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Anodization patterning for organic electronic circuits with low operation voltage

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Abstract

We have successfully fabricated high flexible organic electronics by using patterning of anodized aluminum oxide layer. The organic transistor was operated only 3 V with high mobility of 5 cm^2/Vs and on/off ratio of 10^7. We also fabricated organic pseudo-CMOS circuits and amplifier circuits. This inverter circuits show the high inverter gain of 2000. And pseudo-CMOS inverter based self-feedback amplifier system was operated only 3 V with a signal gain exceeding 1000.

1. Introduction

Flexible devices which have good mechanical flexibility and durability are one of the important technologies for realizing next-generation electronics such as robotic sensory arrays [1], e-paper [2] and organic solar cell [3]. Recently, these flexible electronics have been expected to use bio-medical applications such as flexible electrodes for detecting small bio signals [4, 5], ultra-sensitive pressure sensor [6], and temperature sensor [7]. For improving the mechanical flexibility and durability, the total thickness of device is decreased to less than 2 μm [8-10].

One of the important technology for realizing the high yield and high performance organic circuits with low operation voltage is anodized aluminum oxide gate dielectrics [8]. Anodization process needs to connect the all electrodes to form the aluminum oxide layer. So, the main problem of this anodizing process is difficulty to pattern the gate electrodes.

In this study, we succeed to pattern the anodized aluminum oxide layer by using the photolithography technique. Using anodized aluminum oxide layer, we also succeed to make organic circuits with low operation voltage. Our organic transistor shows the mobility of 5.0 cm^2/Vs, large on/off ratios of 10^7, and small gate leakage current. And also, we succeed to fabricate the organic pseudo-CMOS inverter circuits and amplifier circuits.

2. Fabrication process

The optical microscope image of the organic transistor matric (20 × 20) and stand alone organic transistor are shown in Figure 1. Our organic transitor has very thin gate dielectrics layer which consists of anodized alumnium oxide layer and self assembled monolayer. The aluminum

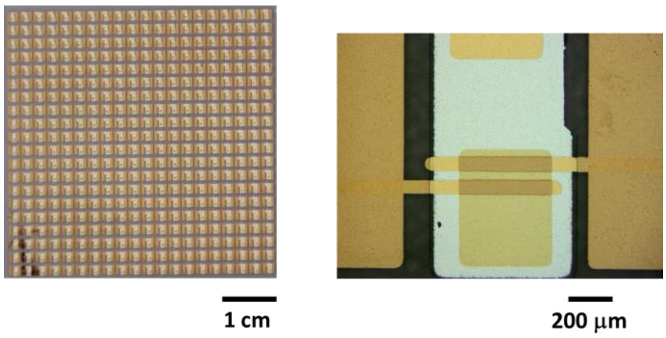

Fig. 1 (a) The optical image of organic transistor matrix. (b) The optical image of stand-alone organic transistor.

oxide layer was patterned by using photoresist (AZ 4400). First, we deposited aluminum by thermal evaporation. Then, we patterned the photo resist on the connection electrodes. After forming the photo resist, we anodized aluminum. Next, we removed the photo resist and etched the conntection electrode by wet etching. The surface of aluminum oxide was exposed to oxygen plasma and formed the self-assembled monolayer by dipping process. After forming the gate dielectrics, we formed DNTT or DPh-DNTT as an organic semiconductor. Finally, we formed gold as source and drain electrodes.

3. Results

Figure 2 shows the characteristics of the transistor. Our p-type organic transistor with DPh-DNTT which was evaporated with substrate heating at 90^{o}C shows the mobility of 5.0 cm^2/Vs, large on/off ratios of 10^7. In addition these organic transistors have low hysteresis and low leakage current (less than 10 pA).

Using these four p-type organic transistors, we fabricated pseudo-CMOS inverter circuits (Fig. 3). Our inverter was worked at only 3 V and also shows the high inverter gain of 2000.

We also fabricated the self-feedback organic amplifier circuits by connecting organic pseudo-CMOS inverter, capacitor and resistor (Fig. 4). Red and blue lines represent input voltage and output voltage, respectively. When we applied the sine wave (1 mV$_{PP}$, 17Hz) as an input voltage, the signal was amplified by 1000 times (Fig. 4). This amplified gain was world highest value in organic amplifier.

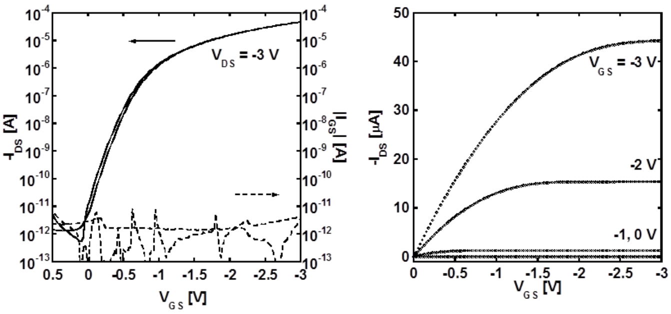

Fig. 2 Organic transistor characteristics (left) transfer curve (right) output curve

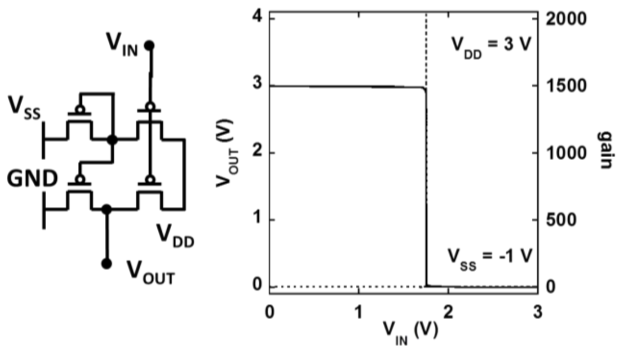

Fig. 3 Pseudo CMOS inverter (left) circuits diagram (right) input output characteristics

4. Conclusions

In this study, we succeed to pattern the anodized aluminum oxide layer. Using this anodized aluminum oxide layer, we fabricated organic transistors and circuits. The organic transistor was operated only 3 V and show the high mobility of 5.0 cm^2/Vs. And also we succeed to fabricate organic pseudo-CMOS inverter circuits. The inverter circuits show the high inverter gain of 2000. Then we fabricated organic self-feedback organic amplifier circuits. This amplifier circuits show the high amplifier gain of 2000 at 17 Hz.

5. Acknowledgements

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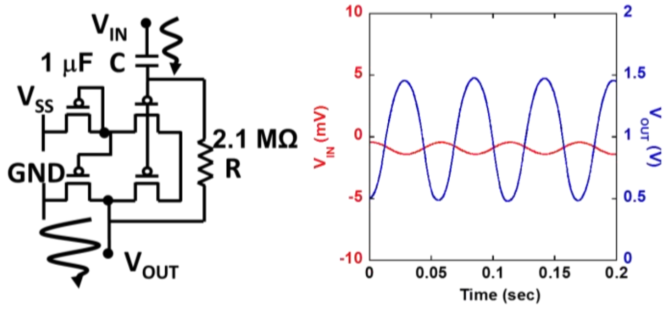

Fig. 4 Self-feedback organic amplifier circuits (left) circuits diagram (right) input output characteristics of amplifier circuits

6. References

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