Supporting information

11.3 % efficient Cu(In,Ga)(S,Se)$_2$ thin film solar cells by drop-on-demand inkjet printing

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Figure S1 Image and result of drop analysis. The drop analysis is obtained from the software integrated in the printing software.

Figure S1 shows that a single droplet can be formed by using the formulated Cu-In-Ga ink. The volume of the droplet is 14.6 pl as estimated by using the integrated software (Figure S1). The volume of the ink used for printing one layer on an inch by inch substrate is less than 2.5 µL as calculated by the following equation:

\[ V_1 = V_{\text{droplet}} \times R_x \times R_y \]

Where \( V_1 \) is the volume of ink for one printing, \( V_{\text{droplet}} \) is the volume for a single droplet, \( R_x \) and \( R_y \) are printing resolutions in x and y direction, respectively.
Figure S2 Comparison of simulated and experimental external quantum efficiencies. For better comparison, all the EQE curves are normalized.

Figure S3 SEM images of a 1.4 µm thick Cu(In,Ga)(S,Se)2 solar cell and its J-V characteristics under standard AM 1.5 illumination. The thicknesses of the large grained layer and the fine grained layer are around 0.67 µm and 0.73 µm, respectively.