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High Quality Two-Dimensional Electron Gases (2DEGs) in Isotopically-Enriched Strained Silicon

JIUN-YUN LI, CHIAO-TI HUANG, Department of Electrical Engineering and Princeton Institute for the Science and Technology of Materials (PRISM), Princeton University, LEONID ROKHINSON, Department of Physics, Purdue University, JAMES OHLHAUSEN, MALCOLM CARROLL, Sandia National Laboratories, JAMES STURM, Department of Electrical Engineering and Princeton Institute for the Science and Technology of Materials (PRISM), Princeton University — Silicon quantum dots (QDs) formed in a Si/SiGe two-dimensional electron gas (2DEG) are a promising candidate for quantum computation. To capture a single electron in a QD, the dot must be very small, which requires a short distance from the surface to Si 2DEG layer for fine gating. Here we demonstrate a high quality modulation-doped Si 2DEG grown by chemical vapor deposition (CVD), with a distance of 65 nm from the surface to 2DEG layer. The electron mobility at 0.3K of 504,000 cm^2/V-s (density 4.3 x 10^{11} cm^{-2}) is the highest yet reported by CVD for ungated Si 2DEGs. Further, a Si 2DEG layer consists of isotopically-enriched ^{28}Si to minimize spin decoherence due to ^{29}Si. SIMS results show that in the Si 2DEG layer, ^{28}Si is enriched from natural abundance of 92.2% to 99.8% with ^{29}Si reduced from 4.7% to an upper limit of $\sim$ 0.24% and ^{30}Si reduced from 3.1% to $\sim$ 63ppm. Finally, effective Schottky gating requires a sharp turn-off slope in phosphorus from the doped layer to the surface for low electric fields near the surface. We have achieved ultrasharp turn-off slope of $\sim$16 nm/dec, and demonstrate Schottky gating to fully deplete the 2DEG with extremely low leakage current.

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