

Pentacene Organic Thin Film Transistor and Inverter with Dual Gate Structure

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Abstract

The pentacene-based OTFTs were demonstrated with field effect mobilities comparable to that of amorphous silicon which has found widespread use in electronic devices. Major problems that are pending for the development and mass production of practical OTFTs are passivation for long term stability and the control of electrical parameters such as threshold voltage (V_{th}) and on-current. These problems can be simultaneously solved using a dual-gate (DG) structured OTFT. We report on the fabrication and characterization of dual-gate pentacene organic thin-film transistors (OTFTs) with plasma-enhanced atomic-layer-deposited (PEALD) 150 nm thick Al_2O_3 as a bottom-gate dielectric and PEALD 200 nm thick Al_2O_3 or parylene 300 nm as a top-gate dielectric. The V_{th} of dual-gate OTFT has changed systematically with the application of voltage bias to top-gate electrode. When voltage bias from -10 V to 10 V is applied to top gate, V_{th} changes from 1.95 V to -9.8 V. Furthermore, the effect of pentacene thickness on the shift of V_{th} was investigated. The range of V_{th} shift in the dual-gate OTFT with a thin 10 nm pentacene layer was much wider than that with a thick 500 nm pentacene layer.

Organic inverter is a basic building block used in organic integrated circuits. V_{th} is an important parameter that needs to be controlled to ensure both low power consumption and proper operation of organic circuits. The voltage transfer characteristic of inverter such as swing range and inversion voltage from low output voltage to high output voltage depend on V_{th} and on-current of transistor. V_{th} can be easily controlled by changing the doping level of semiconductor in Si transistor. However, the control of V_{th} by doping is not available for OTFT yet. Two novel types of the zero drive load logic inverter with dual-gate structure have been proposed and fabricated using PEALD gate dielectric. Based on the transfer characteristics of the dual-gate OTFT, the voltage transfer characteristics of newly suggested inverters could be systematically controlled. Because the variation of V_{th} due to chemical degradation and the spatial variation of V_{th} are inherent in OTFTs, the compensation technology by dual-gate structure can be essential to OTFT applications.

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