Electronic Supplementary

Information(ESI)

Title: Efficient low-cost and facile ITO interdigital micro-photodetector based on mixed cationic perovskite for screening new optoelectronic materials

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Experiment section

Fabrication of MCPs devices：

A layer of $Cs_{0.1}(MA_{0.15}FA_{0.85})_{0.9}Pb(Br_{0.14}I_{0.86})_3$ was deposited on the dried ITO interdigital electrode. The $Cs_{0.1}(MA_{0.15}FA_{0.85})_{0.9}Pb(Br_{0.14}I_{0.86})_3$ precursor solution was prepared by dissolving CsI (18.2 mg), MABr (23.5 mg), $PbBr_2$ (77.1 mg), FAI (204.6 mg), PbI_2 (606.7 mg) in 1 mL mixed solvent of DMF and DMSO (4:1 in volume ratio). The ITO substrate was treated with UV-ozone for 10min before the deposition of perovskite. The perovskite precursor solution was spin-coated on the ITO substrate at 3000 rpm for 30 s and 6000 rpm for 30 s. Antisolvent chlorobenzene was quickly dripped onto the perovskite film at 50 s. The perovskite film was annealed at 100 ℃ for 50 min.

Fabrication of $MASnBrCl_2$ devices：

1 M MABr and 1 M $SnCl_2$ were dissolved in a mixed solvent of DMF and DMSO (volume ratio 4:1) to prepare the $MASnBrCl_2$ perovskite precursor solution. The preparation conditions of $MASnBrCl_2$ film are the same as those of MCP film.

Characterization

Scanning electron microscopy (SEM)：

The morphology of MCPs samples was studied by scanning electron microscope (Thermo Fisher Scientific FIB-SEM GX4, USA) at 10 kV and 43 pA emitter current and a working distance of 4.5 mm. The element content and element mapping of MCPs were measured by an Energy Dispersive Spectroscopy (EDS, Bruker) equipped with SEM. The detection element was X-ray excited by electron beams of 10 kV and 43 pA.

X-ray diffraction (XRD)：

A high-resolution diffractometer (SmartLab 9 kW, Rigaku, Japan) equipped with a 2D matrix high-speed detector was used to record the XRD pattern of MCPs using a Cu Kα (λ = 1.54 Å) radiation source moved from 5 ° to 70 ° (scanning step: 0.01 °, scanning rate: 20 °/min) at 45 kV and 200 mA.

Photocurrent density-time performance (J-t)：

A photoelectrochemical workstation system (ZAHNER CIMPS-2 pro, Germany) was used to test the photocurrent density-time performance of MCPs ITO-IEs with different wavelengths (386, 397, 405, 433, 454, 480, 511, 537, 564, 591, 630, 656, 708, 726, 764, 801, and 820 nm) under different light intensities at different voltages (0, 0.5, 1, 1.5, 2, and 2.5 V). The test parameters are as follows:

recording time: 20 s, light period time: 1 s. The effective light-receiving area of the MCPs ITO-IEs is 0.04 cm^2.

Linear sweep voltammetry (LSV):

The linear sweep voltammetry (LSV) of MCPs ITO-IEs with different wavelengths (386, 397, 405, 433, 454, 480, 511, 537, 564, 591, 630, 656, 708, 726, 764, 801, and 820 nm) at 30 W/m^2 light intensity was tested using a photoelectrochemical workstation system (ZAHNER CIMPS-2 pro, Germany). The scanning rate of LSV is 100 mV s^{-1}, and the scanning range is -2.5 V~2.5 V (absolute value).

Incident monochromatic photon-electron conversion efficiency (IPCE):

The IPCE of MCPs ITO-IEs at 80% light intensity was tested at different wavelengths (365-1020nm) using a photoelectrochemical workstation system (ZAHNER CIMPS-2 pro, Germany).

Contact angle test:

The contact angle of FTO and ITO conductive glass was measured by a contact angle measuring instrument (JC2000C1, China) using a DMF-DMSO mixed solution (4:1).

Responsivity (R):

$$R = \frac{I_{PC} - I_{Dark}}{P \times S} (A\ W^{-1})$$

Detectivity (D):

$$D = \frac{R}{\sqrt[2]{2e \times I_{Dark}}} (Jones)$$

P is the power intensity of incident light, S is the effective light-receiving area of the ITO-IEs, I_{PC} is the current under light and I_{Dark} is the dark current, e = 1.6×10^{-19} C.

Supplementary Figures

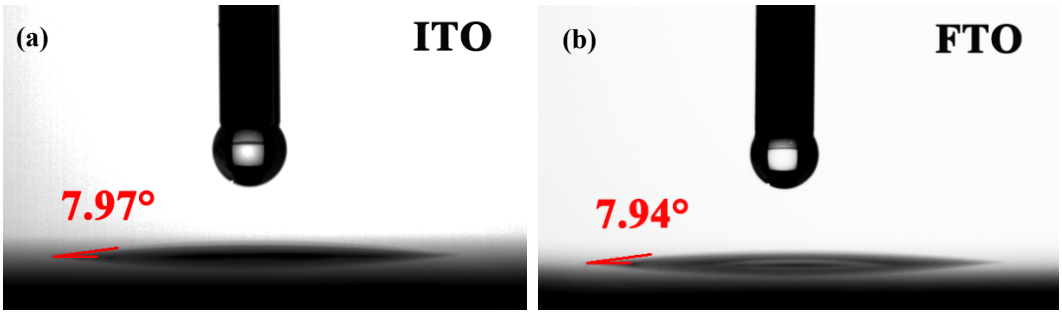


Fig. S1 The contact angle of water on the surfaces of ITO (a) and FTO (b).

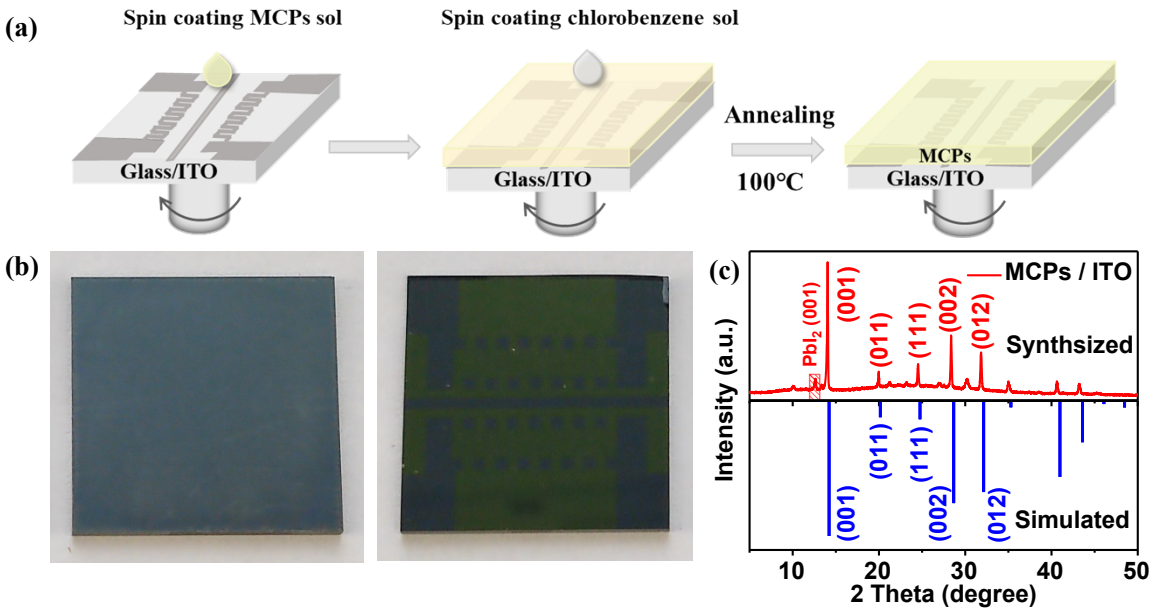
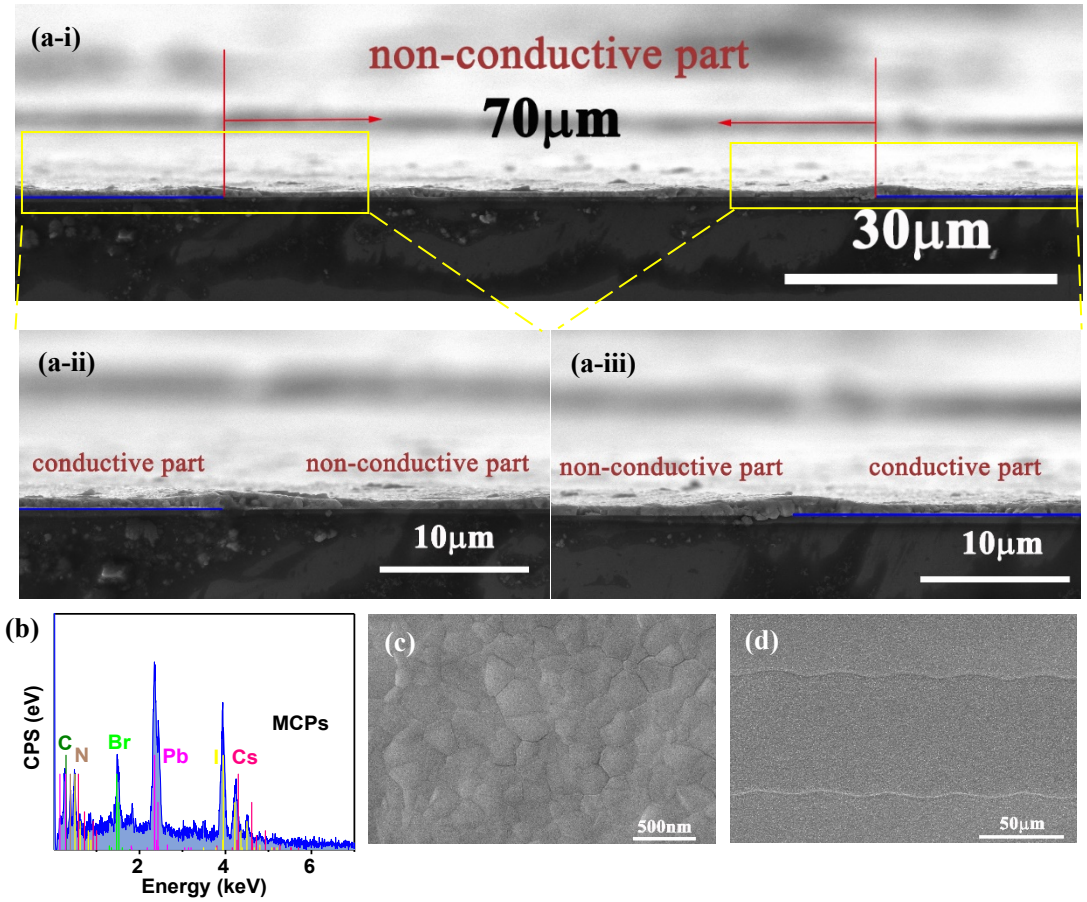


Fig. S2 (a) Schematic diagram of the preparation process of MCPs/ITO-IEs device. (b) Photos viewed along the perovskite sides (left), viewed along the glass sides (right). (c) The XRD patterns of MCPs thin films on the ITO-IE and the simulated XRD patterns by fitting the crystal data in the literature.



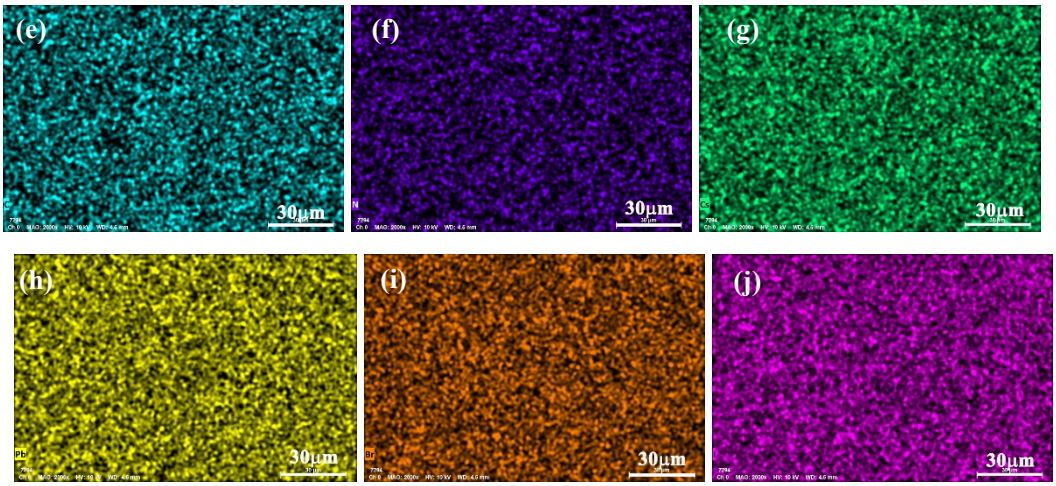


Fig. S3 (a) SEM images of the cross-section of the conductive and non-conductive parts of MCPs ITO-IEs. (b) EDS of MCPs film. (c) SEM images of MCPs films. (d) SEM image of MCPs film on the conductive and non-conductive part of the ITO-IEs. Element mapping of C (e), N (f), Cs (g), Pb (h), Br (i), and I (j) in MCPs.

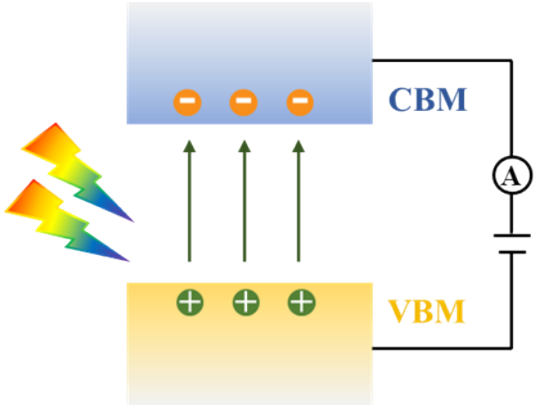


Fig. S4 Working mechanism diagram of MCPs ITO-IEs.

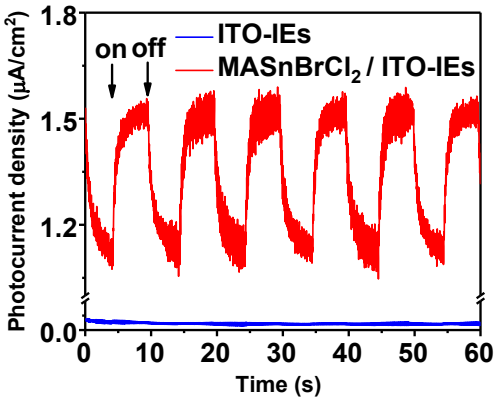


Fig. S5 J-t curves of $MASnBrCl_2$ ITO-IEs and ITO-IEs under white light with 500 mW/cm^2 and 1.5 V bias voltage.

Supplementary Table

Table S1 Element content of MCPs film.

Element	Normalized mass (%)	Atom (%)	abs. error (%) (1 sigma)
C	1.91	15.74	0.48
N	2.38	16.79	0.63
Cs	0.23	0.17	0.08
Pb	32.4	15.48	1.12
Br	5.7	7.06	0.32
I	57.39	44.76	1.88
	100	100	

Table S2 Performance of reported perovskite interdigital electrode

Electrode	Photodetector	Responsivity (R/mA W^{-1})	Detectivity (D/Jones)	Applied conditions	Reference
Au	$CH_3NH_3PbI_3$ film	1.60	no calculation	680 nm, 0.036 mW, 5 V	17
Au	$MAPbCl_3$ SC	0.60 (100) plane 0.62 (110) plane	$<4\times10^9$ (100) plane $<6\times10^9$ (110) plane	10 V, 20 mW	16
Au	$CsCu_2I_3$ film	49.22	2.49×10^{12}	340 nm, 2 V	18
Au	$CsPbBr_3$ film	0.24	no calculation	500 nm, 48.7 μW cm^{-2}	19
Au	$CH_3NH_3PbCl_3$ film	7560	no calculation	360 nm,4 V	20
Au–Ag	$CH_3NH_3PbCl_3$ SC	240	1.1×10^{11}	415 nm, -30 V	21
Ag	$(PEA)_2PbI_4$ nanowires	2098	1.752×10^{12}	4.99 μW cm^{-2}, 520 nm, -5 V	22
Cr	$CsPbI_3$	no calculation	9.2×10^9	100 mW cm^{-2}, 5 V	23
Cr-Au	$MAPbI_3$	140	no calculation	633 nm, 30 mW cm^{-2}	24
Cr	$CsPbBr_3$ film	0.962	2.67×10^9 cm $Hz^{-2}W$	100 mW cm^{-2}, 5 V	25
Au	T-$MAPbCl_3$ SC	0.0277	no calculation	395 nm, 1 W m^{-2}, 3 V	26
ITO-IEs	$Cs_{0.1}(MA_{0.15}F$	7.23	2.36×10^{10}	386 nm,30 W	This

$A_{0.85})_{0.9}Pb(Br_{0.14}I_{0.86})_3$		m^{-2}, 2.5 V	work