VLSI Compatible Si/SiGe/Si p-MOSFET's

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ABSTRACT

Silicon-Germanium (SiGe) has emerged as a promising vehicle for expanding the performance bounds of silicon-based VLSI technology. Attempts are now underway worldwide to demonstrate that SiGe field effect transistors can reach industrial maturity. In particular, SiGe p-MOSFET's require the most urgent attention because of the poor performance of silicon p-channel devices. A novel Si/SiGe/Si p-MOSFET structure is proposed here, whereby the effective hole mobility is maximized by employing a buried SiGe channel with triangular Ge profiles. The benefits of the triangular Ge channel, in comparison with the established rectangular Ge channel profile, were demonstrated both theoretically and experimentally. The SiGe p-MOSFET's were implemented in-house, in a VLSI compatible process that allowed for the integration of silicon and SiGe p-MOSFET's on the same chip. Hole mobilities of 400 cm^2/Vs and 250 cm^2/Vs were measured for devices with 0-50% Ge triangular and 25% Ge rectangular channels, respectively. A factor of two improvement in transconductance with respect to the equivalent, on-chip silicon p-MOSFET was obtained. When compared to rectangular Ge profile devices, the MOSFET's with triangular Ge channel profiles demonstrated 30-40% improvement in mobility, transconductance and cutoff frequency. New methods to characterize the band offset and doping concentration in Si/SiGe layers, as well as the mobility profiles inside the channel, were also developed and validated experimentally.