Supporting Information

Synthesis and Characterization of ZnO/CuO Vertically-aligned Hierarchical Tree-like Nanostructure

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ZnO, CuO, nanostructure, p-n junction, and photoelectrochemistry

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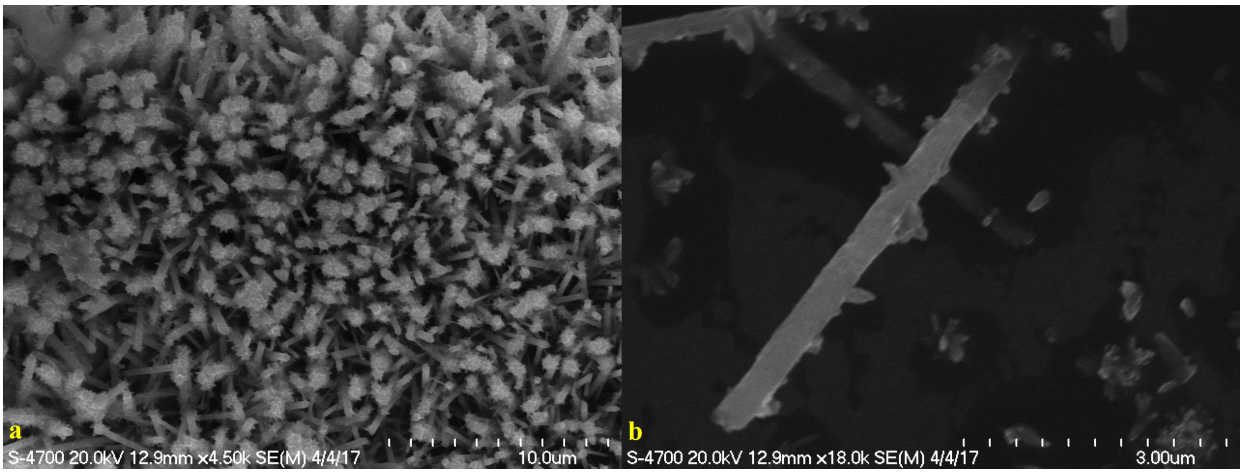
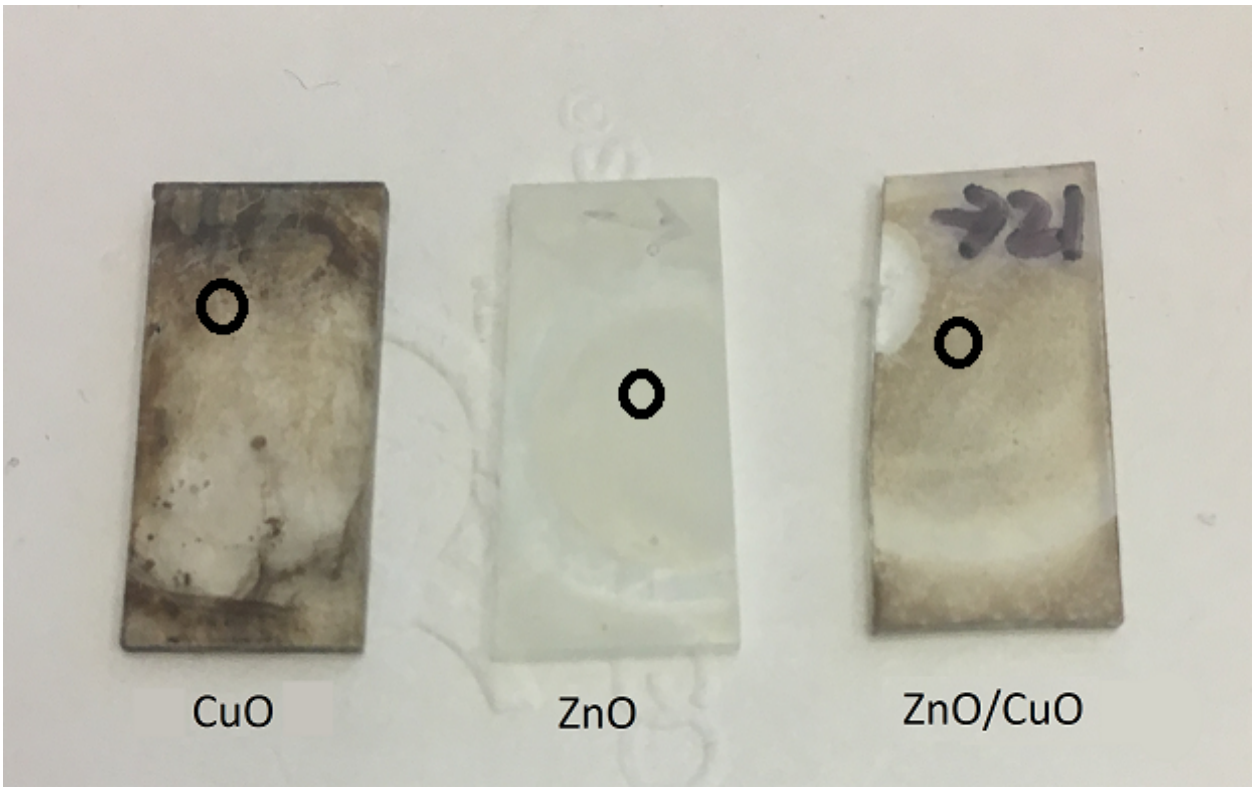
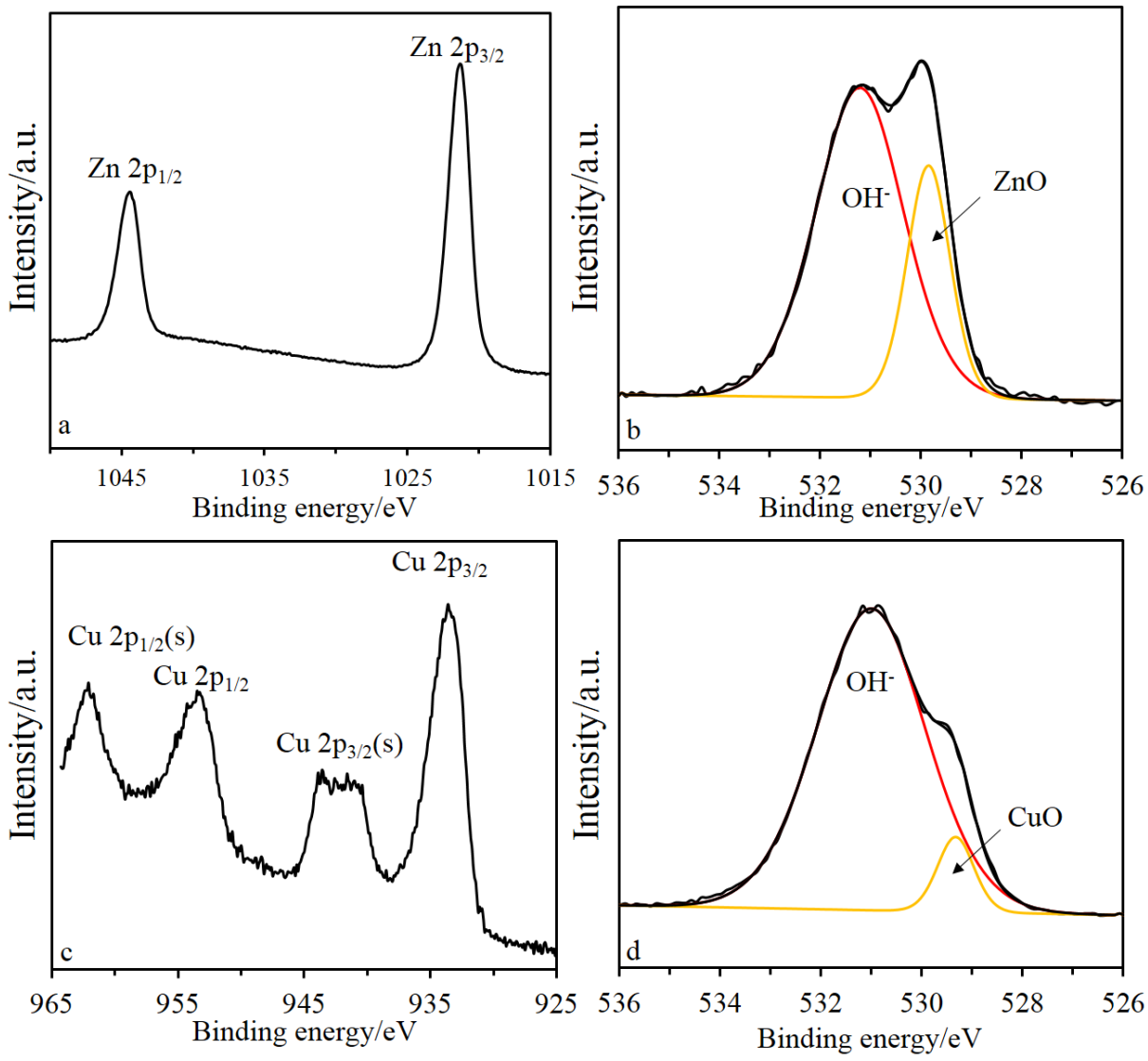


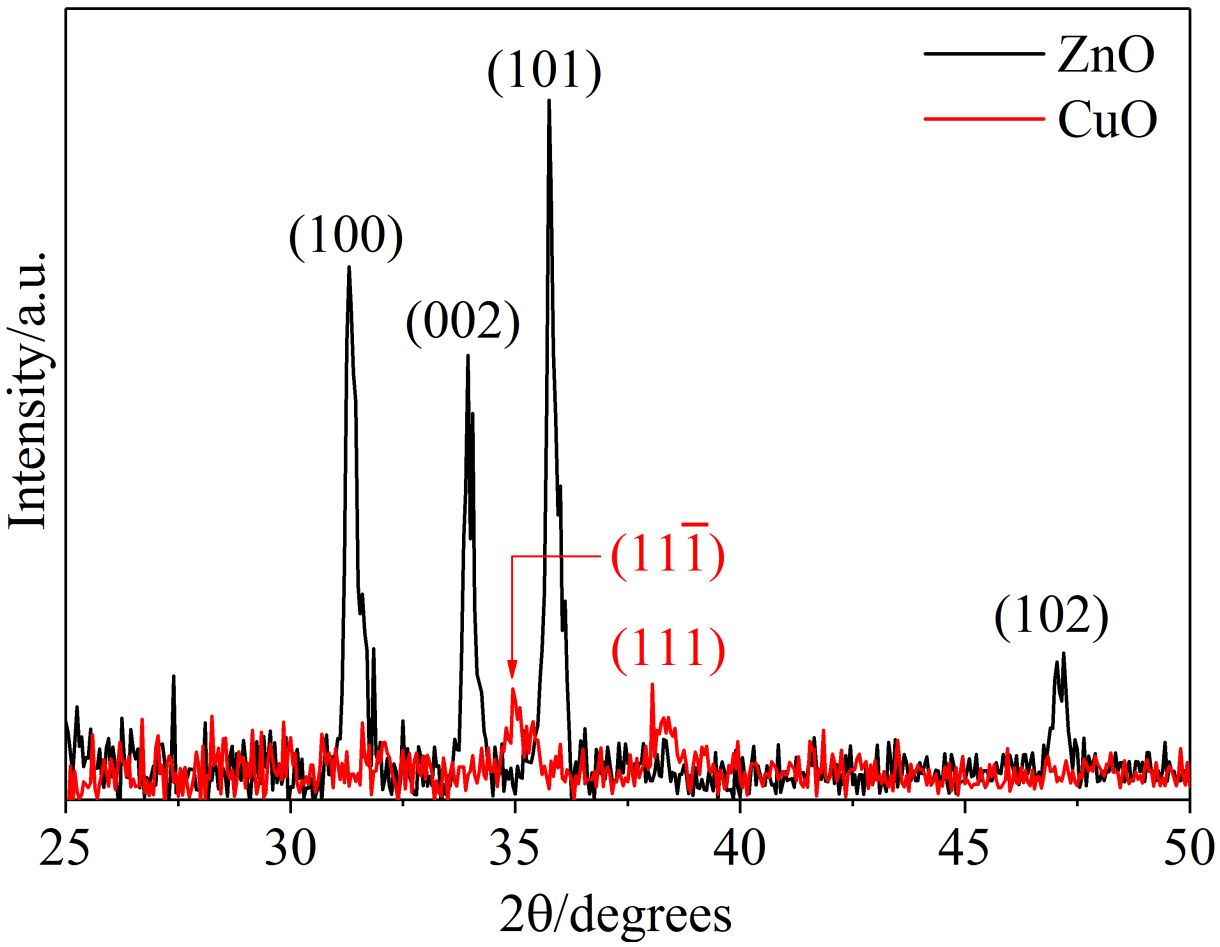
S1: SEM images of ZnO/CuO NTs (a) and a single ZnO/CuO NT (b).



S2: Photos of CuO, ZnO, and ZnO/CuO NTs. The measuring area for SEM and UV-bis is circled.



S3: XPS spectrum of Zn 2p ($2p_{1/2}$: 1044.45, $2p_{3/2}$: 1021.35), O 1s in ZnO nanowires (OH^-: 531.25, ZnO: 529.85), Cu 2p ($2p_{1/2}$(s): 962.07, $2p_{1/2}$: 954.97, $2p_{3/2}$(s): 941.37, $2p_{3/2}$: 933.57), and O 1s in CuO nanorods (OH^-: 531.97, CuO: 529.37).



S4: High-resolution XRD spectra of ZnO nanowires in black and CuO nanorods in red.

S5: Normalize transmittance data sets to 100%

$$A = 2log(\%T) \tag{1}$$

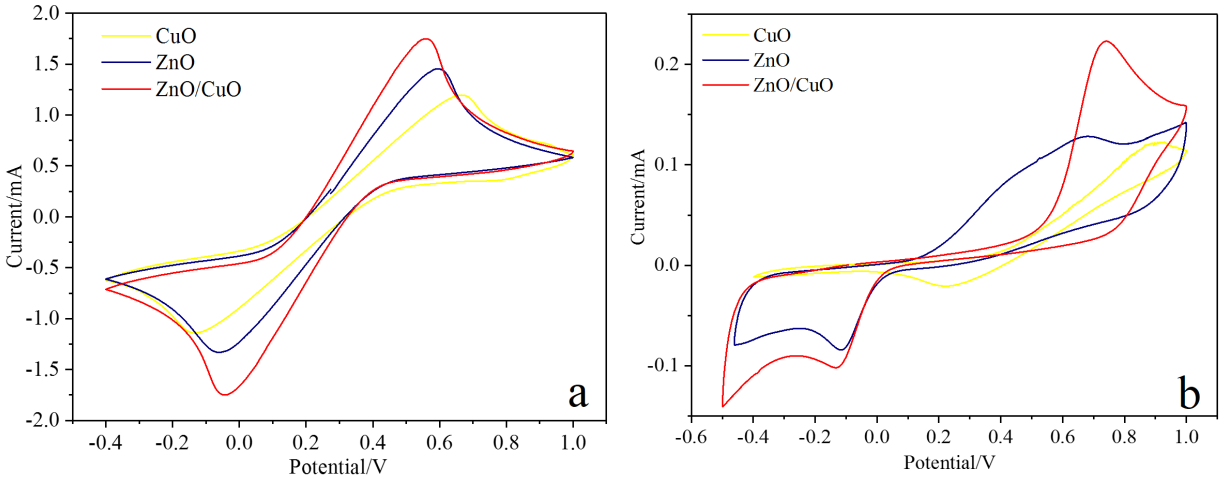
$$A = log(1/R) \tag{2}$$

$$F = \frac{(1-R)^2}{2R} \tag{3}$$

$$Ea(energy\ in\ eV) = \frac{1240}{\lambda} \tag{4}$$

Make a plot, $\sqrt{F \times Ea}$ vs. Ea shown in inset in Figure 5. The band gap value is the intercepting point of the x axis and the tagent along with most sharply increasing $\sqrt{F \times Ea}$.

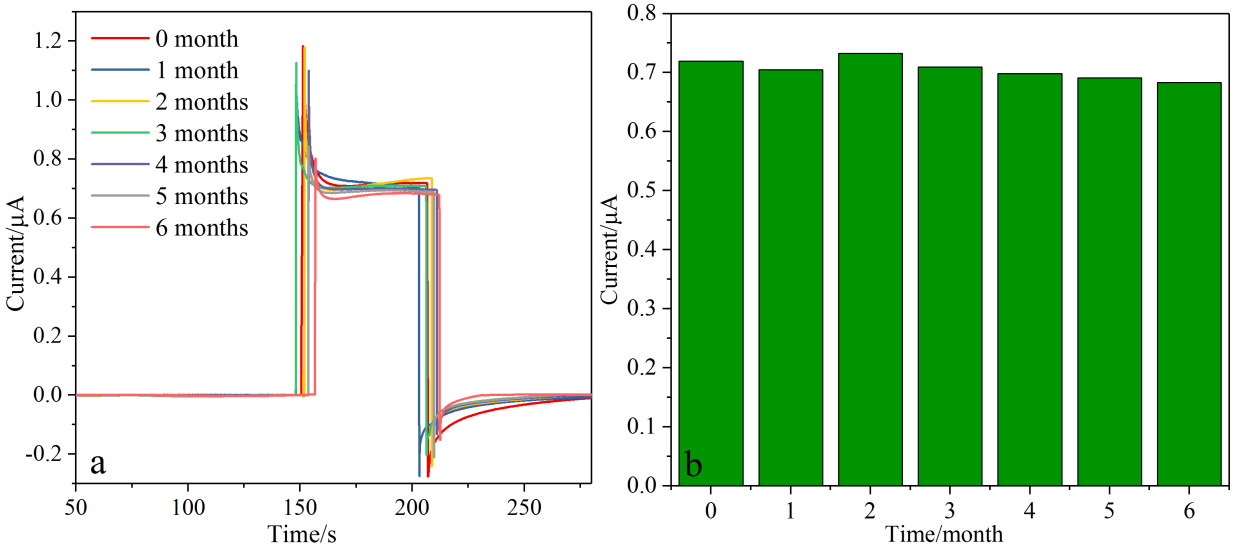
Reference: P. Kubelka and F. Munk, Ein Beitrag zur Optik der Farbanstriche, Z. Tech. Phys. (Leipzig) 12, 593-601(1931).



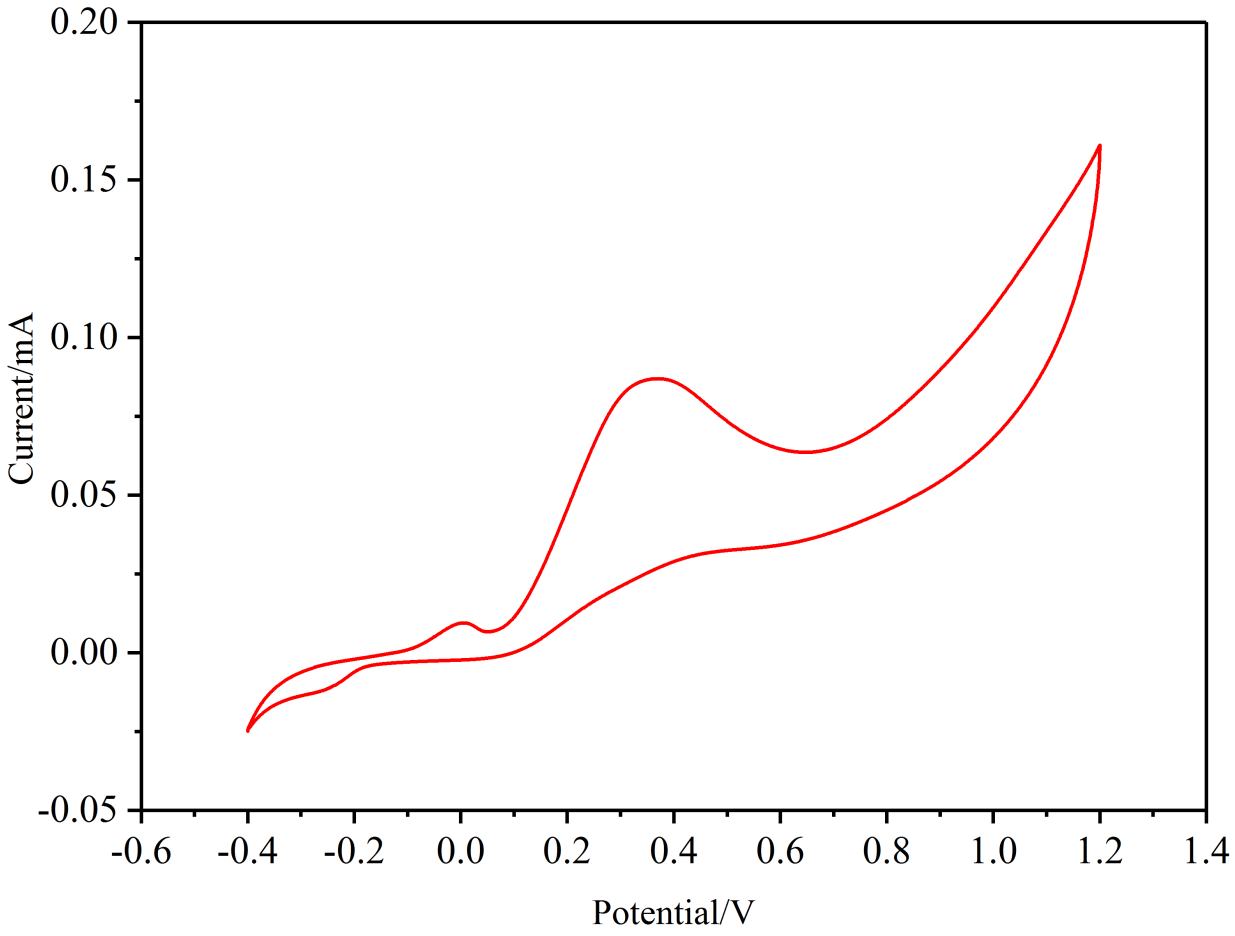
S6: CV curves of CuO, ZnO, and ZnO/CuO NTs in 1 mM $Fe(CN)_6^{3-}/Fe(CN)_6^{4-}$ in 0.1 M KCl aqueous solution (a), and 1 mM ferrocene in 0.1 M $BuNF_4$ in acetonitrile (b).

Solvent	**Material**		**V_{FB}/V**	**Carrier density/cm^{-3}**
Water	ZnO(n-type)		-0.7417	7.31×10^{19}
	CuO(p-type)		+0.3373	1.34×10^{19}
	ZnO/CuO	ZnO	-0.5583	1.79×10^{20}
		CuO	+0.4629	8.57×10^{19}
MeCN	ZnO(n-type)		-0.8804	2.28×10^{19}
	CuO(p-type)		+0.3108	9.96×10^{18}
	ZnO/CuO	ZnO	-0.8911	5.30×10^{19}
		CuO	+0.7842	2.93×10^{19}

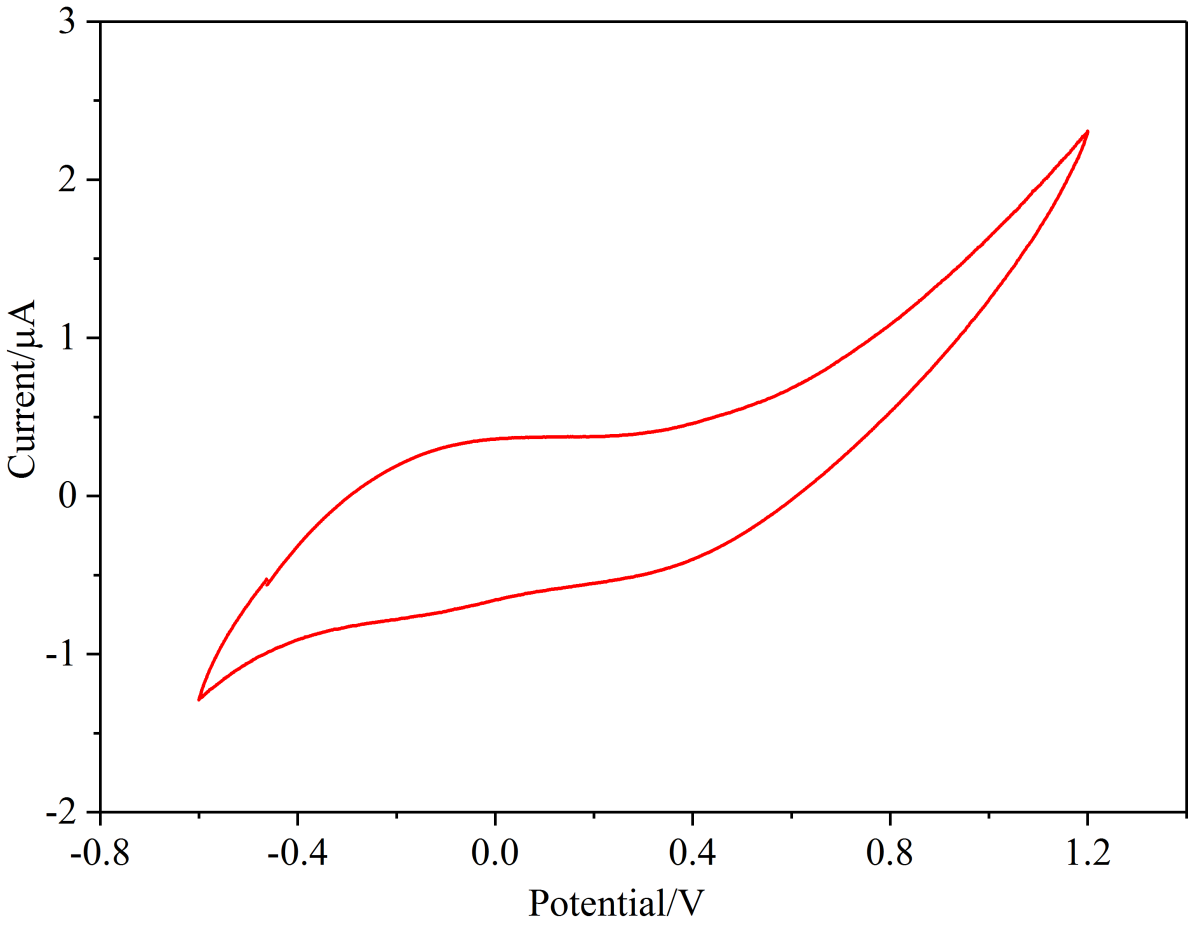
S7: Flat band voltages and carrier densities of ZnO, CuO, ZnO/CuO NTs in 0.1 M KCl aqueous solution and 0.1 M $BuNF_4$ in acetonitrile.



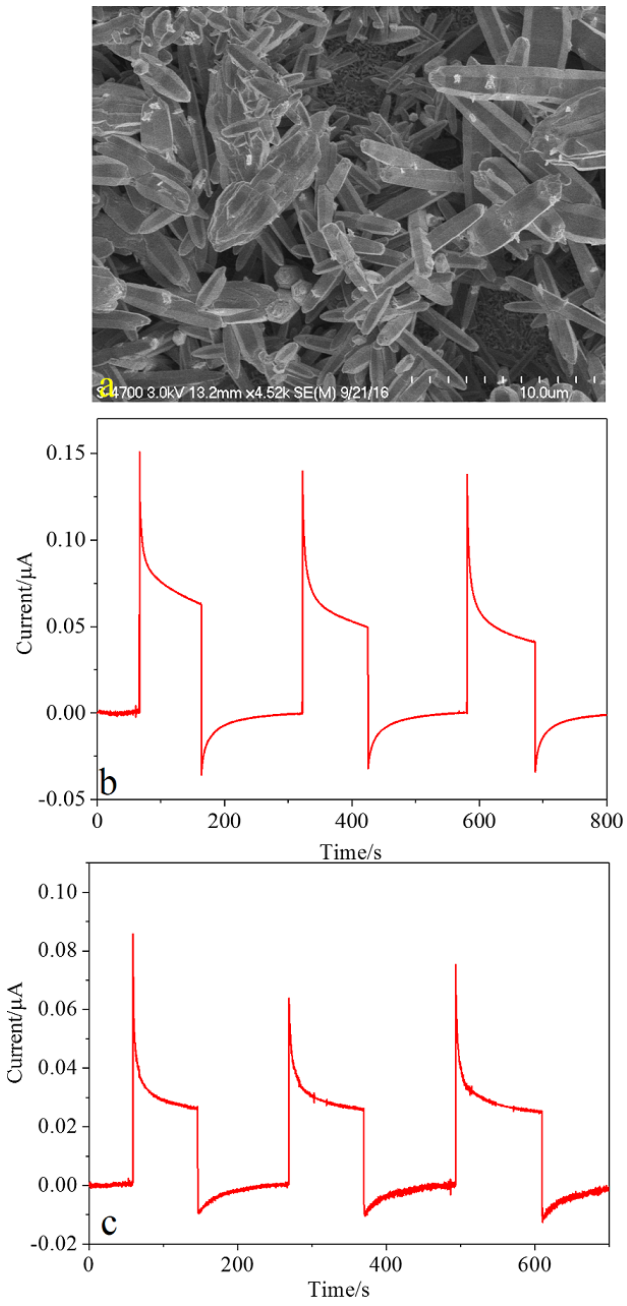
S8: Transient photocurrent curves (a) and photocurrents (b) in 0.1 M KCl aqueous solution recorded in continuous months.



S9: CV curve of 1 mM acetic acid in 0.1 M KCl aqueous solution



S10: CV curve of 1mM toluene in 0.1 M $BuNF_4$ in acetonitrile.



S11: a: SEM image of nontree structure of ZnO/CuO prepared without seeding process; b: transient photocurrent in 0.1 M KCl aqueous solution; and c:transient photocurrent in 0.1 M $BuNF_4$ in acetonitrile.