Rapid thermal annealing process for Se thin-film solar cells

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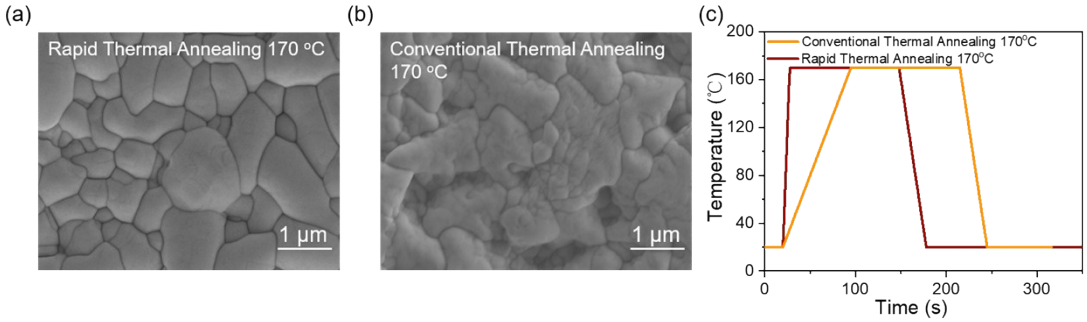

Fig. S1 The SEM image of Se thin films treated with (a) rapid thermal annealing (RTA) and (b) conventional thermal annealing at the same 170 °C. (c) The heating curves of the RTA and the conventional thermal annealing.

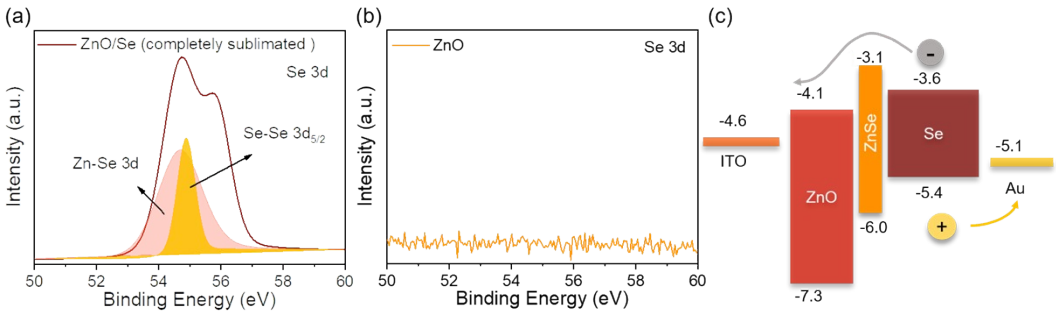

Fig. S2 XPS Se_{3d} spectrum of (a) ZnO/Se (completely sublimated) and (b) pure ZnO. (c) The energy

level diagram of Se solar cell considering the ZnSe at ZnO/Se interface.[1]

Supplementary experiment to confirm the existence of Zn-Se bonds at the ZnO/Se interface:

The Se film of 100 nm was deposited on a ZnO substrate with thermal evaporation. The ZnO/Se sample was treated with RTA at 220 ºC for 2 minutes to ensure the Se film was completely sublimated. XPS characterization was performed on ZnO/Se (completely sublimated) and pure ZnO (Figure S2a,b) to confirm the presence of Zn-Se.

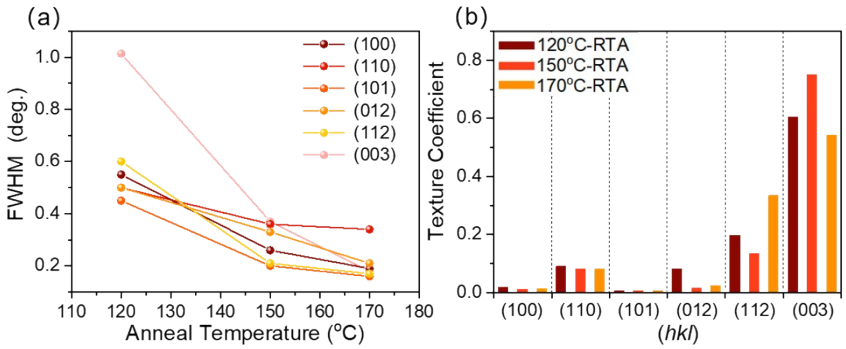

Fig. S3 (a) FWHM and (b) Texture coefficients of [100], [110], [101], [012], [112] and [003] crystal plane of Se thin films that annealed at 120 °C, 150 °C and 170 °C.

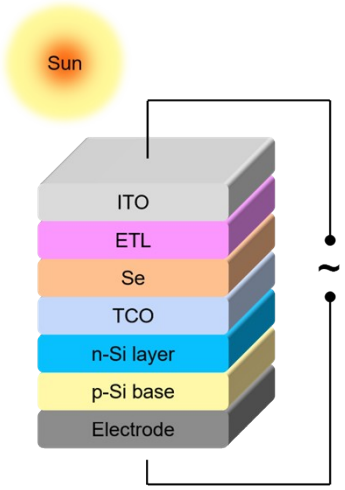

Fig. S4 The structure diagram of the Se solar cell integrating with a Si bottom cell.

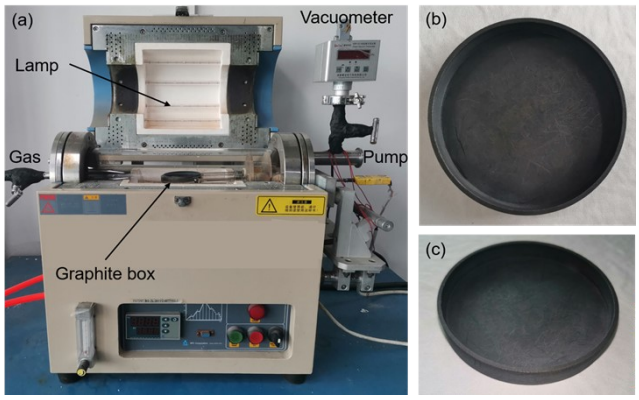

Fig. S5 The photographs of our RTA (a) and the graphite box from (b) the top and (c) side.

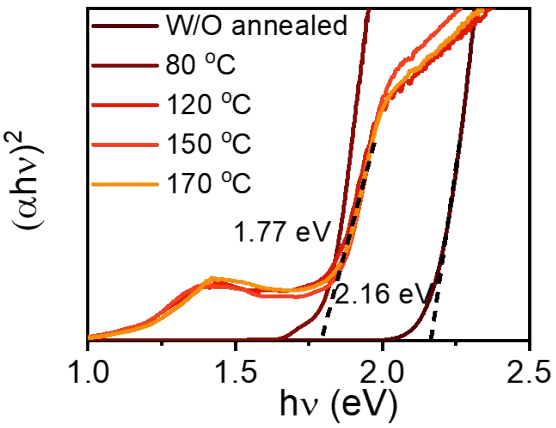

Fig. S6 Tauc plots of Se thin films before and after RTA treatment at 80 ℃, 120 ℃, 150 ℃ and 170 ℃. The optical bandgap can be determined from the Tauc plots.

Table S1 Solar cell parameters of our Se thin-film cell, the record device[2] and the SQ limit.[3, 4]

Device	PCE (%)	FF (%)	V_{OC} (mV)	J_{SC} (mA cm^{-2})
SQ limit	23.9	92.1	1650	15.7
Record ZnMgO/Se/MoO_x/Au	6.51	63.4	969	10.6
Our cell ZnO/Se/Au	3.22	50.93	639	9.9

Notes and references

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3. S. S. Hegedus and W. N. Shafarman, *Prog. Photovolt: Res. Appl.*, 2004, **12**, 155-176.
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