Fabrication of high current density organic thin-film diode with rare-earth electrode

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Magnetoresistance in organic thinfilm-diode has been studied since it is related to interactions between radical spin-pair such as local hyperfine interaction [1]. In previous research, current density in such a device was at most 10^3A/m^2 and impact of an external current/voltage on such interactions has not been mentioned [1]. In this research, we tried to realize high-current density organic diode. Firstly, a small work function material (3.2 eV), Nd, was employed as an electron injection electrode. Secondly, microfabrication was conducted to realize a relatively small junction size to reduce pinholes.

The multilayer structure is depicted in Fig. 1(a): MgO(001) substrate/Cr(50 nm)/Au(2 nm)/ phthalocyanine(H_2Pc, 10 nm)/ tris(8-hydroxyquinolinato)aluminium(Alq_3, 15 nm)/Nd(10 nm)/Au(20 nm). The Cr was post-annealed at 350°C for 30 minutes. All films were deposited at room temperature by electron beam deposition or resistance heating methods. Photolithography and Ar-ion etching were employed for microfabrication. The designed junction area was 5×10 μm^2. Figure 1(b) shows a typical current-voltage characteristics. A high current density (~10^5 A/m^2) was realized. We tested following fittings, namely, space-charge-limit (=SCLC, $I \propto V^m$), tunneling injection limit (=Fowler-Nordheim, $I \propto V^2\exp(-\alpha/V)$) and Schottky injection limit ($I \propto \exp(\alpha V)$), where I, V are current and voltage, respectively [2]. The red solid line is the best fit using the SCLC. Since the fit coefficient was m=5.8, which is deviated from both SCLC with trap free region (m=2) and Ohm's law (m=1), we assumed that the I-V characteristics can be SCLC with trap charge controlled region. Multilayer structure dependence of current-voltage characteristics and magnetoresistance will be reported. This work was supported by JSPS KAKENHI. (Nos. JP15H05420J, P26103002)

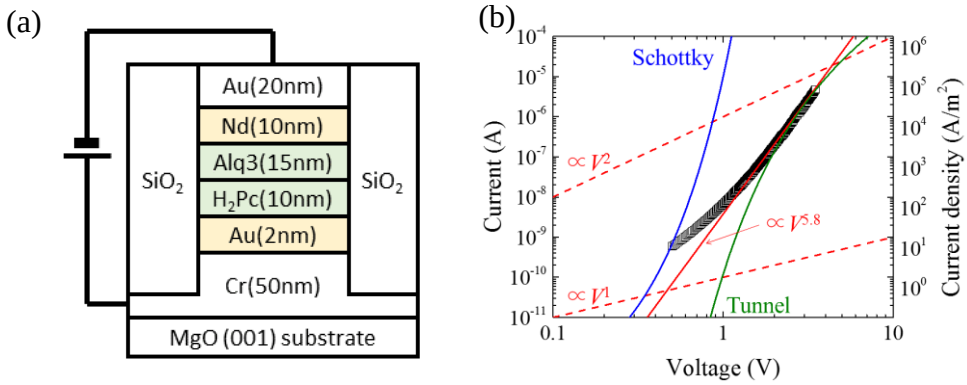

Fig. 1. (a) Sample structure **(b) Current-voltage characteristics**

[1] P. Janssen *et al.*, Nat. Commun. **4**, 2286 (2013). [2] Device physics of organic semiconductors, 講談社.