

Magnetic sensing with GaN high-electron-mobility transistors

Split drain devices on silicon achieve greater sensitivity than pure silicon equivalents.

Researchers at Swansea University in the UK and the University of Nis in Serbia claim the first fabrication of gallium nitride (GaN) magnetic high-electron-mobility transistors (MagHEMTs) [S Faramehr et al, *Semicond. Sci. Technol.*, vol33, p095015, 2018].

The devices featured a split drain (Figure 1) that allowed the deviation of electron paths due to interaction with magnetic fields to be assessed. The relative sensitivity of such devices is given by the current difference between the drain terminals relative to the total drain current over the magnetic field in Teslas (T).

Magnetic sensors are widely used for control in engineering systems covering aeronautical, automotive and industrial applications.

The devices were fabricated on HEMT heteroepitaxial structures with $\text{Al}_{0.25}\text{Ga}_{0.75}\text{N}$ barrier layer. Step-graded AlGaIn was used to transition from the silicon substrate.

The length (L) and width (W) of the device were $35\mu\text{m}$ and $20\mu\text{m}$, respectively. The lengths of the source (L_S), and drain (L_D) were both $5.5\mu\text{m}$. The gate length (L_G) was $1.0\mu\text{m}$. The gate-source distance (L_{GS}) was $1\mu\text{m}$. The widths of the two drain contacts (W_D) were $7.5\mu\text{m}$ each. The device was passivated with 10nm silicon nitride.

With the gate at zero and the drain bias at 0.5V, the sensitivity was found to be $11.98\%/T$ — higher than previously reported values for silicon dual-drain split-current magnetic sensors.

The researchers used the experimental results to calibrate a series of simulations aimed at optimizing performance. The model suggested that improved sensitivity of $23.29\%/T$, at zero gate potential and 0.5V drain bias, could be achieved in a device with altered parameters - $L=65\mu\text{m}$, $W=20\mu\text{m}$, $L_S=5.5\mu\text{m}$, $W_S=5.0\mu\text{m}$, $W_{DD}=5\mu\text{m}$, $L_G=5.0\mu\text{m}$ and $L_{GD}=10\mu\text{m}$

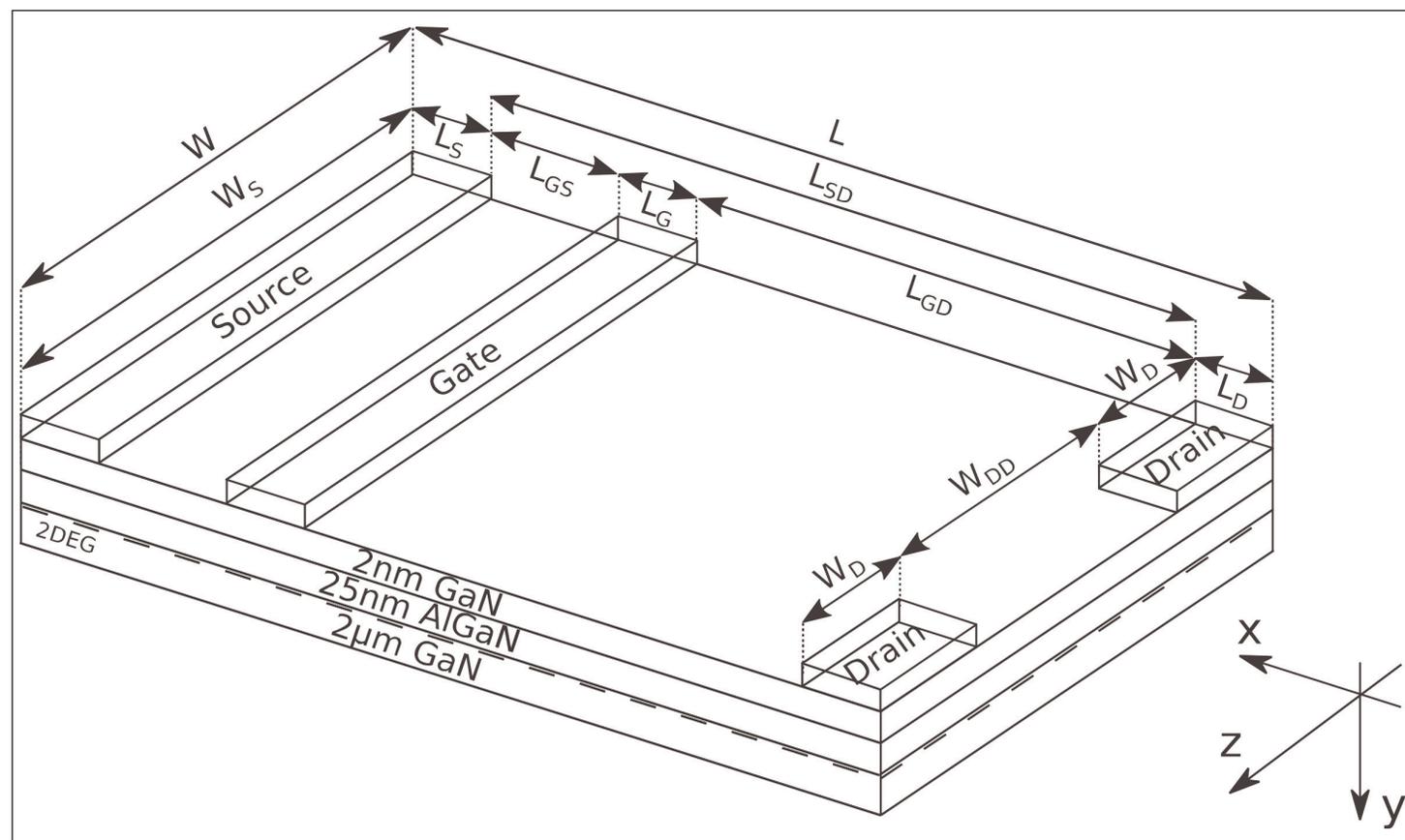


Figure 1. GaN MagHEMT (split-current sensor) schematic showing geometrical parameters used for relative sensitivity optimization.

(Figure 2).

The important changes seem to be a much longer total length of 65 μm and reduced source width of 5 μm . The reduced source contact decreases the total current flow and increases sensitivity to current deflection effects. The longer length also increases source to drain resistance, again reducing total current. The simulations also suggest an order-of-magnitude enhanced sensitivity at around -4V gate potential.

The researchers further studied the simulations at a raised temperature of up to 500K, showing "promising operation of GaN magnetic sensors under harsh environments". However, there was a decrease in

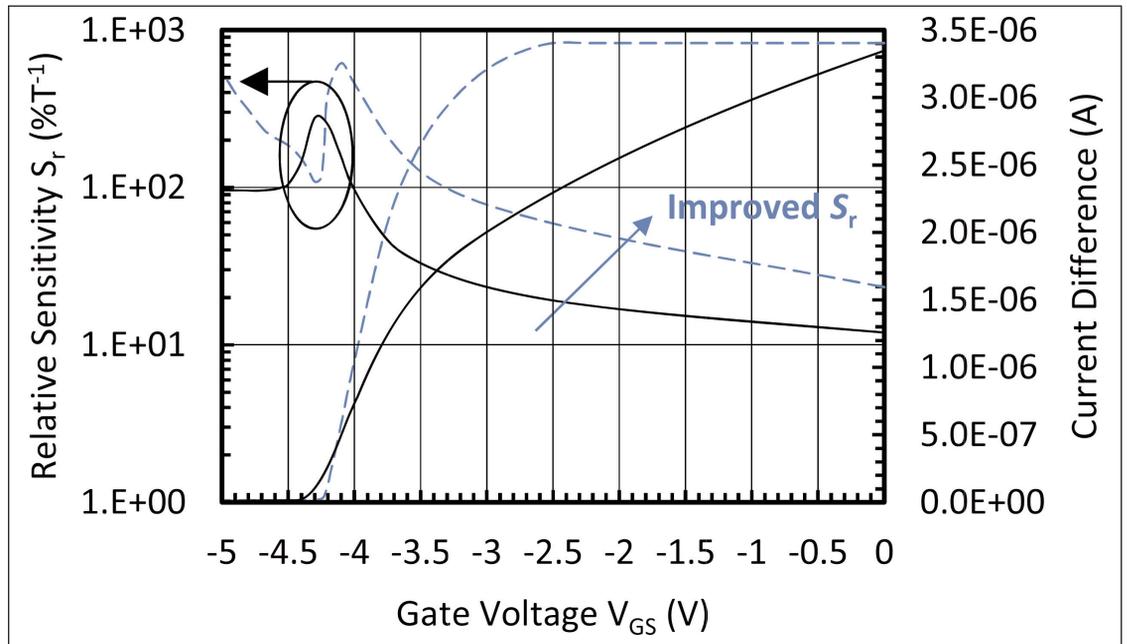


Figure 2. Simulated relative sensitivity (dash) and current difference (dash) of optimized GaN MagHEMT against simulated original GaN MagHEMT.

sensitivity to 4.91%/T for the original device structure. ■
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