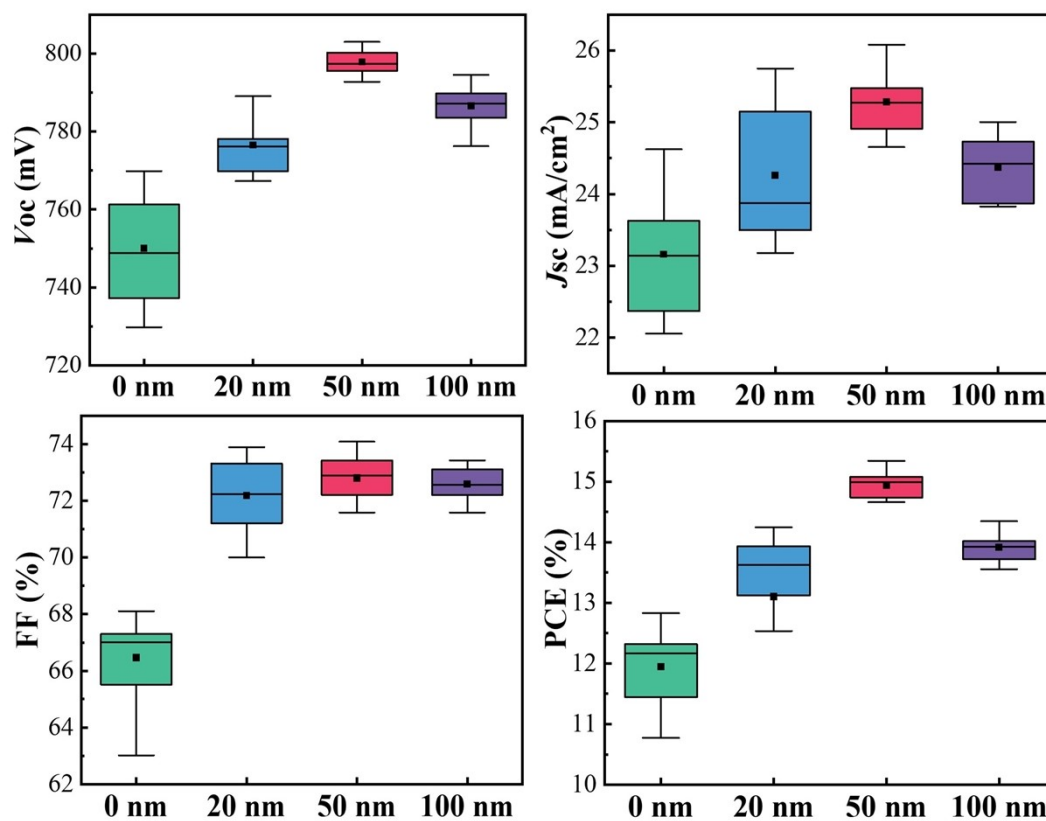
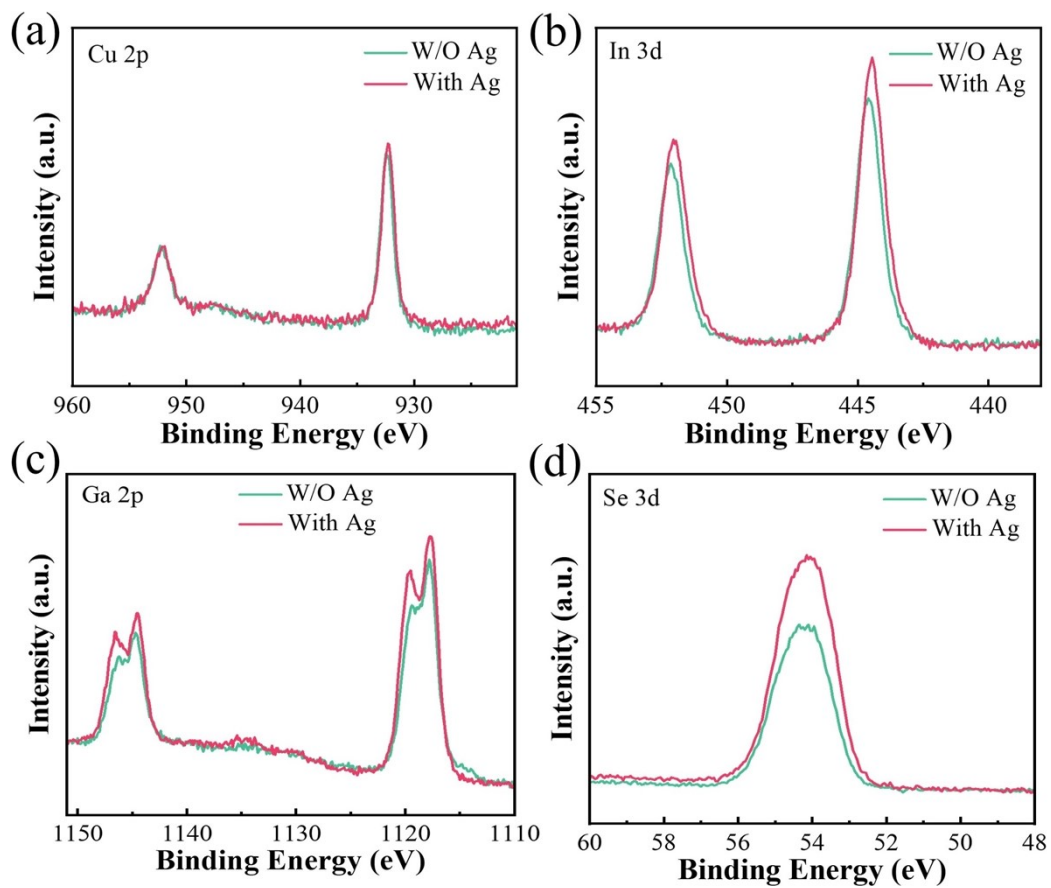


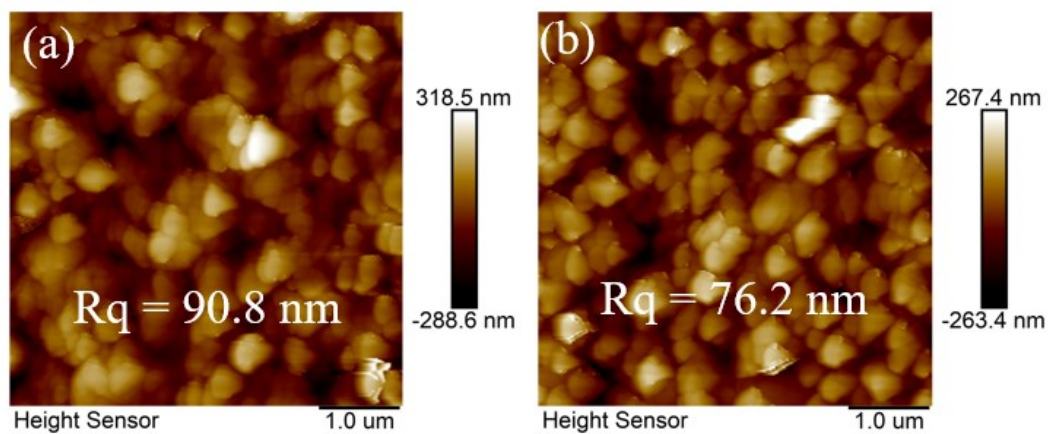
## Analysis of the mechanism for enhanced crystalline quality of wide-bandgap Cu(In,Ga)Se<sub>2</sub> films by pre-deposited Ag precursor



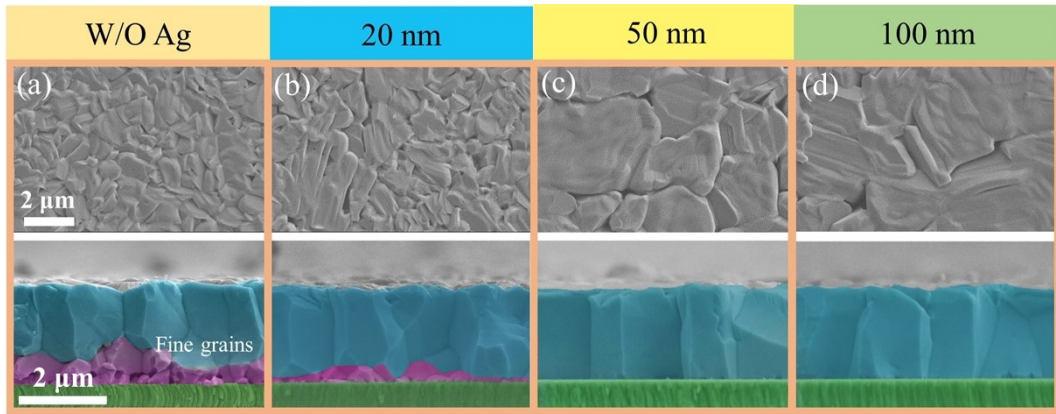
**Fig. S1** Statistic performance distribution of solar cells with different thicknesses of Ag.



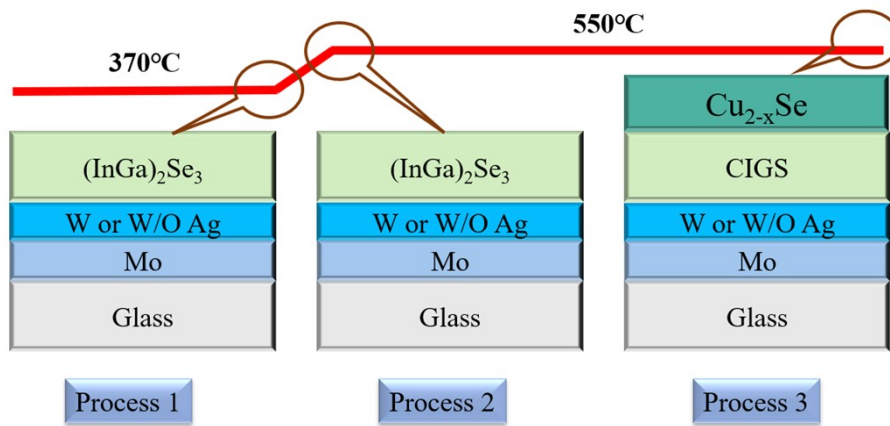
**Fig. S2** High-resolution XPS data Cu 2p, In 3d, Ga 2p and Se 3d, respectively.



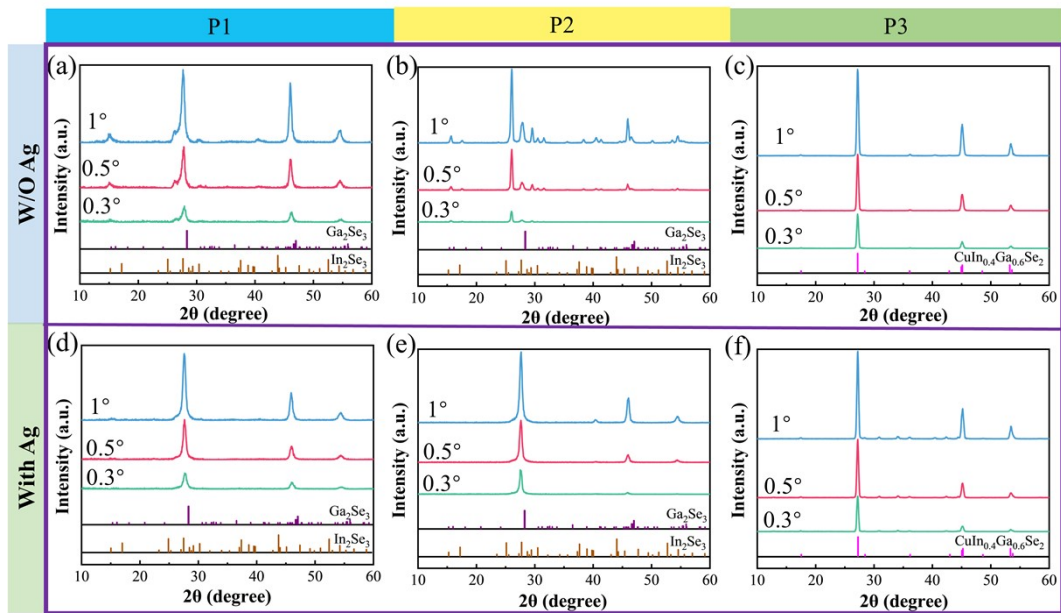
**Fig. S3** AFM images of CIGS film W/O (a) and with (b) Ag precursor.



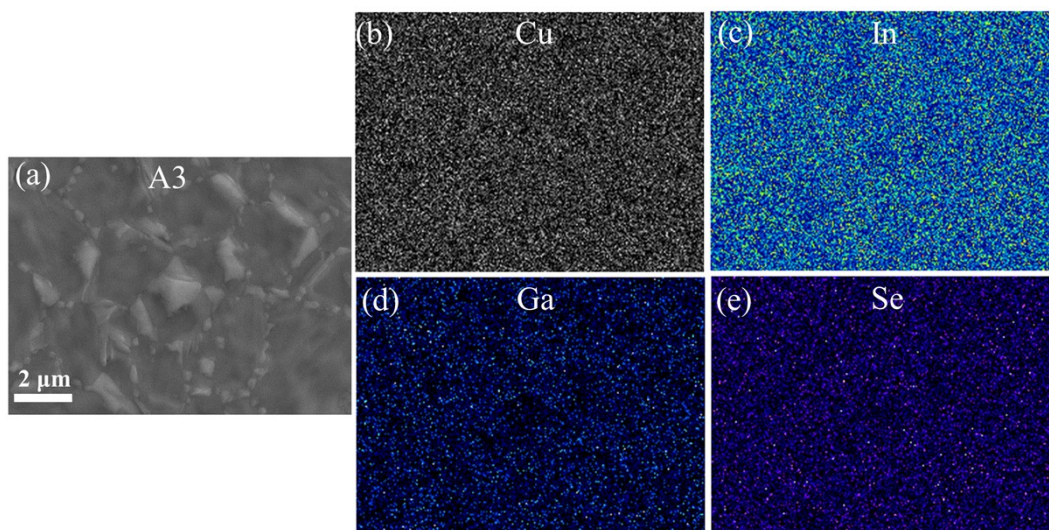
**Fig. S4** Plan-view and cross-sectional SEM images of CIGS films with various thickness of Ag alloying: (a) 0 nm, (b) 20 nm, (c) 50 nm, (d) 100 nm.



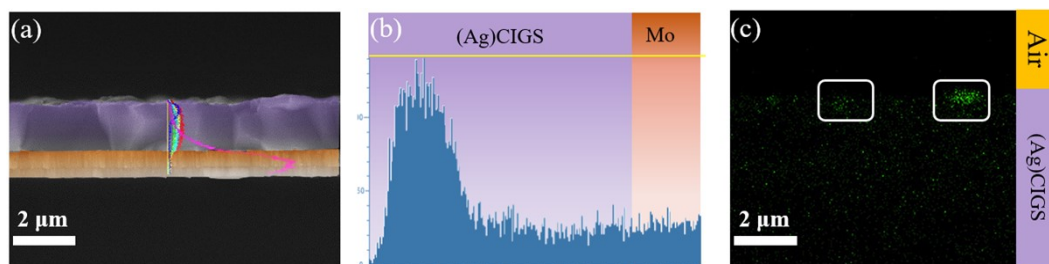
**Fig. S5** The time points selected for different groups of samples



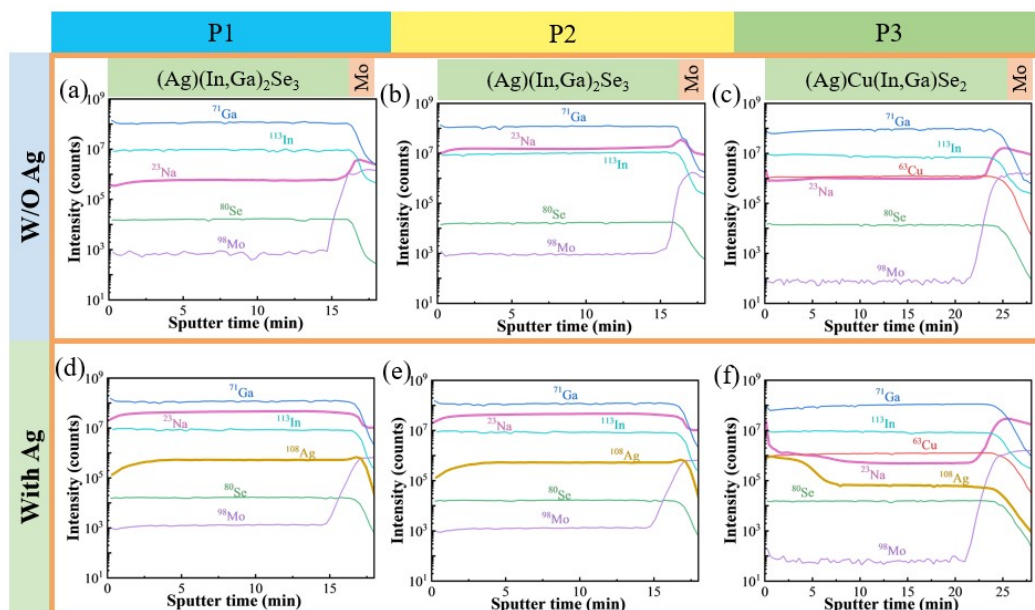
**Fig. S6** GIXRD scans at 0.3°, 0.5° and 1° for sample with (S2d-f) and without (S2a-c) Ag precursor at different stage.



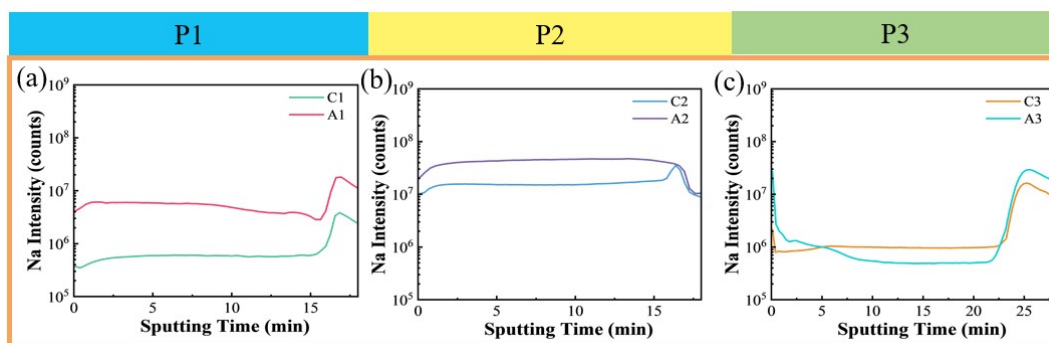
**Fig. S7** Top-views SEM image of A3 sample and corresponding EDS elements distributions.



**Fig. S8** (a) Cross-sectional SEM of A3 and corresponding Ag elemental line (b) and surface (c) scan results.



**Fig. S9** SIMS profiles showing all relevant elements from the surface to the back contact (Mo) obtained from representative film with and without Ag precursor at different evaporation stage. (a) C1, (b) C2, (c) C3, (d) A1, (e) A2, (f) A3.



**Fig. S10** The distribution profiles of Na elements in different samples. Profiles were measured by SIMS from front surface (left) to Mo interface (right).