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$_2$/Mo interfaces with less thickness variation of the MoSe$_2$, 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$_2$ 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$_2$ plasma-treated samples shows no clear trend. Although the Ar-N$_2$ plasma treatment on Mo can reduce the thickness of the formed MoSe$_2$ 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$_2$ plasma treatments. For each type of back contacts, 6 cells are included.