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Interface Charge Transport in Organic Transistors as Investigated by Field-Induced Electron Spin Resonance

TATSUO HASEGAWA, AIST

Most of high-performance organic thin-film transistors (OTFTs) as recently developed is attainable with non-doped, single-component π-conjugated materials that exhibit high layer crystallinity both for small-molecules and polymers. The layer crystallinity is quite suitable to compose channel transport layers of the OTFTs, although the main origin to hinder the charge transport or the intrinsic carrier mobility is still controversial; intra- or intermolecular electron-phonon coupling, polarization effects by the gate-dielectrics, or thermal or extrinsic disorder effects. Here we discuss the interface charge transport in the OTFTs, as investigated by field-induced electron spin resonance (FESR) technique that probes 1/2 spin of carriers induced by gate voltage. It is shown that the FESR technique is extremely useful especially for OTFTs, because of the fairly small spin-orbit interactions in organic materials as well as of the high layer crystallinity and the anisotropy. The following important aspects of the interface charge transport are presented and discussed: (1) Carrier motion in OTFTs can be understood in terms of the multiple trap-and-release (MTR) transport. The analyses of the motional narrowing effects allow us to estimate the average trap residence time that reaches about 1 ns [1]. (2) Carriers are frozen at the respective trap sites at low temperature. The low-temperature spectral analyses allow us to obtain the distribution of trapped carriers over their degree of localization [2, 3]. (3) We also developed a unique technique to investigate the intra- and inter-domain transport in polycrystalline OTFTs by using anisotropic FESR measurements. The method allows us to evaluate the potential barrier height at the domain boundaries within the films [4].

[1] Phys. Rev. Lett. 100, 126601 (2008).
[2] Phys. Rev. Lett. 104, 056602 (2010).
[3] Phys. Rev. B 85.085211 (2012).
[4] Phys. Rev. B 85.035308 (2012).