Supporting information

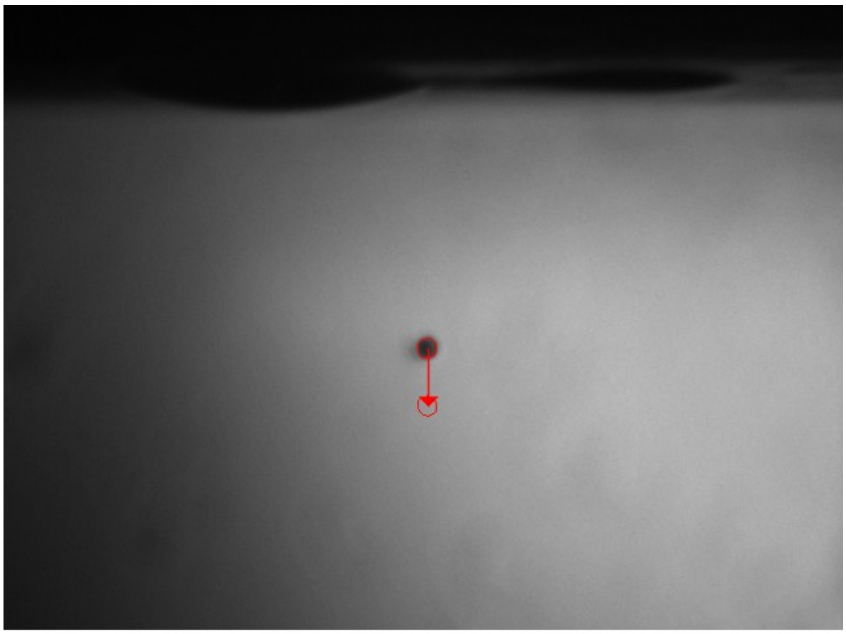
11.3 % efficient $Cu(In,Ga)(S,Se)_2$ thin film solar cells by drop-on-demand inkjet printing

Xianzhong Lin[1*], Reiner Klenk[1], Lan Wang[1], Tristan Köhler[1], Jürgen Albert[1], Sebastian Fiechter[1], Ahmed Ennaoui[1,2], Martha Ch. Lux-Steiner[1,3]

[1] Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, D-14109 Berlin, Germany

[2] Qatar Environment and Energy Research Institute and College of Science and Engineering (CSE), Hamad Bin Khalifa University, Education City, Doha, Qatar

[3]Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin, Germany



	v (m/s)	V (pl)	X (µm)	Y (µm)	Angle (°)
→	1.81	± 14.6	669	545	0.03°

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:

$V_1 = V_{droplet} * R_x * R_y$

Where V_1 is the volume of ink for one printing, $V_{droplet}$ is the volume for a single droplet, Rx and Ry are printing resolutions in x and y direction, respectively.

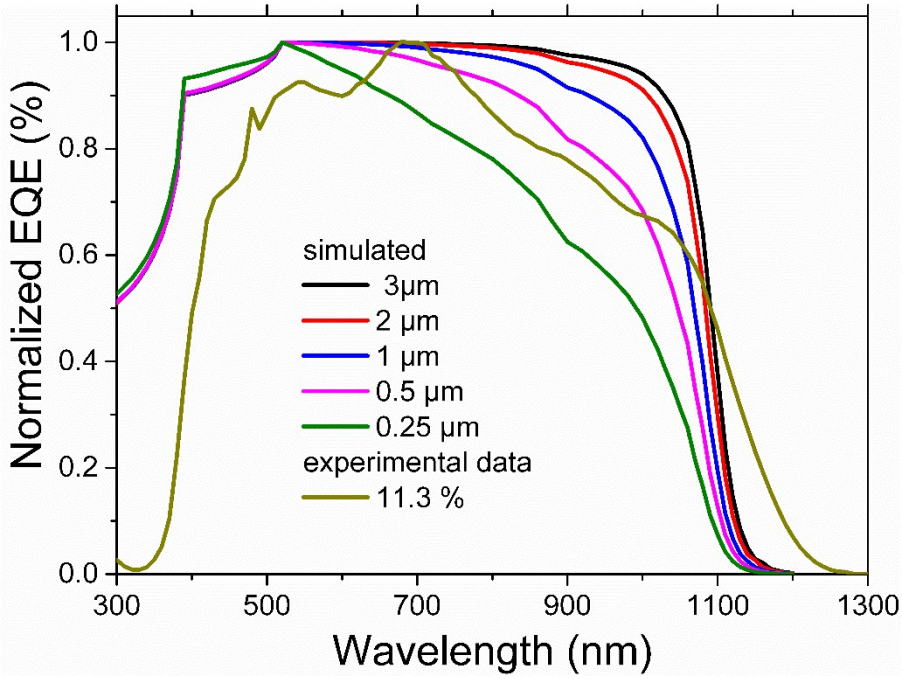


Figure S2 Comparison of simulated and experimental external quantum efficiencies. For better comparison, all the EQE curves are normalized.

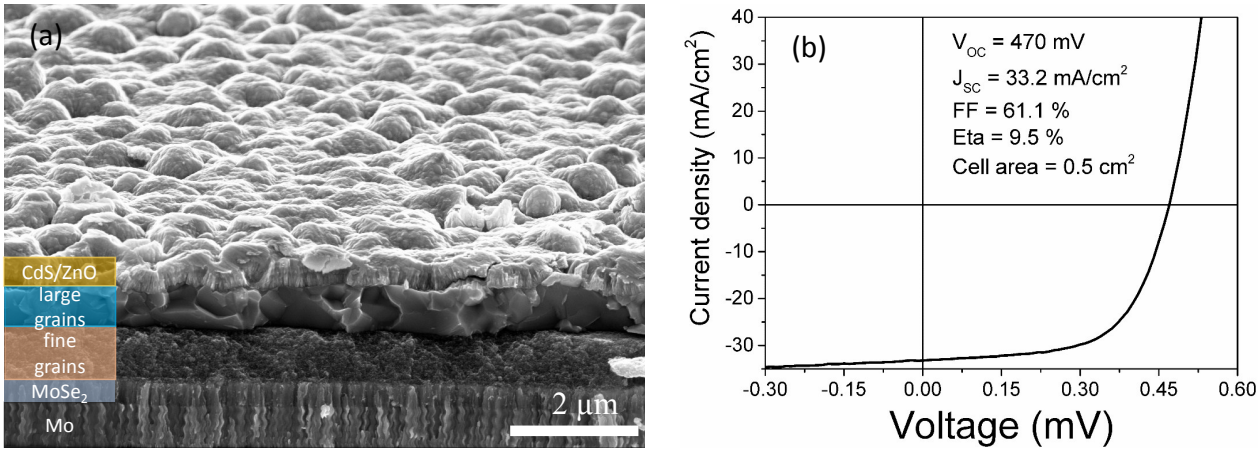


Figure S3 SEM images of a 1.4 µm thick Cu(In,Ga)(S,Se)2 solar cell and its J-V characteristics under standard AM 1.5 illumination. The thicknesses of the large grained layer and the fine grained layer are around 0.67 µm and 0.73 µm, respectively.