(Invited) High Mobility GeSn Nanowire CMOS

Yannik Junk, Omar Concepción Díaz, Marvin Frauenrath, JIngxuan Sun, Jin Hee Bae, Florian Bärwolf, Andreas Mai, Jean-Michel Hartmann, Detlev Grützmacher, Dan Buca and Qing-Tai Zhao

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Abstract

As transistor scaling advances, the necessity to replace silicon with materials possessing superior carrier mobilities intensifies. Group-IV semiconductors, with a particular emphasis on GeSn alloys, are distinguished by their exceptional electron and hole mobilities, rendering them prime candidates for advanced electronic applications. The vertical gate-all-around (GAA) nanowire transistor emerges as the pivotal device architecture, offering enhanced electrostatic control and a minimized physical footprint. This paper provides a comprehensive overview of vertical GAA GeSn nanowire CMOS devices. We construct vertical GAA nanowire transistors with epitaxial GeSn heterostructures, capitalizing on advancements in material growth, precise in-situ doping, and strategic band engineering across the source, channel, and drain regions. By harnessing GeSn's superior mobilities for both electrons and holes, we have developed and fabricated both p-FETs and n-FETs. The p-FET benefits from the high hole mobility of the Ge channel and the elevated injection velocity from the GeSn source, yielding significantly enhanced performance compared to devices solely made of Ge. For n-FETs, our findings reveal that incrementally increasing the Sn content in GeSn alloys leads to continuous performance enhancements, with an 11% Sn composition achieving a fivefold increase in on-current compared to traditional Ge-based devices. These outcomes underscore the immense potential of GeSn alloys in elevating the performance and energy efficiency of next-generation nanoelectronic devices.