Supporting Information

Laser-Pulled Ultralong Platinum and Gold Nanowires

Stephen J. Percival, Noah E. Vartanian and Bo Zhang*

Department of Chemistry, University of Washington, Seattle, WA 98195-1700

Email: zhang@chem.washington.edu

To fabricate the gold contacts used to measure the nanowire resistance a combination of UV photolithography and thermal evaporation of Au followed by metal lift off was employed on polished quartz substrates. First, UV sensitive Photoresist (AZ1512) was spin coated onto cleaned quartz substrates and patterned using printed film UV photo mask. The gold contact pads (50 nm gold with a 5 nm chromium adhesion layer) were thermally evaporated onto the patterned quartz substrates and the photoresist removed, along with excess deposited metal, with an acetone soak overnight followed by thorough rinsing with acetone then IPA completing the metal lift off. The expected distance between the gold contacts was 500 μm.

To transfer the nanowires onto the gold contacts the quartz substrate a procedure referred to as "wedging" was used and is described by Schneider et al.[1]. This involves drop coating a 30 mg/ml solution of a hydrophobic polymer (Cellulose Acetate Butyrate (average M_n = 30,000, Sigma Aldrich) dissolved in Ethyl Acetate (EMD)) onto the silicon chip where the nanowire is sitting and then slowly submerging the silicon chip into DI water at an angle of ~30°. The hydrophobic polymer will lift off of the silicon chip with the wire encased within it and float on top of the water's surface and then can be

transferred and positioned on to the substrate of choice. The wires were transferred from the silicon chips onto either the copper TEM grids for TEM imaging or the polished quartz chips patterned with the gold/chromium contacts for electrical resistance measurements. The polymer was then removed either with acetone or oxygen plasma. Oxygen plasma was used to free the wire from the polymer film in the case of the nanowire conductance devices because the quick dissolution of the polymer in acetone can move the nanowire and would be a problem when trying to position the wire in a precise location, which was not a problem for TEM imaging. Remains of the polymer film can be seen in the SEM images of the single nanowires used to measure the electrical properties where the polymer film was not completely etched away by the plasma.

Figure S1 shows an AFM scan from a platinum nanowire showing the height of the wire, corresponding to the real diameter of the wire, is ~80 nm. The wire looks like it has a larger diameter in the AFM scan because the AFM tip is not sharp enough to accurately reflect the diameter of the wire in the horizontal distance.

Figure S2 shows the XRD reflection peaks for both the 25 μm platinum wire and 25 μm gold wires used to make the nanowires. The {200} peak is present in both cases of the micro wires where after the laser assisted mechanical pulling procedure to make the nanowires, the {200} peak is nearly absent. The micro wire XRD data does show that there is still an unexpected deviation in the {200} peak intensity from the expected relative intensity for platinum, but is not nearly as pronounced as seen with the nanowires.

Figure S3 shows a TEM image of the platinum nanowire shown Figure 3A but at a lower magnification in order to show the long length of this nanowire. The nanowire tapers down to the tip which is below the average grain diameter calculated by the XRD data using the Scherrer equation and the wire can be seen to be crystal grains linked end to end. Pt nanowire supported on a 50 nm thick Si_3N_4 support membrane (Structure Probe Inc) and transferred to it using the “wedging” procedure discussed previously.

Figure S4 shows lower magnification images of the different patterns produced by placing Au nanowires into a specific arrangement showing the patterns were purposefully produced and not taken from a random assortment of wires. Also seen in Figure S4D is another triangular pattern to show that these patterns can be reproducibly made, although there will inevitably be some variability due to the differences in nanowire diameter, length and the specific placement of the wires.

Figure S5 shows SEM images of the broken gold nanowire used to obtain single nanowire electrical measurements. Both ends of the nanowire show significant melting resultant from the increased temperatures the nanowire experienced as a result from the Ohmic heating before eventual failure.

Table S1. Average crystal grain diameters for the 25 µm gold and platinum wires obtained from the XRD data using the Scherrer equation.

	Crystallite size (nm)	
XRD Reflections	25 µm Gold	25 µm Platinum
{111}	43.96	51.95
{200}	64.09	64.5
{220}	46.08	49.9
{311}	46.36	45.6
Average	50.3	53.9

Figure S1. AFM topographic scan of an 80 nm diameter Platinum nanowire where the height shown in the AFM scan is equivalent to the diameter of the wire. The horizontal trace of the wire is extended due to the AFM tip shape.

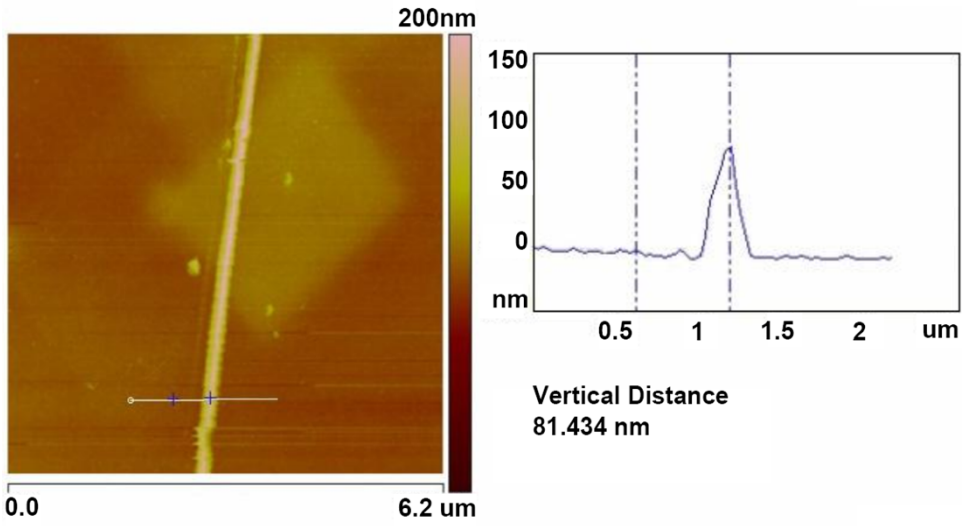


Figure S2. XRD for both 25 µm platinum and gold wires used to make the nanowires.

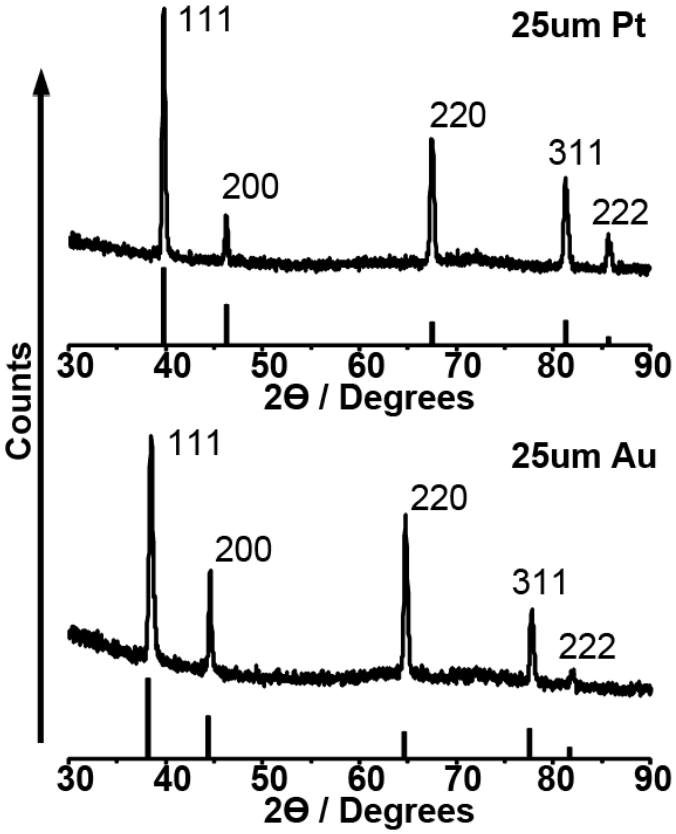


Figure S3. Lower magnification TEM image of the Pt nanowire shown in Figure 3A.

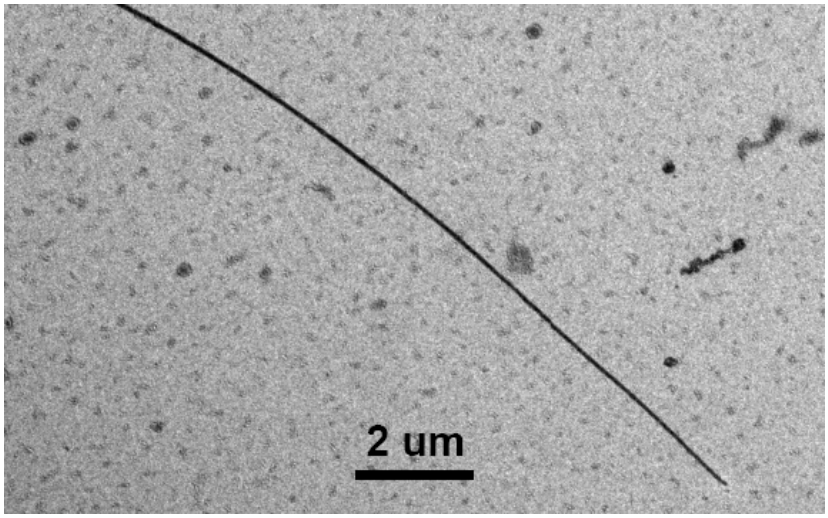


Figure S4. Lower magnification SEM images of the different patterns produced by placing Au nanowires into specific arrangements, (A) the cross, (B) the triangle, and (C) the "pound sign" that are all shown in Figure 4 of the main text. (D) Another example of the "triangle" pattern made by placing 3 Au nanowires into the desired orientation.

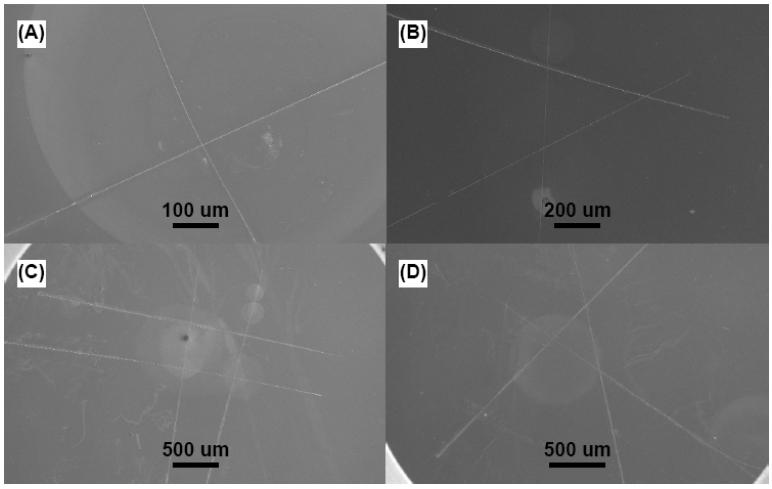
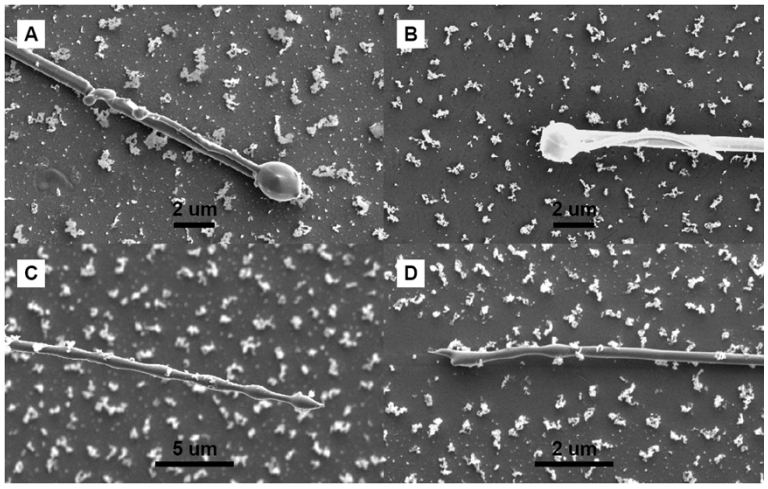


Figure S5. SEM images of the nanowires after measuring the current showing either side of the breakage points associated for the gold nanowire, (A) and (B), and the platinum nanowire, (C) and (D). Both show evidence of substantial heating and melting indicating the increased temperature of the wire upon failure.



REFERENCES

[1] G. F. Schneider, V. E. Clado, H. Zandbergen, L. M. K. Vandersypen, C. Dekker, *Nano Lett*. 2010, **10**, 1912-1916.