Constructive use of metal-semiconductor contact effects in thin-film transistors

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Summary: Conventionally, scientists try to eliminate contact effects in thin-film transistors (TFTs), to improve on-current and turn-on characteristics. Our work focuses on constructive use of contact effects, namely on purposely building in an energy barrier between the metal and the semiconductor, resulting in devices called source-gated transistors (SGTs). While their architecture differs only slightly from conventional TFTs, SGTs can have significantly higher intrinsic gain, increased energy efficiency and tolerance to variations in a range of parameters.

Keywords: Thin-film transistor, energy barrier, gain, energy efficiency, large-area electronics.

This talk outlines the operation and behaviour of source-gated thin-film transistors. These devices can be made in any material system if a reliable energy barrier can be built at the source. Figure 1 presents a typical device cross-section.

Figure 2 shows a typical set of output characteristics, illustrating the most notable tell-tale signs of SGT behaviour: low saturation voltage and flat output characteristics over a large range of drain voltage. The distinctly early saturation of SGT drain current is due to device electrostatics, specifically to the channel pinch-off at the source at very low drain voltage [1-3]. As the current is controlled by the source region and not the channel, saturated current has a low dependence on drain voltage, leading to high intrinsic gain, which can be further improved by device optimization [3, 4].

Extending the gate to overlap the source in a staggered electrode configuration (Figure 1) makes possible the selection of the dominant current injection mechanism: (I) over the barrier at the source edge, modulated by the gate-field induced barrier lowering, and (II) ohmic injection in the bulk of the source resulting from the potential difference between the accumulation layer and the contact [5].

Several beneficial consequences arise from the current control mechanism:

- High intrinsic gain [3];
- Low saturation voltage; potentially 10% that of TFT with the same geometry [4];
- As a consequence of the above, lower series voltage drop when biased for the same drain current, when compared to a TFT of identical geometry;
- Tolerance to geometrical variation (source-drain gap, source-gate overlap, semiconductor thickness) [6];
- Increased bias stress stability (e.g. in amorphous silicon [7]);
- Potentially high sensitivity to temperature, if desired by the application [8].

SGTs can be made in a multitude of material systems [2, 3, 9], and, while frequently a Schottky contact is used, the barrier can be realised in various ways, e.g. [10], with behaviour specific to contact physics.

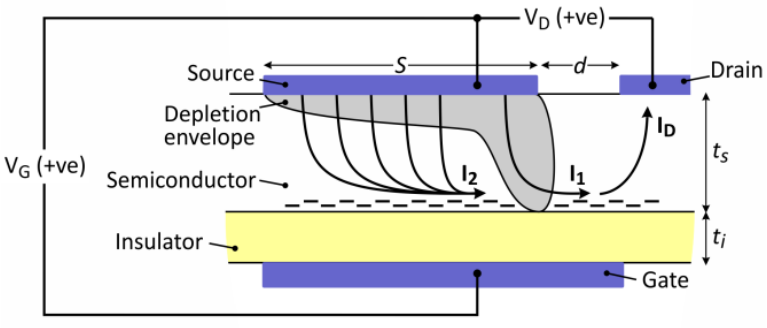

Fig. 1: SGT schematic cross-section, after [5].

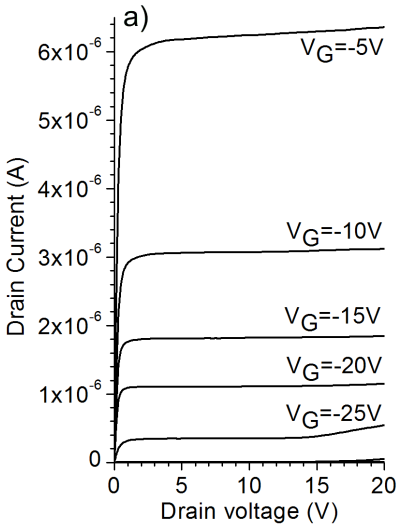

Fig. 2: Typical polysilicon SGT output characteristics, after [3].

In summary, source-gated thin-film transistor offer versatility of design in many material systems, with superior performance uniformity, gain, and energy efficiency, with a trade-off in on-current. Analog as well as digital [11] applications can benefit from these traits.

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