

Supplementary Materials

Computational screening of reconfigurable van der Waals ferroelectric semiconductor heterojunctions for all-in-one optoelectronic devices

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Supplementary Table 1. The in-plane lattice constant $a = b$ (Å), formation energies E_f (eV), PBE bandgap E_g (eV), electrostatic potential difference ΔV (eV), dipole moment μ (Debye) of 64 monolayer ABP₂S₆ materials. The $\Delta V = 0$ and $\mu = 0$ mean that the monolayer ABP₂S₆ prefers to the paraelectric (PE) phase structure

ABP ₂ S ₆	a	E_f	E_g	ΔV	μ	ABP ₂ S ₆	a	E_f	E_g	ΔV	μ
LiScP ₂ S ₆	6.14	-0.882	2.226	0	0	AuGaP ₂ S ₆	6.15	-0.28	1.284	0.413	0.36
LiCoP ₂ S ₆	5.82	-0.451	1.116	0	0	AuInP ₂ S ₆	6.26	-0.298	1.438	0.421	0.377
LiGaP ₂ S ₆	6.01	-0.547	1.936	0	0	AuSbP ₂ S ₆	6.40	-0.228	1.8	0.207	0.193
LiInP ₂ S ₆	6.16	-0.558	1.958	0	0	AuTlP ₂ S ₆	6.34	-0.169	0.639	0.277	0.254
LiSbP ₂ S ₆	6.30	-0.486	1.838	0	0	AuBiP ₂ S ₆	6.42	-0.263	1.935	0.258	0.241
LiTlP ₂ S ₆	6.25	-0.419	0.861	0	0	KAlP ₂ S ₆	6.34	-0.62	2.308	0	0
LiBiP ₂ S ₆	6.36	-0.52	2.225	0	0	KScP ₂ S ₆	6.53	-0.869	2.495	0	0
NaCoP ₂ S ₆	5.98	-0.38	0.731	0	0	KCoP ₂ S ₆	6.21	-0.357	0.337	0	0
NaGaP ₂ S ₆	6.17	-0.496	1.994	0	0	KGaP ₂ S ₆	6.39	-0.508	1.621	0	0
NaInP ₂ S ₆	6.32	-0.513	1.943	0	0	KInP ₂ S ₆	6.55	-0.533	1.676	0	0
NaSbP ₂ S ₆	6.48	-0.447	1.846	0	0	KSbP ₂ S ₆	6.68	-0.479	1.939	0.31	0.273
NaTlP ₂ S ₆	6.43	-0.376	0.985	0	0	KTlP ₂ S ₆	6.65	-0.407	0.811	0	0
NaBiP ₂ S ₆	6.55	-0.48	2.226	0	0	KBiP ₂ S ₆	6.70	-0.518	2.183	0.35	0.304
CuAlP ₂ S ₆	6.01	-0.431	1.608	0	0	RbAlP ₂ S ₆	6.43	-0.585	1.937	0	0
CuScP ₂ S ₆	6.14	-0.649	1.168	0	0	RbScP ₂ S ₆	6.59	-0.847	1.84	0.46	0.44
CuCoP ₂ S ₆	5.87	-0.241	0.709	0	0	RbCoP ₂ S ₆	6.33	-0.312	0.205	0.15	0.137
CuGaP ₂ S ₆	6.04	-0.311	0.931	0	0	RbGaP ₂ S ₆	6.48	-0.478	1.29	0.13	0.127
CuInP ₂ S ₆	6.07	-0.351	1.577	0.46	0.392	RbInP ₂ S ₆	6.61	-0.514	1.062	0.36	0.318
CuSbP ₂ S ₆	6.30	-0.278	1.82	0.19	0.169	RbSbP ₂ S ₆	6.74	-0.466	1.732	0.54	0.493
CuTlP ₂ S ₆	6.24	-0.199	0.257	0	0	RbBiP ₂ S ₆	6.77	-0.508	1.781	0.58	0.538
CuBiP ₂ S ₆	6.33	-0.311	2.091	0.25	0.226	CsAlP ₂ S ₆	6.50	-0.567	1.086	0.36	0.314
AgAlP ₂ S ₆	6.06	-0.441	2.004	0	0	CsScP ₂ S ₆	6.66	-0.839	1.572	0.5	0.467
AgScP ₂ S ₆	6.20	-0.671	2.016	0	0	CsGaP ₂ S ₆	6.55	-0.467	0.628	0.3	0.305
AgCoP ₂ S ₆	5.95	-0.218	0.705	0	0	CsInP ₂ S ₆	6.69	-0.508	0.784	0.4	0.35
AgGaP ₂ S ₆	6.17	-0.316	1.528	0.4	0.338	CsSbP ₂ S ₆	6.84	-0.466	1.634	0.57	0.527
AgInP ₂ S ₆	6.29	-0.336	1.647	0.397	0.354	CsBiP ₂ S ₆	6.87	-0.508	1.695	0.66	0.626
AgSbP ₂ S ₆	6.42	-0.269	1.911	0.283	0.263	Be ₂ P ₂ S ₆	5.73	-0.39	2.114	0	0
AgTlP ₂ S ₆	6.38	-0.203	0.817	0.255	0.229	Zn ₂ P ₂ S ₆	6.07	-0.42	2.133	0	0
AgBiP ₂ S ₆	6.46	-0.304	2.265	0.292	0.273	Cd ₂ P ₂ S ₆	6.29	-0.425	1.982	0	0
AuAlP ₂ S ₆	6.11	-0.391	1.772	0.625	0.534	Ge ₂ P ₂ S ₆	5.98	-0.202	1.06	0	0
AuScP ₂ S ₆	6.25	-0.621	2.152	0.586	0.527	Sn ₂ P ₂ S ₆	6.13	-0.294	1.35	0	0
AuCoP ₂ S ₆	6.05	-0.155	0.756	0.681	0.563	Pb ₂ P ₂ S ₆	6.25	-0.179	0.29	0	0

Supplementary Table 2. The in-plane lattice constant $a = b$ (Å), formation energies E_f (eV), PBE bandgap E_g (eV), electrostatic potential difference ΔV (eV), dipole moment μ (Debye) of 72 monolayer ABP₂Se₆ materials. The $\Delta V = 0$ and $\mu = 0$ mean that the monolayer ABP₂Se₆ prefers to the paraelectric (PE) phase structure

ABP ₂ Se ₆	a	E_f	E_g	ΔV	μ	ABP ₂ Se ₆	a	E_f	E_g	ΔV	μ
LiAlP ₂ Se ₆	6.35	-0.624	2.066	0	0	AuSbP ₂ Se ₆	6.699	-0.253	0.903	0	0
LiScP ₂ Se ₆	6.484	-0.834	1.855	0	0	AuTiP ₂ Se ₆	6.669	-0.204	0.194	0.211	0.18
LiCoP ₂ Se ₆	6.204	-0.46	0.927	0	0	AuBiP ₂ Se ₆	6.73	-0.284	1.059	0.247	0.254
LiGaP ₂ Se ₆	6.379	-0.529	1.303	0	0	KAlP ₂ Se ₆	6.696	-0.605	1.799	0	0
LiInP ₂ Se ₆	6.5	-0.545	1.276	0	0	KScP ₂ Se ₆	6.845	-0.838	2.191	0	0
LiSbP ₂ Se ₆	6.625	-0.489	1.461	0	0	KCoP ₂ Se ₆	6.57	-0.402	0.381	0	0
LiTiP ₂ Se ₆	6.57	-0.429	0.515	0	0	KGaP ₂ Se ₆	6.742	-0.515	1.275	0	0
LiBiP ₂ Se ₆	6.671	-0.519	1.729	0	0	KInP ₂ Se ₆	6.896	-0.535	1.387	0	0
NaAlP ₂ Se ₆	6.497	-0.584	2.115	0	0	KSbP ₂ Se ₆	7.02	-0.488	1.551	0.19	0.19
NaScP ₂ Se ₆	6.64	-0.802	2.221	0	0	KTiP ₂ Se ₆	6.987	-0.424	0.564	0	0
NaCoP ₂ Se ₆	6.359	-0.403	0.64	0	0	KBiP ₂ Se ₆	7.042	-0.521	1.752	0.18	0.189
NaGaP ₂ Se ₆	6.537	-0.488	1.497	0	0	RbAlP ₂ Se ₆	6.788	-0.578	1.529	0	0
NaInP ₂ Se ₆	6.674	-0.504	1.42	0	0	RbScP ₂ Se ₆	6.935	-0.819	1.981	0	0
NaSbP ₂ Se ₆	6.801	-0.451	1.587	0	0	RbCoP ₂ Se ₆	6.68	-0.365	0.244	0	0
NaTiP ₂ Se ₆	6.766	-0.387	0.648	0	0	RbGaP ₂ Se ₆	6.836	-0.493	1.06	0	0
NaBiP ₂ Se ₆	6.845	-0.48	1.873	0	0	RbInP ₂ Se ₆	6.988	-0.516	1.151	0	0
CuAlP ₂ Se ₆	6.377	-0.4	1.007	0	0	RbSbP ₂ Se ₆	7.1	-0.474	1.377	0.31	0.33
CuScP ₂ Se ₆	6.492	-0.608	0.875	0	0	RbTiP ₂ Se ₆	7.072	-0.411	0.394	0	0
CuCoP ₂ Se ₆	6.187	-0.261	0.544	0	0	RbBiP ₂ Se ₆	7.116	-0.509	1.434	0.38	0.368
CuGaP ₂ Se ₆	6.407	-0.309	0.479	0	0	CsAlP ₂ Se ₆	6.876	-0.561	1.225	0	0
CuInP ₂ Se ₆	6.502	-0.306	0.956	0.34	0.299	CsScP ₂ Se ₆	7.01	-0.808	1.389	0.26	0.28
CuSbP ₂ Se ₆	6.611	-0.279	1.109	0.21	0.207	CsCoP ₂ Se ₆	6.789	-0.341	0.072	0	0
CuBiP ₂ Se ₆	6.641	-0.309	1.256	0.26	0.254	CsGaP ₂ Se ₆	6.931	-0.481	0.831	0	0
AgAlP ₂ Se ₆	6.413	-0.427	1.409	0	0	CsInP ₂ Se ₆	7.059	-0.511	0.692	0.23	0.227
AgScP ₂ Se ₆	6.52	-0.642	1.687	0	0	CsSbP ₂ Se ₆	7.197	-0.476	1.082	0.42	0.498
AgCoP ₂ Se ₆	6.311	-0.261	0.571	0	0	CsTiP ₂ Se ₆	7.158	-0.415	0.175	0.22	0.227
AgGaP ₂ Se ₆	6.45	-0.333	0.951	0	0	CsBiP ₂ Se ₆	7.201	-0.511	1.062	0.46	0.469
AgInP ₂ Se ₆	6.581	-0.346	0.874	0	0	Be ₂ P ₂ Se ₆	6.098	-0.343	1.321	0	0
AgSbP ₂ Se ₆	6.697	-0.29	1.313	0.143	0	Mg ₂ P ₂ Se ₆	6.45	-0.725	2.029	0	0
AgTiP ₂ Se ₆	6.689	-0.23	0.438	0.131	0.124	Ca ₂ P ₂ Se ₆	6.879	-0.984	2.045	0	0
AgBiP ₂ Se ₆	6.742	-0.32	1.446	0.132	0.131	Zn ₂ P ₂ Se ₆	6.355	-0.408	1.42	0	0
AuAlP ₂ Se ₆	6.483	-0.376	0.871	0.506	0.488	Sr ₂ P ₂ Se ₆	7.224	-0.985	2.32	0	0
AuScP ₂ Se ₆	6.589	-0.593	1.292	0.489	0.488	Cd ₂ P ₂ Se ₆	6.617	-0.429	1.352	0	0
AuCoP ₂ Se ₆	6.383	-0.201	0.647	0.566	0.527	Ba ₂ P ₂ Se ₆	7.639	-0.975	2.148	0	0
AuGaP ₂ Se ₆	6.513	-0.291	0.628	0.309	0.302	Ge ₂ P ₂ Se ₆	6.387	-0.219	0.74	0	0
AuInP ₂ Se ₆	6.598	-0.31	0.77	0.286	0.283	Sn ₂ P ₂ Se ₆	6.5	-0.3	0.84	0	0

Supplementary Table 3. The in-plane lattice constant $a = b$ (Å), formation energies E_f (eV), PBE bandgap E_g (eV), electrostatic potential difference ΔV (eV), dipole moment μ (Debye) of 49 monolayer ABP₂Te₆ materials. The $\Delta V = 0$ and $\mu = 0$ mean that the monolayer ABP₂Te₆ prefers to the paraelectric (PE) phase structure

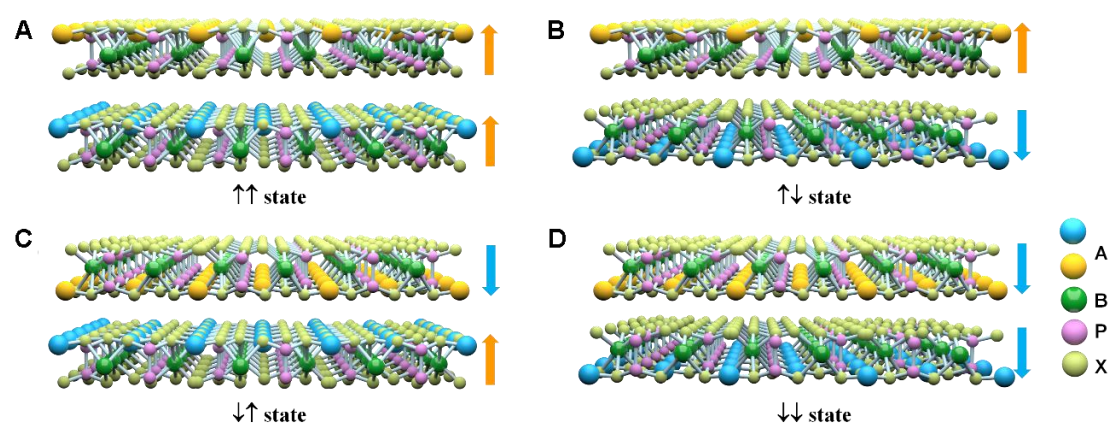
ABP ₂ Te ₆	a	E_f	E_g	ΔV	μ	ABP ₂ Te ₆	a	E_f	E_g	ΔV	μ
LiAlP ₂ Te ₆	6.922	-0.223	1.068	0	0	KGaP ₂ Te ₆	7.297	-0.167	0.905	0	0
LiScP ₂ Te ₆	7.039	-0.422	1.191	0	0	KInP ₂ Te ₆	7.427	-0.176	0.927	0	0
LiCoP ₂ Te ₆	6.79	-0.163	0.616	0	0	KSbP ₂ Te ₆	7.483	-0.149	1.079	0.33	0.391
LiGaP ₂ Te ₆	6.943	-0.154	0.714	0	0	KBiP ₂ Te ₆	7.512	-0.174	1.21	0.28	0.33
LiInP ₂ Te ₆	7.038	-0.169	0.599	0	0	RbAlP ₂ Te ₆	7.347	-0.22	1.237	0	0
LiSbP ₂ Te ₆	7.136	-0.149	1.017	0.3	0.337	RbScP ₂ Te ₆	7.459	-0.444	1.431	0	0
LiBiP ₂ Te ₆	7.181	-0.168	1.159	0.21	0.231	RbCoP ₂ Te ₆	7.26	-0.122	0.38	0	0
NaAlP ₂ Te ₆	7.071	-0.196	1.363	0	0	RbGaP ₂ Te ₆	7.384	-0.151	0.835	0	0
NaScP ₂ Te ₆	7.18	-0.403	1.513	0	0	RbInP ₂ Te ₆	7.523	-0.163	0.933	0	0
NaCoP ₂ Te ₆	6.954	-0.119	0.569	0	0	RbSbP ₂ Te ₆	7.585	-0.133	1.017	0.37	0.456
NaGaP ₂ Te ₆	7.102	-0.124	0.933	0	0	RbBiP ₂ Te ₆	7.616	-0.161	1.095	0.31	0.361
NaInP ₂ Te ₆	7.204	-0.135	0.75	0.11	0.146	CsAlP ₂ Te ₆	7.429	-0.212	1.051	0	0
NaSbP ₂ Te ₆	7.267	-0.112	1.035	0.34	0.395	CsScP ₂ Te ₆	7.545	-0.439	1.209	0	0
NaBiP ₂ Te ₆	7.312	-0.134	1.188	0.23	0.262	CsCoP ₂ Te ₆	7.354	-0.111	0.32	0	0
CuAlP ₂ Te ₆	6.962	-0.029	0.353	0	0	CsGaP ₂ Te ₆	7.472	-0.147	0.685	0	0
CuScP ₂ Te ₆	7.069	-0.217	0.407	0	0	CsInP ₂ Te ₆	7.616	-0.162	0.78	0	0
AgAlP ₂ Te ₆	6.926	-0.069	0.776	0	0	CsSbP ₂ Te ₆	7.72	-0.134	0.937	0.27	0.302
AgScP ₂ Te ₆	7.024	-0.262	0.948	0	0	CsBiP ₂ Te ₆	7.706	-0.16	0.894	0.42	0.536
AgCoP ₂ Te ₆	6.849	-0.016	0.465	0	0	Mg ₂ P ₂ Te ₆	7.011	-0.301	0.96	0	0
AgInP ₂ Te ₆	7.064	-0.011	0.265	0	0	Ca ₂ P ₂ Te ₆	7.401	-0.558	1.188	0	0
AuAlP ₂ Te ₆	7.046	-0.05	0.179	0.417	0.476	Zn ₂ P ₂ Te ₆	6.882	-0.042	0.648	0	0
AuScP ₂ Te ₆	7.143	-0.248	0.52	0.396	0.464	Sr ₂ P ₂ Te ₆	7.739	-0.562	1.341	0	0
KAlP ₂ Te ₆	7.259	-0.237	1.33	0	0	Cd ₂ P ₂ Te ₆	7.117	-0.075	0.934	0	0
KScP ₂ Te ₆	7.374	-0.456	1.518	0	0	Ba ₂ P ₂ Te ₆	8.17	-0.557	1.392	0	0
KCoP ₂ Te ₆	7.16	-0.145	0.449	0	0						

Supplementary Table 4. The in-plane lattice constant $a = b$ (Å), formation energy E_f (eV), PBE and HSE bandgaps E_g (eV), electrostatic potential difference ΔV (eV), work function W_F (eV), electron (m_e) and hole (m_h) effective masses, and spontaneous ferroelectric polarization P_s ($\mu C \cdot cm^{-2}$) of 11 screened highly stable ABP₂X₆ monolayers

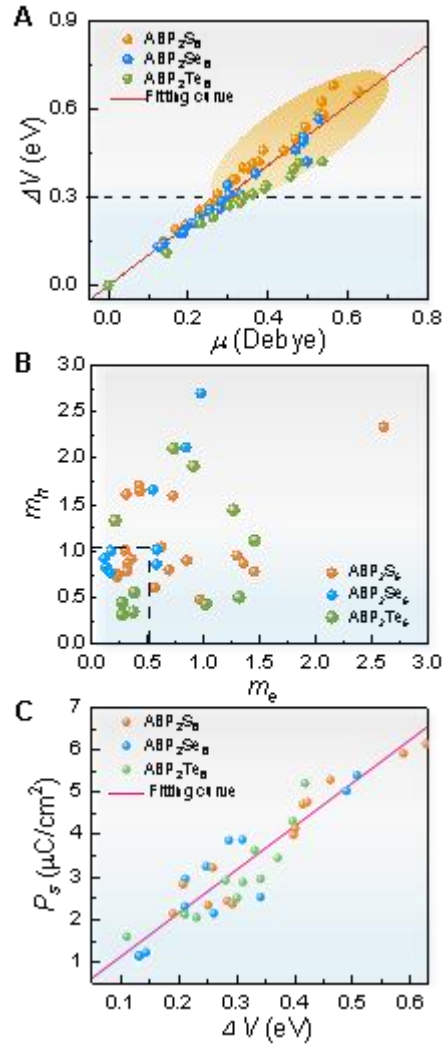
ABP ₂ S ₆	a	E_f	E_g (PBE)	E_g (HSE)	ΔV	W_F	m_e	m_h	P_s
CuInP ₂ S ₆	6.07	-0.351	1.577	2.894	0.46	6.894	0.298	1.009	5.30
AgGaP ₂ S ₆	6.173	-0.316	1.528	2.722	0.4	5.697	0.358	0.917	4.17
AgInP ₂ S ₆	6.296	-0.336	1.647	2.869	0.397	5.674	0.323	0.87	4.01
AuAlP ₂ S ₆	6.115	-0.391	1.772	2.939	0.625	5.657	0.185	0.759	6.15
AuScP ₂ S ₆	6.251	-0.621	2.152	2.986	0.586	5.845	0.311	0.784	5.92
AuGaP ₂ S ₆	6.15	-0.28	1.284	2.441	0.413	5.764	0.231	0.722	4.73
AuInP ₂ S ₆	6.264	-0.298	1.438	2.622	0.421	5.721	0.231	0.752	4.78
CuInP ₂ Se ₆	6.502	-0.306	0.956	2.095	0.34	4.944	0.172	1.006	2.56
AuAlP ₂ Se ₆	6.483	-0.376	0.871	2.050	0.506	5.573	0.114	0.926	5.41
AuGaP ₂ Se ₆	6.513	-0.291	0.628	1.584	0.309	5.576	0.127	0.834	3.90
AuScP ₂ Se ₆	6.589	-0.593	1.292	2.447	0.489	5.602	0.167	0.77	5.04

Supplementary Table 5. The in-plane lattice constant a and b (Å), interlayer binding energy E_b (eV), Conduction and valence band offsets E_C and E_V (eV), electrostatic potential difference ΔV (eV), and band-alignment type of 2D CuInP₂S₆/AuInP₂S₆ VFSH

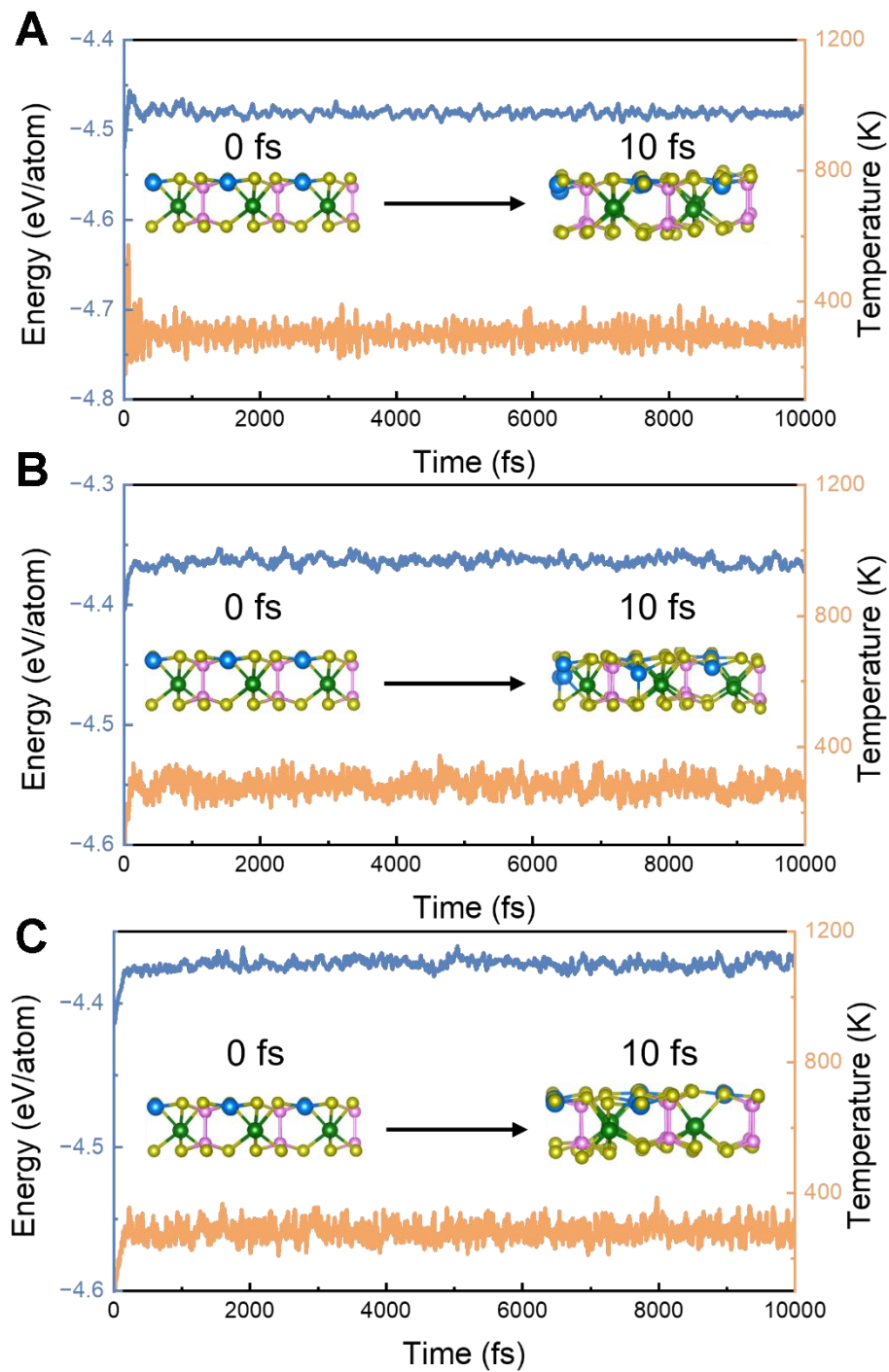
CIPS/AIPS	a	b	E_b	E_g	ΔE_C	ΔE_V	ΔV	Band alignment
↑↑	10.67	6.16	-3.61	2.52	0.48	0.15	0.48	II
↑↓	10.69	6.17	-3.12	2.73	0.03	0.13	0.008	II
↓↑	10.67	6.16	-3.78	2.55	0.01	0.11	0.004	I
↓↓	10.67	6.16	-3.65	2.40	0.48	0.42	0.45	II



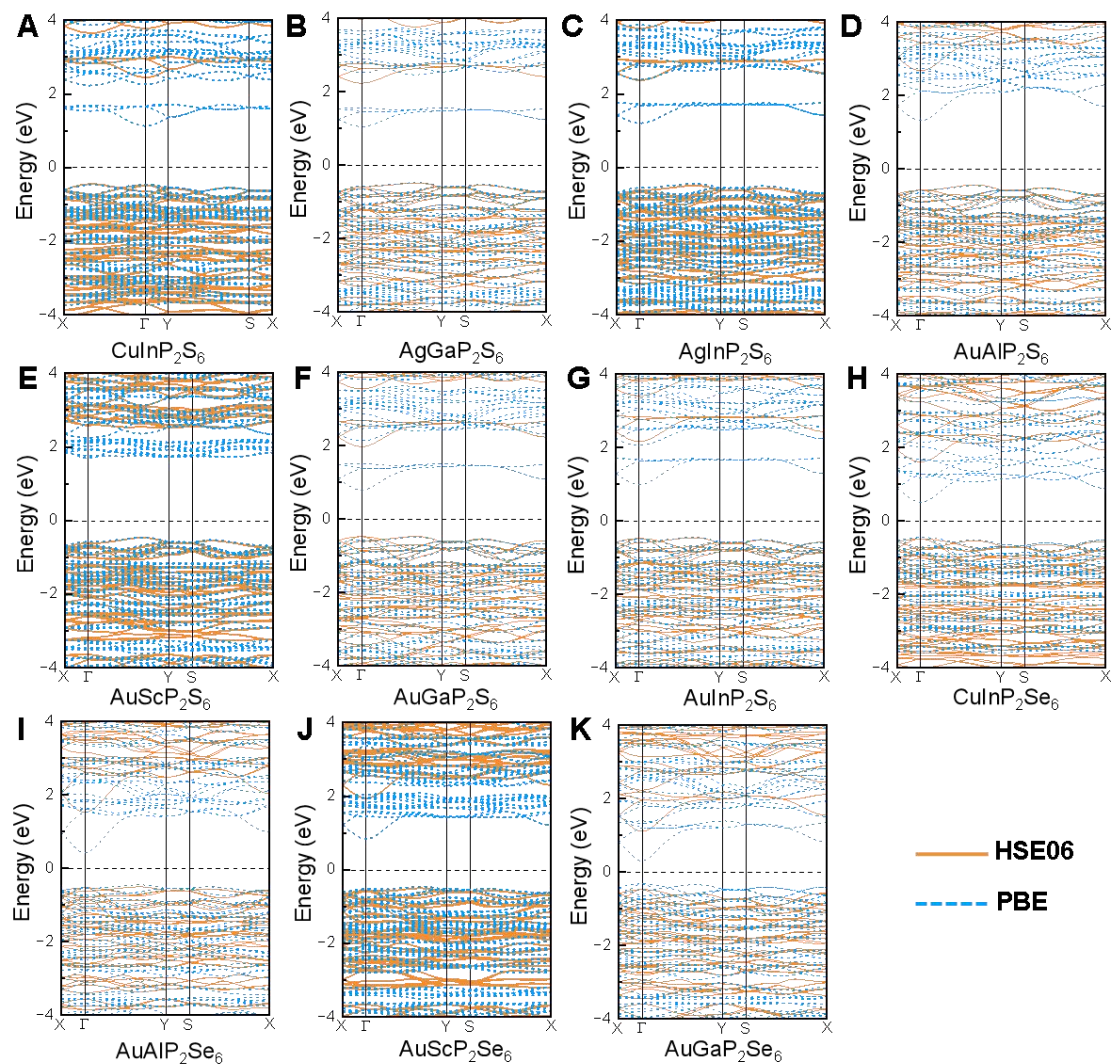
Supplementary Figure 1. Structural models for four stable polarization states of 2D ABP_2X_6 VFSHs. The VFSH in (A) $\uparrow\uparrow$ state, (B) $\uparrow\downarrow$ state, (C) $\downarrow\uparrow$ state, (D) $\downarrow\downarrow$ state. The arrows indicate the polarization direction of each FE layer in the heterojunction.



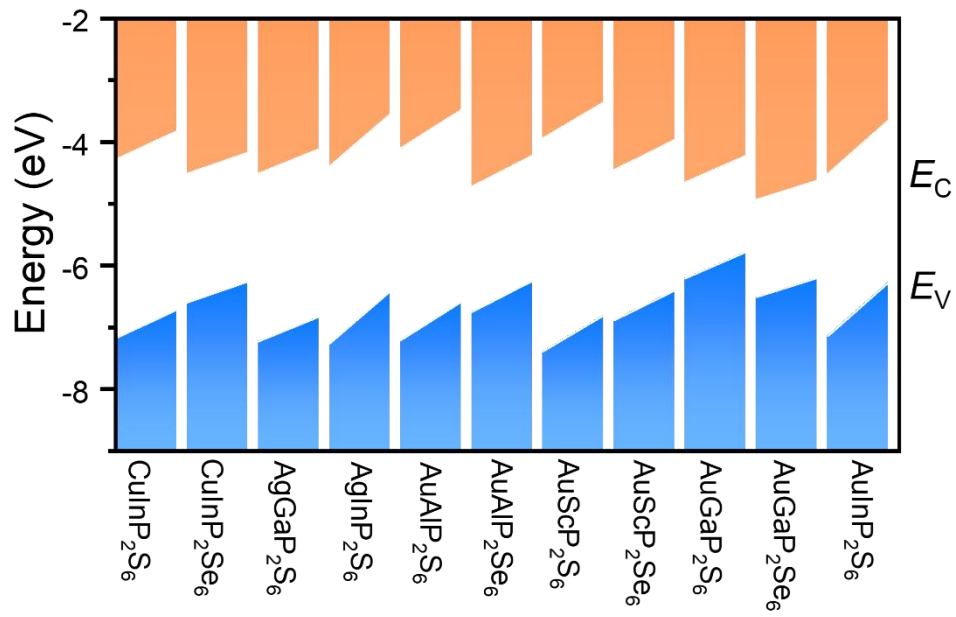
Supplementary Figure 2. Feature electronic and polarization parameters for high-throughput screening of monolayer ABP₂X₆ materials. (A) The linear dependent relationship between the electrostatic potential difference (ΔV) and dipole moment (μ) of monolayer ABP₂X₆. (B) Electron (m_e) and hole (m_h) effective masses of monolayer ABP₂X₆. (C) The linear relationship between the spontaneous polarization (P_s) and ΔV of monolayer ABP₂X₆. Based on high-throughput DFT calculations, using the formation energy (E_f), bandgap (E_g), ΔV and μ , and carrier effective masses m_e and m_h as the feature parameters, 11 highly stable 2D ABP₂X₆ FE semiconductors have been screened.



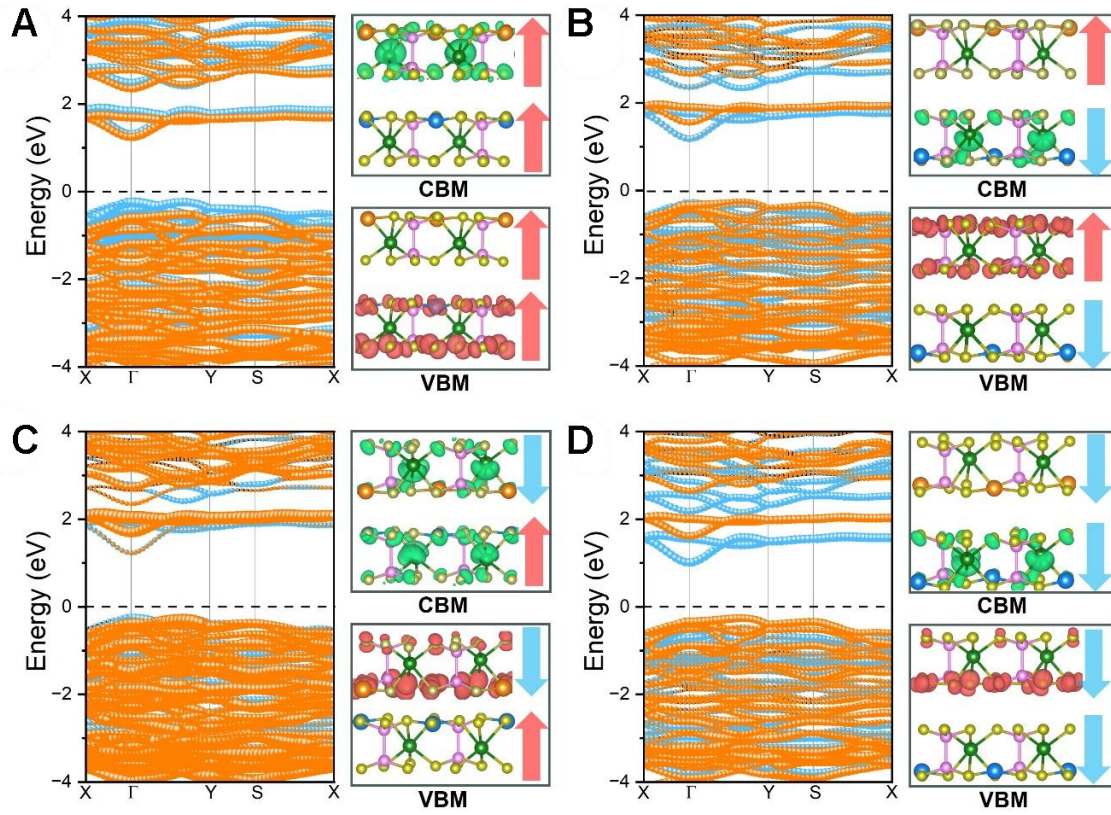
Supplementary Figure 3. Energy (blue lines) and temperature (orange lines) profiles of (A) CuInP_2S_6 , (B) AgInP_2S_6 and (C) AuInP_2S_6 as a function of AIMD simulation time. The insets show the initial and final structures of the heterojunction within the simulation time of 10 ps. The energy and temperature oscillations in all three FE semiconductor monolayers are very small. Moreover, the final structures of these FE semiconductor monolayers do not indicate obvious structural distortion after 10 ps. Therefore, these 2D FE semiconductors are thermodynamically stable.



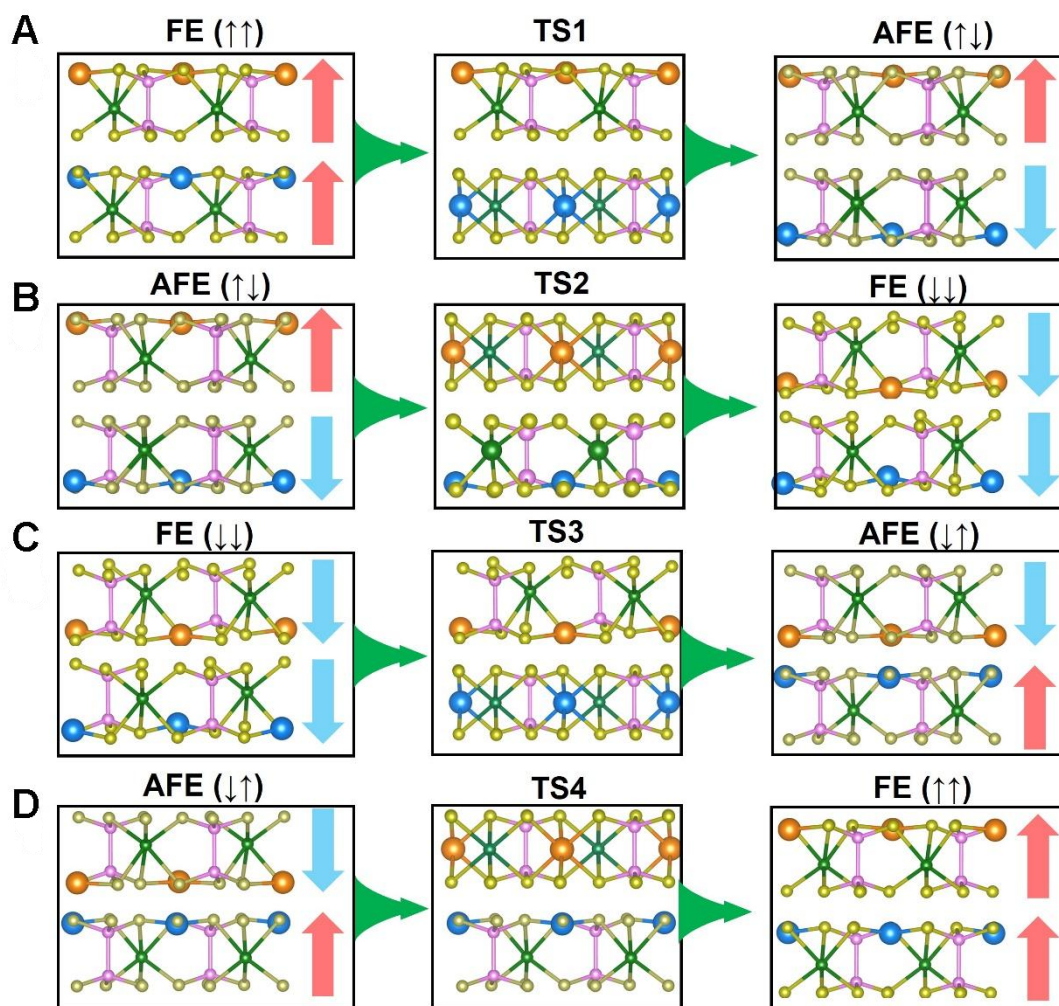
Supplementary Figure 4. Band structure of 11 highly stable ABP_2X_6 monolayers with strong spontaneous polarization. Band structure of (A) $CuInP_2S_6$, (B) $AgGaP_2S_6$, (C) $AgInP_2S_6$, (D) $AuAlP_2S_6$, (E) $AuScP_2S_6$, (F) $AuGaP_2S_6$, (G) $AuInP_2S_6$, (H) $CuInP_2Se_6$, (I) $AuAlP_2Se_6$, (J) $AuScP_2Se_6$, (K) $AuGaP_2Se_6$. The orange solid curves and blue dash curves denote the band structures calculated by the HSE06 and PBE functionals, respectively. The horizontal dash lines at 0 eV correspond to the position of the Fermi level.



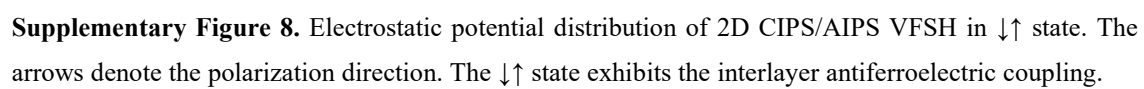
Supplementary Figure 5. The CBM and VBM energies of 11 screened 2D ABP₂X₆ FE semiconductors relative to the vacuum level. E_C and E_V denote the CBM and VBM energies, respectively. The inclined band alignment in these 2D ABP₂X₆ monolayers originates from the polarization-induced band bending.



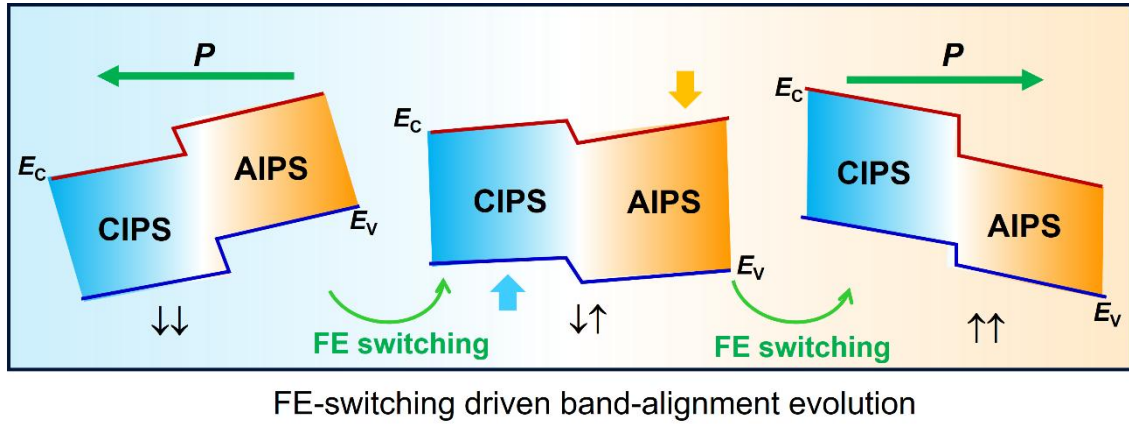
Supplementary Figure 6. Projected band structures (left panel) and charge-density spatial distribution (right panel) of CBM and VBM in AgInP₂S₆/CuInP₂S₆ VFSH. The projected band structure and charge-density spatial distribution of the heterojunction in (A) $\uparrow\uparrow$ state, (B) $\uparrow\downarrow$ state, (C) $\downarrow\uparrow$ state, (D) $\downarrow\downarrow$ state. The horizontal dash lines denote the position of the Fermi energy level. The blue and orange bands (left panel) are contributed by the CuInP₂S₆ and AgInP₂S₆, respectively. The arrows indicate the polarization direction.



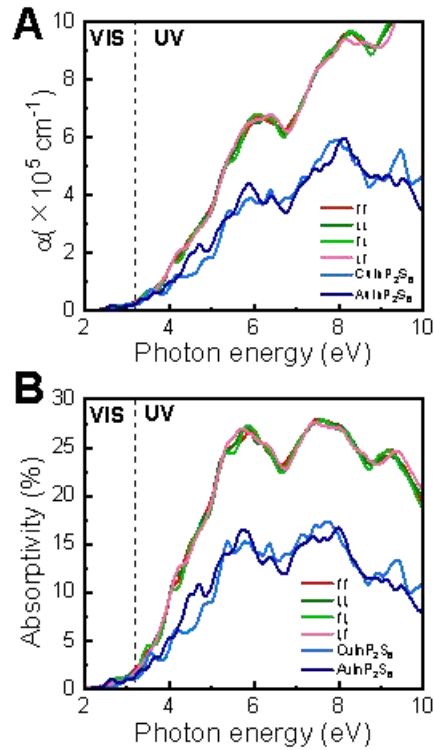
Supplementary Figure 7. Structural models for the transition among four polarization states in 2D CIPS/AIPS VFSS. Atomic models for (A) the transition from $\uparrow\uparrow$ to $\uparrow\downarrow$ state, (B) the transition from $\uparrow\downarrow$ to $\downarrow\downarrow$ state, (C) the transition from $\downarrow\downarrow$ to $\downarrow\uparrow$ state, and (D) the transition from $\downarrow\uparrow$ to $\uparrow\uparrow$ state. The red and blue arrows denote upward and downward polarization directions, respectively. TS1-TS4 denote the intermediate transition state from one polarization state to another polarization state.



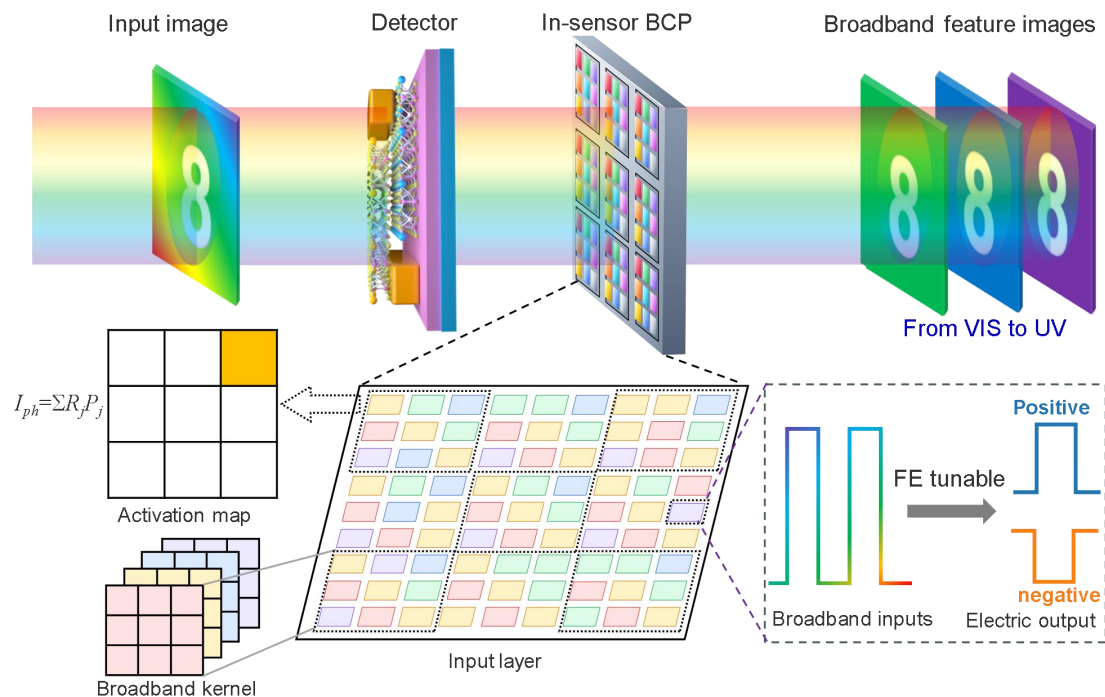
Supplementary Figure 8. Electrostatic potential distribution of 2D CIPS/AIPS VFSH in $\downarrow\uparrow$ state. The arrows denote the polarization direction. The $\downarrow\uparrow$ state exhibits the interlayer antiferroelectric coupling.



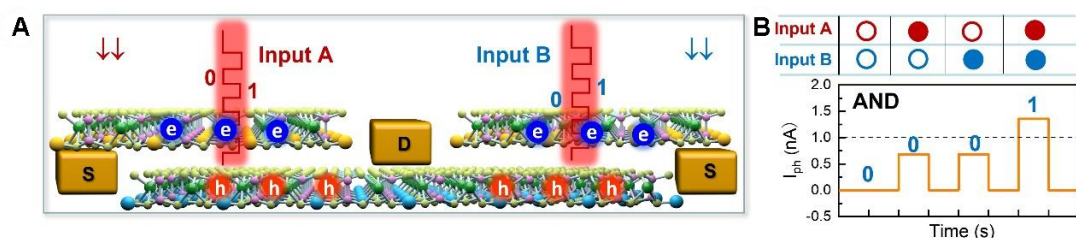
Supplementary Figure 9. Band-alignment evolution of CIPS/AIPS VFSH driven by the polarization switching from $\downarrow\downarrow$, $\downarrow\uparrow$, to $\uparrow\uparrow$ state. The green arrows indicate the polarization direction.



Supplementary Figure 10. Optical absorption ability of 2D CIPS/AIPS VFSH in four polarization states. (A) Absorption coefficients and (B) absorptivity of CIPS/AIPS VFSH in four polarization states as a function of photon energy. The absorption coefficients and absorptivity of monolayer freestanding CuInP_2S_6 and AuInP_2S_6 are also provided for the comparison. The blue, violet, pink, and orange curves represent the result of $\uparrow\uparrow$, $\downarrow\downarrow$, $\uparrow\downarrow$ and $\downarrow\uparrow$ states, respectively. The cyan and green curves represent the result of CIPS and AIPS, respectively.



Supplementary Figure 11. Schematic diagram of implementing in-sensor broadband convolutional processing based on CIPS/AIPS VFSH device for image recognition. The broadband convolution calculation is derived from a weighted electrical output from broadband optical inputs. The broadband kernel values can be represented by photoresponsivity (R_j) that depends on the polarization states controlled by the top/bottom gate voltage. The input layer is represented by the incident light. The pixel values are equivalent to light power (P_j), and the output photocurrent (I_{ph}) can be described by the convolution operation via the equation of $I_{ph} = \sum_j R_j P_j$, and the inset indicates the concept of FE-tunable weight for each pixel that arises from the weighted positive and negative photoresponsivity.



Supplementary Figure 12. Schematic diagram of a complementary CIPS/AIPS phototransistor and photoresponse for implementing AND logic gate. (A) Schematic diagram of a complementary phototransistor consisting of two CIPS/AIPS devices in a state and two optical inputs (A and B). (B) Optical input sequence and corresponding output photocurrent and logic sequence of the phototransistor at $E_{ph} = 2.6$ eV and $P_{light} = 1.0$ W/m².