Fabrication of Nanowire Devices on Unconventional Substrates using Strain-Release Assembly

John W. Durham III and Yong Zhu*

SUPPORTING INFORMATION PARAGRAPH

Si NWs were synthesized by the vapor–liquid–solid (VLS) method using Au colloids as catalysts and silane (SiH_4) as a vapor-phase reactant.[1] Au colloids with diameters ranging from 10 to 50 nm were deposited on Si substrates capped with a 600 nm thick layer of thermal silicon dioxide. The substrates were placed in a quartz tube furnace (EasyTube 3000, First Nano). After a 30 min purge in H_2 ambient at 50 Torr, VLS growth of nanowires was carried out at 480 °C, 15 Torr for 10 min with the flow of SiH_4 (20 sccm) and H_2 (200 sccm).

Figure S1a shows an SEM image of Si NWs produced from 50 nm diameter Au colloids. Figure S1b shows the transmission electron microscopy (TEM) image of a Si NW with diameter close to 20 nm. It can be seen that the NW is not only straight but also uniform in width along the growth direction. The selected area electron diffraction (SAED) pattern in the inset of Figure S1b indicates that the NW growth direction is ⟨110⟩. Figure S1c is a high-resolution TEM image, which indicates the single-crystal nature of the Si NWs. Careful characterization of Si NWs synthesized using this method showed that NWs with diameters larger than 20 nm grow primarily along the ⟨111⟩ direction, whereas the NWs with smaller diameter could have three growth directions: ⟨110⟩, ⟨112⟩, and ⟨111⟩. Furthermore, these Si NWs have little or no visible amorphous oxide on the NW surface (Figure S1c). It is believed that using H_2 as the carrier gas passivates the surface.

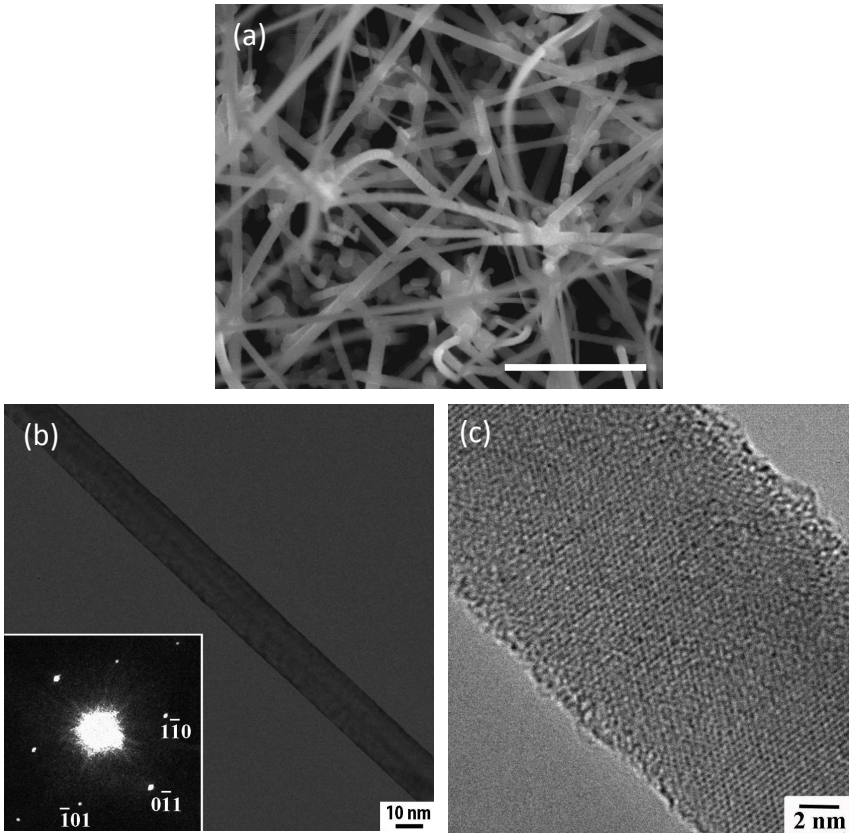

Figure S1. (a) SEM image of the Si NWs grown from 50nm-diameter Au colloids (scale bar is 500nm). (b) TEM image of a single Si NW. Inset is the corresponding SAED pattern of the Si NW. (c) High-resolution TEM image of a NW showing little or no visible oxide layer on the NW surface.

ZnO NWs were also synthesized by the VLS method on Si/SiO_2 substrates with Au colloids as the catalysts.[2] A mixture of ZnO (Alfa Aesar, 99.999%) and graphite (Alfa Aesar, 99.9995%) powders in a quartz boat was used as the Zn source. This quartz boat was heated to 950 °C by a local heater, and the generated Zn vapor was carried by a flow of Ar to the growth zone, where O_2 was injected to enable the NW growth. The temperature of the growth zone was held at 820 °C during the growth under a constant pressure of 7.5 Torr. After the growth (the duration of which was 30 min), the reactor was first pumped to the base pressure and then was cooled down under a flow of Ar.

Figure S2a shows an SEM image of the ZnO NW sample on the silicon substrate. Figure S2b is a TEM image of a single ZnO NW with diameter around 30 nm. It can be seen that the NW is not only straight but also uniform in diameter along the growth direction. The corresponding SAED pattern in the inset indicates that the wires are single-crystalline, with a growth direction along the [0001] axis.

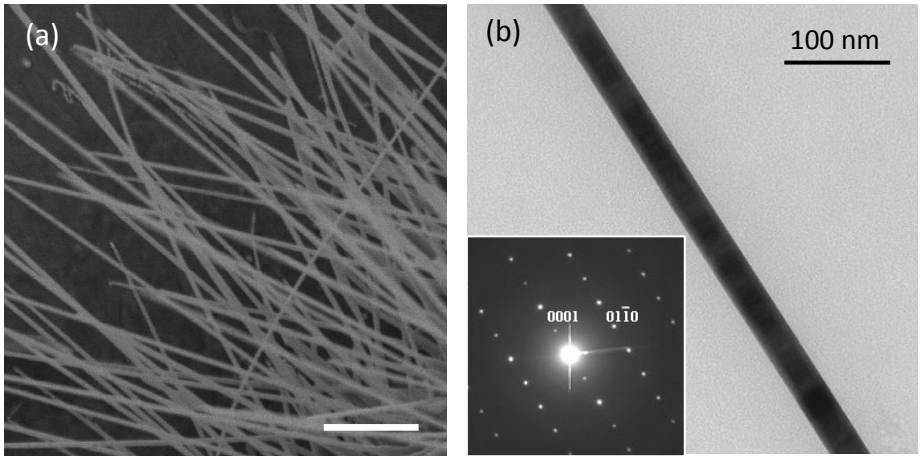

Figure S2. (a) SEM image of as-grown ZnO NWs (scale bar is 1μm). (b) TEM image of a single ZnO NW. Inset is the corresponding SAED pattern of the ZnO NW.

References:
1. Zhu, Y.; Xu, F.; Qin, Q.; Fung, W. Y.; Lu, W. Nano Lett. 2009, 9, 3934–3939.
2. Xu, F.; Qin, Q.; Mishra, A.; Gu, Y.; Zhu, Y. Nano Res. 2010, 3, 271–280.