Supplementary Information

Unravelling transient phases during thermal oxidation of copper for dense CuO nanowire growth

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Experimental

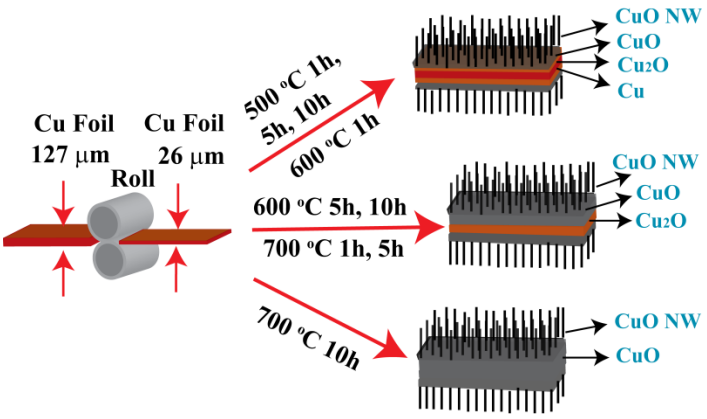

Fig. S1 Schematic of the Cu foil oxidation process. Cu foil 127 μm thick was purchased from (Alfa Aesar ®) with a purity of 99.9%. The Cu foil was rolled it to 26 μm thick to introduce some stress to it and then cut into 1x0.5 cm^2 pieces. After cleaning in 1 M HCl, the foil was anneal at 500, 600, and 700 °C for 1, 5, and 10 hours in ambient, respectively. At 500 °C 1, 5, 10 hours and 600 °C for 1 hour, the structure consisted of Cu, Cu_2O, CuO and CuO NW structure. At 600 °C for 5 hours and 10 hours and 700 °C for 1 hour and 5 hours oxidation, all of the copper was consumed and the oxides below CuO NWs were composed of CuO and Cu_2O. The CuO NWs obtained from 600 °C for 5 and 10 hours oxidation grow much longer than the NWs obtained at 500 °C. At 700 °C for 10 hours, the Cu foil was completely converted to pure CuO with dense NWs on the surface.

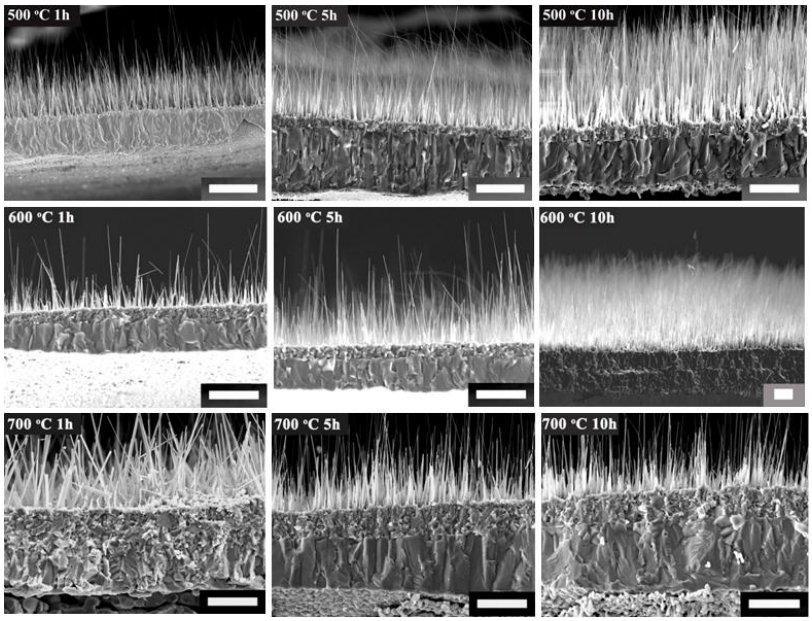

Fig. S2 The SEM cross section images of CuO by oxidizing 26 μm Cu foil in air at 500 °C, 600 °C and 700 °C for 1, 5 and 10 hours in ambient, respectively. All the scale bars are 10 μm.

Table. S1 The CuO NW length, density and combined oxide thickness below NWs.

Temperature (°C)	Time (hours)	NW length (μm)	NW Density (μm^{-2})	Combined oxide thickness (μm)	Copper present?
500	1	16.3	1.0	14.0	Yes
	5	13.7	1.1	27.9	Yes
	10	8.4	1.0	34.6	Yes
600	1	2.8	1.2	22.0	Yes
	5	15.3	1.4	36.4	No
	10	30.9	1.7	25.6	No
700	1	10.2	0.7	32.1	No
	5	10.8	1.3	31.8	No
	10	13.9	0.3	35.2	No

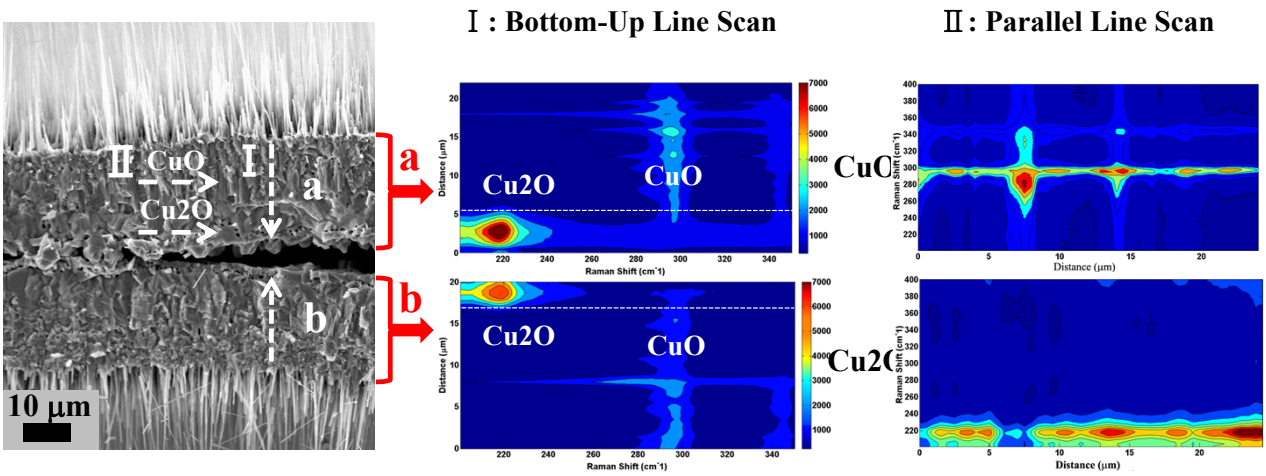

Fig. S3 The SEM image showed complete cross-section of 600 °C 5 hour sample with no copper left after oxidation. The CuO NWs and copper oxide under layer are symmetric on both sides. Two different line scans were made on the cross sections: Part Ⅰ: bottom-up line scan and Part Ⅱ: parallel line scan. Raman line scan from the root of NW to the edge of the oxides layer (Bottom-up line scan) showed that a thick CuO layer formed below CuO NWs and then a pure Cu_2O layer existed below CuO (part I). In order to confirm the CuO and Cu_2O are pure, parallel line scans indicated that both CuO and Cu_2O are pure without impurity phases existing in the grain boundaries (part Ⅱ).