Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supporting Information

Novel ALD-assisted Growth of ZnO Nanorods on Graphene and Its Applications in $Cu_2ZnSn(S_xSe_{1-x})_4$ Solar Cells

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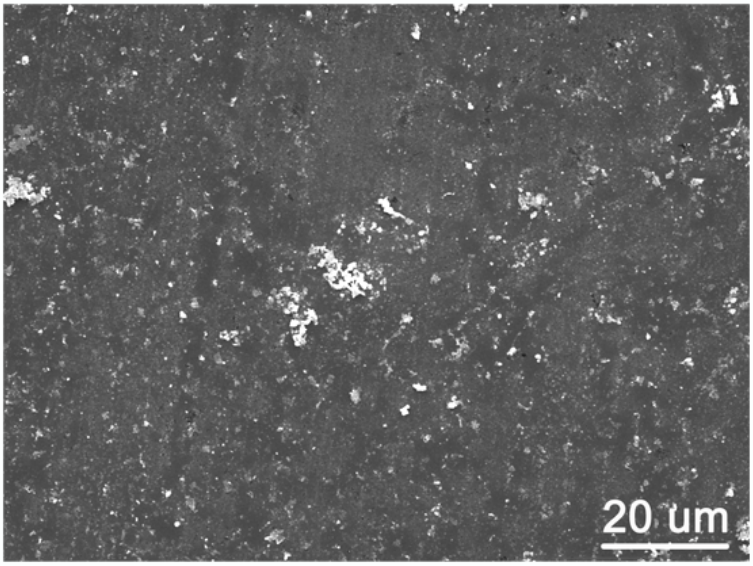
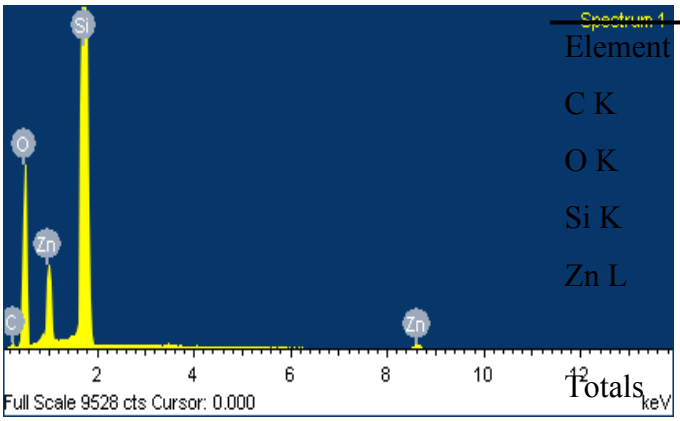
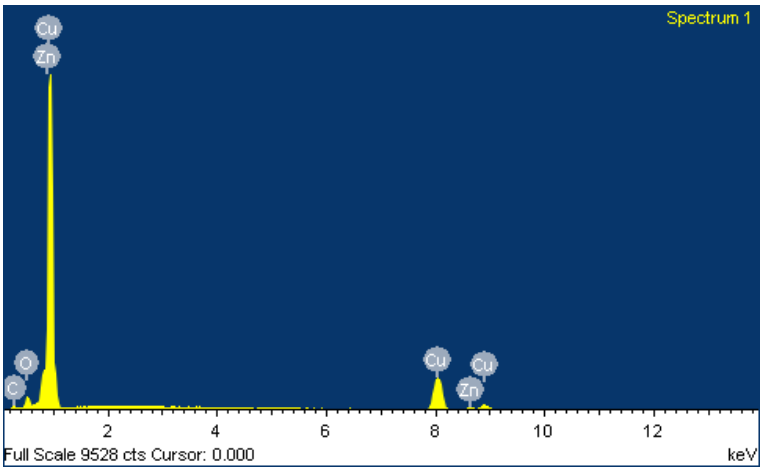




Element	Weight%	Atomic%
C K	3.77	7.25
O K	26.99	38.98
Si K	62.46	51.38
Zn L	6.78	2.39
Totals	100.00	

Figure S1. SEM and EDX spectra of ZnO deposited on SLG/SiO_2.The bright white part is dewetted ZnO islands. Note that the Zn content is only 2.39%, much smaller than ZnO deposited on SLG/Cu (see Figure S2).



Element	Weight%	Atomic%
C K	3.12	13.51
O K	3.11	10.10
Cu L	76.00	62.24
Zn L	17.78	14.15
Totals	100.00	

Figure S2. The EDX spectrum of ZnO deposited on SLG/Cu at 100 ^{o}C. Note that the Zn content is increased to 14.15%, showing the much improved wetting of graphene when it is in contact with copper.

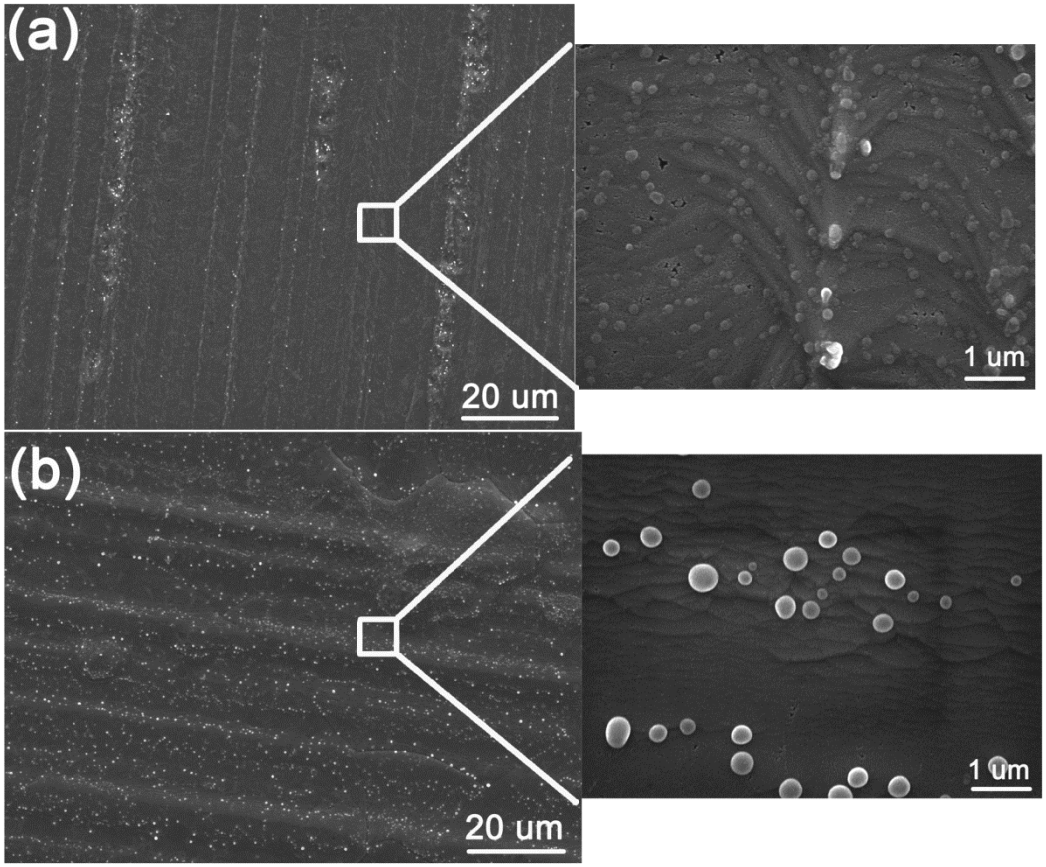


Figure S3. The effects of graphene thickness on ZnO seed layers. (a) three-layer graphene. (b) seven-layer graphene.

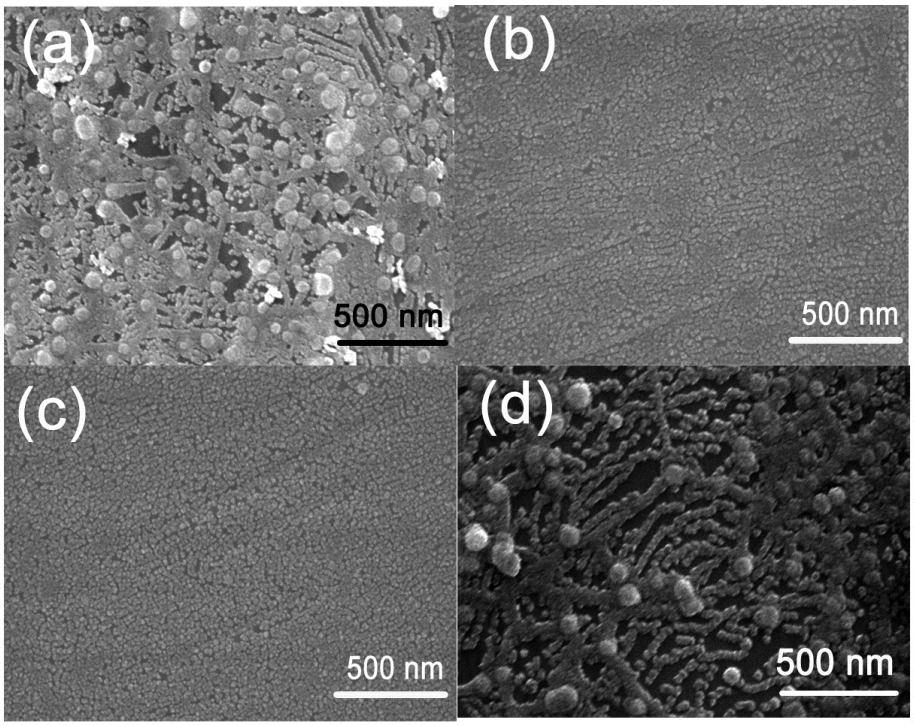


Figure S4. The effects of temperature on ZnO. (a) 90 °C. (b) 96 °C, (c) 104 °C, (d) 110 °C.

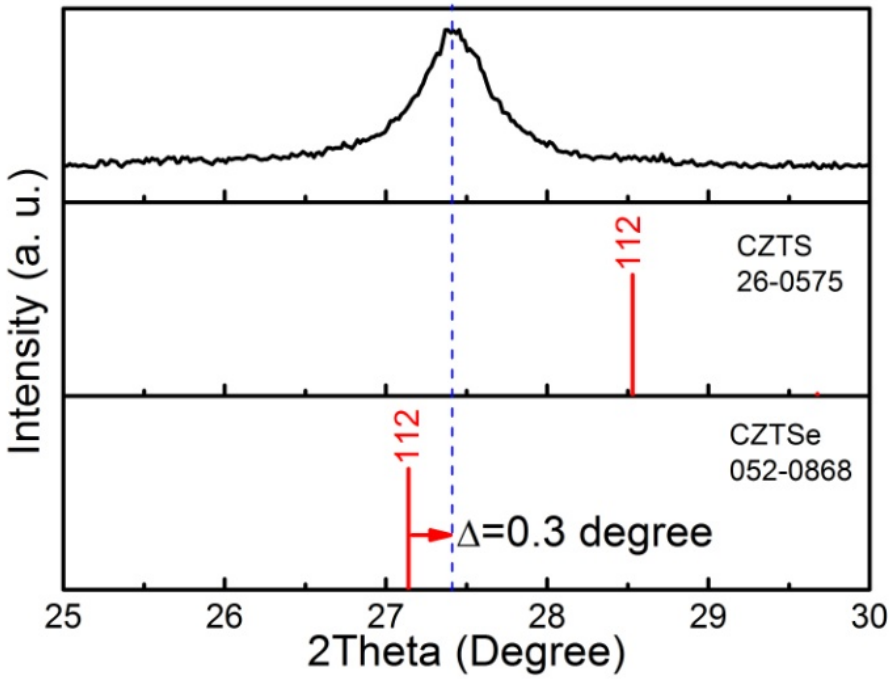


Figure S5. Enlarged XRD pattern of CZTSSe (112) peak. It moves to higher 2theta compared to the pure CZTSe, due to the remaining S atoms.

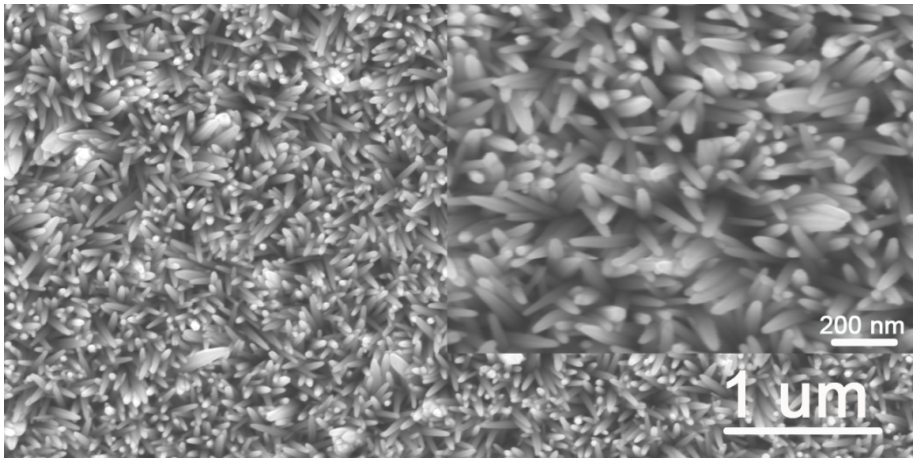


Figure S6. Top-down views of ZnO NRs. The diameters are estimated to be ~40 nm.

Table S1. Comparison of ITO- and graphene-based CZTS(Se) devices

Device	J_{sc} (mA/cm^2)	V_{oc} (V)	FF	PCE(%)
ITO-based (ITO/ZnO(NRs)/CdS/CZTS/Au)	4.1	0.68	0.44	1.2
Graphene-based (graphene/ZnO(NRs)/CdS/CZTSSe/Au. this work)	6.3	0.5	0.32	1.01