Supplementary Information

Enhancement in the Performance of Nanostructured CuO-ZnO Solar Cells by Band Alignment

Amrit Kaphle,[1] Elena Echeverria,[2] David N. Mcllroy,[2,3] and Parameswar Hari[1,3*]

[1]*Department of Physics and Engineering Physics, University of Tulsa, Tulsa, Oklahoma 74104, USA*

[2]*Department of Physics, Oklahoma State University, Stillwater, Oklahoma 74078, USA*

[3]*Oklahoma Photovoltaic Research Institute, University of Tulsa, Tulsa, Oklahoma 74104, USA*

[*]*Corresponding Author: hari@utulsa.edu*

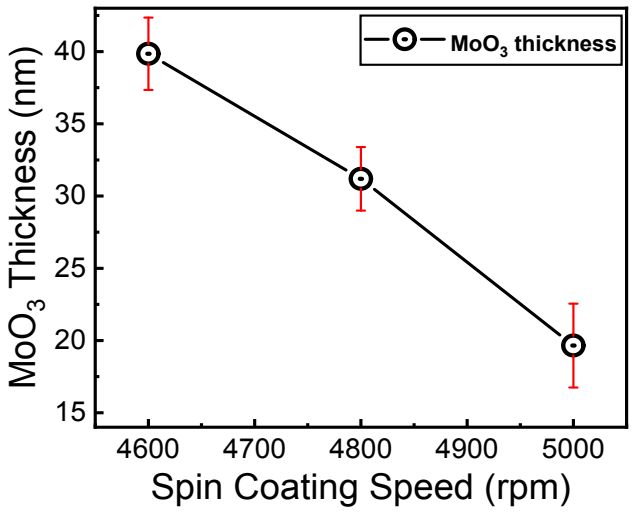

Fig. S1. Thickess of MoO_3 thin film as a function of spin coating speed

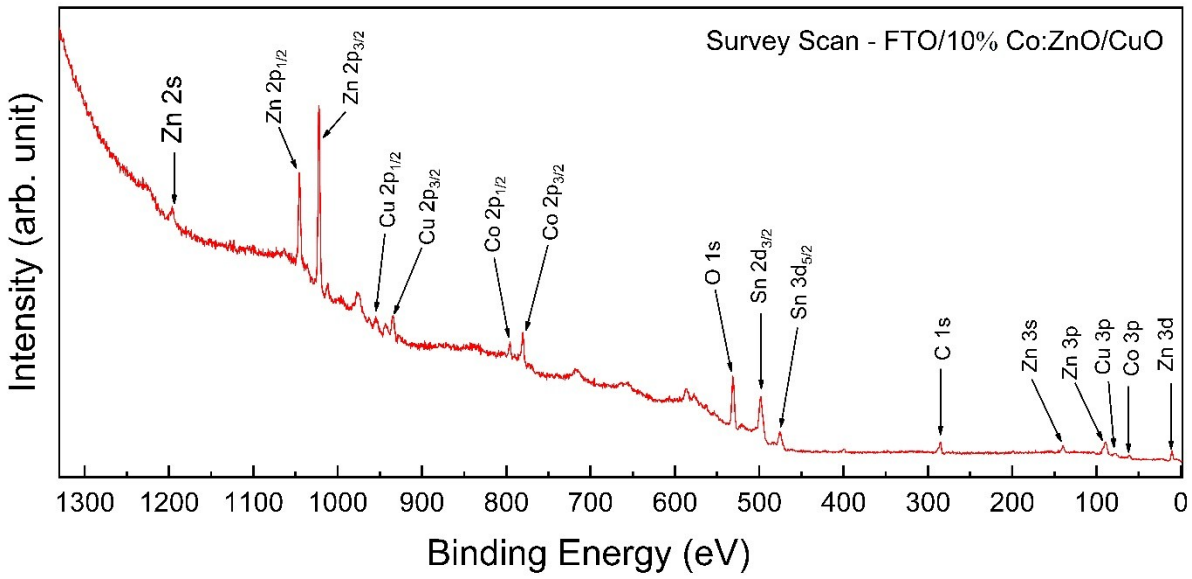

Fig. S2. Full scan survey spectra of 10% cobalt doped ZnO/CuO heterojunction solar cell

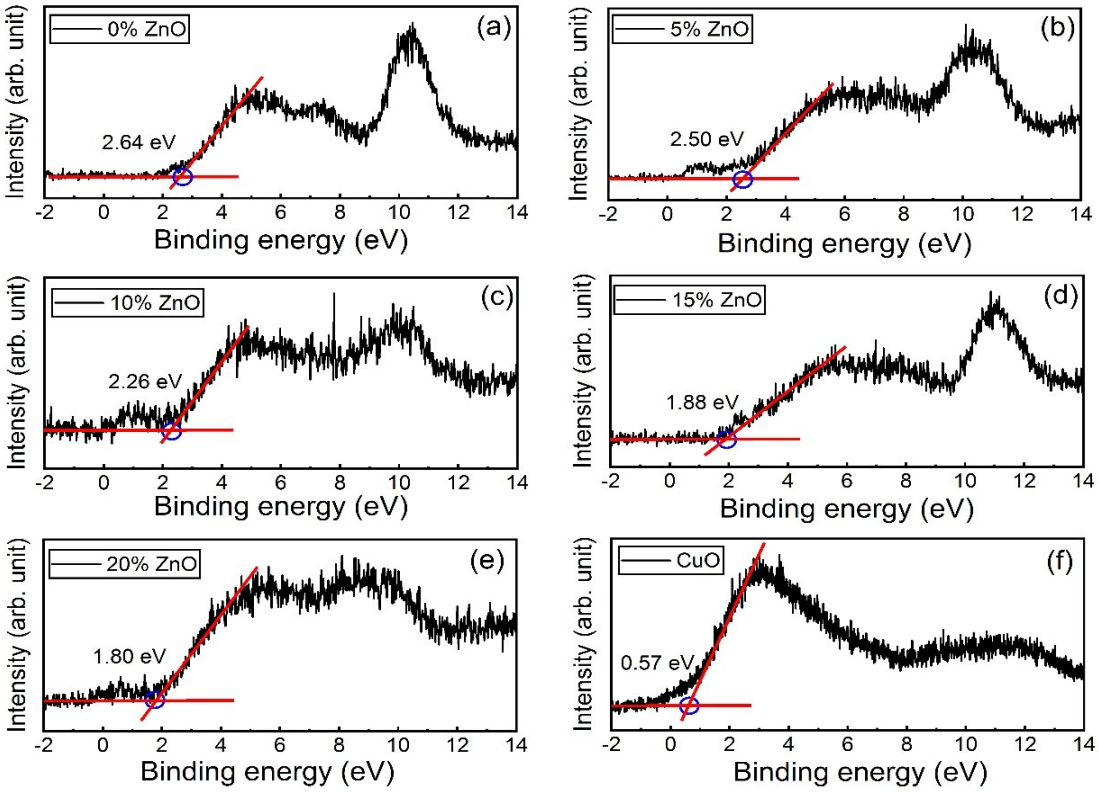

Fig. S3. VB spectra of (a) 0% (b) 5% (c) 10% (d) 15% (e) 20% cobalt doped ZnO nanorods and (f) CuO nanostructures

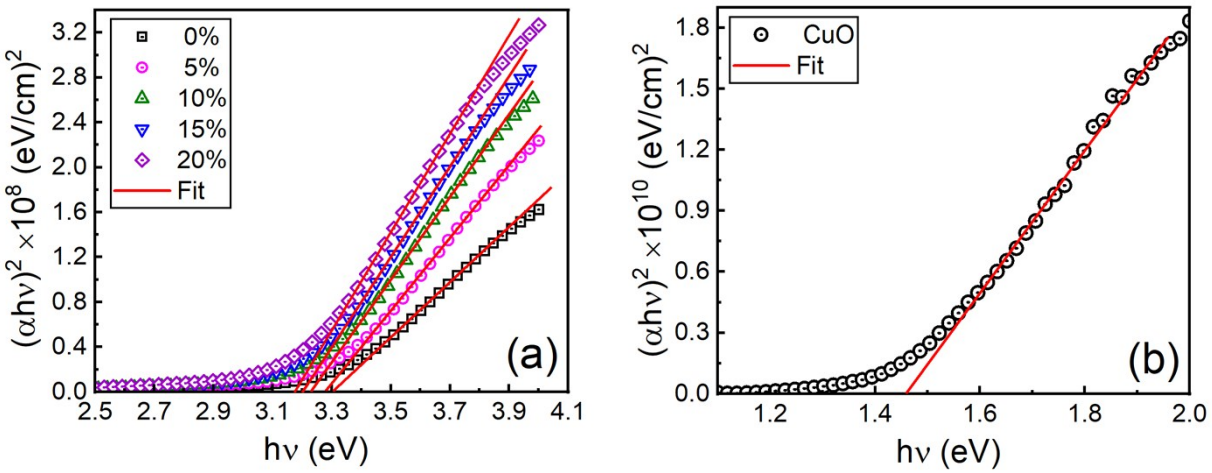

Fig. S4. Tauc plot for calculating bandgap of (a) 0-20% cobalt doped ZnO and (b) CuO nanostructures

Table S1. Rietveld analysis of 0-20% cobalt doped ZnO samples

Co %	Phase (%)	a (A^0)	c (A^0)	V $(A^0)^3$	D (nm)	R_{wp} (%)	R_p (%)	R_e (%)	S	χ^2
0	ZnO (100%)	3.25001	5.20603	47.62050	50.0152	2.31	1.72	1.95	1.18	1.62
5	ZnO (100%)	3.25026	5.20621	47.62947	54.7359	2.48	1.81	1.81	1.37	1.59
10	ZnO (95.6%)	3.25063	5.20641	47.64215	61.1884	2.29	1.72	1.89	1.21	1.64
	$ZnCo_2O_4$ (4.4%)	8.05246	-	522.139	18.3307					
15	ZnO (86.5%)	3.25117	5.20764	47.66924	68.2005	2.51	1.78	1.94	1.29	1.78
	$ZnCo_2O_4$ (13.5%)	8.07631	-	526.792	19.0952					
20	ZnO (84.9%)	3.25139	5.20836	47.68228	73.2398	2.67	1.69	2.01	1.33	1.81
	$ZnCo_2O_4$ (15.1%)	8.08134	-	527.776	22.1495					

Table S2. Average photovoltaic parameters for 0-20% cobalt doped ZnO/CuO heterojunction devices

Co%	V_{OC} (V)	J_{SC} (mA/cm^2)	FF (%)	η (%)	R_S (Ωcm^2)	R_{SH} (Ωcm^2)
0	0.4124±0.0086	8.105±0.1997	46.01±0.2339	1.473±0.0656	42.96±0.5969	576.9±9.982
5	0.4351±0.0060	8.753±0.1784	47.31±0.2823	1.749±0.0618	39.90±0.6614	607.8±10.18
10	0.4544±0.0075	9.174±0.2060	48.22±0.2446	1.870±0.0246	37.69±0.5012	641.0±7.212
15	0.4398±0.0062	7.650±0.3889	47.19±0.2195	1.486±0.0374	38.37±0.5904	582.5±5.749
20	0.4369±0.0076	6.069±0.2747	46.07±0.1728	1.387±0.0281	38.95±0.5631	584.3±11.82

Table S3. Average parameter extracted from dark J-V analysis for 0-20% cobalt doped ZnO/CuO heterojunction devices

Co%	n	$J_0 \times 10^{-4}$ (mA/cm^2)	R_S (Ωcm^2)	R_{SH} (Ωcm^2)
0	3.393±0.0649	8.382±0.2142	30.88±0.5554	736.4±12.73
5	3.196±0.0612	6.139±0.3371	28.96±0.5163	776.3±12.04
10	2.986±0.0657	4.754±0.3038	27.64±0.5332	827.6±10.01
15	3.635±0.0568	9.025±0.2739	35.81±0.6267	659.7±12.16
20	3.840±0.0563	9.501±0.2361	37.33±0.7151	617.7±10.77

Table S4. Parameter extracted from RC circuit fitting of 10% cobalt doped ZnO/CuO heterojunction samples with 0-40 nm thick MoO_3 layers.

MoO_3 (nm)	R_S (Ω)	R_{tr} (kΩ)	R_{rec} (kΩ)	CPE_{tr} (nF)	n1	CPE_μ (nF)	n2	C_{tr} (nF)	C_μ (nF)	$\tau = R_{rec}C_\mu$ (μS)
0	17.4	0.573	7.97	14.5	0.870	19.3	0.900	2.52	7.28	58.0
20	16.9	0.322	8.34	11.7	0.890	13.9	0.950	2.50	8.63	71.9
30	17.1	0.805	7.75	13.3	0.880	16.2	0.920	2.79	7.42	57.5
40	16.6	1.48	7.02	15.7	0.830	22.3	0.890	1.77	7.55	53.1