Supporting Information

Quantifying Surface Roughness Effects on Phonon Transport in Silicon Nanowires

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S1. Various surface morphologies of Si nanowires from two different etching methods.

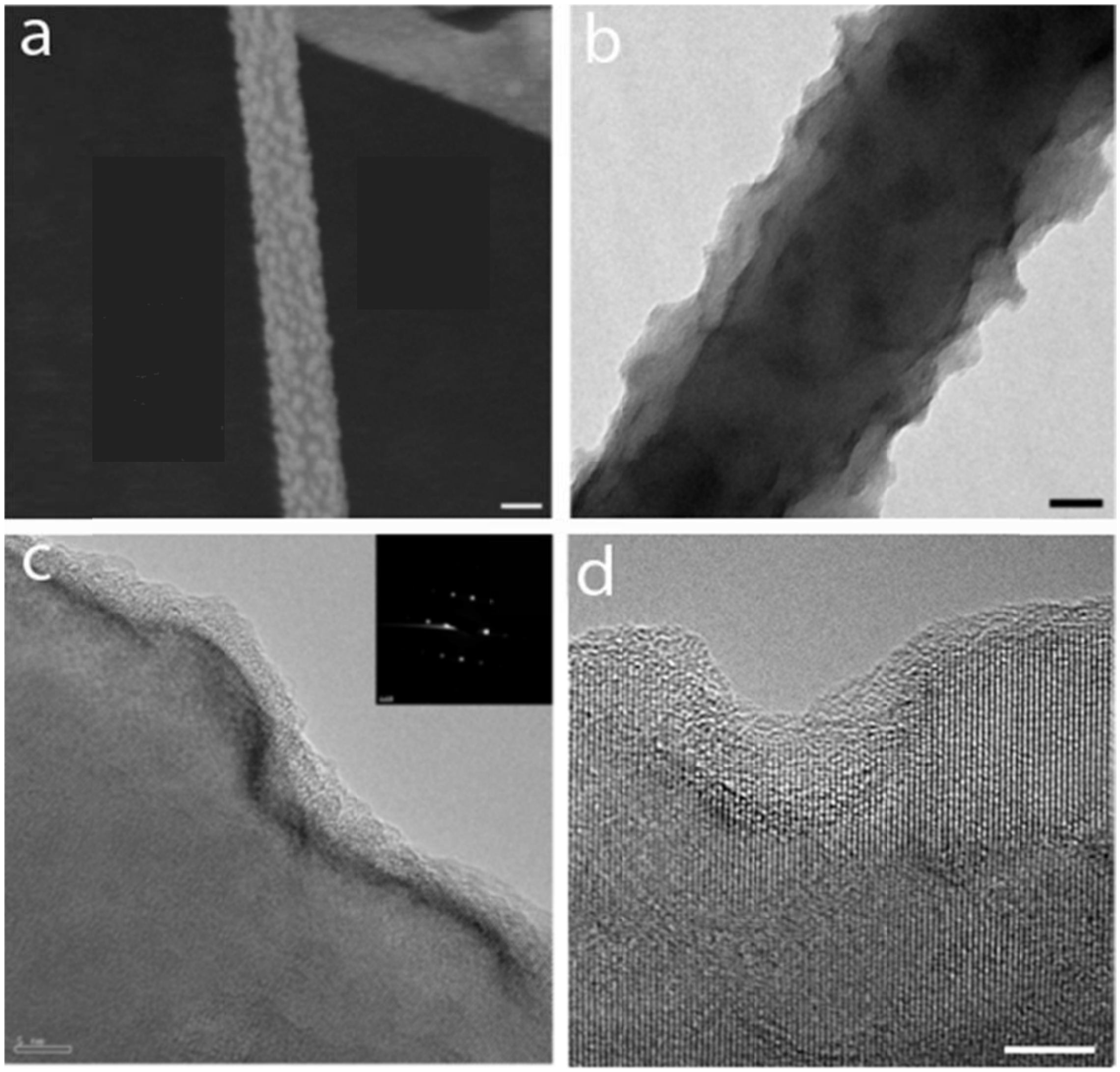

Fig. S1 (a). SEM image of a SiNW with Ag nanoparticles on the surface, (b). TEM image of a SiNW after Ag removal using the etching method #1. (c,d). HRTEM image of SiNWs from etching method #1 and #2, respectively. The inset of (c) is the selective area electron diffraction pattern (SAED). Scale bars for a, b, c, d, are 1 μm, 20 nm, 5 nm, 2 nm, respectively.

S2. Contact resistance calibration.

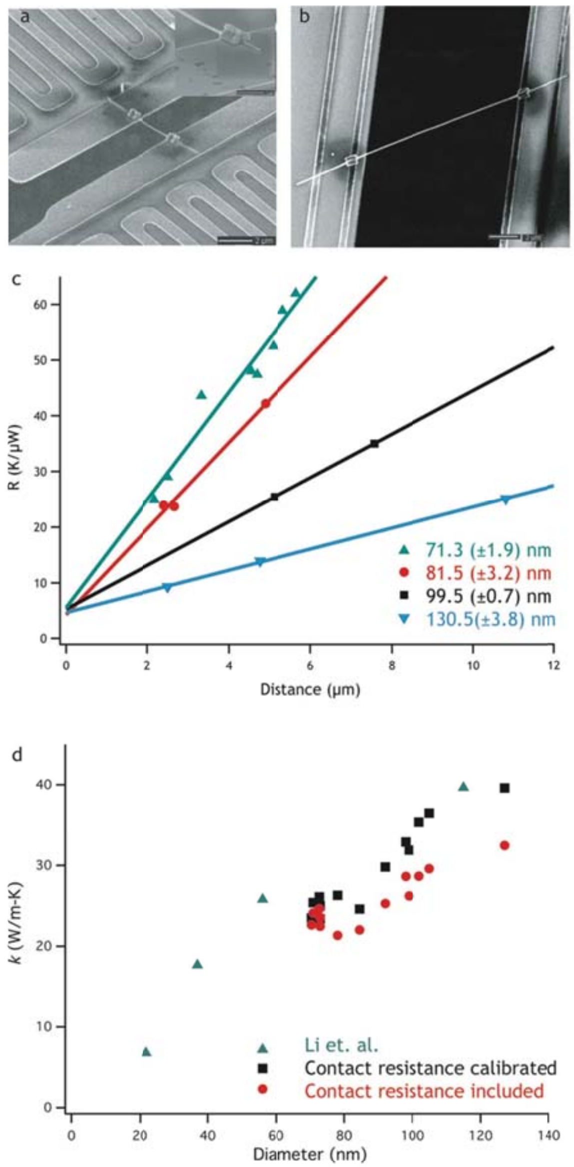

Fig S2. (a,b) SEM images of VLS SiNWs with various lengths on prefabricated MEMS devices for thermal conductivity measurement. The inset of (a) is zoom-in image of Pt/C composite on the end of SiNW. (c). Thermal resistance of VLS Si nanowire with various length and diameter. The intercept on Y axis indicates the average contact resistance ~ 4.5

K/μW, which is less than 10% of the measured value for VLS SiNWs with 71.3 nm diameter and 5 um length. (d) Thermal conductivity of VLS SiNWs with various diameters both accounting for contact resistance (red circles) and without contact resistance calibration (black squares). Data from Li et. al. are also shown (green triangles).[1] The effect of the contact resistance is less than 10% for 70 nm wide SiNWs. It should be noted that the uncertainty associated with contact resistance scales with the thermal resistance of the individual nanowires. Hence, the values measured of thermally resistive nanowires have less uncertainty when compared to conductive nanowires, which result in narrower error bars for lower thermal conductivity. Other sources of the uncertainties are discussed elsewhere and has been applied in this work as well.[2]

S3. Surface roughness information (full length).

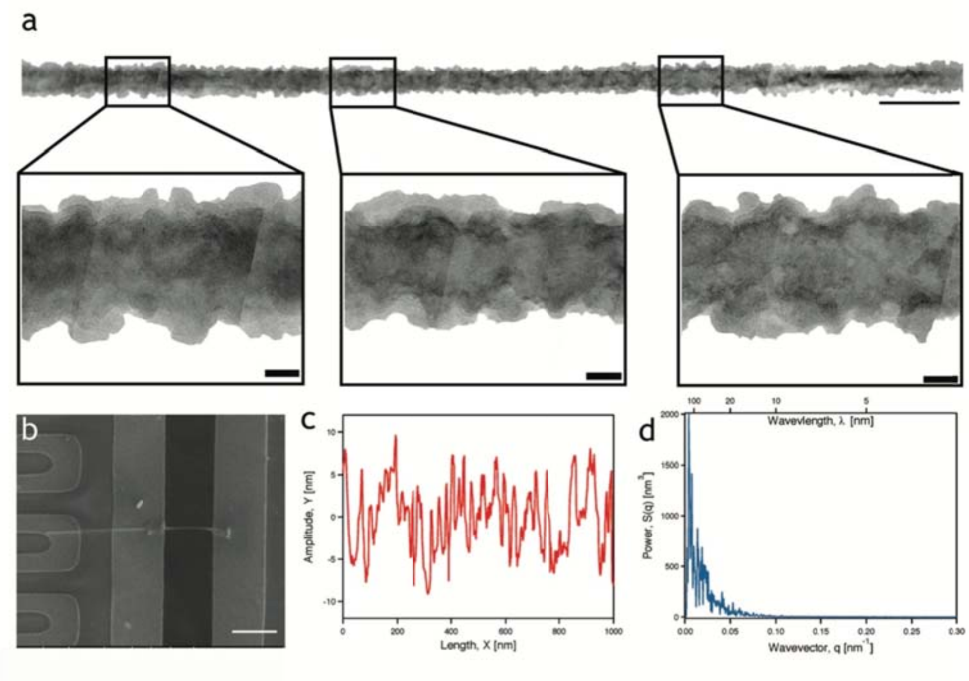

Fig. S3 -1 Surface roughness characterization. (a) Serial TEM images of SiNWs along the length with zoom-in images at different position. (b) SEM image of the identical nanowires from (a) on thermal measurement device. (c) Surface profiles from serial TEM images. The length is 1μm. (d) Averaged power spectrum from sectioned surface profiles. Scale bars for panel a are 200 nm and 20 nm, panel b is 2 μm.

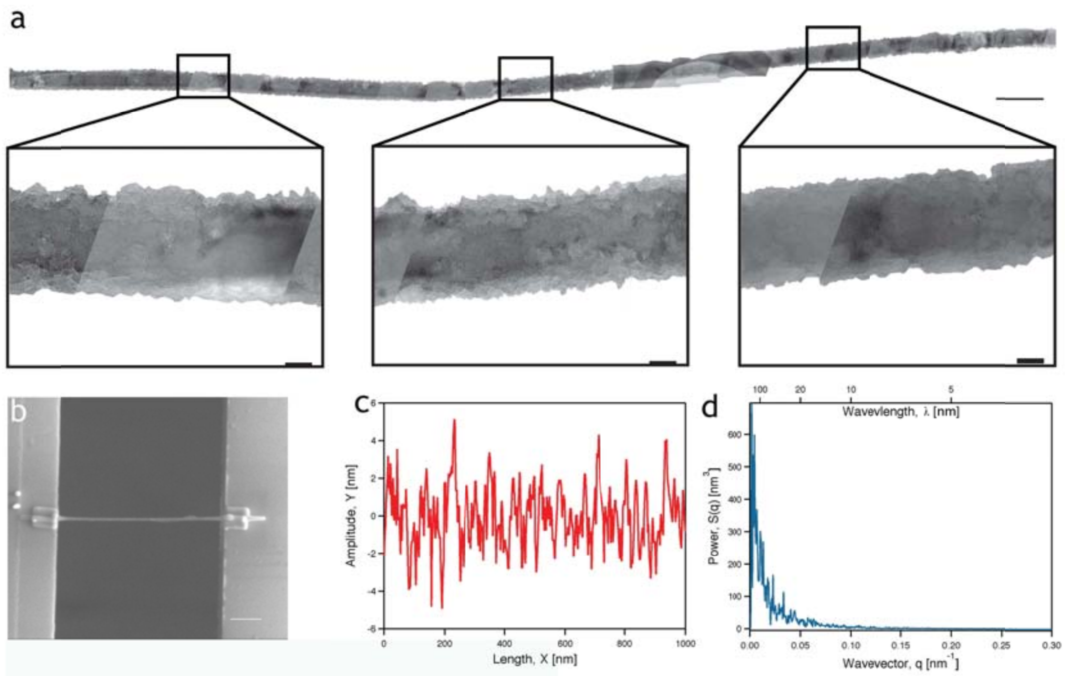

Fig. S3 -2 Surface roughness characterization. (a) Serial TEM images of Si nanowires along the length with zoom-in images at different position. (b) SEM image of the identical nanowires from (a) on thermal measurement device. (c) Surface profiles from serial TEM images. The length is 1μm. (d) Averaged power spectrum from sectioned surface profiles. Scale bars for panel a are 200 nm and 20 nm, panel b is 1 μm.

Table 1. Roughness parameters with measured thermal conductivity at various temperature.

Dia.	rms_right	rms_left	rms_ave.	Corr. Leng.	rms/*L*	Power Law (α(q0/q)^n)		Therm. Cond. (W/m-K)		
D (nm)	σ_R (nm)	σ_L (nm)	σ_Ave (nm)	*L*_Loren (nm)	σ/*L*	n	α (nm^3)	k(300K)	k(200K)	k(100k)
50.2	2.5	3.0	2.8	9.73	2.86E-01	2.59	2.95E-04	14.6	13.9	10.7
57.0	2.2	2.1	2.2	7.03	3.07E-01	2.80	1.07E-04	12.5	13.0	9.5
54.4	3.4	3.3	3.3	13.47	2.48E-01	2.65	4.50E-04	8.2	7.9	5.8
54.4	2.1	2.8	2.4	8.41	2.87E-01	2.65	4.08E-04	8.8	6.1	4.5
65.4	4.1	4.3	4.2	8.40	5.02E-01	2.67	3.50E-04	10.6	10.3	7.9
67.7	3.0	3.2	3.1	9.05	3.42E-01	2.82	7.73E-05	15.1	15.5	12.1
69.4	1.8	1.8	1.8	14.18	1.24E-01	2.90	3.20E-05	19.3	20.6	16.8
68.5	3.0	3.9	3.4	15.66	2.18E-01	2.80	9.74E-05	13.6	13.7	11.2
68.0	2.6	1.7	2.1	8.77	2.45E-01	2.70	2.09E-04	13.2		
63.0	3.5	3.0	3.2	5.96	5.41E-01	2.74	3.51E-04	8.2	7.6	5.5
61.6	4.0	3.5	3.7	5.29	7.07E-01	2.72	5.86E-04	7.4	7.5	5.6
69.7	4.0	4.6	4.3	8.36	5.14E-01	2.76	3.51E-04	5.1	4.8	3.2
71.8	2.9	2.5	2.7	11.83	2.27E-01	2.73	1.23E-04	13.6	13.4	10.9
77.9	3.5	3.0	3.3	13.10	2.49E-01	2.82	1.01E-04	17.2	19.6	13.6
74.2	3.2	3.1	3.1	9.54	3.30E-01	2.70	1.88E-04	13.6	12.9	11.0
77.9	2.4	3.5	2.9	12.22	2.41E-01	2.81	8.66E-05	18.6	19.4	15.7
71.0	2.5	3.7	3.1	11.19	2.78E-01	2.72	1.91E-04	10.7	10.9	7.2
77.5	2.8	1.8	2.3	8.91	2.59E-01	2.67	3.01E-04	10.7	11.4	8.1
79.8	2.9	2.5	2.7	8.39	3.20E-01	2.60	4.98E-04	8.5	8.5	6.1
75.0	2.7	2.8	2.8	10.14	2.73E-01	2.70	2.45E-04	14.3		
70.0	2.7	3.0	2.8	6.41	4.44E-01	2.63	6.50E-04	7.8	7.5	4.8
83.7	2.1	2.4	2.2	8.48	2.63E-01	2.97	3.11E-05	20.6	21.6	16.9
91.3	2.4	2.4	2.4	8.73	2.74E-01	2.85	1.27E-04	14.5		
99.0	1.9	2.1	2.0	6.60	3.03E-01	2.66	2.56E-04	14.8	14.2	10.8

(1) Li, D.; Wu, Y.; Kim, P.; Shi, L.; Yang, P.; Majumdar, A. *Applied Physics Letters* **2003**, *83*, 2934-2936.

(2) Hippalgaonkar, K.; Huang, B.; Chen, R.; Sawyer, K.; Ercius, P.; Majumdar, A. *Nano Lett* **2010**, *10*, 4341-4348.