Degradation Study of Organic TFTs under UV irradiation stress

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Abstract

Pentacene based TFT showed a degraded mobility and saturation current (Ion) after exposure to the high energy ultraviolet (UV). In this article, we optimize the thickness of UV resisted layer on OTFT to restrain the degradation from protect layer deposition and study the UV aging effect of pentacene based TFT. The OTFT deivce with UV resisted layer could keep over 50% mobility after suffered UV 10^3J.

1. Introduction

Organic thin film transistors (OTFTs) show the great potential for flexible display and electronic devices and pentacene is the most attracted semiconductor material due to its easy manufacturing and air stability. Recently, Polymer Vision had demonstrated rollable EPD display driving by OTFT and planning to manufacture. In SID 2007, Sony demonstrated the 2.5" qqVGA OLED panel driving by 2T1C OTFT structure [1]. The information indicated that OTFT driving ability had been proven for display application. Personal portable display could be the first application combining the display and flexible concept that indicated OTFT would be operated in the outdoor environment. However, sunlight wavelength between 300nm to 450nm is located at pentacene highly absorption range [2]. Kim et al. [3] and Jassi et al. [4] have shown that pentance TFT performance would be degradation over 50% after exposure to UV energy from 0.2~2J. In this article, we develop the UV resisted layer process and investigate relation between OTFT performance degradation and UV energy. The result reveals that the OTFT device with UV resist layer keep performance 50% after suffered UV energy 10^3J.

2. Experimental

To investigate the relation of OTFT and UV energy, the bottom gate bottom contact structure was used due to there is nothing to block the UV irradiation to pentacene except UV resist layer. Figure 1(a) is the schematic cross-section of OTFT and UV resist layer and (b) is the plane view of optical microscopy image. First, All of the electrode are 1000Å ITO film which deposited by DC sputtering and pattering by photolithography. The dielectric layer is 3000Å TEOS-SiO_2 and deposition with PECVD. Before pentacene deposition, sample was immersing in IPA and alcohol with ultrasonic oscillation 10 minutes. Pentacene thickness is 1000Å and deposited by thermal evaporation with deposition rate 0.1Å/s.

The design of the test device is Channel length 30 μ and width 500 μ m. The UV resisted structure is comprised with organic and inorganic materials. The first layer on the pentacnen is PVA with spin coating process. The water based PVA solution is used as the buffer layer to release the stress from inorganic thin film. In this study, we choose the thermal evaporation/E-beam SnOx and TiOx as the UV resist layer due to its absorption in the UV region. Figure 2 is the optical transmittance profile of SnOx with difference thickness. The 60nm SnOx thin film absorbs or reflects exceeding half intensity of UV region. However, the drain current of OTFT device with 60nm SnOx is degradation about 30%. This is the reason why we choose the 20nm SnOx as the UV resisted layer.

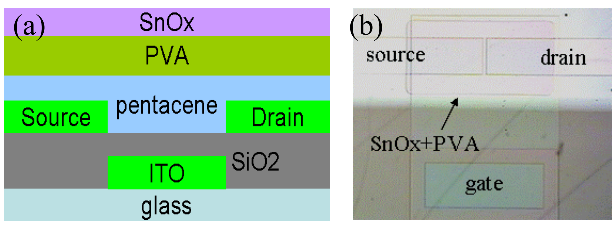

Fig. 1. (a) the cross-section of OTFT structure (b) the plane view OM image

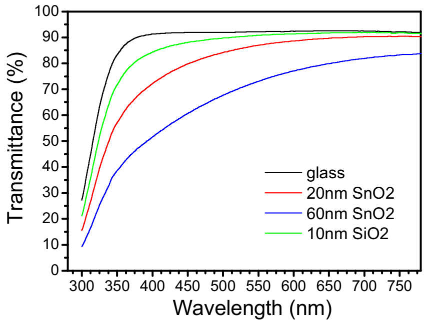

Fig. 2. The optical transmittance of different thickness SnOx film

3. Results and discussion

Figure 3 is the Id-Vg profile of OTFT with different SnOx thickness. The result shows the thicker SnOx will increase the leakage current and reduce the drain current. This phenomenon is caused by the stress from SnOx deposited. The mobility before SnOx deposited is 0.057cm^2/V-s and 0.055, 0.027, 0.025 is the mobility after SnOx deposited with 200Å, 400Å and 600Å, respectively. The optimized thickness of SnOx is 200Å. Figure 4 shows the mobility ratio (μ / μ_0) after OTFT irradiation with different UV energy. If OTFT without any UV resist layer, the mobility will be degraded to 50% after UV irradiated 2J and reduced 70% after UV energy accumulated to 10J. This behavior is very similar to the literature report [3-4]. The black circle in Fig. 4 is OTFT deposited 200Å SnOx and shows great UV resisted behavior. The mobility is almost the same before irradiation UV energy less than 1J and degraded less than 20% when UV energy accumulated to 10J. If the lifetime definition is mobility reduce to 50%, the OTFT with UV resisted layer could suffer UV irradiation to 10^{3}J.

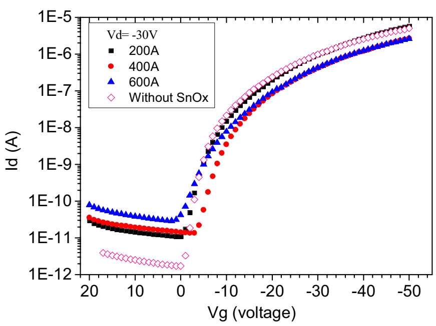

Fig. 3. The Id-Vg profile of OTFT with different thickness SnOx film

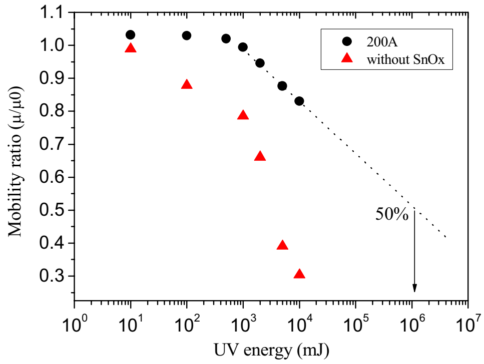

Fig. 4. The relation of UV energy and OTFT performance degradation

4. Summary

In this study, we develop the UV resisted layer to protect the OTFT device and optimize the deposition condition to minimization the degradation of mobility and Ion current. The UV resisted layer could enhance the lifetime of OTFT to suffer UV energy 10^{3}J and realize OTFT applied to outdoor portable flexible device.

5. References

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