Supporting Online Material for

Encoding Electronic Properties by Synthesis of Axial Modulation-Doped Silicon Nanowires

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Supporting Online Material

Materials and Methods

Modulation-doped silicon nanowires were prepared using 20 nm gold nanoclusters as catalysts *(1)*, silane as the silicon reactant, phosphine as the n-type dopant *(2)*, and H_2 as the carrier gas. The flow rate of silane was varied between 0.6 to 0.8 standard cubic centimeters per minute (sccm), while the H_2 flow rate was fixed at 100 sccm. Dopant modulation was accomplished by switching the flow rate of phosphine (0.1% in H_2) between 0.31 and 5 sccm for n and n^+ regions in Figs. 1, 2 and 3, although in Fig. 2C the flow was switched between 1 and 5 sccm. For QD structures, the phosphine flow rate of was switched between 0 and 10 sccm. The temperature of the growth substrate was controlled using a local heater (Heat Wave Labs, Inc), with nucleation and subsequence elongation temperatures of 480 and 460 °C, respectively.

Following growth, nanowires were sonicated in ethanol to produce stable dispersions, and deposited on substrates for analysis. Copper grids were used for TEM studies with a JEOL 2010F microscope. Degenerately doped silicon substrates (600 or 50 nm thick oxide) were used for SGM and device measurements. Electrode contacts were defined using e-beam lithography followed by thermal evaporation of Ni and annealing at 350 °C for 1-2 min.

SGM measurements were carried out with a Nanoscope IIIa and SGM tips (Nanosensor^{TM}) with 25 nm thick Cr and Pt-Ir coating; the radii of curvature were 10-30 nm. SGM data were acquired in lift mode (lift height = 20 nm; scan rate = 0.5-1 Hz), while simultaneously measuring the drain current for V_{sd} = 1V. The spatial resolution of the SGM measurements, which was determined by the tip-sample distance and the tip

radius, was estimated *(3)* by simulating the case of a spherical tip over silicon oxide (Quickfield 5.2, Tera Analysis, Ltd).

Repeat spacing vs. growth time plot were determined from analysis of SGM data by measuring the peak to peak separation in conductance plotted along the nanowire axis. The lengths of single regions were estimated from the full-width at half-maximum of the conductance profile. For data recorded from growth experiments at 320 torr, each repeat spacing point was averaged from the SGM measurements on four nanowires. Data were obtained in a similar manner for experiments at 160 and 80 torr. The variations in growth rate were determined by calculating the slopes of the repeat spacing vs. growth time curves at 320, 160, and 80 torr.

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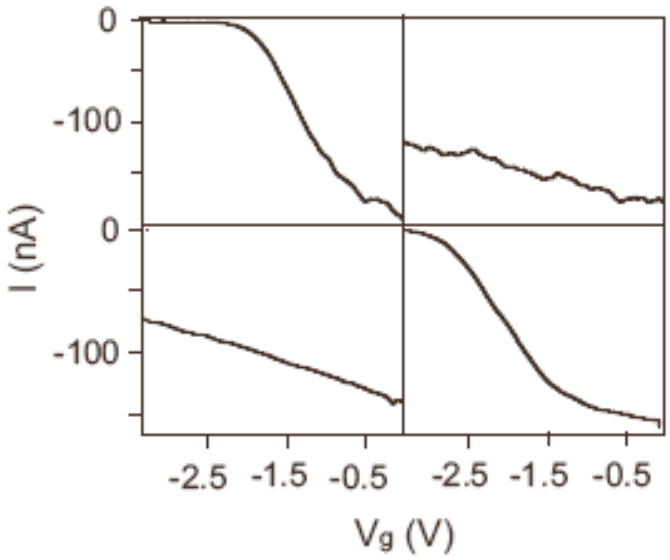

Figure S1. Current vs. V_g for each cross point in the 2 x 2 modulation-doped nanowire decoder shown in Fig. 3B. Clockwise from the top left quadrant, the data are obtained from junctions In1/Out1, In2/Out1, In2/Out2, and In1/Out2, respectively; V_{sd} = -1V.