NDR-mode RFET: A Reconfigurable Transistor Functionally Diversified by Negative Differential Resistance

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Advancing transistors beyond static operations is a promising strategy for emerging computing paradigms such as artificial intelligence and neuromorphic electronic applications. This can be achieved by reconfigurable field-effect transistors (RFETs) capable of dynamic run-time switching between n- and p-type operation. In this regard, Ge nanosheets (NSs) and nanowires (NWs), exhibiting half the band gap and significantly smaller effective masses compared to Si, have been identified as an emerging transistor material. Nevertheless, Ge RFET prototypes have so far fallen short in reaching the promised performance due to metal-semiconductor and oxide-semiconductor interface instabilities, as well as in reaching the current-voltage (I/V) symmetry necessary for circuit applicability.

This work addresses these complex issues by the systematic development and combination of measures, including the choice of transistor channel material as well as dedicated junction and oxide interface engineering solutions. The thereof proposed Ge RFETs exhibit an inherently high I/V symmetry between n- and p-type operation suited for chip-scale integration. Importantly, an entirely new Ge RFET with programmable negative differential resistance (NDR), an important feature relevant for analog and multi-bit logic applications that had so far required complex and mostly non-CMOS compatible technologies, was realized. Based on this technology platform, basic circuits, where a single multi-gate NDR-mode RFET replaces a cascode of NDR devices, are experimentally demonstrated. Most notably, the realized devices and circuits complement conventional CMOS technology and contribute to an increased functional density.