Modulation Doped Si/$Si_{1-x}Ge_x$-Field Effect Transistors

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Modulation doped Si/$Si_{1-x}Ge_x$ samples show high electron mobilities because of the motion of the carriers along a crystalline heterointerface and the absence of ionized impurities in the conduction channel. We have developed a process sequence to implement n- and p-type MODFETs with 100 nm T-gates in the institute's cleanroom.

The modulation-doped layer sequences are grown by MBE and subsequently processed in a Schottky gate, mesa-isolation process with six lithographic steps. The ohmic contacts are ion implanted and activated by low-temperature rapid thermal annealing. Reactive ion etching is employed for mesa separation of the devices. The submicron gates are defined by e-beam lithography and lift-off. To minimize the series resistance along the gate finger, which can severely limit the achievable switching speed due to the parasitic R-C time constant, a new process was developed that results in a T-shaped cross section of the gates. For this purpose e-beam exposure of a three-layer resist is employed. With an appropriate stack of PMMA and co-polymer resists of different sensitivity the T-shape of the gates is defined in a self-aligned fashion, i.e. only one exposure run is required. Devices with 100 nm gate length show excellent I-V characteristics with complete pinch-off.