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Fully Self-Aligned Organic Field-Effect Transistors

Kuniaki Nomura, Shigeki Naka, and Hiroyuki Okada

Graduate School of Science & Engineering, University of Toyama
3190 Gofuku, Toyama 930-8555, Japan
Phone: +81-76-445-6729 Fax : +81-76-445-6732 E-mail: m0771019@ems.u-toyama.ac.jp

1. Introduction

Organic electron devices with potential of large area production, lightweight, thin and flexible are actively investigated. Especially, in organic light-emitting diodes (OLEDs), commercial production of mobile phone and MP3 player are started and production of television also scheduled within a year. In order to utilize a flexible substrate for a purpose of an ultra-lightweight and -thin display, an organic field-effect transistor (OFET) is one of promising options for back-plane of active-matrix panel production.[1-7] During fabrication process of the OFET, thermal process, *i.e.*, baking, treatment, annealing and crystallization are inevitable. Resultant thermal shrinkage is one or two orders magnitude larger than that of a glass substrate. Therefore, free alignment process without alignment mismatch should be considered.

To solve this problem, self-alignment process is suitable for defining shapes of layout. We have investigated self-aligned (SA) OFETs and its logic circuit using back-surface exposure method.[7-9] This method is interesting because a position of gate and source/drain electrodes are defined using patterning of gate electrode. And alignment margin of these electrodes are minimized within 0.5 μm. In this time, we have investigated fully self-aligned (FSA) OFET to define all of electrode patterns are defined using a layout of the first gate electrode.

2. Concept of Fully Self-Aligned Organic Transistors

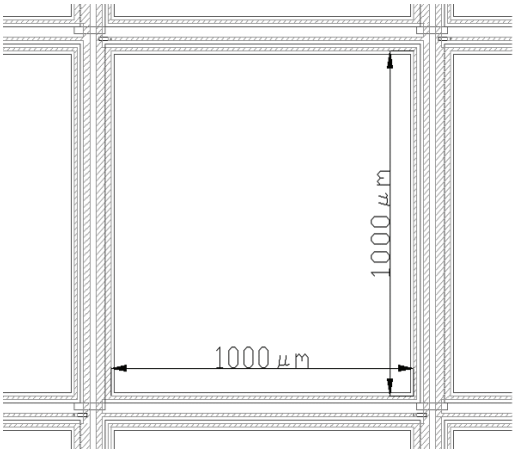

Fig.1 Layout of fully self-aligned organic transistor for back-plane application.

Figure 1 shows design concept of FSA-OFET for active-matrix driven liquid crystal display (LCD). Hatched region is a pattern of gate electrode. Shape of another pattern of source/ drain electrodes bring to be determined using the first gate pattern as a mask, such as, back-surface exposure method. Additional patterns of drain cutting and row wiring are added. Alignment of these patterns is no severe compared to above OFET electrodes. As shown in this layout, all of other patterns are invisible. Therefore, the fully self alignment is well carried out.

3. Experiment and Experimental Results

3-1 Experiment

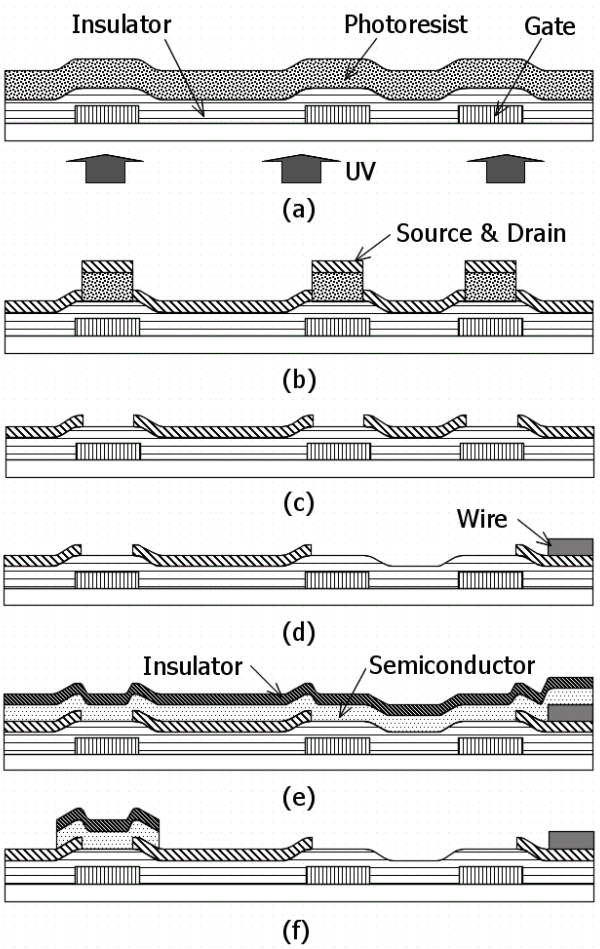

Fig. 2 Process steps of the fully self-aligned OFET.

Figure 2 shows a fabrication process of the FSA-OFET. The fabrication process and material under study are as follows: The glass substrate used was a fusion-formed aluminosilicate glass (Corning 1737). First, gate electrode of Mo (1,000 Å) was evaporated and patterned using a solution of cerium (IV) diammonium nitride. Second, insulating layer of polyimide (Kyocera Chemical CT-4112, 1,600 Å) was coated and baked at 190ºC for 1 hr. Third, back surface exposure was carried out, where the gate electrode was used as the photomask (Fig. 2(a)). Fourth, ohmic electrode of Cr (50 Å)/Pd (500 Å) was evaporated (Fig. 2(b)) and the lift-off process was carried out (Fig. 2(c)). Where, Cr was act as an adhesion layer and Pd exhibit excellent ohmic contact. Then, cutting patterning of a wire along a row direction was done to isolate each pixel. Interconnection of Ti (200 Å)/ Mo (1,000 Å) was also evaporated along row direction (Fig. 2(d)). And then, organic semiconductor of pentacene (1,000 Å) was evaporated at 70ºC and insulating layer of SiO_x (1,000 Å) was evaporated for passivation (Fig. 2(e)). Finally, photolithographic process and O_2 plasma etching were done (Fig. 2 (f)).

Figure 3 shows view image of fabricated 8x8 matrix panel. Channel length and width of the FSA-OFET was 10 μm and 3 mm. Chip size was 1 inch squared. A manual prober (Micronics 705A-6) and a parameter analyzer (HP 4155B) were used to measure electrical characteristics.

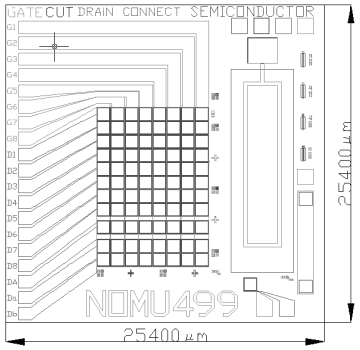

Fig. 3 Layout of fabricated 8x8 matrix panel.

3-2 Experimental results

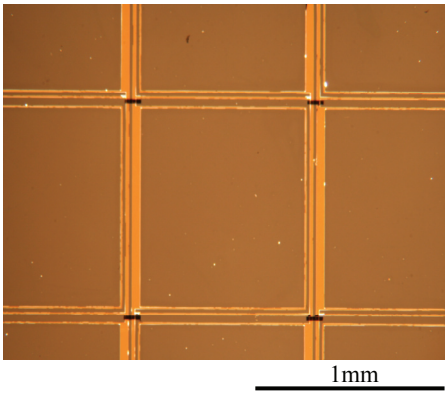

Fig. 4 Photograph of fabricated FSA-OFET pixel.

Figure 4 shows fabricated FSA-OFET at pixel of the panel. All of transistor operation at 8x8 matrix was confirmed. Figure 5 shows typical transistor characteristics. From this characteristics, field-effect mobility of 0.02 cm^2/Vs and on-off ratio of 10^3 were obtained. To improve the device characteristics, optimization of the passivation layer is urgent subject.

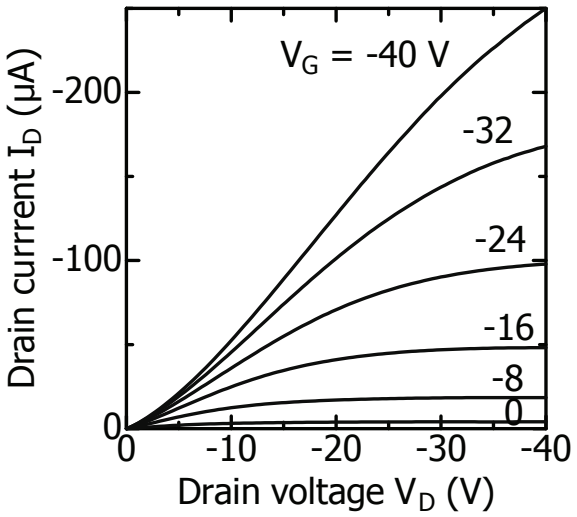

Fig. 5 Drain voltage vs drain current characteristics.

4. Conclusions

In this time, we had studied the fully self-aligned organic field effect transistor. Full operation of 8x8 matrix panel was confirmed. At this initial stage of fabrication, substrate material of glass was used. Possibility of application to plastic substrate is next stage subject.

Acknowledgment

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