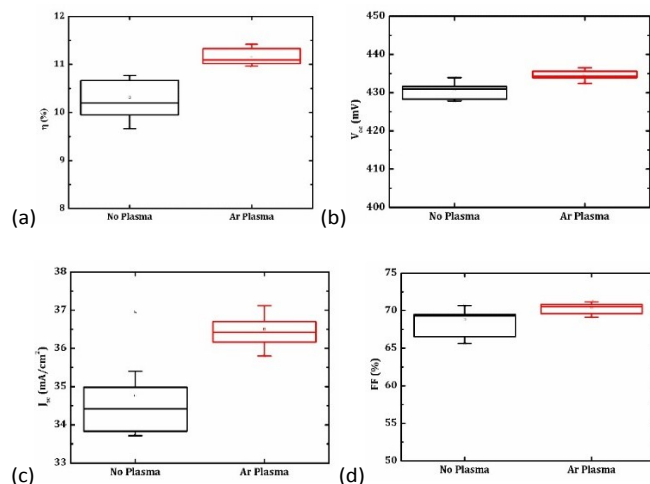


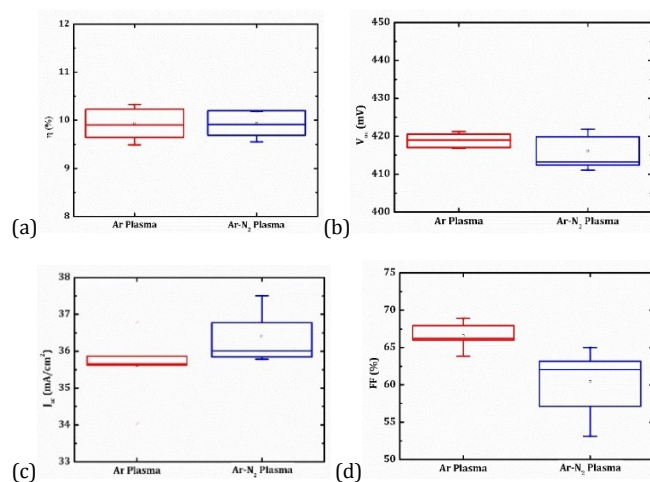
## Supplementing information

The influence of the Ar plasma treatments on the device performance is shown in Fig. S1. The solar cells prepared from an Ar plasma-treated Mo back contact show an enhancement in all parameters with high statistical reproducibility. This is ascribed to the more uniform CZTSe/MoSe<sub>2</sub>/Mo interfaces with less thickness variation of the MoSe<sub>2</sub>, as discussed in the main manuscript, which could lead to a general improvement of the CZTSe/back contact interface quality. Possibly, a clean Mo surface also ensures the formation of a purer CZTSe absorber without excessive defects, because adverse effects from contaminants on the reaction process during annealing are reduced.



**Fig. S1** Box plots of solar cell parameters for the samples without and with Ar plasma treatments. For each type of back contacts, 6 cells are included.

For solar cells with mixed Ar-N<sub>2</sub> plasma treatments, the device performance compared to that with Ar plasma treatment is shown in Fig. S2. Note that the two Ar plasma-treated samples shown in Fig. S1 and S2 were fabricated in a different batch. The comparison of the pure Ar and the Ar-N<sub>2</sub> plasma-treated samples shows no clear trend. Although the Ar-N<sub>2</sub> plasma treatment on Mo can reduce the thickness of the formed MoSe<sub>2</sub> layer, no clear noticeable performance difference is observed.



**Fig. S2** Box plots of solar cell parameters for the samples with Ar and standard Ar-N<sub>2</sub> plasma treatments. For each type of back contacts, 6 cells are included.