organic magnetoresistance based onto exciplex states

Kenichi Goushi and Chihaya Adachi
Center for Organic Photonics and Electronics Research (OPERA), and Center for Future Chemistry, Kyushu University, Fukuoka 819-0395, Japan
E-mail: goushi@cstf.kyushu-u.ac.jp

In organic light-emitting diodes (OLEDs), magnetic-field-dependent current has been observed even with a low external magnetic field, named as organic magnetic-resistance (OMAR). The mechanism has been still hotly debated, and several groups have proposed the different models. Here, we focus on one model of them, in which the magnetic-field-dependent generation of secondary charge carriers is responsible for magnetic-field-dependent current.1, 2) These carriers are caused by the dissociation of bound electron-hole pairs via hyperfine interaction1, 2), forming further space-charges in organic semiconductors. In the framework of the model, the dissociation efficiency from carrier-pair states should be an important factor to determine OMAR, since the dissociation process occurs mainly from carrier-pair states and not from excitonic states due to the strong exciton binding energy. In this study, we investigated the OMAR devices based on exciplex formation in which large magnetic-field effects can be expected due to an increased duration of stay in the carrier-pair states, since exciplex states provide rather efficient carrier dissociation process due to the smaller binding energy of exciplex states.

We investigated magnetic field effects on current in OLEDs consisted of ITO / m-MTDATA doped into Alq3 / Ca / Al. The m-MTDATA/Alq3 interface is well-known for the exciplex formations.3)

The MR based onto the exciplex states is higher than that based onto Alq3 excitonic states. These results suggest that exciplex states provide large OMAR. To investigate the validity of our proposed concept, the dissociation efficiency is estimated from the electrical field dependence of photoluminescence decay curves. As a result, dissociation efficiency of exciplex states is higher than that of neutral excited states. Therefore, we concluded that the higher MR based onto exciplex states is due to the weak binding energy of exciplex sates.

References

1. V. N. Prigodin, J. D. Bergeson, D. M. Lincoln, and A. J. Epstein, Synth. Met. 2006, 156, 757-761.
2. B. Hu, and Y. Wu, Nature Materials, 2007, 6, 985-991.
3. N. Matsumoto, M. Nishiyama, and C. Adachi, J. Phys. Chem. C, 2008, 112, 7735-7741.