

Supporting Information

Strain-insensitive Viscoelastic Perovskite Film for Intrinsically Stretchable Neuromorphic Vision-Adaptive Transistors

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Supplementary Methods

Surface energy measurements

The surface energy of PDMS substrates, PQD films and all the conjugated polymer films were calculated according to the Owens-Wendt method¹:

$$\gamma_s = \gamma_s^p + \gamma_s^d \quad (1)$$

$$(1 + \cos \theta_l) \gamma_l = 2 \left(\sqrt{\gamma_l^d \gamma_s^d} + \sqrt{\gamma_l^p \gamma_s^p} \right) \quad (2)$$

where γ_s , γ_s^p and γ_s^d were the total surface energy, polar component and dispersive component of surface energy, respectively. The total surface energy (γ_l), dispersion component (γ_l^d) and polar component (γ_l^p) were 50.8 mJ m⁻², 50.42 mJ m⁻² and 0.38 mJ m⁻² for diiodomethane, and 72.8 mJ m⁻², 29.1 mJ m⁻² and 43.7 mJ m⁻² for water, respectively.

Defect state density measurements

The defect-tunability of the perovskite film was certified according to hole-only device measurements and calculated as followed:

$$V_{TFL} = \frac{eN_t L^2}{2\epsilon\epsilon_0} \quad (3)$$

where e was the elementary charge, L was the thickness of the semiconductor film, ϵ_0 was the vacuum dielectric constant, and ϵ was the relative dielectric constant⁴⁰.

Electronic properties measurements

The mobility (μ) and threshold voltage (V_{th}) were important parameters for evaluating the electronic performances of OFETs. These values could be extracted from the curve of the drain current (I_{DS}) versus the gate voltage (V_G). In the saturation regime, the drain current (I_{DS}) versus the gate voltage (V_G) according to the following equation²:

$$I_{DS} = \frac{W}{2L} C_i \mu_{sat} (V_G - V_{th})^2 \quad (4)$$

where W and L represented the channel length and width, respectively. C_i was the capacitance of the gate dielectric.

The mobility was calculated by the slop of $\sqrt{|I_{DS}|}$ versus V_G according to the following equation³:

$$\mu_{sat} = \left(\frac{\partial \sqrt{|I_{DS}|}}{\partial V_G} \right)^2 \frac{2L}{WC_i} \quad (5)$$

$$|V_G - V_{th}| < |V_{DS}| \quad (6)$$

The V_{th} of the device was obtained by extrapolating a plot of $\sqrt{|I_{DS}|}$ versus V_G to $I_{DS} = 0$.

Works of adhesion measurements

The works of adhesion between different hybrid photosensitive films and nanoconfined semiconductor films were calculated as followed⁴:

$$W_{SI/S2} = 2 \left(\sqrt{\gamma_{SI}^d \gamma_{S2}^d} + \sqrt{\gamma_{SI}^p \gamma_{S2}^p} \right) \quad (7)$$

where W , γ^d and γ^p were the calculated works of adhesion, polar component and dispersive component of measured surface energy, respectively.

1 Photosensitivity calculation for adaptive behaviors

2 To quantitatively evaluate the light response under different bias voltages (V_G) and light
3 intensities (P_{in}), the photosensitivity (S_{ph}) was defined as follows:

$$4 \quad S_{ph} = \frac{I_{ph}}{I_{dark}} = \frac{I_{illumination} - I_{dark}}{I_{dark}} \quad (8)$$

5 where I_{ph} was the difference between photocurrent and dark current. I_{dark} and $I_{illumination}$
6 represented the dark- and photo-current, respectively.

8 Fitting curves of the dependence between PPF and Δt

9 The dependence of the extracted PPF index on the Δt could be well fitted by a double exponential
10 decay function as follow⁵:

$$11 \quad PPF = A_0 + A_1 \times \exp(-\Delta t / \tau_1) + A_2 \times \exp(-\Delta t / \tau_2) \quad (9)$$

12 where A_1 and A_2 were rapid and slow facilitation magnitudes; τ_1 and τ_2 were rapid and slow decay
13 time in PPF. In detail, A_1 , A_2 , τ_1 and τ_2 were calculated to be 3.14, 0.61, 0.50, and 19.08, respectively.

15 Fitting curves of the dependence between τ and t

16 The index (τ) referred to the relationship between the ratio of rise time to fall time, and it could
17 be defined as follows:

$$18 \quad \tau = \frac{t_{fall}}{t_{rise}} \quad (10)$$

19 where t_{rise} was the time for the current to rise from the dark state to the 90% of the maximum
20 photocurrent, and t_{fall} was the time for the decay from the illumination just stopped to the 10% of
21 its photocurrent.

22 The dependence between τ and lighting time (t) could also be well fitted by a double exponential
23 decay function as follows:

$$24 \quad \tau = A_0 + A_1 \times \exp(-t / \tau_1) + A_2 \times \exp(-t / \tau_2) \quad (11)$$

25 where A_1 and A_2 were rapid and slow facilitation magnitudes; τ_1 and τ_2 were rapid and slow decay
26 time in τ . In detail, A_1 , A_2 , τ_1 and τ_2 were calculated to be 25.49, 1.78, 1.85, and 9.24, respectively.

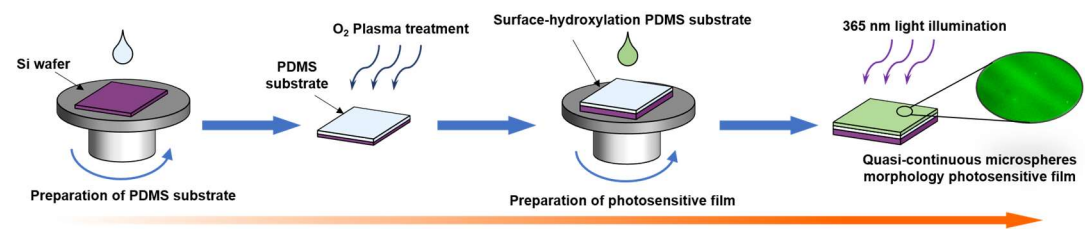
28 Consumption calculation of synaptic behavior

29 The energy consumption (E) of typical synaptic behaviors could be calculated as follows⁶:

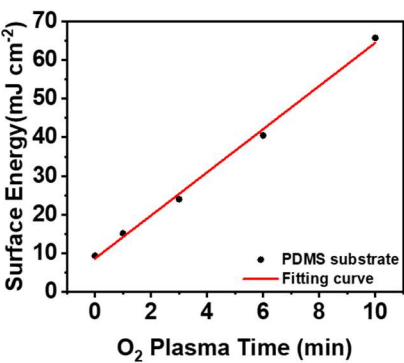
$$30 \quad E = I_{peak} \times t \times V \quad (12)$$

31 where I_{peak} , t , and V were the peak value of EPSC, light pulse width, and operating voltage,
32 respectively.

Supplementary Figures



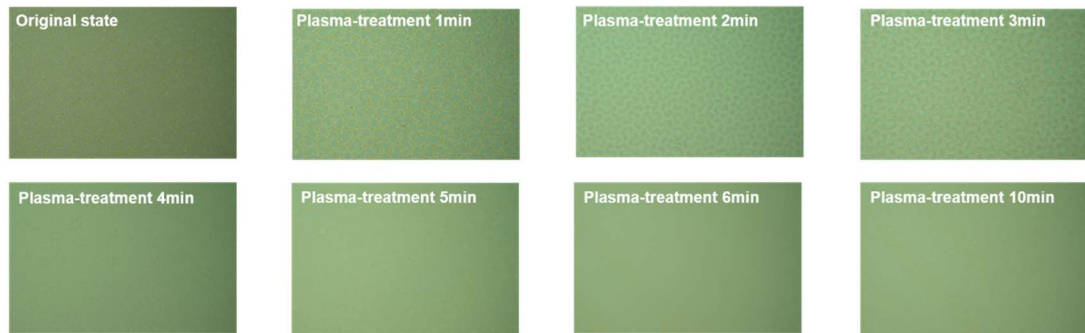
Supplementary Figure 1. Schematic illustration of the fabrication process for optimized photosensitive films with the QCM morphology.



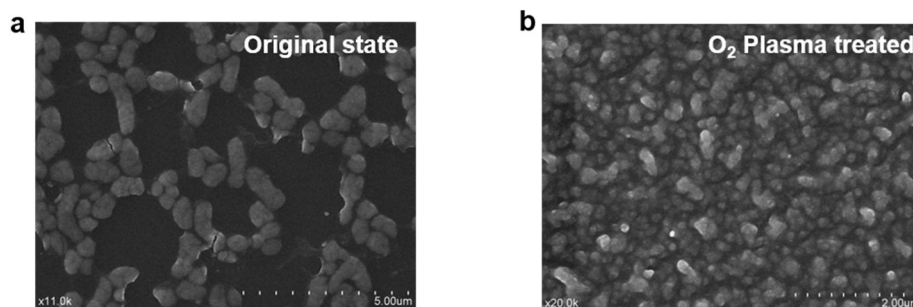
Supplementary Figure 2. Relationship between surface energy and O₂ plasma treatment time of PDMS substrates.

Supplementary Table 1. Surface energy evolution of the PDMS substrates under different treatment times of O₂ plasma.

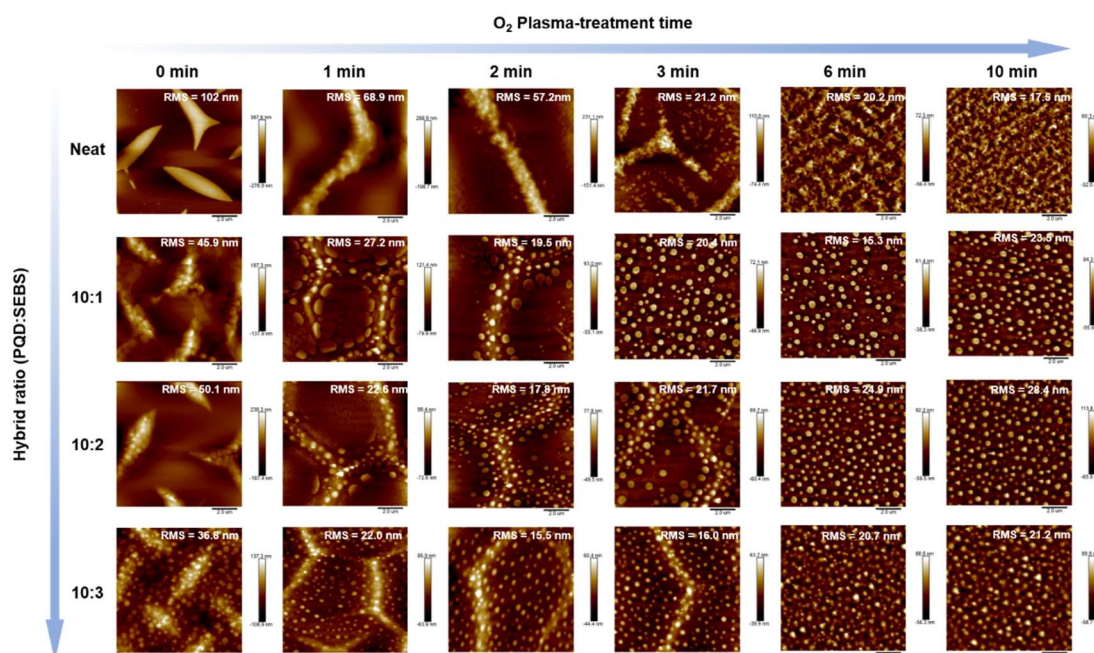
Materials	O ₂ plasma treatment	Contact angles (°)						Surface Energy (mJ m ⁻²)		
		H ₂ O			CH ₂ I ₂			γ_s	γ_s^d	γ_s^p
PDMS Substrate	0 min	112.5	114.35	113	99.85	99.05	98.9	9.42	8.52	0.9
	1 min	104.5	104.55	104.05	85.75	86.25	85.6	15.17	13.99	1.18
	3 min	93.9	94.65	92.55	69.5	68.35	70.05	24.03	22.37	1.67
	6 min	79.15	79.15	77.9	40.2	40	40.55	40.49	38.11	2.39
	10 min	29.1	28.8	29.7	32.6	33.2	33.3	65.72	37.38	28.34



Supplementary Figure 3. Optical microscopes of the morphology evolution of the hybrid photosensitive films. The hybrid photosensitive solution (PQDs: SEBS=10:1) was spin-coated onto the PDMS substrates with the O₂ plasma treatment of 0 min, 1 min, 2 min, 3 min, 4 min, 6 min, 6 min and 10 min, respectively.

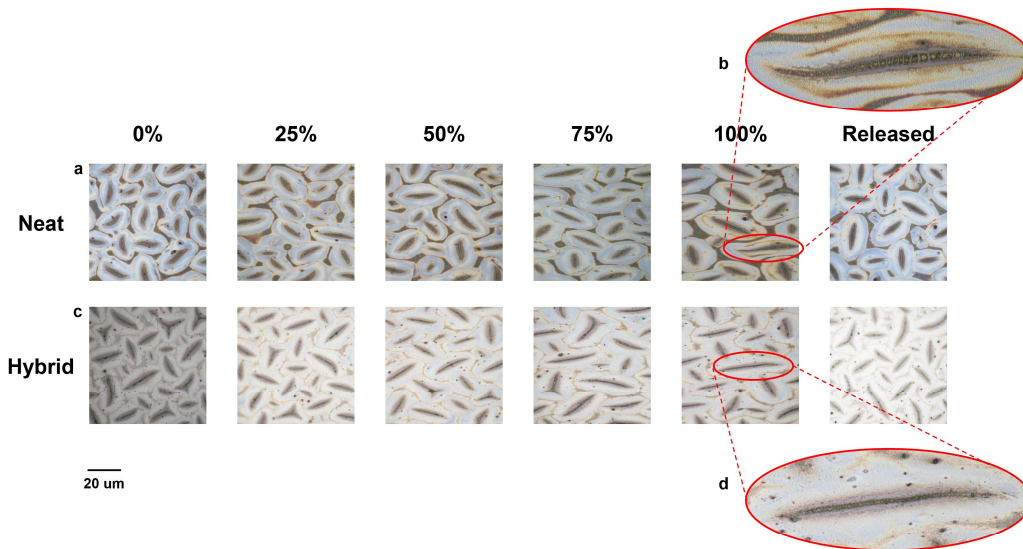


Supplementary Figure 4. Scanning electron microscope images of hybrid photosensitive films at different morphologies. **a** Original state with a spindle-like morphology. **b** O₂ plasma treated state with the QCM morphology. There was an obvious transformation from discontinuous morphologies to quasi-continuous morphologies with smaller PQD microspheres.



Supplementary Figure 5. Atomic force microscope (AFM) images of the hybrid photosensitive film morphologies with different hybrid ratios and O₂ plasma treatment times. The transforming states showed that the introduction of elastomer could wrap the perovskite quantum dots and greatly reduce the surface roughness. Moreover, as the O₂ plasma treatment time increased, the film morphologies could undergo an evolution process from a spindle-like morphology, then a honeycomb-like morphology, and eventually to a QCM morphology with gradually decreased surface roughness.

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3 **Supplementary Figure 6.** Optical microscope images of the comparison between the neat PQD
4 film and the PQD/SEBS hybrid film under different strain. **a** The neat film under various strain from
5 0% to 100%; **b** The enlarged detail of neat film under 100% strain; **c** the neat hybrid film under
6 various strain from 0% to 100%; **d** The enlarged detail of hybrid film under 100% strain. It
7 demonstrated obvious cracks in stretched neat film while the hybrid film did not, and the SEBS
8 increased the viscoelasticity and stretchability.

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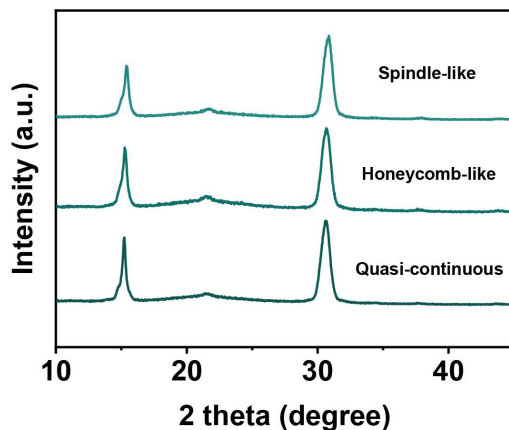
Materials	Neat			Hybrid		
Treatment	0 min	3 min	6 min	0 min	3 min	6 min
Hight						
DMT Modulus						
Modulus (MPa)	267	686	1244	69.7	191	113

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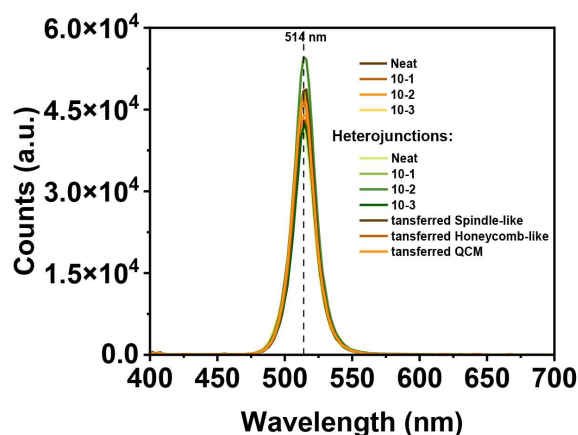
12 **Supplementary Figure 7.** DMT modulus measurement of neat and hybrid perovskite films (PQDs :
13 SEBS = 10:1, w/w) under different O₂ plasma treatment.

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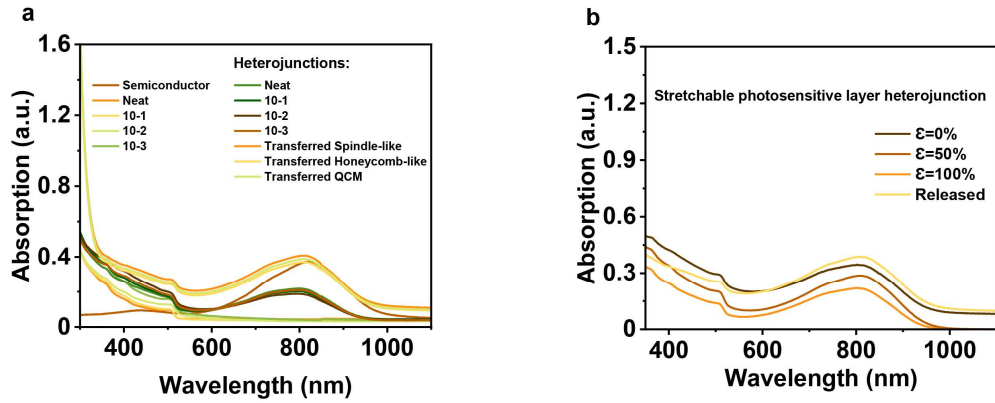
Supplementary Figure 8. X-ray diffraction diagrams of hybrid photosensitive films with different morphologies.



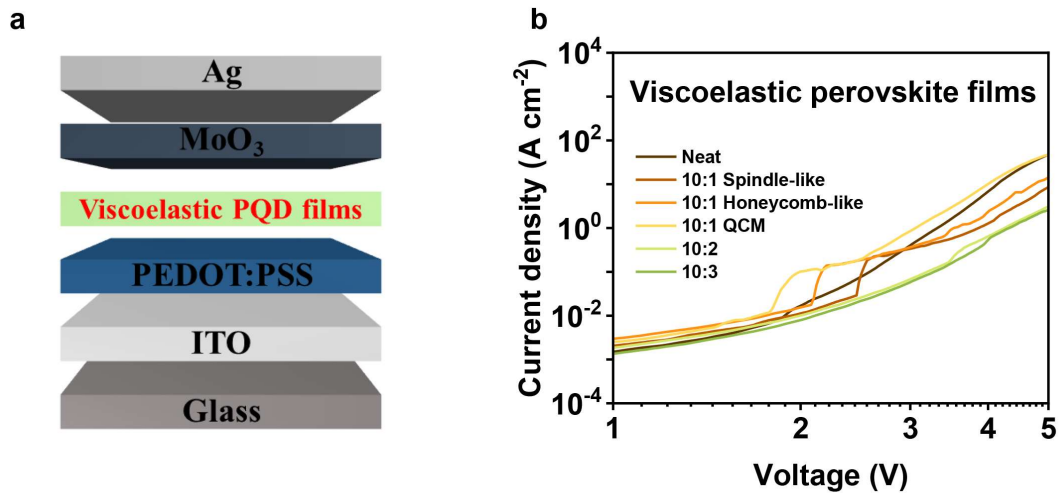
Supplementary Figure 9. Steady state photoluminescence (PL) spectra of photosensitive films with different O₂ plasma treatments and their corresponding layer heterojunctions.

Supplementary Table 2. Surface energy and works of adhesion between nanoconfined semiconductor layer and photosensitive films under different SEBS contents and O₂ plasma treatment times. (The introduced SEBS and a proper O₂ plasma treatment would together provide closer surface energy for the ideal interfacial contact between photosensitive films and semiconductor films, and better photogenerated charge transport and stretchability.)

Materials	O ₂ plasma treatment	Surface Energy (mJ m ⁻²)			Works of Adhesion(mJ m ⁻²) (with semiconductor layer)
		γ_s^d	γ_s^p	γ_s	
Neat PQDs	6 min	26.69	19.07	45.76	60.12883638
PQDs:SEBS=10:1	0 min	13.94	2.64	16.57	42.58886004
	3 min	23.93	0.7	24.63	55.06926426
	6 min	29.76	0	29.76	60.88436252
	6min	36.16	0.5	36.66	67.51251448
PQDs:SEBS=10:2	6min	36.57	0.77	37.34	67.98830646
PQDs:SEBS=10:3	6min	36.57	0.77	37.34	67.98830646
DPPT-TT:SEBS=5:5		31.14	0.08	31.22	



Supplementary Figure 10. **a** UV-vis absorption spectra of photosensitive films and layer heterojunctions with different hybrid ratios and different O₂ plasma treatments. **b** The photosensitive layer heterojunction under 0%, 50%, 100% strains and after the release.

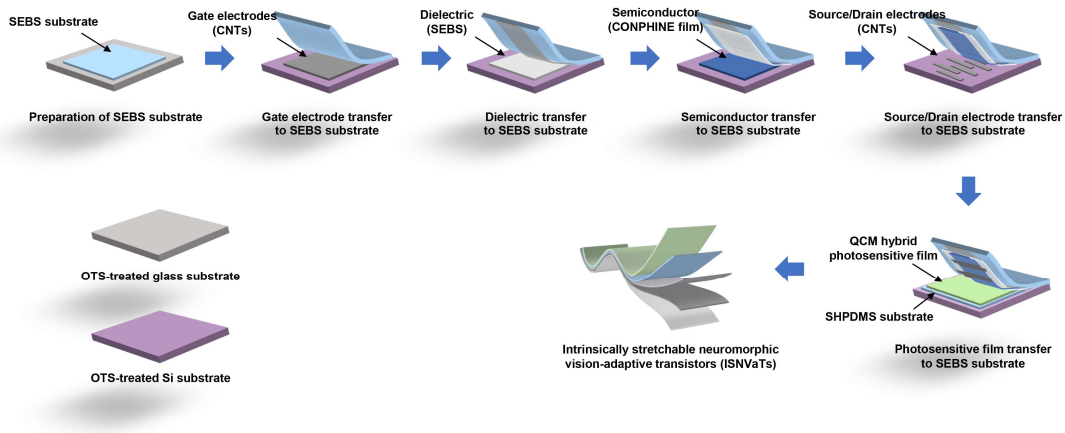


Supplementary Figure 11. Defect-tunability of different viscoelastic perovskite films. **a** Schematic diagram of device structure for the hole-only devices measurement; **b** SCLC curves of different viscoelastic perovskite films.

Supplementary Table 3. The V_{TFL} and N_t among various viscoelastic perovskite films.

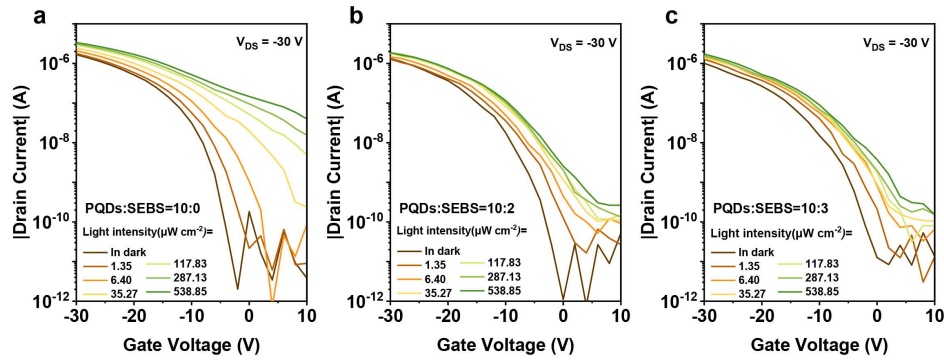
	V_{TFL} (V)	N_t (cm ⁻³)
Neat	1.71	5.62×10^{18}
10:1 Spindle-like	2.42	7.96×10^{18}
10:1 Honeycomb-like	2.07	6.81×10^{18}
10:1 QCM	1.76	5.79×10^{18}
10:2	3.03	9.96×10^{18}
10:3	3.28	1.08×10^{19}

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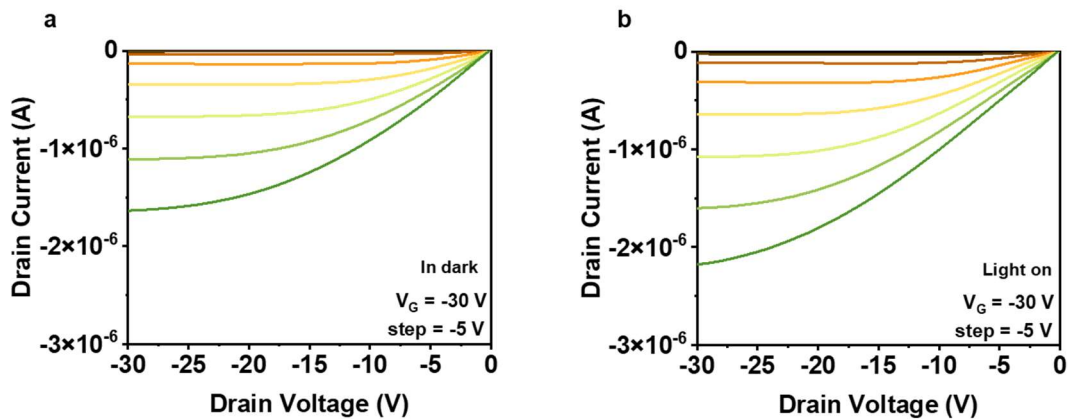
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Supplementary Figure 12. Schematic illustration of the fabrication process for intrinsically stretchable neuromorphic vision-adaptive transistors (ISNVaTs).



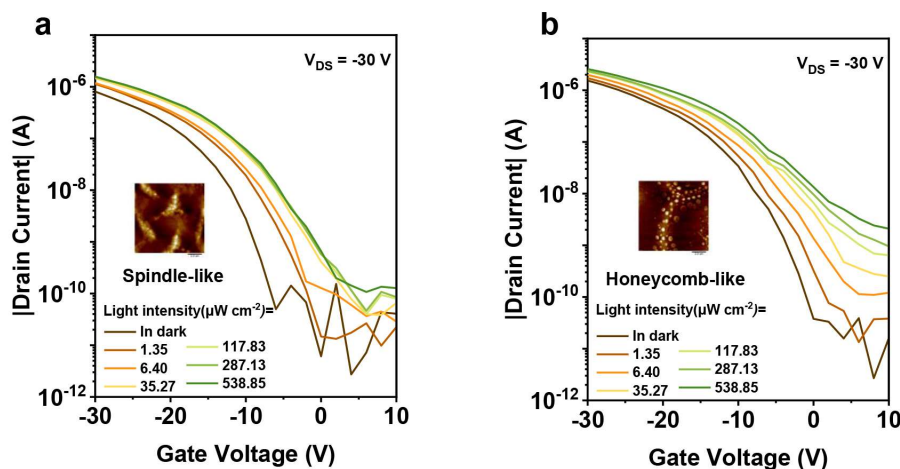
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Supplementary Figure 13. Typical transfer curves of ISNVaTs under various light intensities with photosensitive films of different hybrid ratios (PQDs:SEBS). **a** The neat film. **b** Hybrid ratio of 10:2. **c** Hybrid ratio of 10:3. We selected the hybrid photosensitive films with similar quasi-continuous morphologies and surface roughness to avoid other variables.

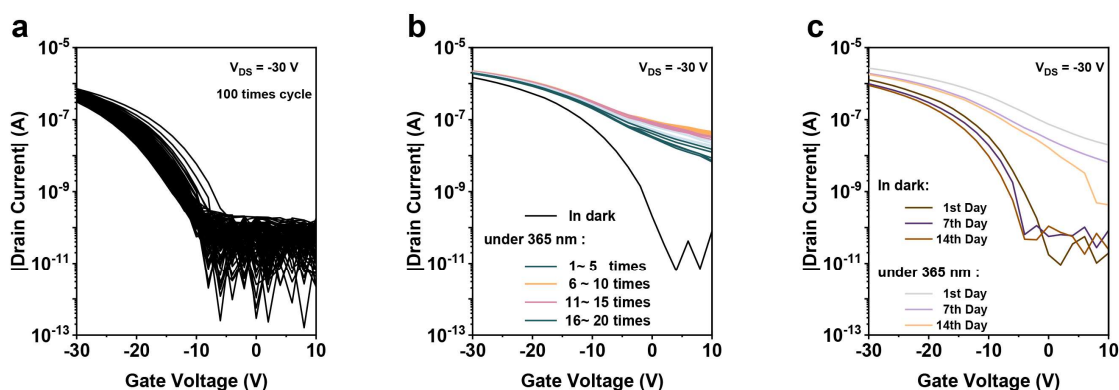


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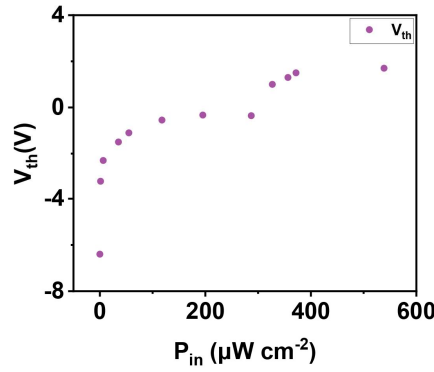
Supplementary Figure 14. Typical output curves of ISNVaTs. **a** In the dark state. **b** Under 365 nm light illumination at a P_{in} of $35.27 \mu\text{W cm}^{-2}$.



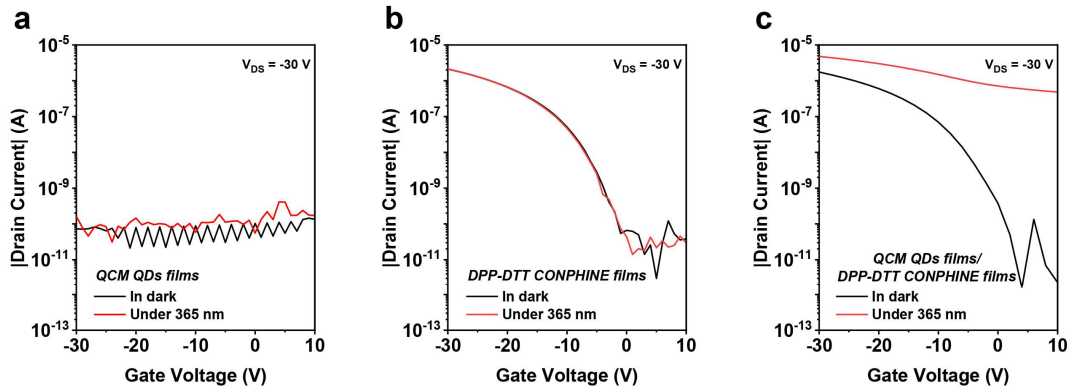
Supplementary Figure 15. Typical transfer curves of ISNVaTs under various light intensities with different morphologies at 10:1 hybrid ratio. **a** Typical transfer curves with spindle-like morphology photosensitive films. **b** Typical transfer curves with honeycomb-like morphology photosensitive films. The device with spindle-like morphology photosensitive film showed rather poor photoresponse because its high surface roughness severely hindered the photogenerated carrier transport. Similarly, the device with honeycomb-like morphology photosensitive film performed improved photoresponse and the QCM hybrid photosensitive film showed the best performance.



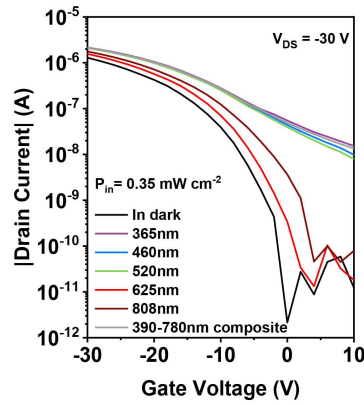
Supplementary Figure 16. Stability test of ISNVaTs. **a** Cycle test stability in the dark state; **b** Cycle test stability under 365 nm illumination ($P_{in} = 538.85 \mu\text{W cm}^{-2}$); **c** Temporal stability in nitrogen atmosphere for 14 days ($P_{in} = 538.85 \mu\text{W cm}^{-2}$).



Supplementary Figure 17. The threshold voltage (V_{th}) under different light intensities (P_{in}). The increased light intensities favored the injection of photogenerated holes into the active layer channel, and the threshold voltage (V_{th}) of the devices drifted steadily from -6.4 to 1.7 V as the illumination was enhanced from 0 to 538 $\mu\text{W cm}^{-2}$, proving the stable light recognition.

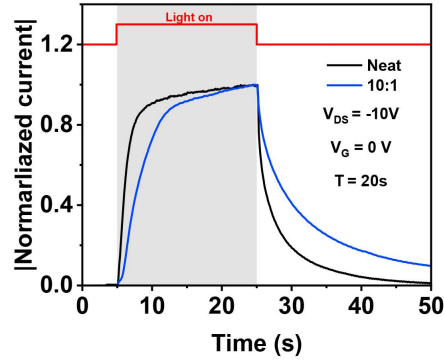


Supplementary Figure 18. Comparison of typical transfer curves on various active layers. **a** QCM QDs films; **b** DPP-DTT CONPHINE films; **c** QCM QDs films/DPP-DTT CONPHINE films.



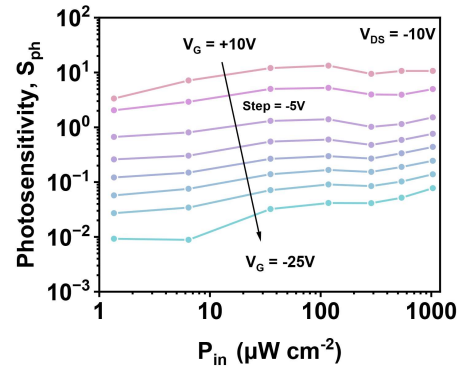
Supplementary Figure 19. Typical transfer curves of ISNVaTs under various light wavelengths at a P_{in} of 0.35 mW cm^{-2} .

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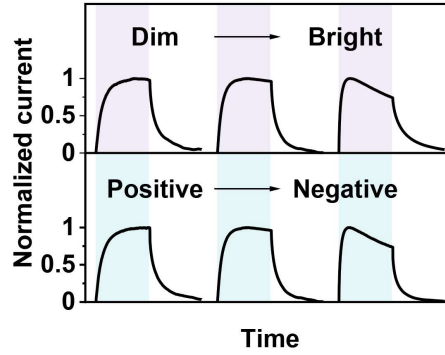
Supplementary Figure 20. Normalized I - T curves of the ISNVaTs based on neat PQD film and QCM hybrid photosensitive film at 10:1 hybrid ratio. As shown in the figure, the ISNVaT devices with elastic QCM hybrid photosensitive films displayed slower rise and recovery of photocurrent, indicating better synaptic and adaptive functions.



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Supplementary Figure 21. Photosensitivity versus P_{in} under different V_G values. It demonstrated an obvious growth trend of S_{ph} with increasing P_{in} and higher values at positive gate bias. These results verified that light intensity and gate voltage could together modulate the photoresponse of the device, allowing the emulation of negative feedback functions in the visual system.

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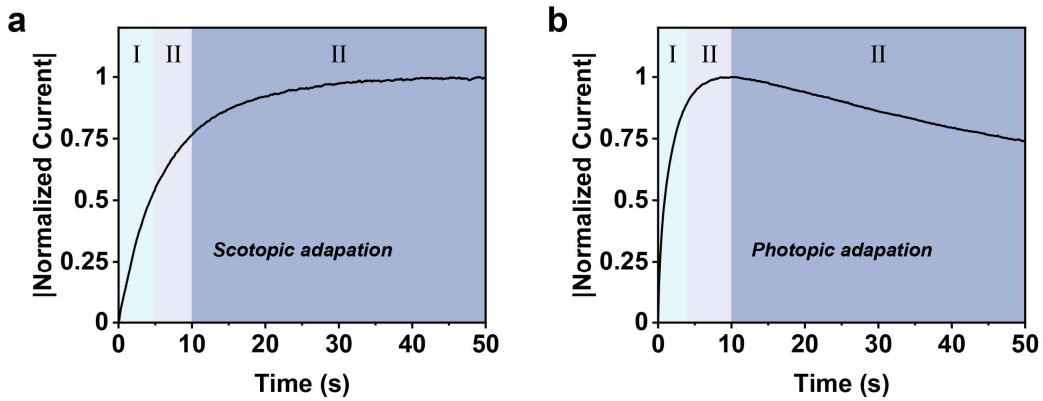


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3 **Supplementary Figure 22.** Single-curve normalized current of light intensity dependence (top, V_G
 4 $= 0$) and gate voltage dependence (bottom, $P_{in} = 356.69 \mu\text{W cm}^{-2}$) adaptation behaviors of ISNVaTs.
 5 (dim: $6.41 \mu\text{W cm}^{-2}$, normal: $356.69 \mu\text{W cm}^{-2}$, bright: $698.09 \mu\text{W cm}^{-2}$; positive: $+10 \text{ V}$, normal: 0
 6 V negative: -10 V)

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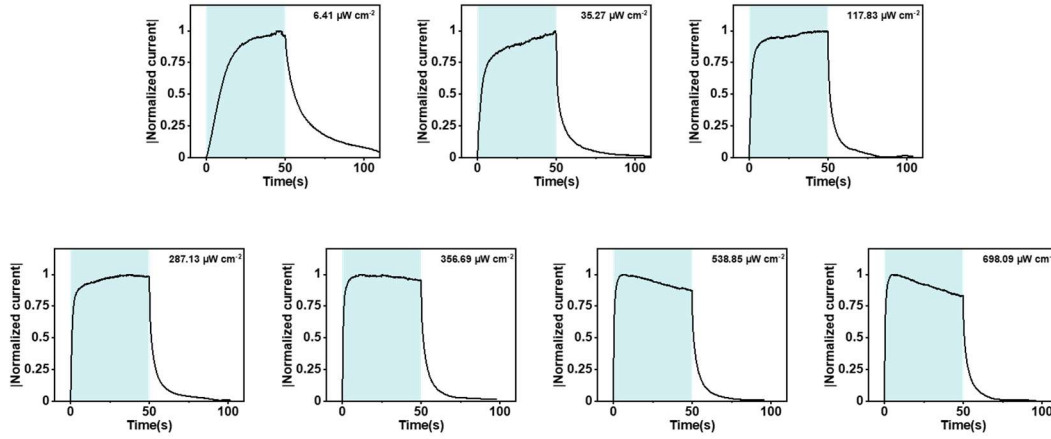
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10 **Supplementary Figure 23.** Schematic diagram of the adaptation process. **a** Scotopic adaptation. **b**
 11 Photopic adaptation. (I. Reception and perception; II. Transformation; III. Adaptation.)

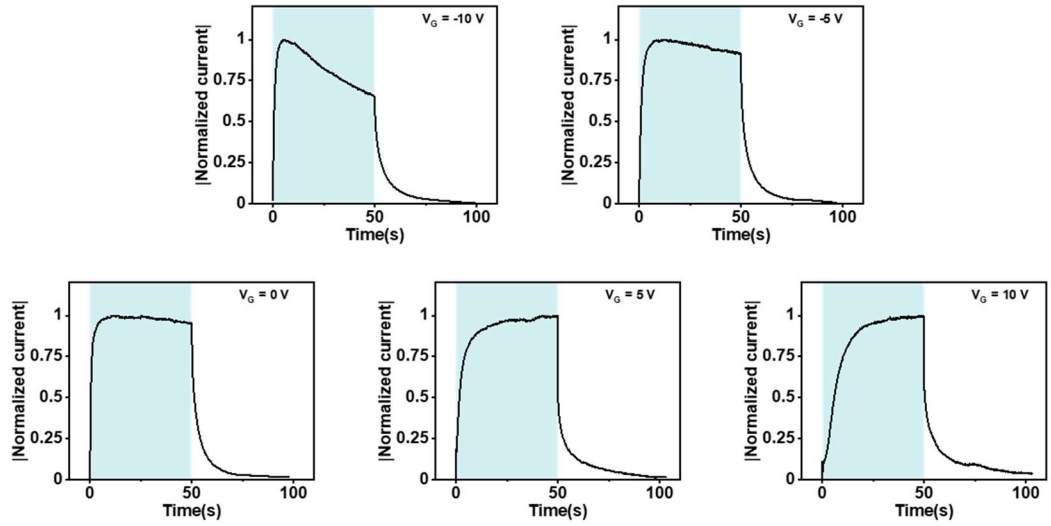
12 In the biological system, the transition point from cone-mediated to rod-mediated thresholds was
 13 termed as the rod-cone break, and it was almost about one fifth (10 min) of the entire adaptation
 14 time (45-50 min). Analogizing with biological adaptive systems, we categorized the adaptation into
 15 several processes: I. Reception and perception, II. Transformation, III. Adaptation. It could be
 16 noticed that the rod-cone break typically occurred near 10 s (the end of process II). Therefore, we
 17 defined CCR based on the photocurrent at 10 s rather than the initial current, which was believed to
 18 be more in consistent with the real situation time of visual adaptation.

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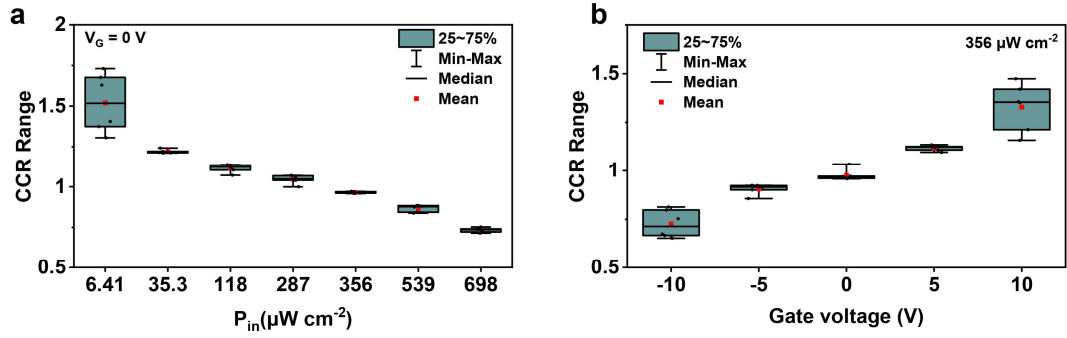


Supplementary Figure 24. Light-intensity-dependence adaptive behaviors. The ISNVaTs were applied 50 s-temporal illumination with different intensities (6.41, 35.27, 117.83, 287.13, 356.69, 538.85 and 698.09 $\mu\text{W cm}^{-2}$, respectively.) at a gate voltage of 0 V.



Supplementary Figure 25. Light-intensity-dependence adaptive behaviors. The ISNVaTs were applied 50 s-temporal illumination under 356.69 $\mu\text{W cm}^{-2}$ at different gate voltages of -10 V, -5 V, 0 V, 5 V and 10 V, respectively. Notably, the illumination value of 356 $\mu\text{W cm}^{-2}$ used in our manuscript can be converted to 427.2 lux, which is consistent with the comfortable indoor illumination on sunny days (100-1000 lux).

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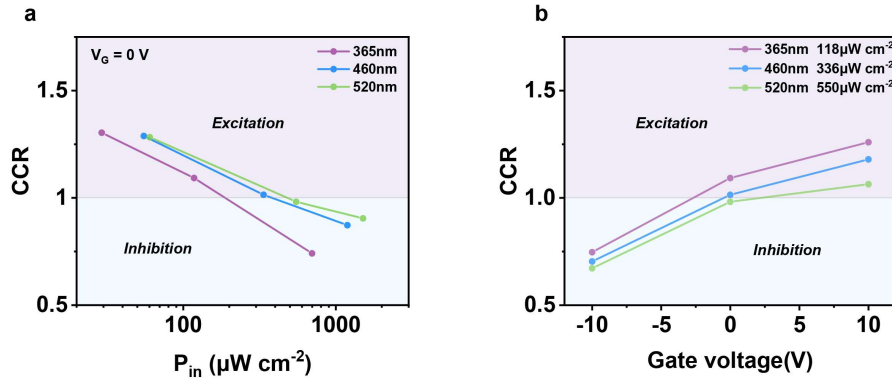


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3 **Supplementary Figure 26.** Statistical data pots of adaptation behaviors. **a** Light-intensity
 4 dependence that CCR at different P_{in} values. **b** Gate-voltage dependence that CCR at different V_G
 5 values. ($N=6$)

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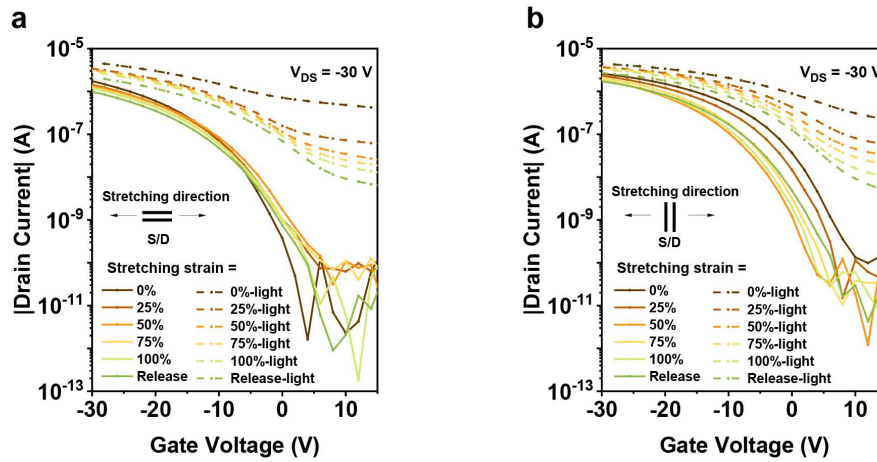
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9 **Supplementary Figure 27.** **a** Extracted CCR at different P_{in} values. **b** Different V_G values under
 10 365 nm, 460 nm and 520 nm light, respectively. The photoresponse of ISNVaT was lower under
 11 visible regions than ultraviolet light, resulting in weaker adaptive behaviors. Although with lower
 12 utilization of visible light, the ISNVaTs could still mimic the visual adaptation and be modulated by
 13 light intensity and gate voltage over multiple wavelengths.

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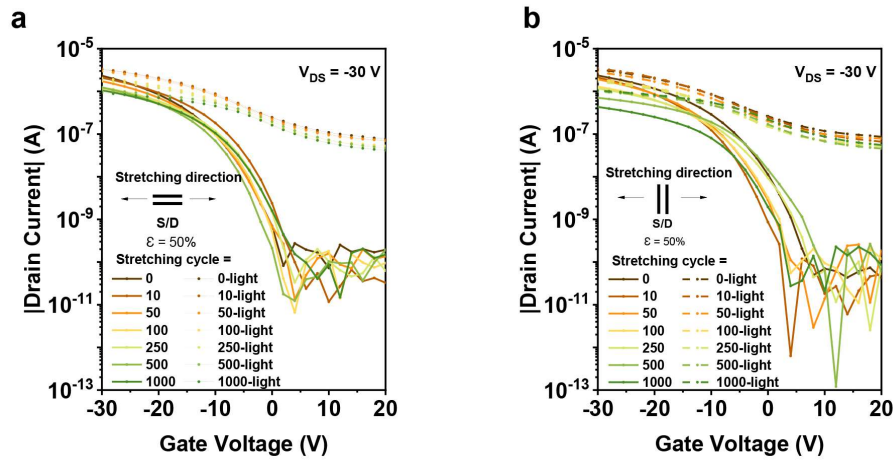


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3 **Supplementary Figure 28.** Strain-tolerance characteristics of ISNVaTs. The ISNVaTs with QCM
 4 hybrid photosensitive films at 10:1 hybrid ratio were subjected to stretching strain from 0% to 100%
 5 in different direction. **a** Typical transfer curves under the stretching direction perpendicular to the
 6 charge transport direction. **b** Typical transfer curves under the stretching direction parallel to the
 7 charge transport direction.

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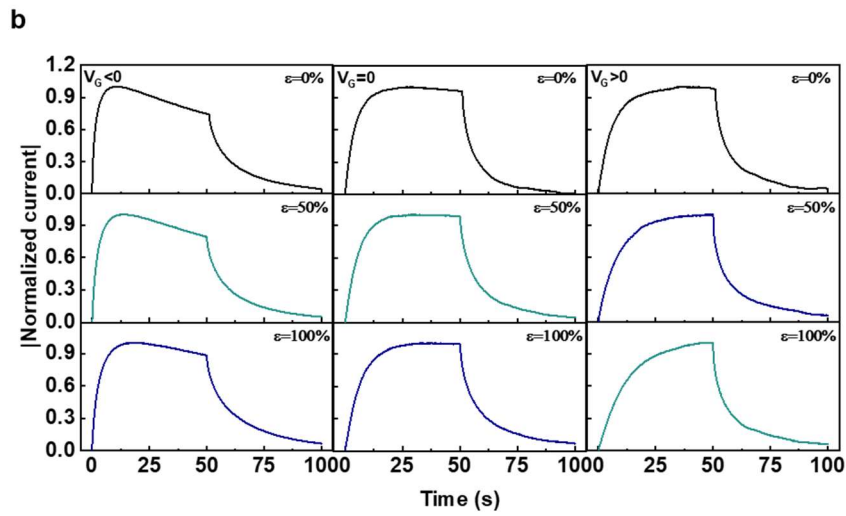
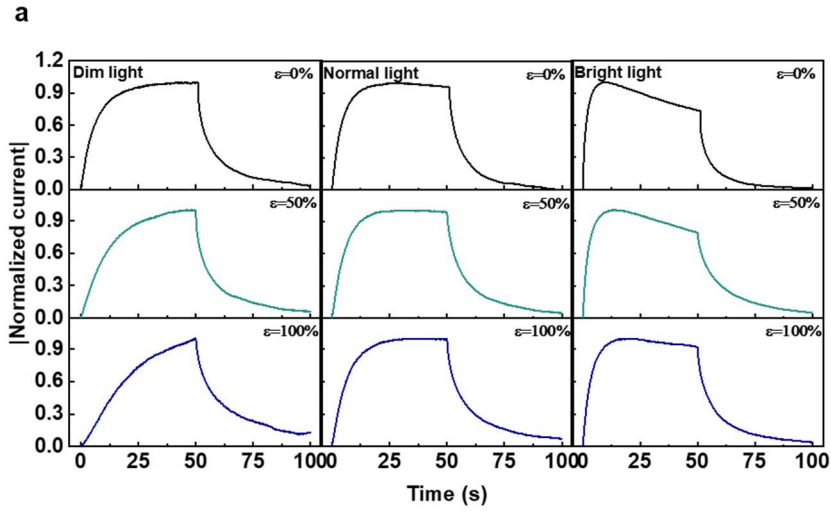
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11 **Supplementary Figure 29.** Electrical stability characteristics against stretching cycle of ISNVaTs.
 12 The ISNVaTs with QCM hybrid photosensitive films at 10:1 hybrid ratio were subjected to multiple
 13 stretching-releasing cycles up to 1000 times at 50% strain in different direction. **a** Typical transfer
 14 curves under the stretching direction perpendicular to the charge transport direction. **b** Typical
 15 transfer curves under the stretching direction parallel to the charge transport direction.

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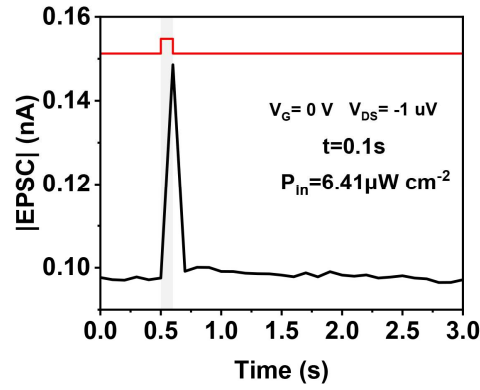
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Supplementary Figure 30. Adaptive behaviors of ISNVaTs under different strains. A 50-second temporal response was provided to evaluate the dependence of adaptive behaviors of ISNVaTs under the 0%, 50% and 100% stretching strain, respectively. **a** Light-intensity-dependence. **b** Gate-voltage-dependence.

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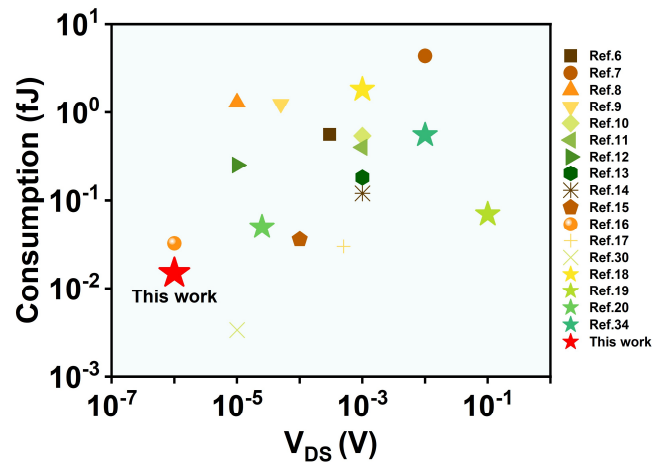


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3 **Supplementary Figure 31.** EPSC triggered by the single light pulse of the ISNVaT at $V_{DS} = -1 \mu\text{V}$.
 4 The energy consumption was calculated from a typical synaptic behavior and an ultra-low power
 5 consumption of 15 aJ was obtained.

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9 **Supplementary Figure 32.** Consumption comparison of previously reported organic synaptic
 10 phototransistors with our ISNVaT device.

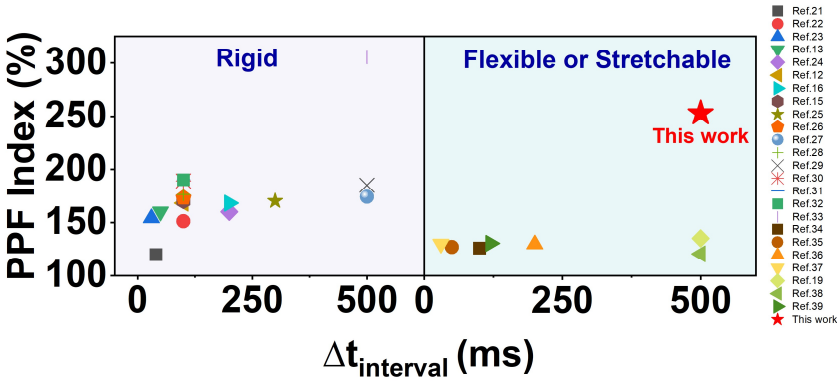
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Supplementary Table 4. List of previously reported organic synaptic phototransistors with our ISNVaT device.

Active layer	Stretchability	Consumption (fJ)	V _{DS} (V)	Duration (s)	Reference
HTEB	Rigid	4.29	-1×10^{-2}	0.05	[7]
CsPbBr ₃ /PDPP4T	Rigid	1.3	-1×10^{-5}	0.5	[8]
Pentacene/PVSK-PhB	Rigid	1.25	-5×10^{-5}	1	[9]
P3HT-b-P2VP	Rigid	0.56	-3×10^{-4}	0.2	[6]
DNTT	Rigid	0.54	-1×10^{-3}	0.05	[10]
DNTT/MoS ₂	Rigid	0.4	-1×10^{-3}	0.02	[11]
Chlorophyll/PDPP4T	Rigid	0.25	-1×10^{-5}	0.05	[12]
CsPbBr ₃ QDs/P3HT/CNFs	Rigid	0.18	-1×10^{-3}	0.05	[13]
DPPDTT/SEBS	Rigid	0.12	-1×10^{-3}	N/A	[14]
CsPbBr ₃ QDs /TIPS	Rigid	0.036	-1×10^{-4}	0.05	[15]
PV2T-BT	Rigid	0.0324	-1×10^{-6}	0.2	[16]
P3HT/FAPbBr ₃ QD	Rigid	0.03	-5×10^{-4}	0.05	[17]
PDP4T/carotene	Rigid	0.0034	-1×10^{-5}	0.01	[30]
P3HT-b-PPI(5F)/PMMA	Flexible	1.82	-1×10^{-3}	1	[18]
PbS QDs/PMMA/Pentacene	Flexible	0.55	-1×10^{-2}	0.1	[34]
DiF-TES-ADT	Flexible	0.07	-1×10^{-1}	0.25	[19]
C8-BTBT/P(VDT-TrFE)	Flexible	0.05	-2.5×10^{-5}	0.02	[20]
CsPbBr ₃ QCM film /DPP-DTT CONPHINE film	100% Stretchable	0.015	-1×10^{-6}	0.1	This work



Supplementary Figure 33. Comparison of the PPF index among reported synaptic phototransistors prepared by different organic semiconductors.

Supplementary Table 5. Comparison of the PPF index among synaptic phototransistors prepared by different organic semiconductors.

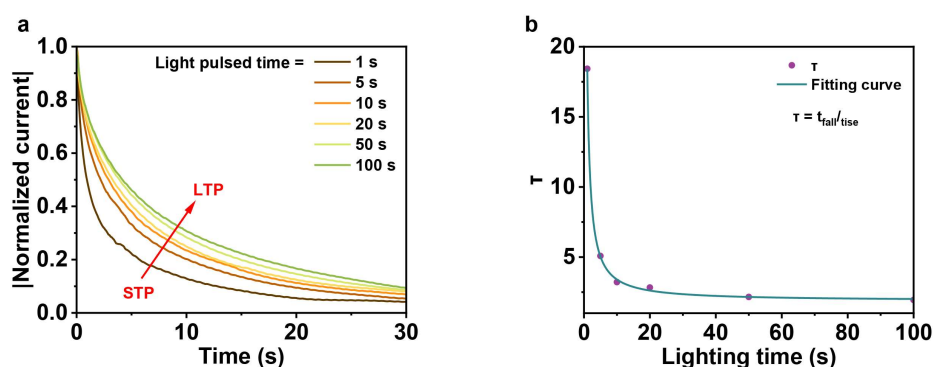
Active layer	Stretchability	PPF index(%)	Δt (ms)	Reference
NT-CN/PMMA/Pentacene	Rigid	120	40	[21]
CsPbBr ₃ QDs/PVP/PDVT-10	Rigid	151	100	[22]
Si NCs/P3HT	Rigid	154	30	[23]
CsPbBr ₃ QDs/P3HT/CNFs	Rigid	160	50	[13]
CsPbBr ₃ QDs/TIPS	Rigid	160	200	[24]
Chlorophyll/PDPP4T	Rigid	168*	100*	[12]
PV2T-BT	Rigid	168	200	[16]
CsPbBr ₃ QDs/TIPS	Rigid	170	100	[15]
CsPbBr ₃ QDs/DPPDTT	Rigid	170	300	[25]
CsPbBr ₃ /P3HT	Rigid	173*	100*	[26]
CsPbBr ₃ QDs/PDVT-10	Rigid	174	500	[27]
PAN/C8-BTBT	Rigid	176	100	[28]
P3HT/PCBM/Ion gels	Rigid	185	500	[29]
PDP4T/carotene	Rigid	189	100	[30]
PDPP3T/Chitosan	Rigid	190	100	[31]
P3HT	Rigid	190*	100*	[32]
C ₁₂ -BTBT/P-FPS	Rigid	305*	500	[33]
PbS QDs/PMMA/Pentacene	Flexible	129*	100*	[34]
PbS QDs/PDPP-C ₆ Si	Flexible	130*	50*	[35]
P3HT-b-MH/BCHL	Flexible	133	200	[36]
DNTT/OPP	Flexible	133.5	30	[37]
Dif-TES-ADT	Flexible	139	500	[19]
IDT-BT	100% Stretchable	123	500	[38]
P3HT NWs/Ion gels	100% Stretchable	134	120	[39]
CsPbBr ₃ QCM film /DPP-DTT CONPHINE film	100% Stretchable	270	600	This work

The “*” in table indicated that the PPF indexes were not published directly and were derived by the given equations and graphs.

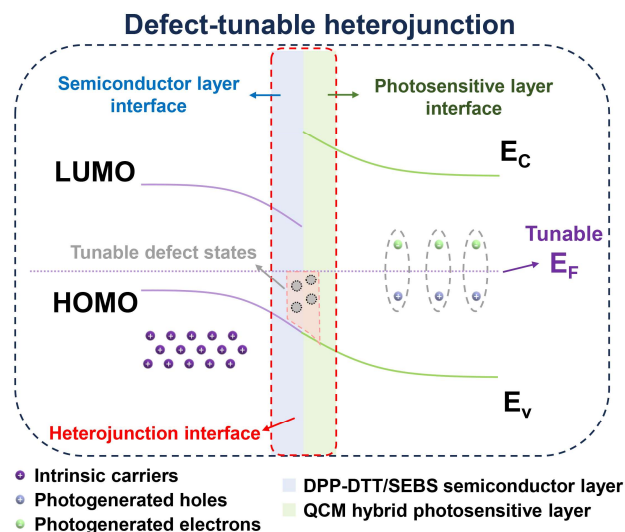
Supplementary Table 6. Comparison of the PPF index and consumption among synaptic phototransistors prepared by different organic semiconductors.

Active layer	Stretchability	Consumption (fJ)	$ V_{ds} $ (V)	PPF index(%)	Δt (ms)	Reference
P3HT-b-P2VP	Rigid	0.56	3×10^{-4}	138	100	[6]
HTEB	Rigid	4.29	1×10^{-2}	210*	10	[7]
CsPbBr ₃ /PDPP4T	Rigid	1.3	1×10^{-5}	146.5*	100	[8]
Pentacene/PVSK-PhB	Rigid	1.25	5×10^{-5}	176*	100	[9]
DNTT	Rigid	0.54	1×10^{-3}	206	50	[10]
DNTT/MoS ₂	Rigid	0.4	1×10^{-3}	113.5*	500	[11]
Chlorophyll/PDPP4T	Rigid	0.25	1×10^{-5}	168*	50	[12]
CsPbBr ₃ QDs/P3HT/CNFs	Rigid	0.18	1×10^{-3}	160	50	[13]
DPPDTT/SEBS	Rigid	0.12	1×10^{-3}	124*	400*	[14]
CsPbBr ₃ QDs /TIPS	Rigid	0.036	1×10^{-4}	170*	100*	[15]
PV2T-BT	Rigid	0.0324	1×10^{-6}	168	200	[16]
P3HT/FAPbBr ₃ QD	Rigid	0.03	5×10^{-4}	196*	100*	[17]
NT-CN/PMMA/Pentacene	Rigid	18.06	3×10^{-1}	120	40	[21]
CsPbBr ₃ QDs/TIPS	Rigid	76	1×10^{-3}	160	200	[24]
CsPbBr ₃ QDs/DPPDTT	Rigid	0.5	5×10^{-4}	170	300	[25]
PDP4T/carotene	Rigid	0.0034	1×10^{-5}	189	100	[30]
P3HT-b-PPI(5F)/PMMA	Flexible	1.82	1×10^{-3}	118*	1000	[18]
DiF-TES-ADT	Flexible	0.07	1×10^{-1}	139	500	[19]
C8-BTBT/P(VDT-TrFE)	Flexible	0.05	2.5×10^{-5}	121*	500	[20]
PbS QDs/PMMA/Pentacene	Flexible	0.55	1×10^{-2}	129*	100*	[34]
CsPbBr ₃ QCM film /DPP-DTT CONPHINE film	100% Stretchable	0.015	1×10^{-6}	270	500	This work

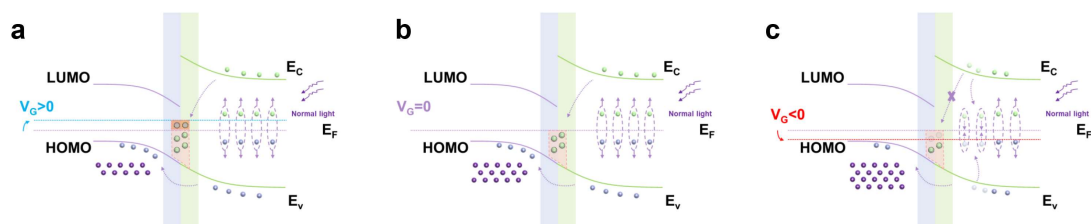
The “*” in table indicated that the PPF indexes were not published directly and were derived by the given equations and graphs.



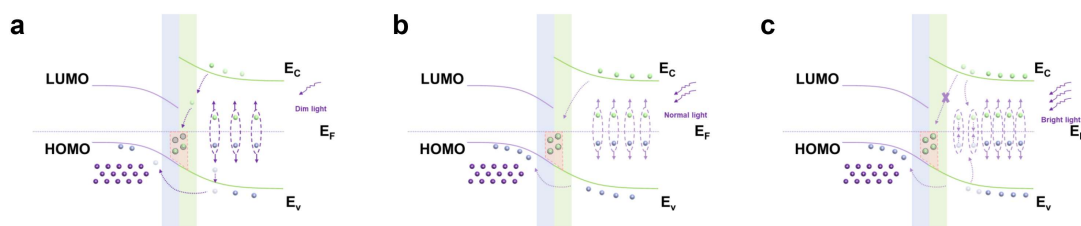
Supplementary Figure 34. Synaptic behaviors of the ISNVaTs. **a** Transformation from STP to LTP by modulating the light pulse duration. **b** Extracted τ as a function of lighting time.



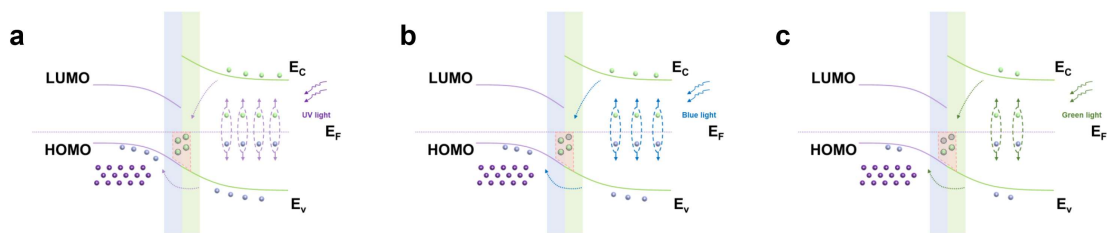
Supplementary Figure 35. Mechanism diagram of defect-tunable heterojunction.



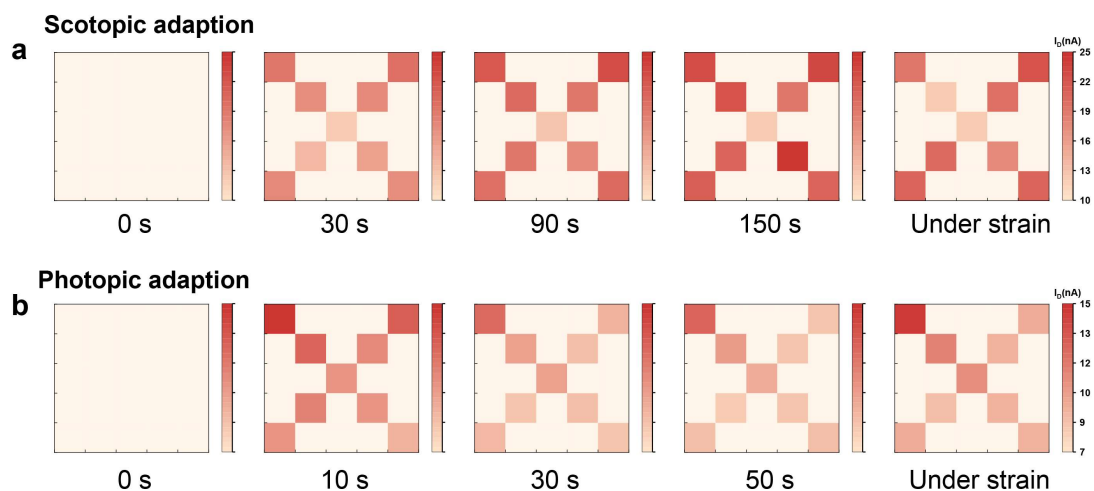
Supplementary Figure 36. Mechanism diagram of gate-voltage dependence. **a** Adaptation under positive gate voltage; **b** Adaptation under zero gate voltage; **c** Adaptation under negative gate voltage.



Supplementary Figure 37. Mechanism diagram of light-intensity dependence. **a** Adaptation under dim light; **b** Adaptation under normal light; **c** Adaptation under bright light.



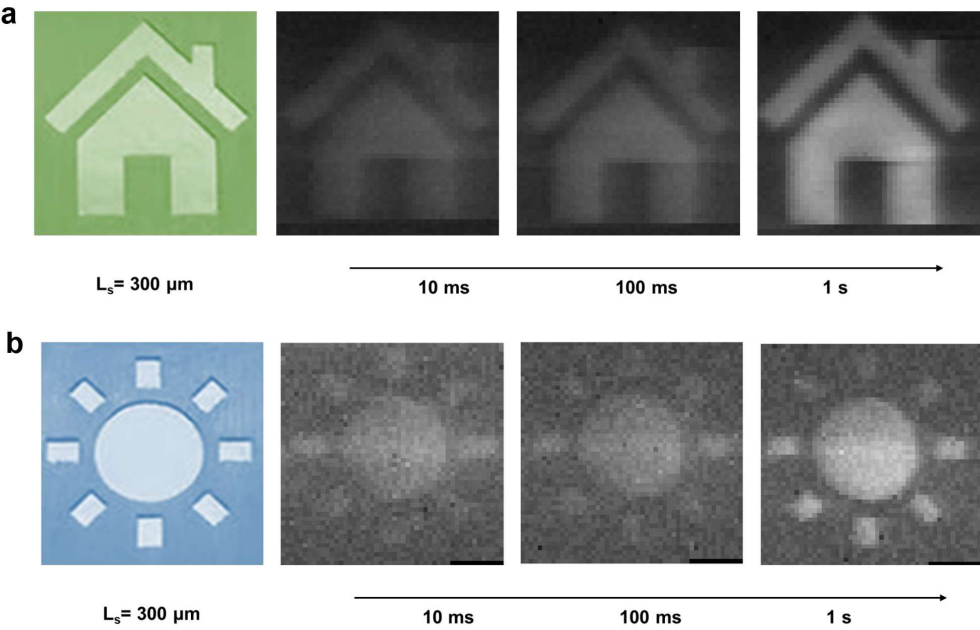
Supplementary Figure 38. Mechanism diagram of wavelength dependence. **a** Adaptation under UV light; **b** Adaptation under blue light; **c** Adaptation under green light.



Supplementary Figure 39. Visual adaptation imagination of the 5*5 ISNVaT array under different gate voltage. **a** Scotopic adaptation ($V_G = +10$ V, $P_{in} = 356.69 \mu\text{W cm}^{-2}$); **b** Photopic adaptation ($V_G = -10$ V, $P_{in} = 356.69 \mu\text{W cm}^{-2}$). (The device at the center was applied at $V_G = -10$ V as a comparison.)

Supplementary Table 7. Comparison of adaptive time among recent related works.

Active layer	Stretchability	Semiconductor type	Visual adaptation	Adaptation time (s)	Reference
CsPbBr ₃ QDs/MoS ₂	Rigid	2D	Photopic adaptation	> 4	[41]
CsFAMA	Rigid	2D	Photopic adaptation	4.8	[42]
CsPb(Br _{1-x} I _x) ₃ /MoS ₂	Rigid	2D	Photopic adaptation	> 60	[43]
MOF	Rigid	2D	Photopic adaptation Scotopic adaptation	10 10	[44]
MoS ₂	Rigid	2D	Photopic adaptation Scotopic adaptation	80 10	[45]
Graphene/PbS QDs/graphene	Rigid	2D	Photopic adaptation Scotopic adaptation	100s	[46]
CdSe&IGZO	Rigid	Inorganic oxide	Photopic adaptation Scotopic adaptation	10 10	[47]
MAPbI ₃ &IZO	Rigid	Inorganic oxide	Photopic adaptation Scotopic adaptation	> 40	[48]
MoO ₃ /LiTFSI	Rigid	Inorganic oxide	Photopic adaptation Scotopic adaptation	> 50	[49]
InP QDs/ITZO	Rigid	Inorganic oxide	Photopic adaptation Scotopic adaptation	300 300	[50]
Two bulk heterojunctions	Rigid	Organic	Photopic adaptation	2	[51]
CsPbBr _x I _{3-x} /TIPS	Rigid	Organic	Photopic adaptation Scotopic adaptation	> 300	[52]
CsPbBr ₃ QCM film /DPP-DTT CONPHINE film	100% Stretchable	Organic	Photopic adaptation Scotopic adaptation	< 150	This work



Supplementary Figure 40. Single-pixel adaptive imaging of ISNVaTs. **a** Simulated visual adaptation results under green light with a house-shaped mask; **b** Simulated visual adaptation results under blue light with a sun-shaped mask. (illumination intervals: 10 ms, 100 ms and 1 s)

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