Supporting Information

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SI Text

Materials and Methods. ***Nanowire synthesis.*** Single crystal p-doped silicon nanowires were synthesized by the nanocluster-catalyzed vapor-liquid-solid process as described previously (1). Briefly, 30 nm diameter gold nanoparticles (Ted Pella) were dispersed on SiO_2/Si growth substrates, and growth was carried out using silane (4 sccm), diborane (4 sccm, 100 ppm in H_2) and hydrogen carrier (60 sccm) at a total pressure of 40 torr and temperature of 440–450 °C for 30 min.

Fabrication of NWFETs on quartz. 1 × 3 in quartz slides (Finkenbeiner, Inc.) were cleaned in Piranha solution (30% H_2O_2:98% H_2SO_4 = 1:3) at 90 °C for 15 min, washed thoroughly with de-ionized water and blown dry in N_2. Outer electrodes were then defined by photolithography and deposition of Cr/Au, 10/70 nm. Aligned silicon nanowires were transferred to specific locations by contact printing (2), and photolithography was used to define connections between the nanowires and outer electrodes, which were metallized with titanium/palladium/titanium (1.5/60/5 nm). 60 nm Si_3N_4 layer was deposited by plasma-enhanced chemical-vapor deposition before lift-off to passivate the inner electrodes. Last, 2 μm thick SU-8 polymer (Microchem) was defined by photolithography to cover electrodes except for a 5-10 μm diameter window around NW devices. In some experiments, inner electrodes were defined by electron-beam lithography instead. The preparation of devices follows standard protocols for bottom-up nanodevice fabrication and should be accessible to laboratories working in this area. In addition, the Lieber group is open to mutually agreeable collaborations and can provide specific help in NWFET chip fabrication.

Preparation of olfactory bulb slice. Modified parasigittal slices (300–500 μm) containing both the olfactory bulb and piriform cortex were prepared from rats (postnatal day 17–20) using standard procedures[34]. Slices were prepared in ice-cold artificial CSF (aCSF) containing (in mM) 83 NaCl, 2.5 KCl, 3.3 $MgSO_4$, 1 NaH_2PO_4, 26.2 $NaHCO_3$, 22 glucose, 72 sucrose, and 0.5 $CaCl_2$, and equilibrated with 95% O_2/5% CO_2. Slices were allowed to recover for 20 min at 37 °C and at room temperature (21–23 °C) thereafter. All physiological recordings were performed within 10 h of slice preparation. All animal procedures conformed to US National Institutes of Health guidelines and were approved by Harvard University's Animal Care and Use Committee.

Stimulation. 50 μm/200 μm (inner/outer) diameter bipolar concentric Pt/Ir electrodes (FHC Inc.) were used to stimulate the LOT region of the slice with bipolar 200 μs amplitudes from 50 μA to 2.5 mA current pulses (Model 2100, A-M Systems, Inc.). The minimum stimulation intensity was determined by gradually reducing the pulse height until one of the devices under test start to show no p-spike in some of the stimulations but still displayed signal response in >60% of the trials.

Patch clamp measurements. Patch pipettes were pulled from 1.5 mm diameter borosilicate glass tubes (P-97 Flaming/Brown Micropipette Puller, Sutter Instruments). Pipettes were filled with intracellular medium containing (in mM) 130 potassium gluconic acid, 10 NaCl, 10 HEPES, 3 magnesium-ATP, 1 EGTA, 1 sodium-GTP, 0.133 $CaCl_2$, pH 7.4, and the resistance was measured with 5 mV pulses to be approximately 7 MΩ. Neurons were patched in cell-attached mode with the pipette held at -70 mV for voltage clamp measurements (Axopatch 200B, Molecular Device Systems (MDS)). Data were recorded at a sampling rate of 20 kHz using Digi1440A and Clampex 10 software (MDS). All recordings were done at room temperature (21–23 °C) in oxygenated aCSF medium (see *NWFET electrical measurements*).

NWFET electrical measurements. NW device recording was carried out with a 150 mV DC source voltage, and the current was amplified with a home-built multi-channel current/voltage preamplifier with a typical gain of 10^7 A/V. The signals were filtered through a Cyberamp 380 signal conditioner with band-pass of 1Hz-3 kHz and 60 Hz notch, digitized at a sampling rate of 20 kHz (Axon Digi1440A) and recorded using Clampex 10 software (MDS). Ag/AgCl reference electrodes were used to connect the medium to ground during experiments. The brain slice is perfused with oxygenated (95% O_2/5% CO_2) aCSF medium containing (in mM) 119 NaCl, 2.5 KCl, 2.5 $CaCl_2$, 1.3 $MgSO_4$, 1 NaH_2PO_4, 26.2 $NaHCO_3$, 22 glucose. All recordings were done at room temperature (21–23 °C).

Signal analysis in 2D mapping. After all tests, the voltage applied to the Ag/AgCl reference electrode in solution was swept from $-0.1\ V$ to $+0.1\ V$ and the conductance change for each device was recorded and divided by the gate voltage change (0.2 V) to yield the sensitivity. The recorded conductance data were converted into corresponding potential change using the sensitivity for each device. The peak area representing the p-spike (e.g., *Shaded Area*, Fig. 5*B*) was integrated and adjusted by the sensitivity to represent the intensity of neural activities. When stimulation was strong, the recorded signal intensity of each device was used as the reference for 100% value. When stimulating with minimum current pulses at different spots along the LOT, the signal intensity for each device was divided by the corresponding 100% value to yield a map of relative signal intensities. The standard deviation of the correlation is determined by a self-correlation analysis: first, the recordings of each device were split into two groups, for example, odd traces and even traces, and then signals (treated as previously) were correlated for each device between these two groups. The distribution of all deviations from the $y = x$ line was used to define the standard deviation and uncertainty.

1. Wu Y, et. al. (2004) Controlled growth and structures of molecular-scale silicon nanowires. *Nano Lett* 4:433–436.

2. Javey A, Nam S, Friedman RS, Yan H, and Lieber CM (2007) Layer-by-layer assembly of nanowires for three-dimensional, multifunctional electronics. *Nano Lett* 7:773–777.

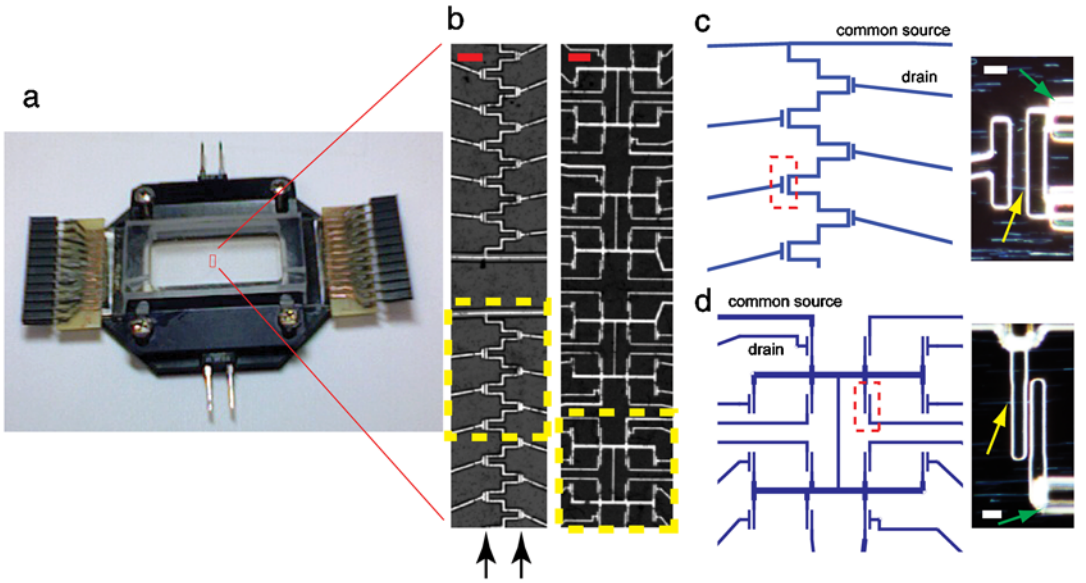

Fig. S1. Flexible configuration of Si NWFET arrays. (*A*) A photograph of a fully assembled device chip and heated measurement chamber. The devices reside in the middle part of the quartz substrate as marked by the red box. (*B*) Optical microscope images of the device region marked in *A*, showing different device array designs. The left image shows the design for a 1D array, where NWFET devices are arranged in two vertical lines as marked by the arrows at the bottom of the image. The right image shows the design for a 2D array. The yellow dashed box marks a 4×4 array unit, where there are four units per device chip. The red scale bars in these images correspond to 50 μm. (*C*, *D*) The device design for the 1D and 2D array, respectively, and the optical image (dark field) of a single device for each. The yellow arrows point to Si NWs in the devices, and the green arrows mark the edge of the SU-8 polymer passivation covering the outer areas of the electrodes.

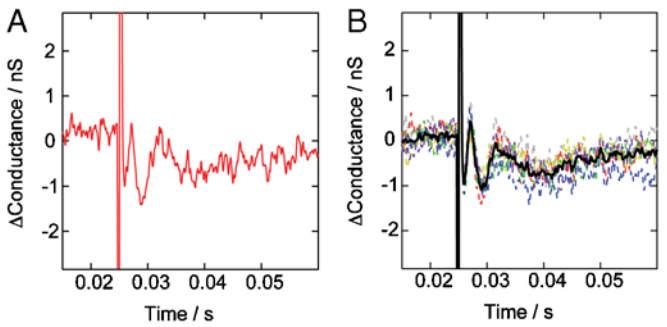

Fig. S2. Comparison between single raw traces and averaged data. (*A*) A representative raw single data trace recorded from a NWFET. (*B*) Six raw traces (*Dashed Color Lines*) recorded from NWFET overlaid with the averaged of the six (*Solid Black Line*). Averaged results were used to accurately identify the peak position and peak width for comparison across different devices and samples.

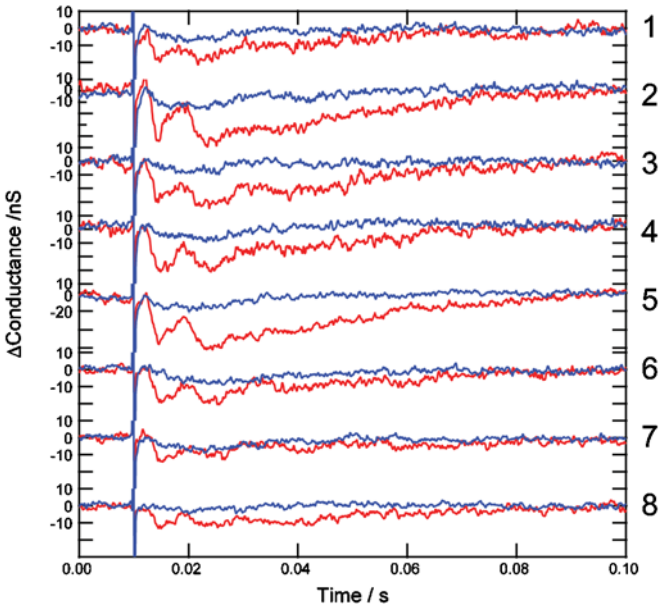

Fig. S3. Synaptic blocker test for 2D Si NWFET array. The conductance change in devices 1–8 (as labeled in Fig. 5*A*) were recorded when stimulating with a 200 μs, 400 μA current pulse (*Red Traces*). CNQX and APV were then applied and devices were recorded with the same parameters (*Blue Traces*). The results show that recorded signals from all devices were blocked by CNQX and APV.