Electrical Characteristics of Organic TFTs Using ODPA-ODA and 6FDA-ODA Polyimide Gate Insulators

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Abstract

A new dry-processing method of organic gate dielectric film in field-effect transistors (FETs) was proposed. The method use vapor deposition polymerization (VDP) that is continuous and low temperature process. It has the advantages of shadow mask patterning and dry processing in flexible low-cost large area applications.

Here, 80 nm-thick Al as a gate electrode was evaporated through shadow mask. Gate insulators used two different polyimides. The one material was 4,4'-oxydiphtahlic anhydride (ODPA) and 4,4'-oxydianiline (ODA). Another was 2,2-bis(3,4-dicarboxyphenyl) Hexafluoropropane Dianhydride (6FDA) and 4,4' -oxydianiline (ODA). These were co-deposited by high-vaccum thermal-evapora and cured at 150 ℃for 1 hour, respectively. Pentacene as a semiconductor and 100 nm-thick Au as a source and drain electrode were evaporated through shadow mask.

1. Introduction

The processing technology of organic thin-film transistors (OTFTs) performances have improved for the last decade. Gate insulator layer has generally used inorganic layer, such as silicon oxide which has properties of a low electrical conductivity and a high breakdown field. However, inorganic insulating layers, which are formed at high temperature, may affect other layers formed on a substrate through preceding processes. On the other hand, organic insulating layers, which are formed at low temperature, dose not affect pre-process. Known wet-processing methods for fabricating organic insulating layers include a spin coating, dipping and Langmuir-Blodgett film processes. In this paper, we propose the new dry-processing method of organic gate dielectric film in field-effect transistors. Vapor deposition polymerization (VDP) that is mainly used to the conducting polymers is introduced to form the gate dielectric. This method is appropriate to mass production in various end-user applications, for example, flat panel displays, because it has the advantages of shadow mask patterning and *in-situ* dry process with flexible low-cost large area displays.

2. Experimental

Here, first, 80 nm-thick Al was evaporated as a gate electrode through a shadow mask. Second, gate insulators used two different polyimide. The one material was 4,4'-oxydiphthalic anhydride (ODPA) and 4,4'-oxydianiline (ODA). Another was 2,2-bis(3,4-dicarboxyphenyl) Hexafluoropropane Dianhydride (6FDA) and 4,4'-oxydianiline (ODA), These were co-deposited by high-vaccum thermal-evaporation and cured at 150   for 1 hour.

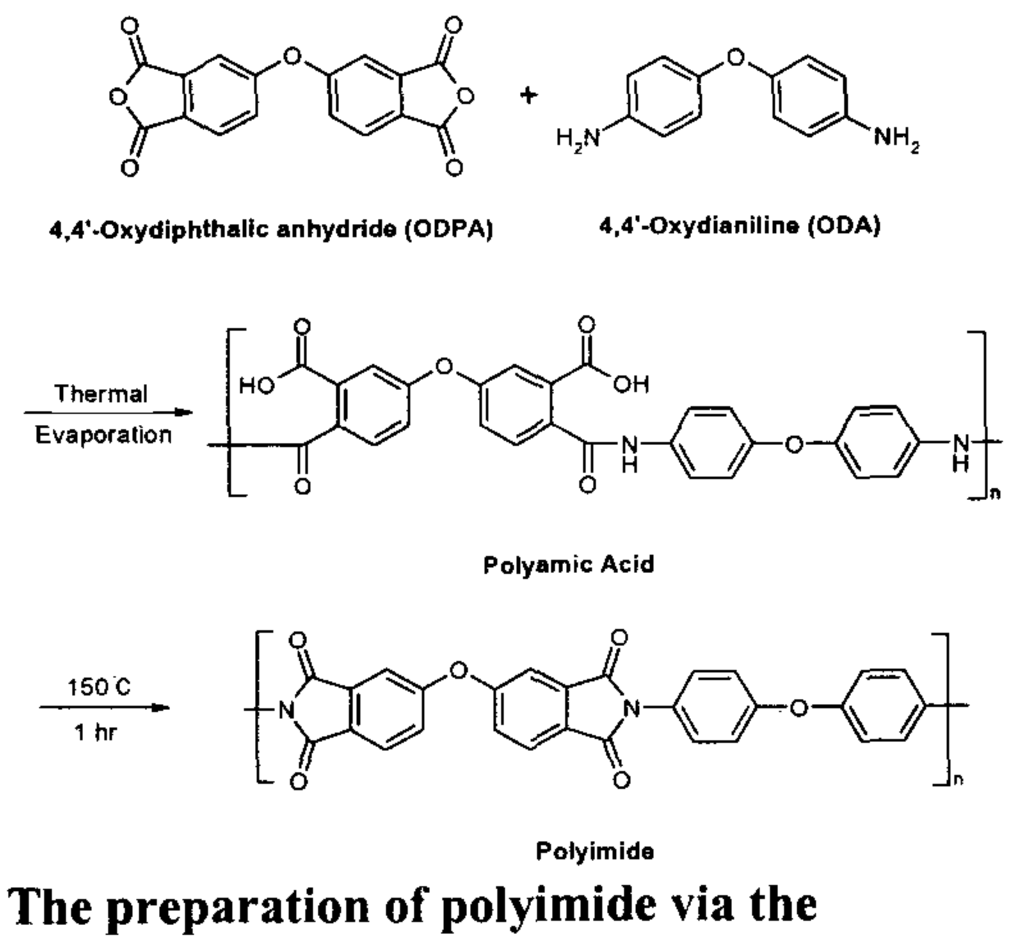

Fig.1. The preparation of polyimide via the condensation of carboxylic dianhydride and dianiline

In the ITO-polyimide-Al structure, breakdown field was larger than 0.3 MV/cm and electrical conductivity was smaller than 10^{-11} S/cm. Polyimides are polymers made from the polymerization of an acid dianhydride and a diamine. The curing process and the associated cross-linking will affect mechanical, thermal, and electrical properties of polyimide. And pentacene active layers were deposited by thermal evaporation at 5×10^{-7} Torr, with deposition rate of 0.2 /s and thickness of 80 nm. During the deposition of pentacene, the substrates were held at room temperature. Finally, the devices are completed by thermal deposition of gold (Au) to form source and drain contacts through a shadows mask. All-organic thin-film transistors with staggered-inverted top-contact structure were fabricated on glass substrates as shown in Fig.2. In this structure, two different voltage sources were used, one across the dielectric layer (V_G), which generates the charges (charge accumulation), and the second one (V_D) along the active layer to drive them from source to drain (charge injection).

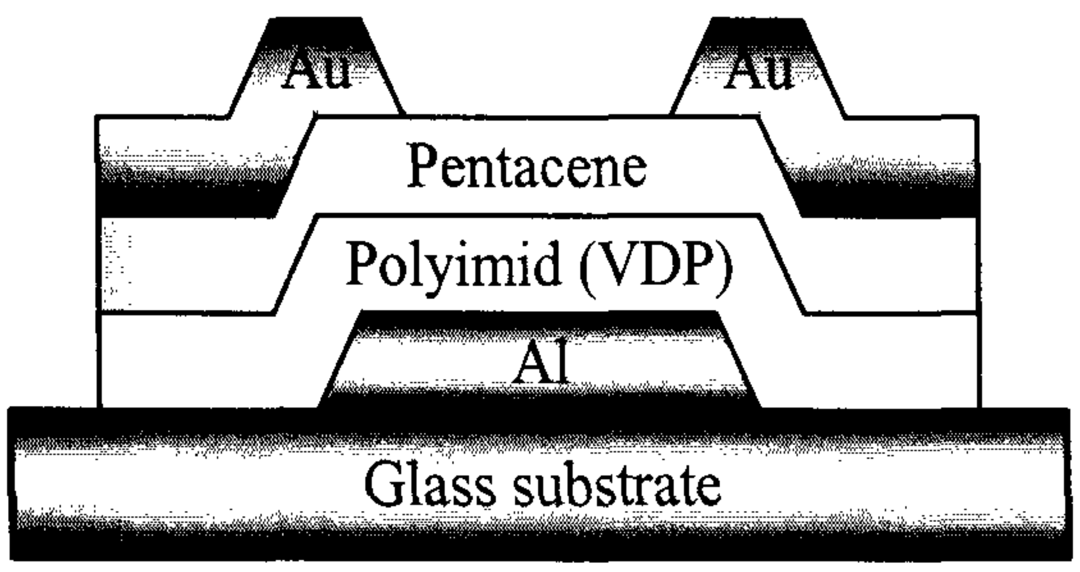

Fig.2. Device structure of organic thin-film transistors

3. Results and discussion

ODPA-ODA polyimide using the gate insulator have mobility 0.06~0.1 cm²/V· s, threshold voltage –7 V, and subthreshold slope 2.2 V/decade in the saturation region. However, Fig. 3 shows the electrical transfer characteristics of 6FDA-ODA poly imide gate insulator OTFTs, 6FDA-ODA Polyimide using the gate insulator have mobility 0.1-0.2 cm²/V· s, threshold voltage –5 V, and subthreshold slope 1.2 V/decade in the saturation region at –20V. Fig. 4 shows electrical output characteristics of organic thin-film transistor, W/L= 25, V_G = 0 ~ -30V. It was investigated that on-off current ratios with ODPA-ODA and 6FDA-ODA polyimide gate insulator films were 10^4 and 10^7, respectively

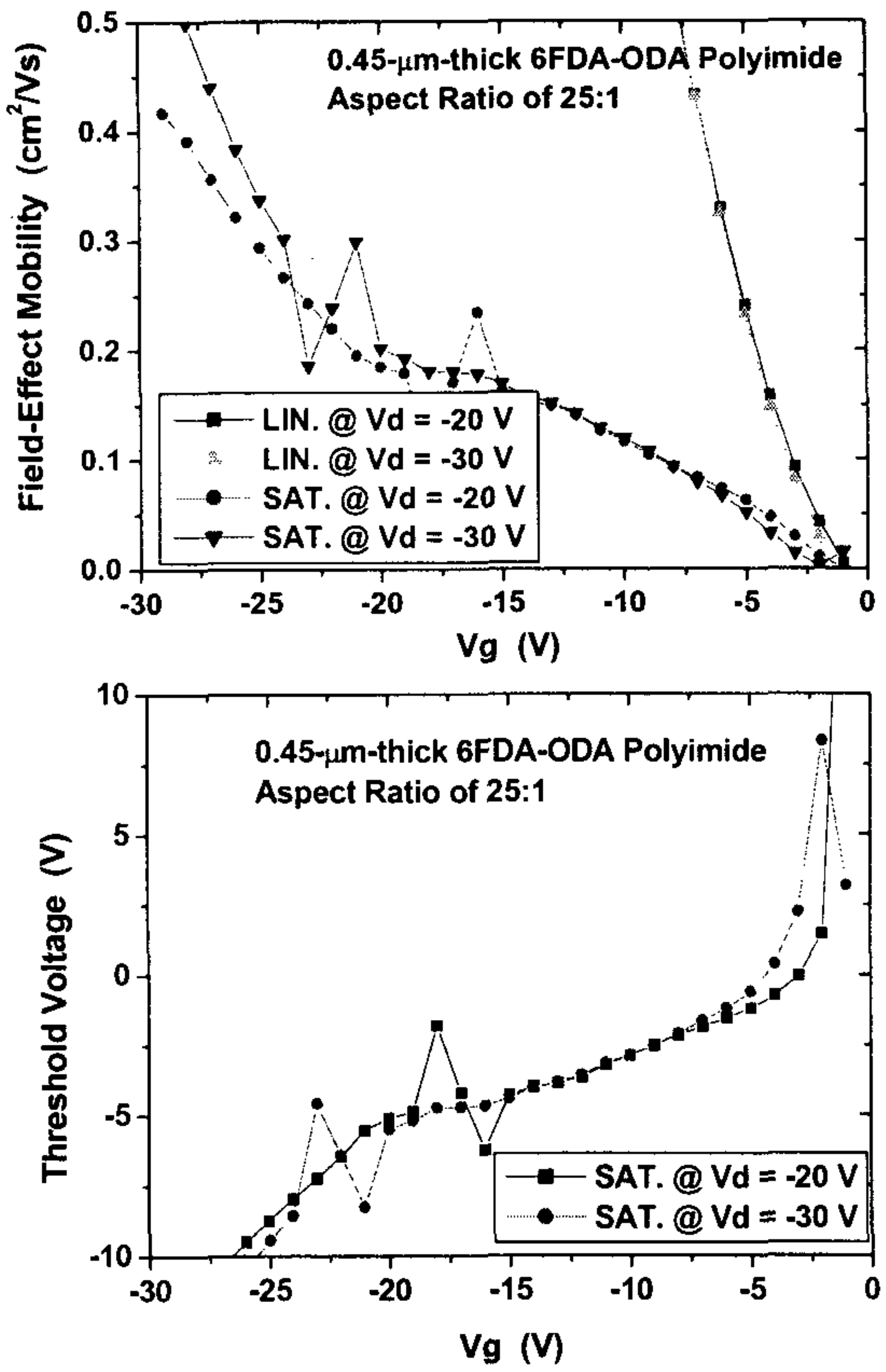

Fig.3. The electrical transfer characteristics of 6FDA-ODA ployimide gate insulator OTFTs, W/L=25, V_G = 0 ~ -30 V.

6FDA-ODA polyimide gate insulator OTFTs is better than ODPA-ODA polyimide in electrical characteristics. We guess that 6FDA-ODA polyimide gate insulator morphology and material characteristics affect pentacene and insulator interface. So that we will measure pentacene and insulator interface with AFM, XPS, XRD.

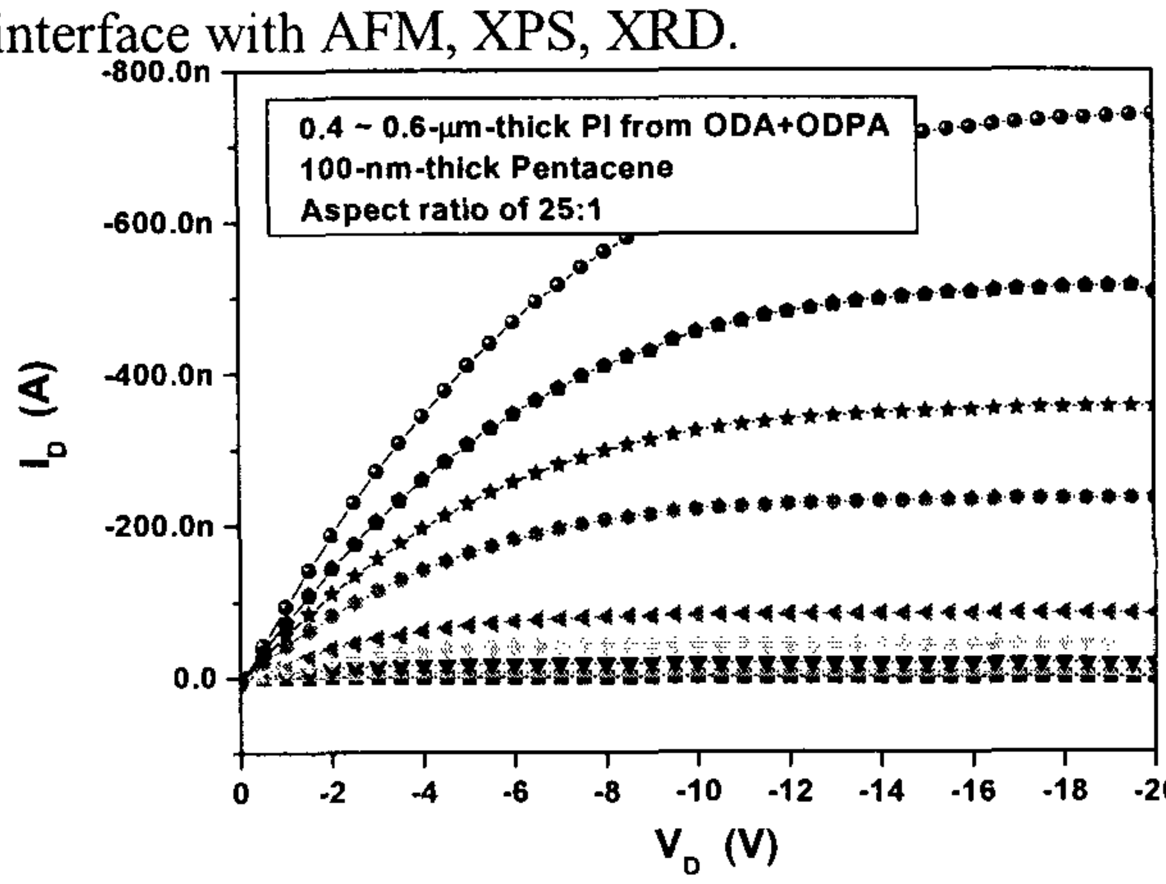

Fig.4-1 The electrical output characteristics of ODPA-ODA polyimide insulator OTFTs, W/L=25, V_G = 0 ~ -20 V.

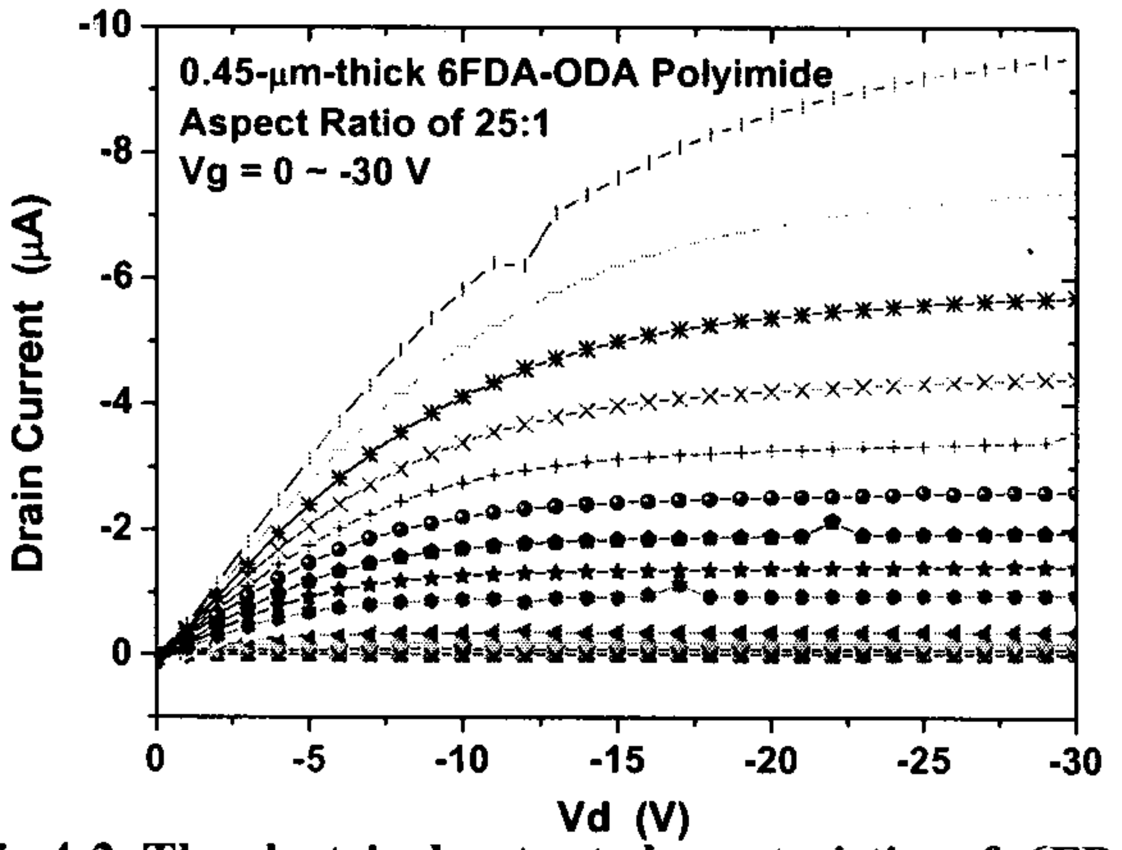

Fig.4-2. The electrical output characteristics of 6FDA-ODA polyimide gate insulator OTFTs , W/L=25, V_G = 0 ~ -30 V.

4. Conclusion

A new dry-processing method of organic gate dielectric film in field-effect transistors (FETs) was proposed. The method use vapor deposition polymerization (VDP) that is continuous and low temperature process. It has the advantages of shadow mask patterning and dry processing in flexible low-cost large area applications

5. References

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