Low-frequency Noise in Polysilicon Source-Gated Thin-Film Transistor

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In thin-film field-effect transistors (TFET) that aim at high-voltage operation for e.g. large-area display or analog applications, by overlapping the gate with a Schottky source contact, a new type of device named Source-Gated Transistor (SGT) [1] provides many advantages, such as reduced short-channel effects and high intrinsic gain [2]. Low-frequency noise (LFN) like $1/f$ noise is critical for analog circuits, has barely been studied in SGTs. Hence, in this work, $1/f$ noise of silicon-on-insulator (SOI)-based polysilicon TFETs and SGTs is investigated.

The schematic cross-section of the device is shown in Fig. 1(a) [3]. The device width, channel length (d) and source length (s) are 50, 4 and 4 µm, respectively. The polysilicon layer is 40 nm thick and n-doped. The device transfer and output curves are illustrated in Fig. 1(b) and (c) for 2 different n-type bulk doping doses. The current clearly saturates at very low drain voltage (below 1 V) and that the output impedances are considerably high, due to the pinch-off region under source that induced by the reverse biased Schottky barrier.

Fig. 2 shows drain current noise spectral densities (S_{id}) of SGT devices measured in linear operation (V_{DS} = 0.5 V). The S_{id} follows the behavior of typical $1/f^{\gamma}$ where γ is close to 1. To study the current level dependence (fig. 2b-c), the carrier number fluctuation (CNF) model ($S_{id}/(I_d^2) = (g_m/I_d)^2 \bullet S_{vfb}$) is considered [4], where g_m is the device transconductance and S_{vfb} is the flat-band voltage noise spectral density. In Fig. 3, the normalized noise spectral densities (S_{id}/I_d^2) at 10 Hz vary proportionally to $(g_m/I_d)^2$ under high I_d in both linear (V_{DS} = 0.5 V) and saturation regimes (V_{DS} = 5 V), which implies that the $1/f$ noise is mainly correlated to the CNF, while the noise under low I_d relates to the fluctuation in Schottky barrier height [5]. By swapping the source with another drain, we obtain the characteristics of a standard polysilicon TFET for comparison. In Fig. 4, the S_{id}/I_d^2 at 10 Hz of counterpart TFET device deviates from $(g_m/I_d)^2$ and varies approximately as I_d^{-1}, which suggests the carrier mobility fluctuation (CMF) dominates low-frequency noise in this case [4], while CNF is not completely ruled out.

In conclusion, the low-frequency noise of SOI-based polysilicon SGTs appears dominated by CNF in high I_d region and by Schottky barrier height fluctuation in low I_d region, while the low-frequency noise of polysilicon TFET appears mainly correlated with the CMF. Further studies are required to comprehensively investigate the LFN dependence in SGT with source length and Schottky barrier height, which are crucial parameters for SGT behaviors and optimization.

References

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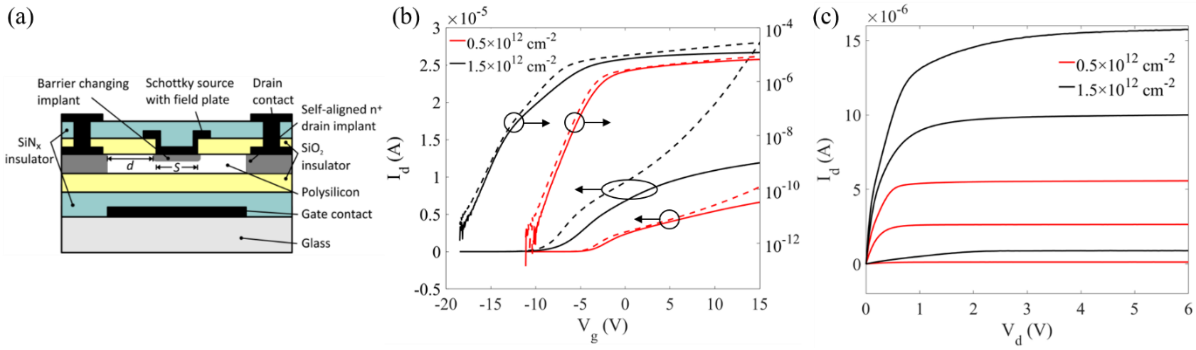

Fig.1 (a) Schematic cross-section of the SOI polysilicon SGT [4]. (b) Transfer curves for 2 different doping doses at V_{DS} = 0.5 V (solid lines) and 5 V (dashed lines). (c) Output characteristics under different gate voltages for 0.5×10[12] and 0.5×10[12] cm[-2] doping doses.

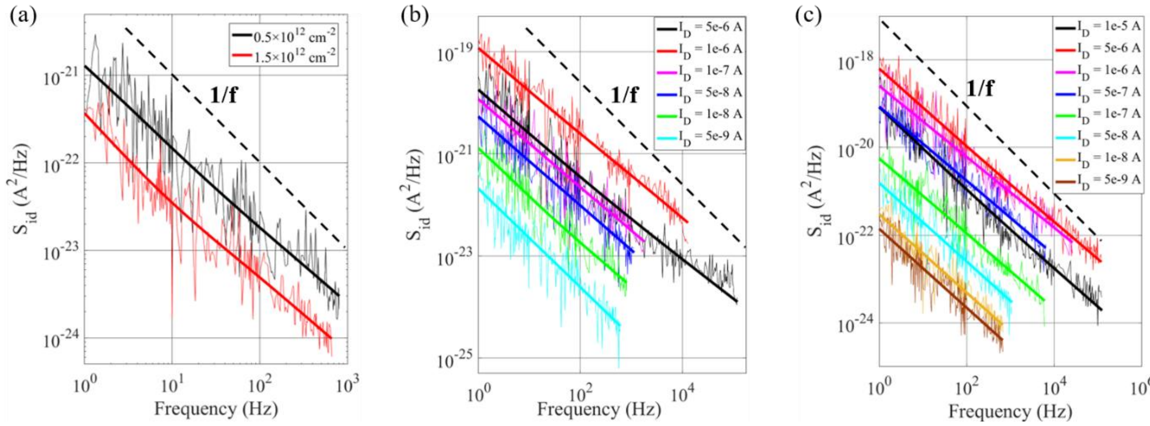

Fig.2 Current noise spectral densities (S_{id}) for the devices with (a) both doping doses at fixed drain current I_D = 10 nA, (b, c) different fixed I_D at doping doses = 0.5×10[12] (b) and 1.5×10[12] cm[-2] (c) respectively. V_{DS} = 0.5 V.

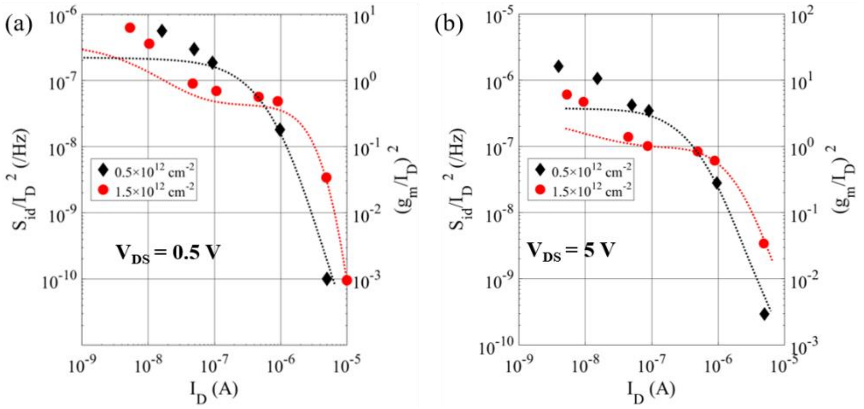

Fig.3 Normalized S_{id} / I_D^2 at 10 Hz (dots) and $(g_m/I_D)^2$ (dashed lines) as functions of I_D for SGT for the 2 different doping doses at V_{DS} = 0.5 (a) and 5 V (b).

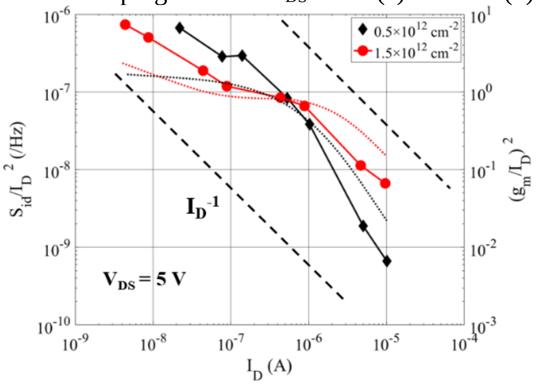

Fig.4 Normalized S_{id} / I_D^2 at 10 Hz (dots) and $(g_m/I_D)^2$ (dashed lines) as functions of I_D for counterpart TFET with Ohmic contacts for the 2 different doping doses at V_{DS} = 5 V.