Supplementary information

Highly-efficient semi-transparent organic solar cells utilising non-fullerene acceptors with optimised multilayer MoO_3/Ag/MoO_3 electrodes

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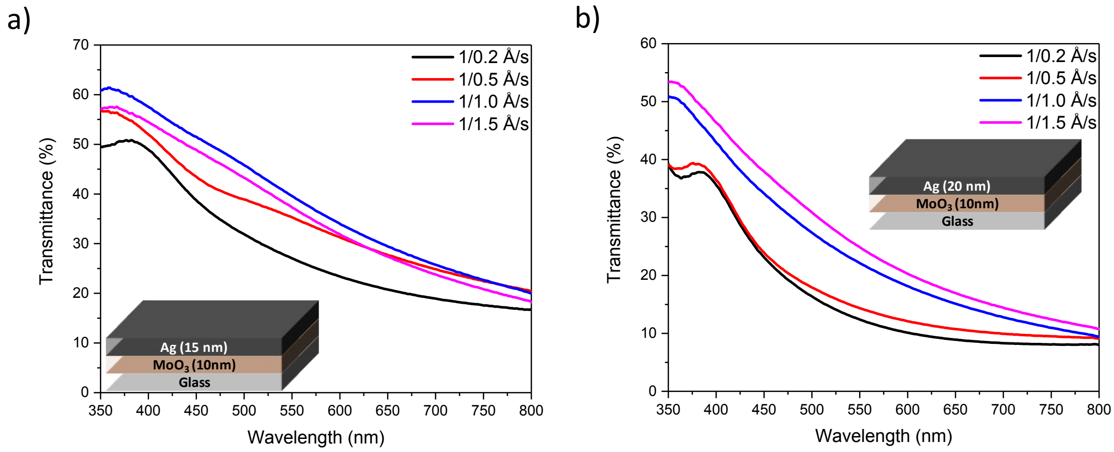
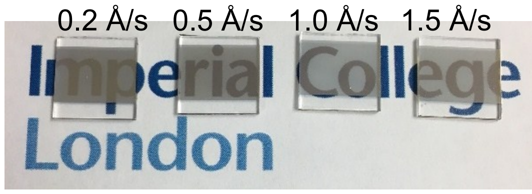
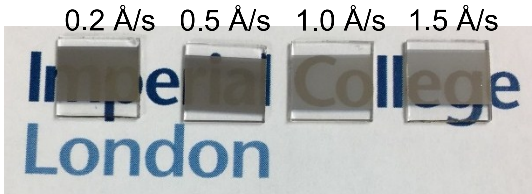


Fig.S1 Transmittance spectra of bilayer electrodes using a) 15 nm Ag and b) 20 nm Ag film

Table S1. Summarised optical and physical characteristics of MoO_3/Ag electrodes

Electrodes	Deposition rates (MoO_3/Ag)	R_{sheet} (Ω/□)	AVT (%)	Images of electrodes [b]
10/15 nm MoO_3/Ag	1/0.2 Å/s	5.8	29.9	
	1/0.5 Å/s	3.4	36.3	
	1/1.0 Å/s	3.2	40.8	
	1/1.5 Å/s	3.1	38.5	
10/20 nm MoO_3/Ag	1/0.2 Å/s	4.2	16.0	
	1/0.5 Å/s	2.5	17.6	
	1/1.0 Å/s	2.2	24.7	
	1/1.5 Å/s	2.0	27.5	

[a] Sheet resistance measurement was not available because resistance value was out of the measurable range of instrument. [b] The rates in each images represents the deposition rates of the Ag film

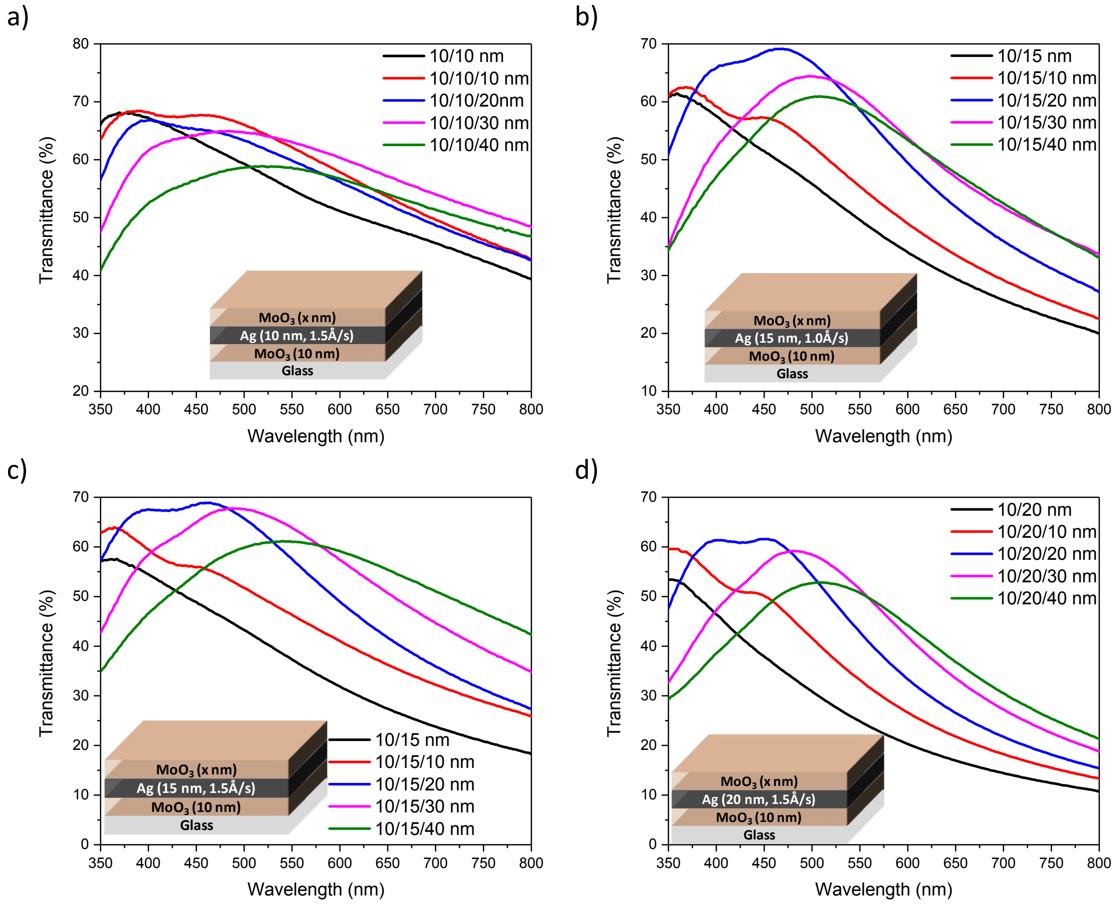


Fig.S2 Transmittance spectra of DMD electrodes based on varying MoO_3 thicknesses using a) 10 nm Ag (1.5 Å/s), b) 15 nm Ag (1.0 Å/s), c) 15 nm Ag (1.5 Å/s) and d) 20 nm Ag (1.5 Å/s)

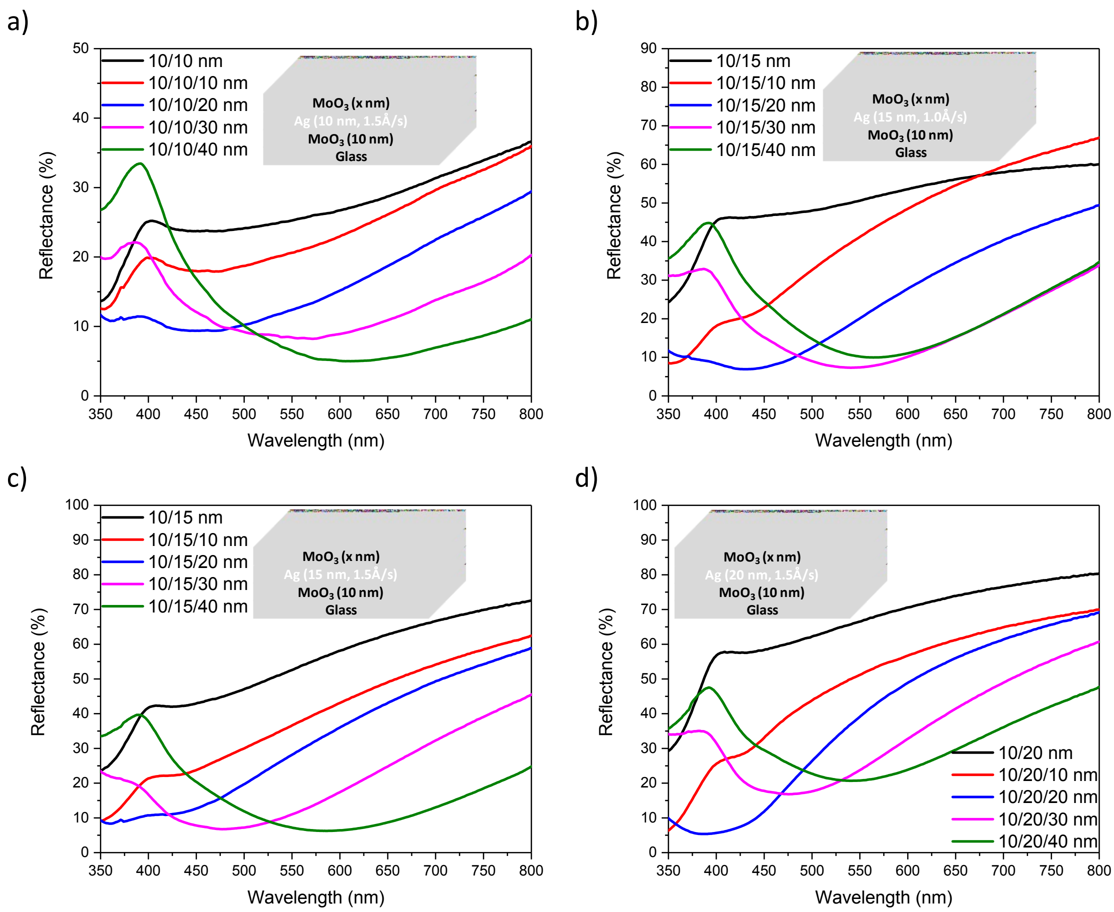
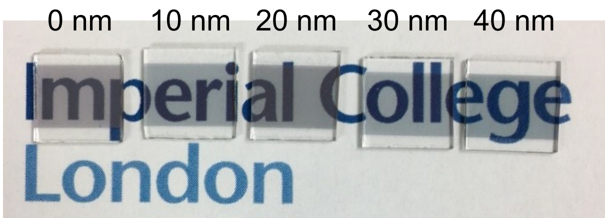
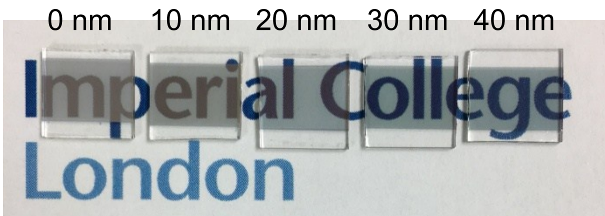
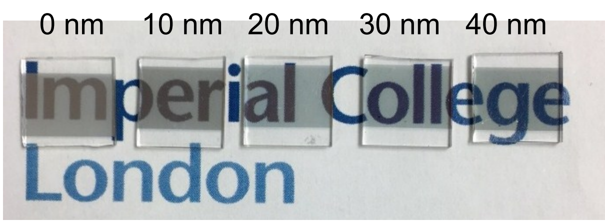
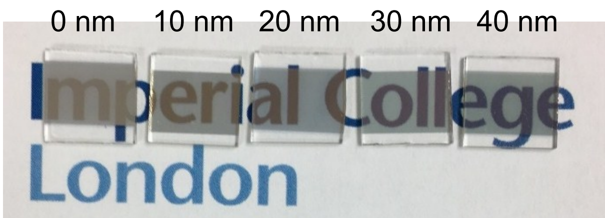


Fig.S3 Reflectance spectra of DMD electrodes based on varying MoO_3 thicknesses using a) 10 nm Ag (1.5 Å/s), b) 15 nm Ag (1.0 Å/s), c) 15 nm Ag (1.5 Å/s) and d) 20 nm Ag (1.5 Å/s), where reflectance is measured from outer MoO_3 side.

Table S2. Summarised optical and physical characteristics of MoO_3/Ag/MoO_3 electrodes

Sample [a]		R_{sheet} (Ω/□)	AVT (%)	AVR (%)	Images of electrodes
1.0 Å/s	10/10 nm	6.6	57.3	28.4	
	10/10/10 nm	7.6	62.0	16.5	
	10/10/20 nm	7.4	52.5	21.8	
	10/10/30 nm	7.1	65.4	8.6	
	10/10/40 nm	7.5	60.1	8.9	
1.0 Å/s	10/15 nm	3.2	40.8	50.9	
	10/15/10 nm	3.0	45.7	39.0	
	10/15/20 nm	3.4	56.4	20.6	
	10/15/30 nm	3.6	55.7	14.0	
	10/15/40 nm	3.5	53.6	18.4	
1.5 Å/s	10/15 nm	3.1	38.5	52.5	
	10/15/10 nm	3.5	46.6	36.0	
	10/15/20 nm	3.6	56.1	27.6	
	10/15/30 nm	3.1	59.4	15.2	
	10/15/40 nm	3.4	56.3	13.8	
1.5 Å/s	10/20 nm	2.0	27.5	66.0	
	10/20/10 nm	2.2	35.4	47.7	
	10/20/20 nm	2.2	43.9	35.0	
	10/20/30 nm	2.3	46.6	28.7	
	10/20/40 nm	2.2	44.4	28.1	

[a] The rates stand for the deposition rates of Ag layers, the rates for MoO_3 were controlled at 1 Å/s, as mentioned in the fabrication section.

Table S3 Optical properties of DMD electrode based ST-OPVs using PFBDB-T:C8-ITIC

Device electrodes (Silver deposition rate)	AVT (%)	AVR (%)		Colour coordinates
		Top	Bottom	
Active layer	40.1	N/A		(0.23 0.28)
10/20/40 nm (1.5 Å/s)	19.1	23.3	12.6	(0.22, 0.27)
10/20/30 nm (1.5 Å/s)	17.7	23.2	10.4	(0.20, 0.25)
10/15/40 nm (1.5 Å/s)	22.0	18.5	12.1	(0.24, 0.29)
10/15/30 nm (1.5 Å/s)	25.1	19.4	10.6	(0.22, 0.28)
10/15/40 nm (1.0 Å/s)	16.6	12.8	13.5	(0.22, 0.26)
10/15/30 nm (1.0 Å/s)	19.4	20.6	13.4	(0.22, 0.26)
10/10/40 nm (1.5 Å/s)	23.5	10.3	13.6	(0.25, 0.29)
10/10/30 nm (1.5 Å/s)	26.2	8.2	13.6	(0.24, 0.29)
10/10/40 nm (1.0 Å/s)	22.0	12.3	13.5	(0.24, 0.29)
10/10/30 nm (1.0 Å/s)	22.3	9.1	11.5	(0.23, 0.28)

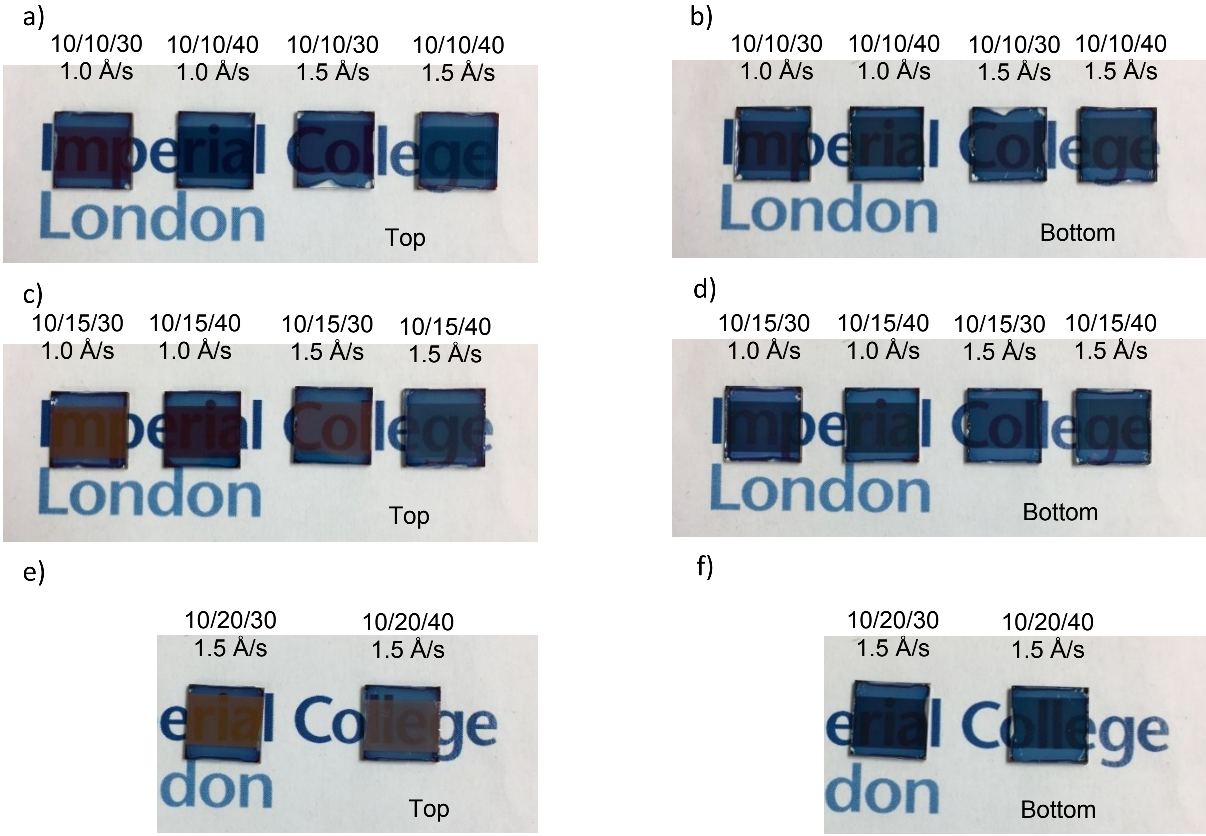


Fig.S4 Pictures of PFBDB-T:C8-ITIC based ST-OPV devices using different DMD electrode: a)&b) 10 nm Ag layer; c)&d) 15 nm Ag layer and e)&f) 20 nm Ag layer, where pictures were taken through both sides of device, the number in each picture indicates the thickness of each layer of electrode (unit in nm) and the rate stands for the depositon rate of Ag film.

Calculation of colour coordinates in CIE 1931 colour space:

The calculation was undertaken following the CIE standard procedure. The colour coordinates (x,y) of ST devices in the CIE 1931 colour space chromaticity diagram were calculated from transmittance spectra following the CIE 13.3-1995 procedure. The tristimulus values (X,Y,Z) were first calculated using the following equations:

$$X = \int_{390\ nm}^{700\ nm} S(\lambda) \times \bar{x}(\lambda) \times T(\lambda) d\lambda$$

$$Y = \int_{390\ nm}^{700\ nm} S(\lambda) \times \bar{y}(\lambda) \times T(\lambda) d\lambda$$

$$Z = \int_{390\ nm}^{700\ nm} S(\lambda) \times z(\lambda) \times T(\lambda) d\lambda$$

Here S(λ) is the CIE standard D65 illuminant spectrum which represents the average daylight illuminant. □,□,□ are defined as the colour matching functions and T(λ) is the experimental transmittance spectrum. The colour coordinates were then calculated using the expressions below:

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

$$z = \frac{Z}{X + Y + Z}$$

As CIE 1931 colour space is two dimensional, only x, y are sufficient to express the colour coordinates.