

## Supplementary Information

### **Formation of Ga double grading in submicron Cu(In,Ga)Se<sub>2</sub> solar cells by pre-depositing a CuGaSe<sub>2</sub> layer**

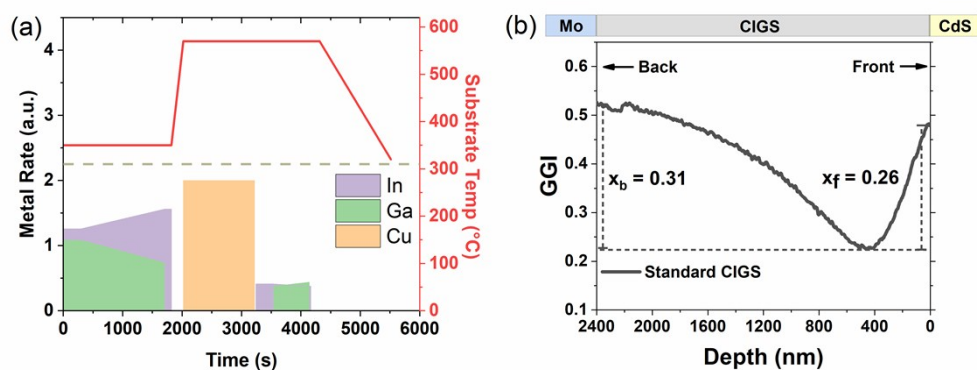
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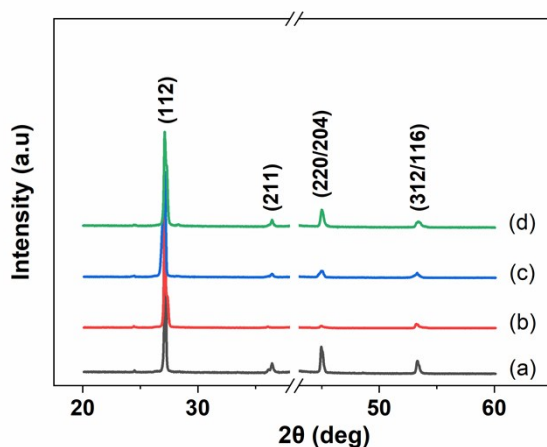
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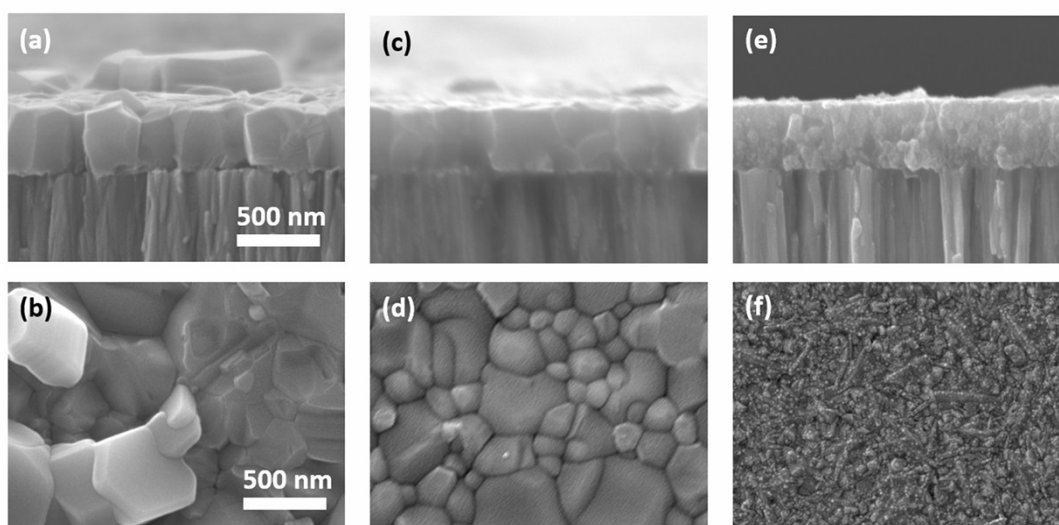
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**Fig. S1.** (a) Metal flux rates and sequences for a traditional three-stage growth profile of a standard thick CIGS film. (b) The corresponding GGI curve extracted from the SIMS results.



**Fig. S2.** XRD spectra of submicron thick CIGS films with different growth profiles: (a) traditional profile, (b) Ga-In-Ga extreme profile, (c) Ga-In extreme profile, (d) CGS+CIGS profile.



**Fig. S3.** SEM cross-sectional view and top view of CGS with different Cu/Ga ratio (a-b) Cu/Ga = 1.15, (c-d) Cu/Ga = 1, (e-f) Cu/Ga = 0.86.

**Table S1** Parameters of Ga grading of Sample D and E.

Sample	$x_b$	$x_f$	$GGI_{\min}$	$d_n$ (nm)
D	0.25	0.03	0.24	246
E	0.34	0.15	0.20	254