

NANOWIRE WEEK 2022
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Low-frequency Noise in Room-temperature quasi-ballistic Ge NW Transistors

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Nanoscale Ge devices are attractive for both fundamental studies of low-dimensional nanostructures as well as for future high-performance nanoelectronic and quantum devices. Along with confinement effects, the inherently high surface-to-volume ratio of nanostructures causes their properties to strongly depend on the surface. Due to the presence of sub-stoichiometric GeO_x between the Ge channel and the high-k passivation layer, trapping phenomena are highly affecting the device characteristic, leading to hysteresis and gate-voltage shifting of the transfer characteristic.

In this work, crystalline and monolithic Al-Ge-Al heterostructure nanowires (NW) [1] with different Ge channel lengths L - ranging from 826 nm to 18 nm (Fig. 1a) - are analyzed from a low-frequency noise perspective to further investigate these trapping mechanisms in Al-Ge-Al NW FETs [2] biased in accumulation. $1/f$ noise is dominant in long channel and random telegraph noise (RTN) in short channel devices. $1/f$ noise, measured at selected values of drain bias V_D for individual Ge segment lengths and varied back-gate voltage V_{BG} , has been analyzed within both the mobility and carrier number fluctuation models (MFM and CNFM). The normalized power spectral density of drain current fluctuations ($S(I)/I_D^2$) at low resistance values follows a $\sim 1/I_D$ dependence (Fig. 1b). Taking into account MFM, the NW channel lengths and hole mobility of $300 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$, the Hooge noise parameter α spreads in the interval 2×10^{-4} to 1×10^{-2} , with lower values for shortest devices which can be due to a reduction of scattering mechanisms in the ballistic regime [3]. Using the same data and CNFM, the density of interface states N_{ss} was estimated using the transconductance extracted from the quasi-static transfer IV characteristics (i.e. with negligible drift). The extracted N_{ss} values range from $3 \times 10^{11} \text{ cm}^{-2}\text{eV}^{-1}$ to $4 \times 10^{11} \text{ cm}^{-2}\text{eV}^{-1}$. In some devices a saturation of $S(I)/I_D^2$ is observed at high currents, which is attributed to dominant contact noise. RTN has been observed in devices with $L = 34 \text{ nm}$ and 18 nm , attributed to a low number of active traps in the channel (Fig. 1c). The relative RTN amplitude $\Delta I_D/I_D$ at various V_{BG} is in the 1-5% range. Evaluating the capture and emission times showed that the capture time decreases at higher I_D , i.e. higher $|V_{BG}|$.

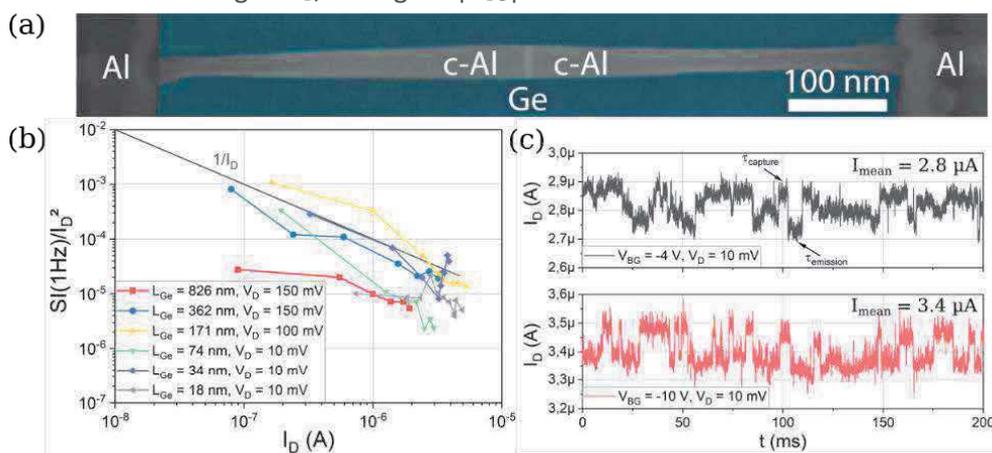


Figure 1 (a) SEM image of a back-gated Al-Ge-Al NW FET with a channel length of 18 nm. (b) $S(I)/I_D^2$ data for six different channel lengths. (c) RTN of a device with a channel length of 34 nm.

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