NANOWIRE WEEK 2022

25-29 April, 2022 Chamonix, FRANCE

Book of Abstract
Oral Sessions

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 (SI/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 $cm^{-2}V^{-1}s^{-1}$, the Hooge noise parameter α spreads in the interval $2x10^{-4}$ to $1x10^{-2}$, 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 $3x10^{11}$ $cm^{-2}eV^{-1}$ to $4x10^{11}$ $cm^{-2}eV^{-1}$. In some devices a saturation of SI/I_D^2 is observed at high currents, which is attributed to dominant contact noise. RTN has been observed in devices with L = 34 nm and 18 nm, attributed to a low number of active traps in the channel (Fig. 1c). The relative RTN amplitude dI_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 $|V_{BG}|$.

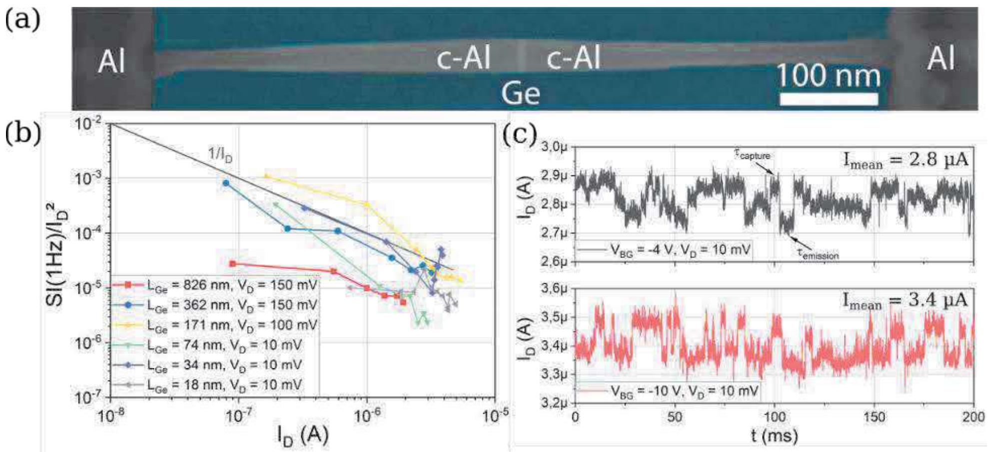

Figure 1 (a) SEM image of a back-gated Al-Ge-Al NW FET with a channel length of 18 nm. (b) SI/I_D^2 data for six different channel lengths. (c) RTN of a device with a channel length of 34 nm.

[1] M. Sistani, P. Staudinger, J. Greil, M. Holzbauer, H. Detz, E. Bertagnolli, and A. Lugstein, Nano Letters **17** (2017).

[2] S. Zhang, E. R. Hemesath, D. E. Perea, E. Wijaya, J. L. Lensch-Falk, and L. J. Lauhon, Nano Letters **9** (2009).

[3] W. Wu, H. Wu, W. Sun, M. Si, N. Conrad, Y. Zhao, and P. D. Ye, IEEE Transactions in Electron Devices, **65** (2018).