Supplementary Legends

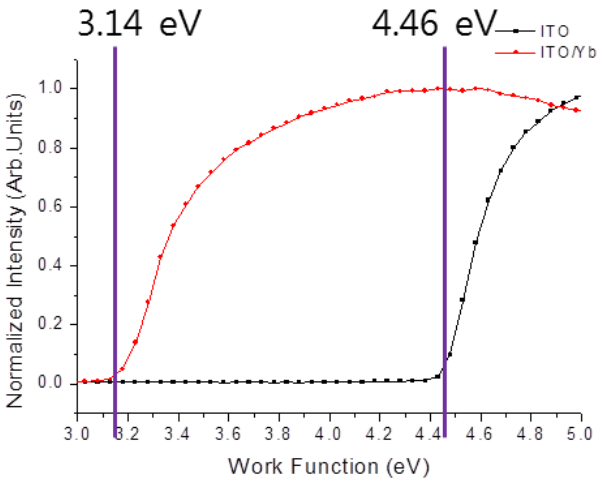


Fig. S1 The work function of Yb on ITO and ITO by UPS analysis

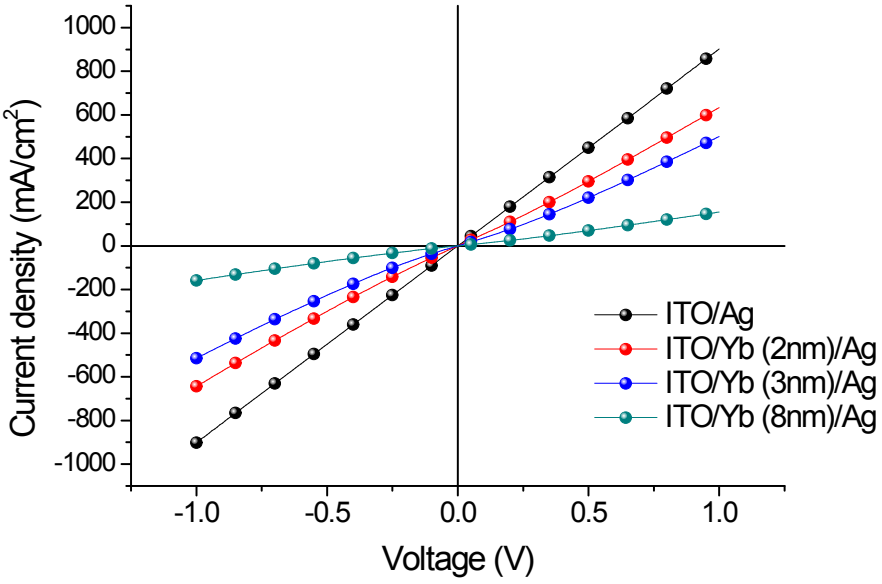


Fig. S2 I-V curve for the samples composed of ITO/Yb(20 Å)/Ag and the samples composed of ITO/Ag

The I-V curve for the sample composed of ITO/Yb/Ag reveals the ohmic properties of the sample. The resistance of the sam ple composed of ITO/Yb/Ag increases when the thickness of Yb increases. This indicates that the thickness of Yb on ITO is a critical factor in determining the series resistance of the entire device on the inverted OPV when it is used. As shown, even slight increases in Yb thickness affect the Rs values having low values of I-V slope. Even though the value of Rs increases, a ll samples using Yb show signs of ohmic contact implying that Yb is energetically well matched with the ITO in inverted OP Vs.

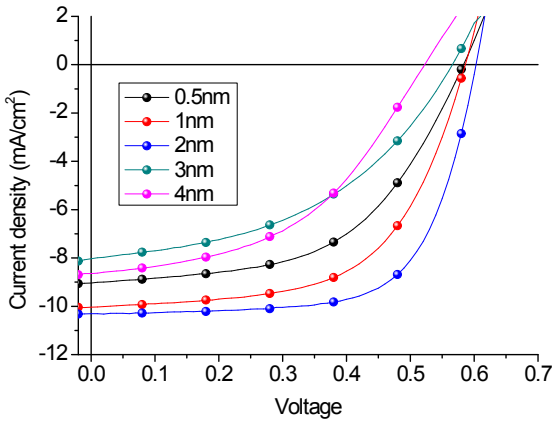


Fig. S3 J-V curve of the inverted OPV featuring Yb with varying thicknesses

Table S1 Parameters of the Inverted OPV with Varying Thicknesses of Yb

Yb [nm]	Jsc [mA/cm^2]	Voc [V]	FF	PCE [%]
0.5	9.04	0.58	0.53	2.8
1	10.04	0.59	0.58	3.46
2	10.32	0.6	0.67	4.15
3	8.65	0.52	0.47	2.12
4	8.03	0.57	0.45	2.04

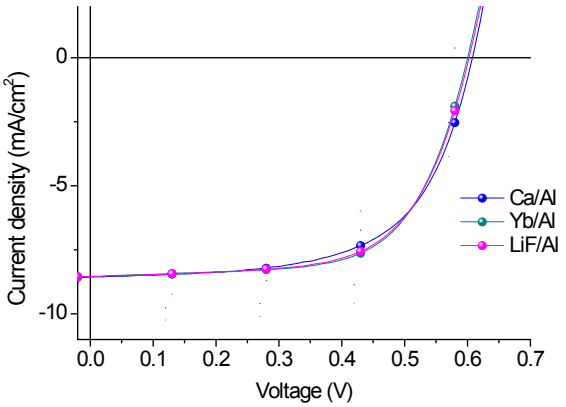


Fig. S4 The J-V curve for the conventional OPVs with Ca, Yb and LiF as ETLs

As shown in S2, the use of Yb is not superior in conventional OPVs as it achieves values of PCE similar to those of other ETLs such as LiF and Ca. The advantage of using Yb in inverted OPVs is realized in its improvements in power conversion efficiency and air stability

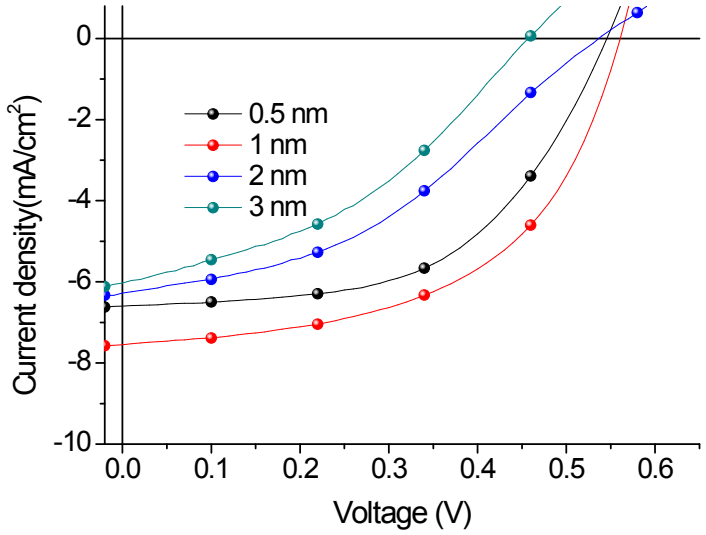


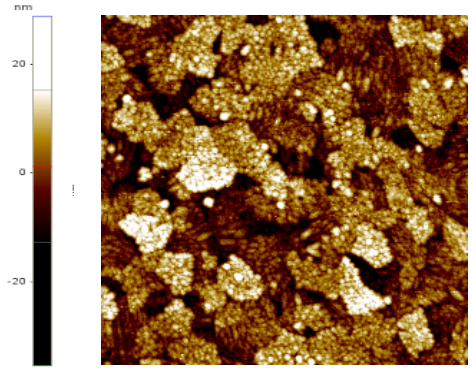
Fig. S5 J-V curve for the inverted OPV with LiF at thicknesses varying from 0.5 nm to 3nm

Table S2 Parameters of the Inverted OPV with LiF at Thicknesses Ranging from 0.5 nm to 3nm

Thickness of LiF [nm]	Jsc [mA/cm^2]	Voc [V]	FF	PCE [%]
0.5	6.60	0.55	0.55	1.96
1	7.54	0.56	0.54	2.27
2	6.60	0.54	0.41	1.47
3	6.03	0.46	0.39	1.08

Using a manner similar to the method used to optimize the inverted OPV with Yb, we constructed the inverted OPV with Li F at varying thicknesses. When the thickness of LiF is larger than 2nm, s-shape curves occur, resulting in poor performances. In the case of LiF, a thickness of 1 nm achieved the best PCE, 2.27%.

(a)



(b)

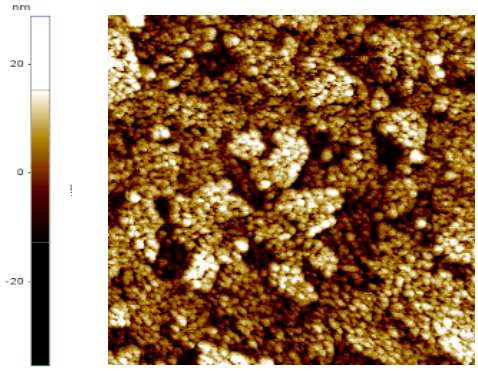


Fig.S6 (a) AFM image of Yb (2 nm) on ITO (b) AFM image of LiF (2 nm) on ITO

As shown in Fig.S6, the surface of Yb on the ITO is more densely distributed compared to that of LiF even whe n the two elements have the same thicknesses. The roughness value of the Yb on the ITO is 1.84 nm while that o f the LiF is 3.417 nm. As such, the surface of Yb is smoother than that of LiF which allows for lesser interface r esistance between the ETL and the active layer. The surface properties of the ETL are critical especially in inver ted OPVs as the active layer is deposited onto the surface of the ETL. The dense distribution and low surface ro ughness of Yb on the ITO compared to LiF lead to the ideal interface between the ETL and the active layer, as t hey allow for low values of Rs and reduce short circuiting.

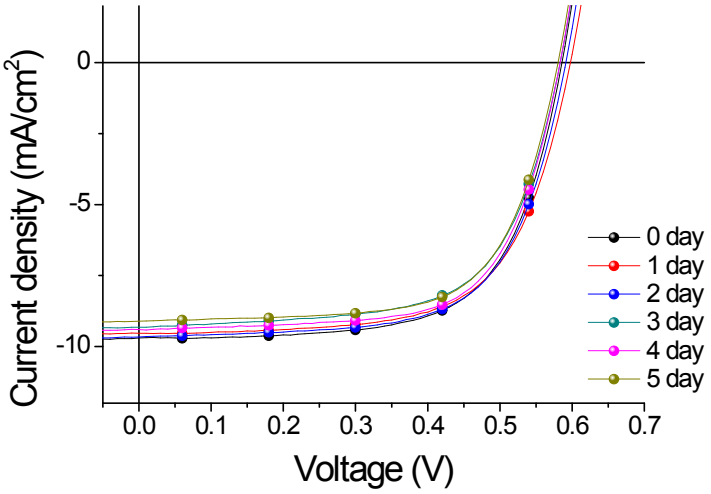


Fig. S7 The J-V curve for the inverted OPV with PEIE over time.

Table S3 Parameters of the Inverted OPV with PEIE over Time

	Jsc [mA/cm2]	Voc [V]	FF	PCE [%]	Rs [Ωcm^2]
0 day	9.71	0.59	0.63	3.61	2.35
1 day	9.54	0.60	0.63	3.60	2.38
2 day	9.66	0.59	0.63	3.59	2.41
3 day	9.33	0.58	0.63	3.41	2.41
4 day	9.41	0.58	0.62	3.38	2.47
5 day	9.10	0.58	0.62	3.27	2.55

The Rs of the inverted OPV with PEIE is likely to increase, which is contrary to the Rs of the inverted OPV with Yb.

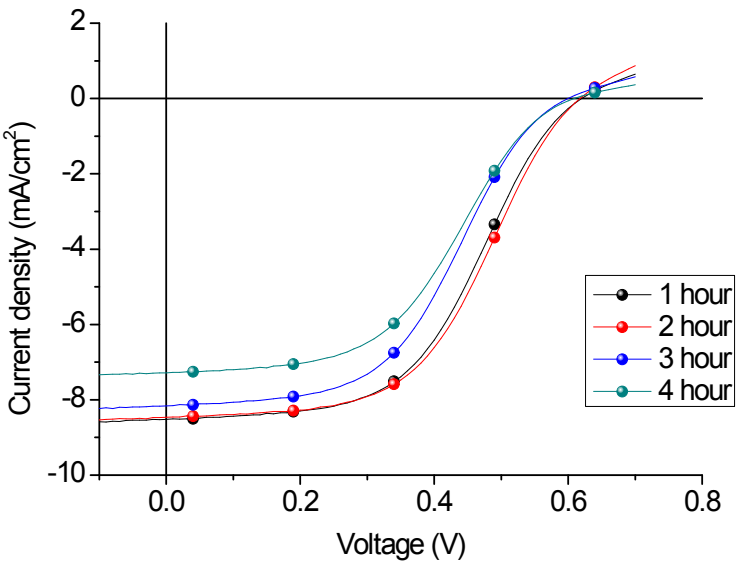


Fig. S8 J-V curve of the OPV with Yb where Yb is exposed to ambient air before the deposition of the active layer under various exposure times

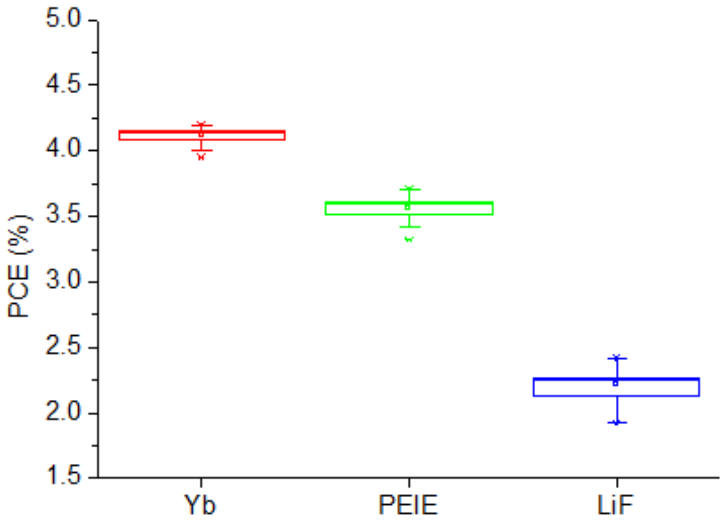


Fig. S9 Box and whisker plot of the PCE of the inverted OPVs with each ETL.

Table S4 Standard Deviation of PCEs and Average PCE of 24 samples with Each ETL

	Standard deviation of PCE	Average PCE
Yb	0.060	4.120
PEIE	0.087	3.567
LiF	0.120	2.216

The statistical data was gathered from 24 devices with each ETL (Yb (2 nm), PEIE (3 nm), LiF (1.5nm)) immediately after t heir fabrication. The highest recorded PCE for each ETL, Yb , PEIE and LiF were found to be 4.2 %, 3.71 % and 2.42 % res pectively. In this paper, we chose the cells with the ETL whose PCE was closest to the average PCE.