Non-volatilely Reconfigurable Frequency Modulation with a III-V Ferroelectric Transistor

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Modulating analog signals with reconfigurable functionality can significantly reduce area and complexity of the circuit architecture for highly scaled low-power operations [1-3]. Here, we experimentally demonstrate a single vertical nanowire ferroelectric tunnel field-effect transistor (ferro-TFET) that can modulate the frequency of an input signal with non-volatile reconfigurability, which enables high-density, energy-efficient, and multifunctional analog circuits.

The nanowire consisting of n-InAs drain, non-intentionally-doped (nid) InAs channel, and p-(In)GaAsSb/GaSb source was firstly grown by MOCVD on a highly-doped InAs buffer layer on Si. Next, the gate-stack was formed by 13-nm HZO and 60-nm W which was intentionally aligned above the tunneling interface for gate/source overlap (Fig. 1a). The sample was then annealed to crystallize HZO film and finalized by depositing Al_2O_3 as top spacer and Ni/Au as contacts (Fig. 1b). The detailed processing flow is here [4].

Fig. 1c illustrates the ferroelectric polarization in the ferro-TFET depending on VPro, resulting in reconfigurable threshold-voltage shift (Fig. 1d). Due to the gate/source overlap in the device, anti-ambipolar transfer characteristics are achieved at various VDS in both states (Fig. 1d). Fig. 2a presents the working principle of the reconfigurable frequency doubling which was experimentally demonstrated in Fig. 2c based on the circuit in Fig. 2b. The corresponding power spectra indicate robust frequency modulation in both modes with substantial suppression of harmonics.

The presented ferro-TFET shows merits of non-volatile reconfigurability, reduced footprint, and low supply voltage for signal modulation and provides the possibility for integration of steep-slope TFETs and reconfigurable ferro-TFETs towards energy-efficient digital/analog-mixed circuits.