Flexible Metal-Oxide Thin-Film Transistors with Organic Gate Insulators

Hsing-Hung Hsieh[1], Shiuan-Iou Lin[1], William C. Sheets[2], Su Jin Kang[2], Wan-Yu Hung[1], Scott Bull[2], Antonio Facchetti[2] and Chung-Chin Hsiao[1]

[1]Polyera Taiwan Corporation, 4F-11, No. 38, Taiyuan St., Zhubei, Hsinchu 30265, Taiwan

Tel.:886-3-560-0690, E-mail: hh.hsieh@polyera.com

[2]Polyera Corporation, Suite 140, 8045 Lamon Avenue, Skokie, Illinois 60077, USA

Flexible and wearable displays are very attracting opto-electronic devices, which might affect our daily life considerably [1-3]. Yet thin-film transistors (TFTs) with high good electrical characteristics and mechanical flexibility are essential to develop this new technology. Traditional silicon-based TFTs are mature backplane technologies, but the mechanical flexibility is questionable. Organic semiconductor-based TFTs are known to exhibit good flexible properties [4-5], but their electrical performance such as field-effect mobility is somehow limited. An alternative path to achieve high-performance optoelectronics is to use TFTs based on amorphous oxide semiconductors coupled to organic gate insulators. This combination should ensure both high TFT performance and flexibility because of the amorphous nature of the key TFT materials components. However, existing oxide TFTs with organic gate insulators suffer from several drawbacks such as low mobility, large subthreshold swing, large I-V hysteresis, high off-current, low on/off current ratio, and poor bias stress stability [6].

In this work, we demonstrate a new photo-patternable and thermally stable organic gate insulator platform for high performance IGZO TFTs. The new organic gate insulator exhibits several key technological advantages such as low leakage current (~10 nA/cm^2 at 2 MV/cm), high breakdown voltages, good mechanical flexibility (functions at radius less than 1 cm), photo-patternability (5~10 µm), and substantial temperature stability (up to temperature of 300 ^{o}C), considerable adhesion, and high transparency (>97% in visible). In addition, we have also explored various TFT device architectures to optimize the device architecture specifically for IGZO transistors with an organic gate insulator. Our devices were first optimized on glass substrates, then the process flow was transferred to plastic substrates, with both platforms exhibiting good and similar performance (e.g., high mobility of ~15 cm^2/Vs). Finally, we compared the performance of the Polyera OGI-based IGZO TFTs to those TFTs based on conventional organic dielectrics, demonstrating the great potential of our materials both in term of device performance and manufacturability.

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