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SUPPORTING INFORMATION

Table S1: Average photovoltaic performance of $MA_{0.57}FA_{0.38}Rb_{0.05}PbI_3$ PSCs (FB-SC scan direction, scan rate of 0.05 V/s) having different layer thickness of fullerene film along with an optimized 45 nm sol-gel ZnO film ETL

Fullerene Layer Thickness (nm)	Open Circuit Voltage, V_{OC} (mV)	Short Circuit Current Density, J_{SC} (mA/cm^2)	Fill Factor, FF (%)	Average Efficiency (%)
0	962.57	21.53	63.93	13.25
~20	981.33	21.78	67.45	14.42
~35	1013.98	22.14	70.19	15.76
~55	992.25	21.62	66.27	14.22
~70	955.43	20.91	59.86	12.79

Table S2: JV parameters (V_{OC}, J_{SC}, FF and PCE values) of ten (10) ITO/ZnO/$MA_{0.57}FA_{0.38}Rb_{0.05}PbI_3$ perovskite/Spiro-OMeTAD/Ag devices (ZnO devices) in FB-SC direction from a single, random batch at a scan rate of 0.05 V/s

Sample No.	Open Circuit Voltage, V_{OC} (mV)	Short Circuit Current Density, J_{SC} (mA/cm^2)	Fill Factor, FF (%)	Efficiency (%)	Series Resistance, R_S (Ω.cm^2)	Shunt Resistance R_{Sh} (Ω.cm^2)
1	970.06	21.51	64.02	13.36	7.79	1566
2	963.43	21.44	63.85	13.19	7.83	1472
3	965.04	21.57	63.75	13.27	7.88	1472
4	960.39	21.49	63.73	13.15	7.83	1463
5	961.78	21.41	63.28	13.03	8.37	1490
6	969.38	21.38	64.67	13.41	7.56	1358
7	959.21	21.81	64.59	13.51	7.43	1366
8	962.44	21.42	63.66	13.12	7.88	1553
9	954.66	21.68	64.42	13.33	7.43	1484
10	959.30	21.59	63.31	13.11	8.28	1350

Table S3: JV parameters (V_{OC}, J_{SC}, FF and PCE values) of ten (10) ITO/C-ZnO/$MA_{0.57}FA_{0.38}Rb_{0.05}PbI_3$ perovskite/Spiro-OMeTAD/Ag devices (C-ZnO devices) in FB-SC direction from a single, random batch at a scan rate of 0.05 V/s

Sample No.	Open Circuit Voltage, V_{OC} (mV)	Short Circuit Current Density, J_{SC} (mA/cm^2)	Fill Factor, FF (%)	Efficiency (%)	Series Resistance, R_S (Ω.cm^2)	Shunt Resistance R_{Sh} (Ω.cm^2)
1	1012.45	22.23	70.01	15.76	6.26	1798
2	1027.53	22.07	70.67	16.03	6.30	1731
3	1020.03	22.04	70.51	15.85	6.21	1744
4	1014.16	22.20	69.07	15.55	6.57	1744
5	1007.09	22.22	69.92	15.64	6.26	1812
6	1001.58	22.17	70.75	15.71	6.21	1893
7	1012.14	22.08	70.41	15.73	6.26	1821
8	1008.90	22.22	69.89	15.67	6.30	1830
9	1015.93	22.16	70.18	15.80	6.21	1735
10	1019.86	22.11	70.29	15.85	6.17	1739

Table S4: JV parameters (V_{OC}, J_{SC}, FF and PCE values) of ten (10) ITO/P-ZnO/$MA_{0.57}FA_{0.38}Rb_{0.05}PbI_3$ perovskite/Spiro-OMeTAD/Ag devices (P-ZnO devices) in FB-SC direction from a single, random batch at a scan rate of 0.05 V/s

Sample No.	Open Circuit Voltage, V_{OC} (mV)	Short Circuit Current Density, J_{SC} (mA/cm^2)	Fill Factor, FF (%)	Efficiency (%)	Series Resistance, R_S (Ω.cm^2)	Shunt Resistance R_{Sh} (Ω.cm^2)
1	978.29	22.38	67.02	14.68	7.52	1760
2	977.69	22.31	66.51	14.51	6.83	1611
3	980.47	22.36	68.38	14.99	6.80	1827
4	976.73	22.41	64.79	14.18	7.05	1611
5	978.29	22.38	67.02	14.68	7.52	1760
6	973.65	22.37	64.72	14.09	6.91	1755
7	981.81	22.49	67.62	14.93	7.25	1688
8	982.71	22.31	64.89	14.22	7.51	1665
9	984.52	22.29	65.37	14.34	7.69	1728
10	979.09	22.43	65.63	14.41	7.37	1593

Table S5: Stabilized current density and PCE of ZnO, C-ZnO and P-ZnO devices at maximum power point (MPP)

Device	Voltage at MPP (V)	Stabilized PCE (%)	Stabilized Current Density (mA/cm^2)
ZnO	~0.71	~12.83	~18.56
C-ZnO	~0.82	~15.10	~19.33
P-ZnO	~0.76	~14.31	~19.43

Table S6: Start, peak and end binding energy of elemental peaks, peak width/full width at half maximum and atomic percentage of ZnO ETL film calculated by the spectral fitting from X-Ray photoelectron spectroscopy (XPS) data

Peak	Start Binding Energy (eV)	Peak Binding Energy (eV)	End Binding Energy (eV)	Full Width at Half Maximum (FWHM) (eV)	Atomic Percentage (%)
O_{1s} A	534.91	529.90	526.40	1.31	33.19
O_{1s} B	534.91	531.56	526.40	1.31	11.22
Zn_{2p}	1050.50	1021.26	1015.70	1.60	51.20
C_{1s}	297.30	285.00	281.20	1.71	4.39

Table S7: Start, peak and end binding energy of elemental peaks, peak width/full width at half maximum and atomic percentage of C-ZnO ETL film calculated by the spectral fitting from X-Ray photoelectron spectroscopy (XPS) data

Peak	Start Binding Energy (eV)	Peak Binding Energy (eV)	End Binding Energy (eV)	Full Width at Half Maximum (FWHM) (eV)	Atomic Percentage (%)
C_{1s} A	292.16	284.80	281.16	1.19	5.25
C_{1s} B	292.16	285.77	281.16	1.18	4.26
C_{1s} C	292.16	286.81	281.16	1.19	1.15
C_{1s} D	292.16	289.46	281.16	1.45	3.76
O_{1s} A	535.36	530.55	526.66	1.13	26.25
O_{1s} B	535.36	532.02	526.66	1.66	19.64
Zn_{2p}	1025.86	1021.91	1017.86	1.61	39.70

Table S8: Start, peak and end binding energy of elemental peaks, peak width/full width at half maximum and atomic percentage of P-ZnO ETL film calculated by the spectral fitting from X-Ray photoelectron spectroscopy (XPS) data

Peak	Start Binding Energy (eV)	Peak Binding Energy (eV)	End Binding Energy (eV)	Full Width at Half Maximum (FWHM) (eV)	Atomic Percentage (%)
C_{1s} A	291.98	284.80	282.08	0.82	78.11
C_{1s} B	291.98	285.52	282.08	0.82	5.48
C_{1s} C	291.98	287.00	282.08	0.82	1.25
C_{1s} D	291.98	289.08	282.08	1.32	2.41
C_{1s} E	291.98	290.81	282.08	1.32	1.11
O_{1s} A	535.98	530.84	528.18	1.21	4.19
O_{1s} B	535.98	532.15	528.18	1.21	3.17
O_{1s} C	535.98	533.43	528.18	1.21	1.58
Zn_{2p}	1025.9	1022.12	1016.38	1.50	2.71

Table S9: Relative normalized peak intensity, peak width and estimated dimension of individual crystallite, microstrain and dislocation density of $MA_{0.57}FA_{0.38}Rb_{0.05}PbI_3$ perovskite films on top of ZnO, C-ZnO and P-ZnO films, calculated by the spectral fitting from XRD measurement data

Characteristic Peak	ETL Layer underneath perovskite	Relative Normalized Peak Intensity	Peak Width (FWHM) (Degree)	Crystallite Size (nm)	Microstrain ($x10^{-3}$)	Dislocation Density ($x10^{11}$ cm^{-3})
(110)	P-ZnO	0.87	0.33533	24.94	11.95	1.75
	C-ZnO	1.00	0.30542	27.38	10.90	1.45
	ZnO	0.97	0.30919	27.05	11.04	1.49
(220)	P-ZnO	0.51	0.29686	28.83	5.16	1.31
	C-ZnO	0.53	0.28689	29.83	4.98	1.23
	ZnO	0.50	0.33011	25.93	5.73	1.62
(310)	P-ZnO	0.40	0.27976	30.83	4.32	1.15
	C-ZnO	0.44	0.27184	31.73	4.19	1.08
	ZnO	0.41	0.28179	30.62	4.34	1.16
(224)	P-ZnO	0.19	0.28716	30.80	3.41	1.15
	C-ZnO	0.19	0.31905	27.71	3.79	1.42
	ZnO	0.19	0.30805	28.70	3.66	1.32
(314)	P-ZnO	0.13	0.37420	23.83	4.16	1.92
	C-ZnO	0.15	0.24892	35.83	2.76	0.85
	ZnO	0.87	0.28234	31.58	3.14	1.09

Table S10: Values of contact angles of water droplets on ZnO, C-ZnO and P-ZnO ETL films on two different spots of respective surfaces in both left and right directions from Fig. 5(A)-5(C)

ETL Layer	Contact Angle (Spot 1) (Degree)		Contact Angle (Spot 2) (Degree)		Average Contact Angle with Standard Deviation (Degree)
	Left	Right	Left	Right	
ZnO	25.6	26.5	21.0	21.4	23.6±2.8
C-ZnO	33.9	34.2	34.1	34.3	34.1±0.2
P-ZnO	72.8	73.7	71.7	74.6	73.2±1.2

Table S11: Average and root mean square (RMS) surface roughness of identically fabricated $MA_{0.57}FA_{0.38}Rb_{0.05}PbI_3$ perovskite films on ZnO, C-ZnO and P-ZnO ETL layers calculated from surface topography imaging with AFM

ETL Layer underneath perovskite	Root Mean Square (RMS) Surface Roughness (R_Q) (nm)	Average Surface Roughness (R_A) (nm)
ZnO	16.80	13.50
C-ZnO	12.90	10.20
P-ZnO	12.80	10.20

Table S12: Recombination resistance, recombination capacitance and recombination lifetime of of ZnO, C-ZnO and P-ZnO devices calculated from Nyquist plot fitting at different applied bias voltages

Device	Applied Bias (V)	Recombination Resistance, R_{Rec} (kΩ)	Recombination Capacitance, C_{Rec} (nF)	Recombination Lifetime, τ_{Rec} (μs)
ZnO	0.90	1.78	5.65	10.06
	0.92	1.43	4.75	6.79
	0.94	1.31	4.70	6.16
	0.96	1.17	4.65	5.44
	0.98	1.03	4.57	4.71
	1.00	0.92	4.43	4.08
C-ZnO	0.90	2.99	8.66	25.89
	0.92	2.40	9.28	22.27
	0.94	2.07	10.20	21.11
	0.96	1.78	10.20	18.16
	0.98	1.53	10.10	15.45
	1.00	1.35	10.00	13.50
P-ZnO	0.90	2.07	5.73	11.86
	0.92	1.89	5.89	11.13
	0.94	1.73	5.91	10.22
	0.96	1.49	5.90	8.79
	0.98	1.28	5.95	7.62
	1.00	1.15	5.88	6.76

Table S13: Hysteresis index (HI) of ZnO, C-ZnO and P-ZnO devices calculated from JV measurements in both FB-SC and SC-FB directions at a scan rate of 0.05 V/s

Device	Current Density at (V_{OC}/2) in FB-SC scan (mA/cm^2)	Current Density at (V_{OC}/2) in SC-FB scan (mA/cm^2)	Hysteresis Index (HI)
ZnO	21.10	20.76	0.016
C-ZnO	21.36	21.43	0.003
P-ZnO	21.87	21.80	0.003

Table S14: Day wise PCE, J_{SC}, V_{OC} and FF values of ZnO PSC stored in a N_2 filled glovebox for 30 days (Scan direction: FB-SC, scan rate: 0.05 V/s)

Number of Days	Open Circuit Voltage, V_{OC} (mV)	Short Circuit Current Density, J_{SC} (mA/cm^2)	Fill Factor, FF (%)	Efficiency (%)
0	970.06	21.51	64.02	13.36
2	970.43	21.31	64.11	13.25
4	969.17	21.17	64.18	13.17
6	967.32	20.95	64.05	12.98
8	963.46	20.86	64.07	12.88
10	960.72	20.73	64.02	12.75
12	956.53	20.62	63.95	12.61
14	952.18	20.49	63.81	12.45
16	945.33	20.35	63.73	12.26
18	938.87	20.29	63.65	12.13
20	931.25	20.18	63.51	11.94
22	921.57	20.13	63.39	11.76
24	910.32	19.95	63.21	11.48
26	898.55	19.86	63.13	11.27
28	884.78	19.81	63.08	11.06
30	875.39	19.77	63.05	10.92

Table S15: Day wise PCE, J_{SC}, V_{OC} and FF values of a C-ZnO PSC stored in a N_2 filled glovebox for 30 days (Scan direction: FB-SC, scan rate: 0.05 V/s)

Number of Days	Open Circuit Voltage, V_{OC} (mV)	Short Circuit Current Density, J_{SC} (mA/cm^2)	Fill Factor, FF (%)	Efficiency (%)
0	1012.45	22.23	70.01	15.76
2	1013.74	22.18	70.05	15.75
4	1013.82	22.04	70.42	15.73
6	1011.77	22.08	70.33	15.71
8	1008.63	22.08	70.13	15.64
10	1001.82	22.05	70.17	15.50
12	997.35	21.93	70.67	15.45
14	999.12	21.85	70.68	15.43
16	999.04	21.84	70.68	15.43
18	995.02	21.75	70.78	15.32
20	993.45	21.76	70.50	15.24
22	989.89	21.65	70.66	15.14
24	986.61	21.67	70.50	15.07
26	985.94	21.58	70.41	14.98
28	984.83	21.55	70.37	14.93
30	983.78	21.51	70.23	14.86

Table S16: Day wise PCE, J_{SC}, V_{OC} and FF values of a P-ZnO PSC stored in a N_2 filled glovebox for 30 days (Scan direction: FB-SC, scan rate: 0.05 V/s)

Number of Days	Open Circuit Voltage, V_{OC} (mV)	Short Circuit Current Density, J_{SC} (mA/cm^2)	Fill Factor, FF (%)	Efficiency (%)
0	981.81	22.49	67.62	14.93
2	982.05	22.40	67.70	14.89
4	982.11	22.35	67.75	14.87
6	981.15	22.34	67.35	14.76
8	979.07	22.32	67.03	14.66
10	977.29	22.31	66.73	14.55
12	973.95	22.17	66.67	14.40
14	970.97	21.96	66.63	14.21
16	965.92	21.85	66.58	14.05
18	962.35	21.72	66.43	13.89
20	959.13	21.57	66.31	13.72
22	955.75	21.43	66.23	13.57
24	952.47	21.37	66.15	13.46
26	949.63	21.29	66.18	13.38
28	946.85	21.18	66.13	13.26
30	944.73	21.11	66.11	13.18

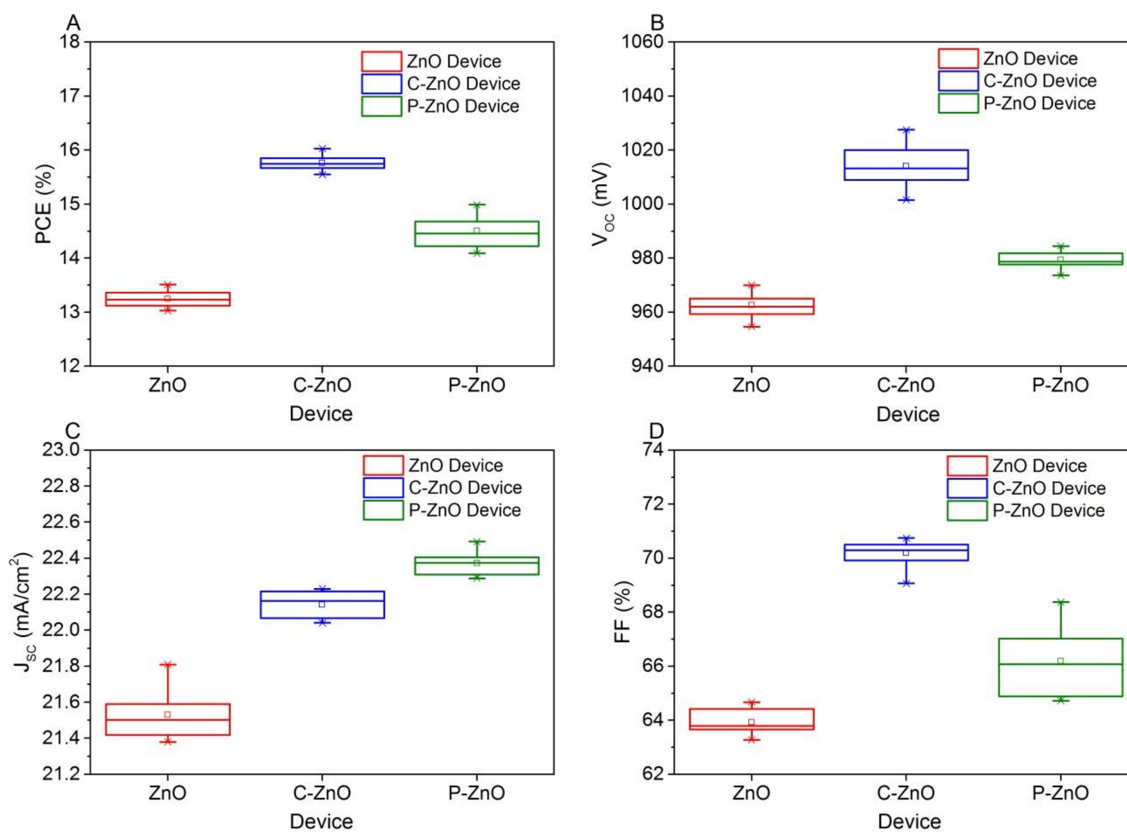

Fig. S1 Statistical box-chart showing the range of variation in (A) PCE, (B) V_{OC}, (C) J_{SC} and (D) FF in FB-SC direction obtained from ten identically fabricated ZnO, C-ZnO and P-ZnO devices in a single, random batch at a scan rate of 0.05 V/s

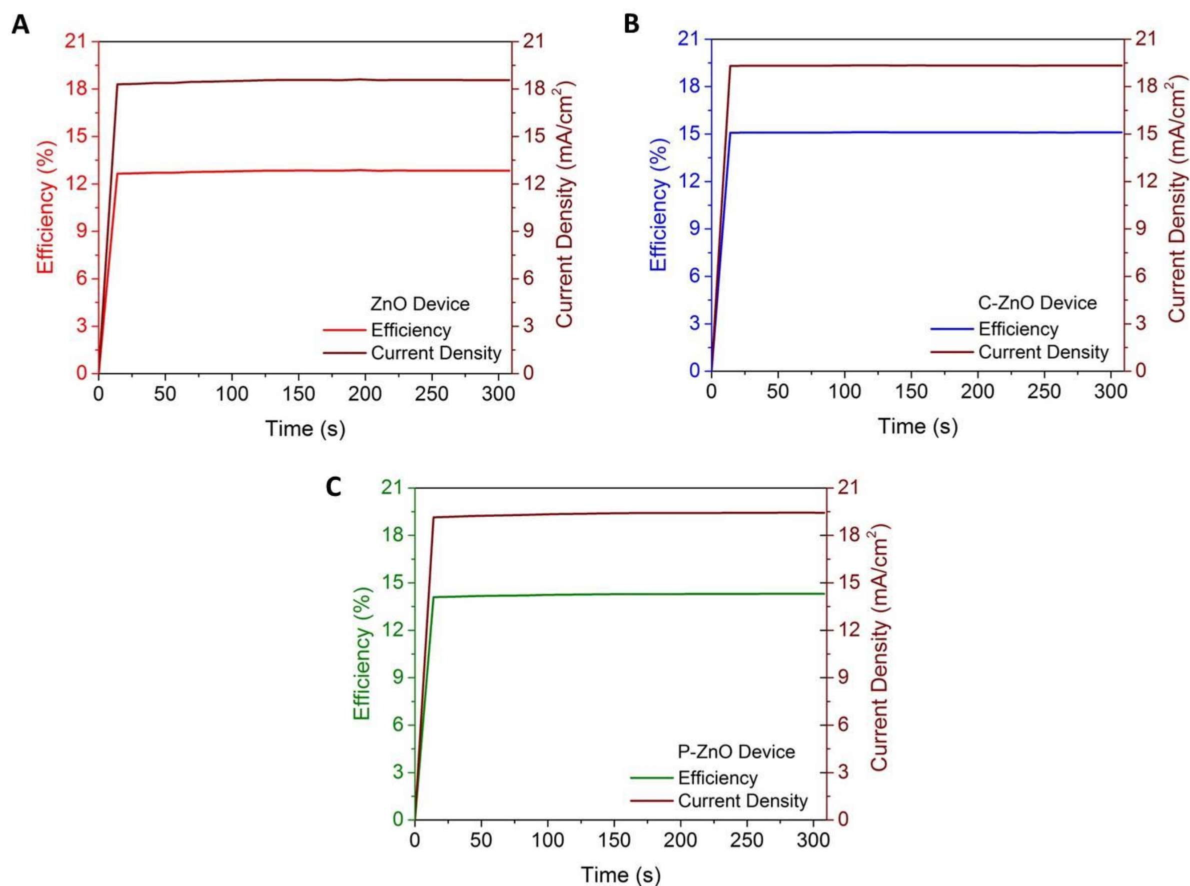

Fig. S2 Stabilized current density and stabilized PCE as a function of time for the best performing (A) ZnO, (B) C-ZnO and (C) P-ZnO device

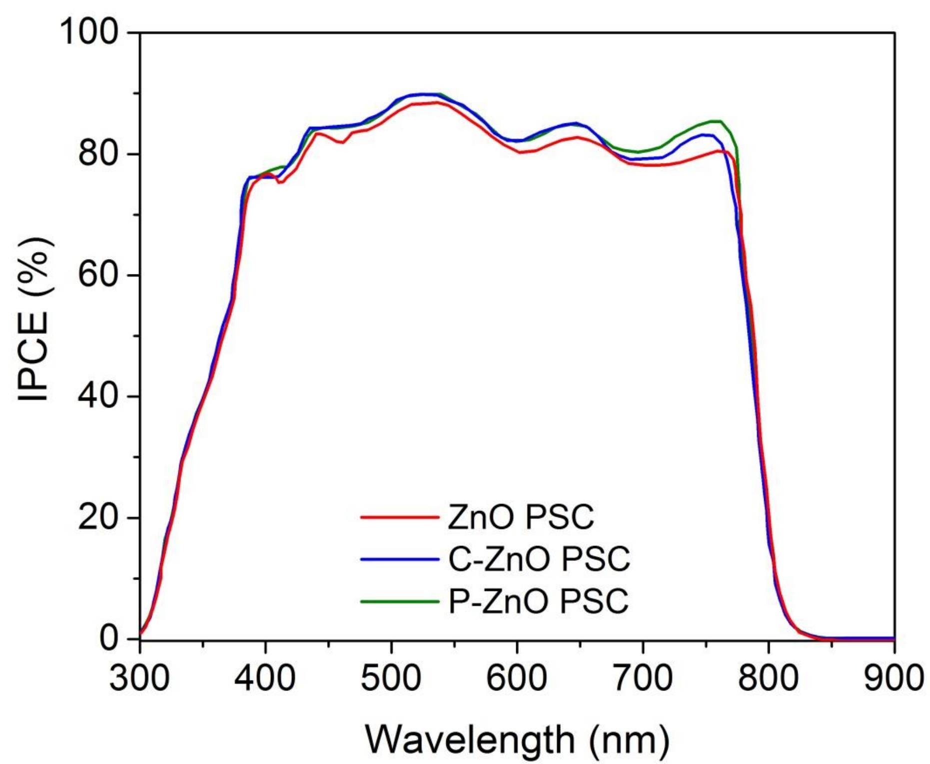

Fig. S3 Incident photon-to-current conversion efficiency (IPCE) curves of ZnO, C-ZnO and P-ZnO PSCs

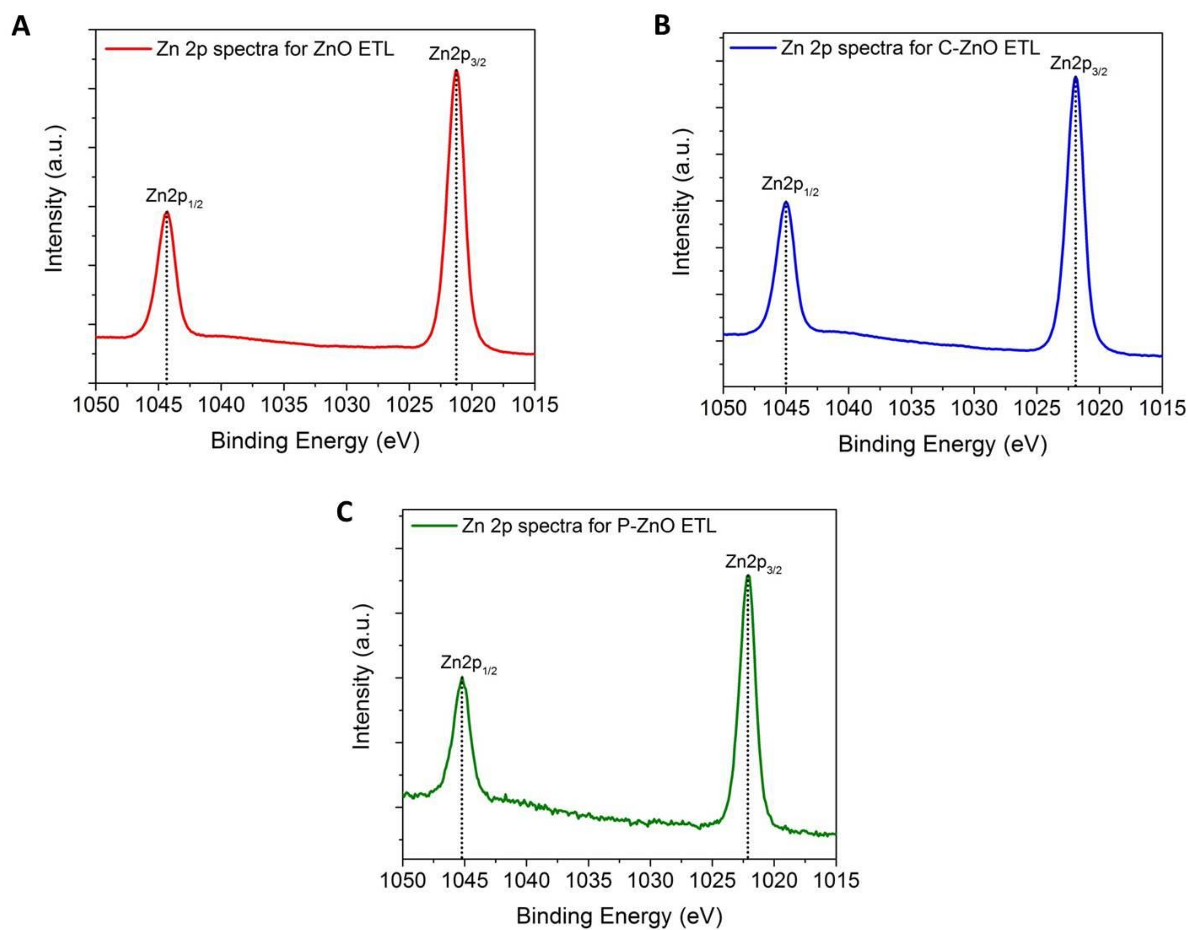

Fig. S4 High resolution XPS spectra of Zn_{2p} for (A) ZnO, (B) C-ZnO and (C) P-ZnO ETL films on ITO/glass substrate

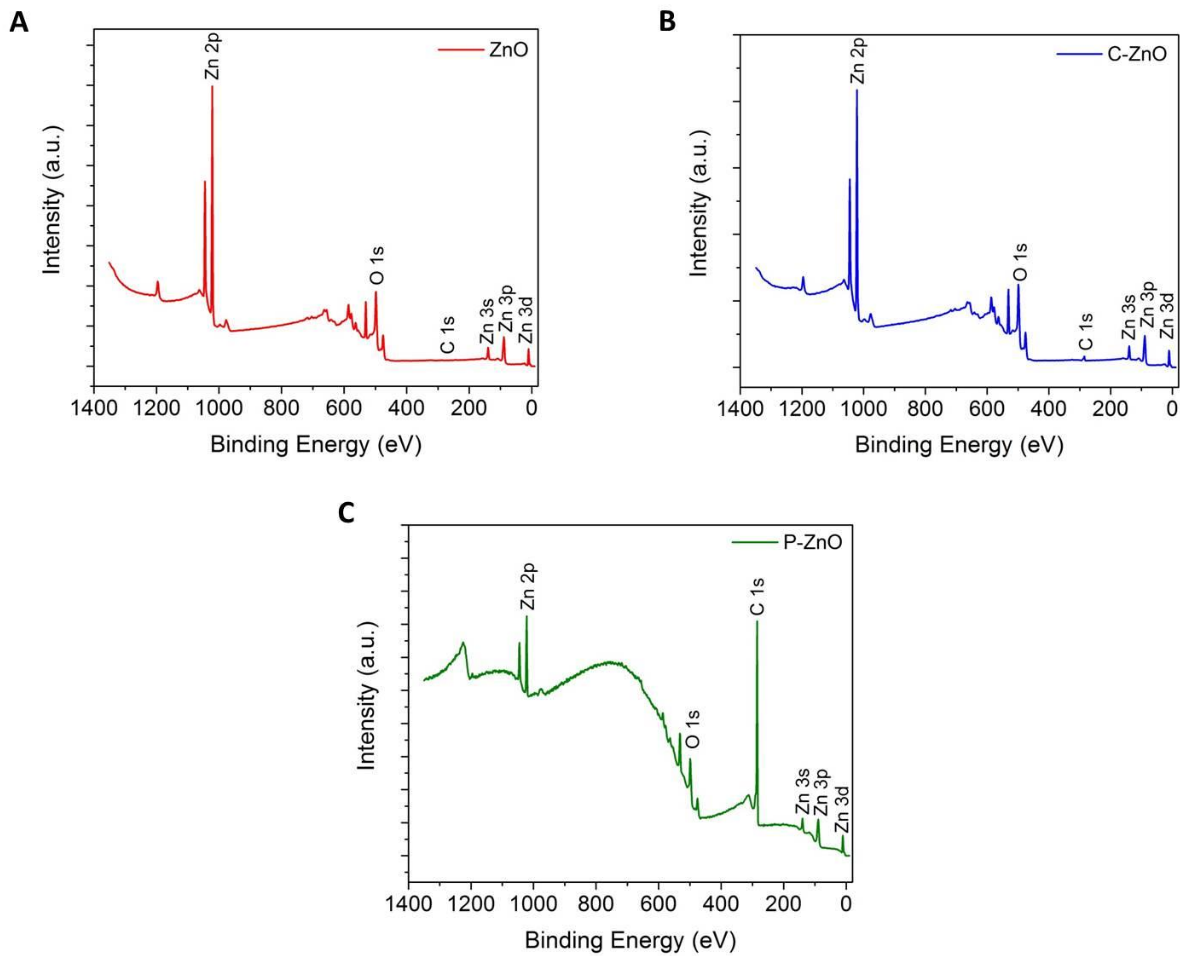

Fig. S5 XPS survey spectra of (A) ZnO, (B) C-ZnO and (C) L-ZnO film on ITO/glass substrate

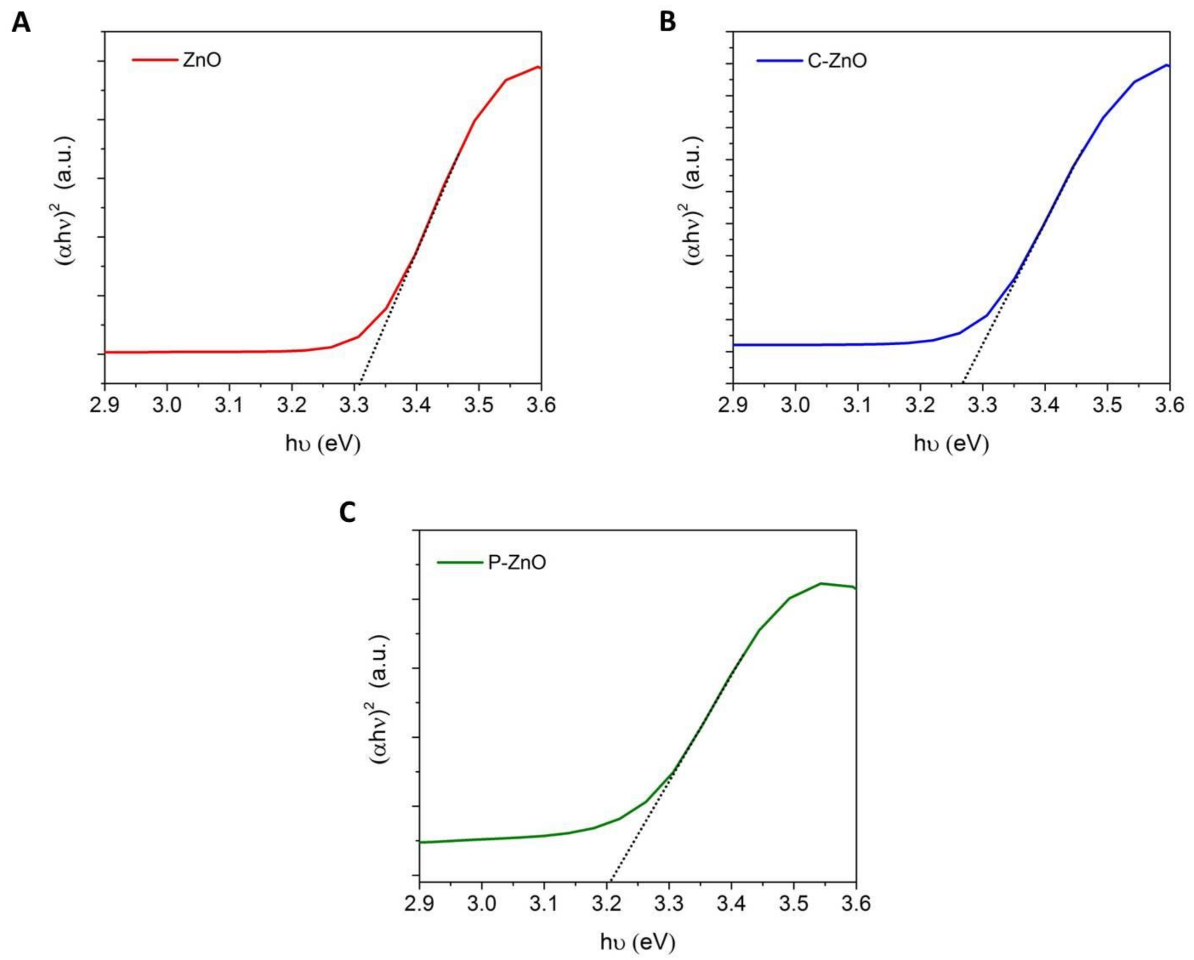

Fig. S6 Estimation of approximate material bandgap of (A) ZnO, (B) C-ZnO and (B) P-ZnO ETL films from corresponding Tauc plots