Supplementary Document for

**Strongly scale-dependent charge transport from interconnections of**

**silicon quantum dots and nanowires**

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**Materials and Methods (\*)**

**Thin film fabrication.** Thin films were deposited onto p-type, 1-5 Ω.cm, (100)-oriented Si wafers and quartz substrates via magnetron sputtering system (Vaksis, NanoD-100 PVD). 3"-diameter 99.995%-pure SiO2 and Si targets were co-sputtered with RF (*P*SiO2 = 180 W) and DC (*P*Si = 81 W) powers applied, respectively. Depositions were performed at room temperature and 99.99% pure Ar was used as the process gas, where base pressure was ~2x10−6 Torr. The target-substrate distance was kept at 150 mm during deposition. Post-annealing was performed in a high-temperature furnace for 1 h under constant flow of N2 gas at 1100 °C.

**Thin film characterization.** EFTEM imaging was performed using an image-corrected FEI Titan 80-300 microscope operating at an accelerating voltage of 300 kV and equipped with a Gatan Imaging Filter 863. Valence-band plasmon energy-loss imaging at *Eloss* ≈ 17 eV and 27 eV for Si and SiO*x* plasmon peaks, respectively was used. Pseudo-colored images, which are a superposition of a Si plasmon EFTEM image (green) and the corresponding SiO*x* plasmon EFTEM image (red) were used for representing the analysis results.

APT specimen preparation was performed on FEI Nova and Helios NanoLabTM dual-beam focused-ion beam instruments using standard lift-out methods enabled by an Omniprobe AP200TM micromanipulator. Samples were analyzed using CAMECA LEAP® 5000 XS and CAMECA LEAP® 4000X HR. For the former, detection efficiency was ~77% yielding a ~24 million ion dataset, where the data was collected in 250 kHz puled-laser mode with a pulse energy of 50 pJ, base temperature of 30 K, and ion detection rate of 5 ions per 1000 laser pulses. For the latter detection efficiency was ~40% yielding a ~7 million ion dataset, where data was collected under identical conditions except the ion detection rate was 3 ions per 1000 laser pulses. Reconstruction, analysis, and visualization were done using CAMECA IVASTM software. The same voltage-based reconstruction parameters where used for each dataset (*k* = 3.3, ICF = 1.65, *Fevap* = 35 V/nm).

PL measurements were taken under Nd:YAG laser excitation (532 nm line) at room temperature. PL setup used to record the PL excitation spectra comprises a Nd:YAG laser, Hamamatsu C7041 detector head, Oriel Instruments MS257 monochromator and a series of lenses and mirrors. EL analyses are also performed in the same setup where we used Keitley 2440 ammeter in order to inject charge carriers. The measurements have been carried on light-emitting diodes, where p-type, 0.01-0.05 Ω.cm, (100) oriented Si wafers were used as the substrate. Current flow was measured between thermally evaporated aluminum point contacts (~1 μm thick) on magnetron sputter-deposited AZO layer on film surface and Ag contact evaporated onto the back surface of the Si wafer.

Conductivity analyses were carried through *I-V* measurements both in the vertical and in the lateral directions. p-type, 0.01-0.05 Ω.cm, (100) oriented Si wafers were used for vertical *I-V* measurements whereas quartz substrates were used for lateral *I-V* measurements. For vertical *I-V* analyses the current flow was measured between thermally evaporated aluminum point contacts (~1 μm thick) on film surface and Al contact evaporated onto the back surface of the Si wafer. For lateral *I-V* analyses ~1 μm-thick coplanar Al contacts were thermally evaporated with 1.5 cm spacing onto film surface on a quartz substrate. Current flow between the contacts was measured via a Keitley 2440 ammeter and a Hewlett-Packard 4140B picoammeter. Newport Oriel Sol3A Class AAA solar simulator at 0.9 A.M. was used for the light-illuminated *I-V* measurements.

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