臺北科技大學暨深圳大學
學術合作專題研究計畫成果發表

Quasi-2D Perovskite with Ligand Engineering to Improve the Stability of Phototransistor Memory with a Floating Gate

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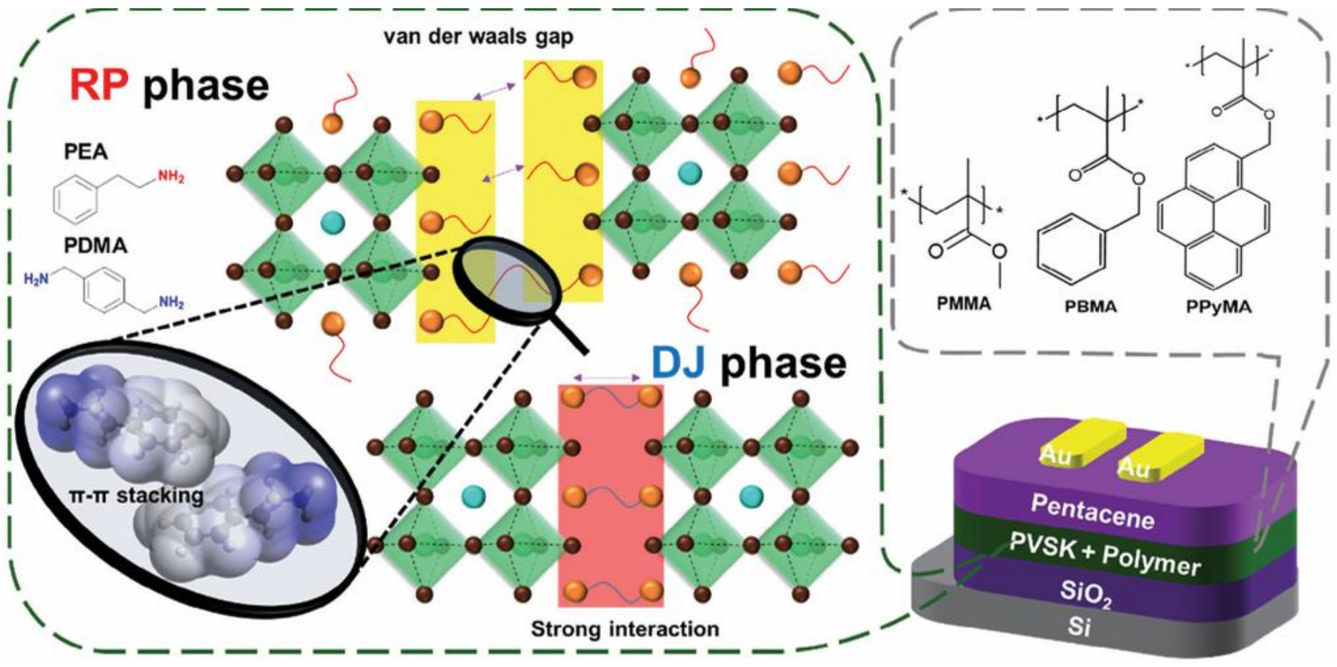
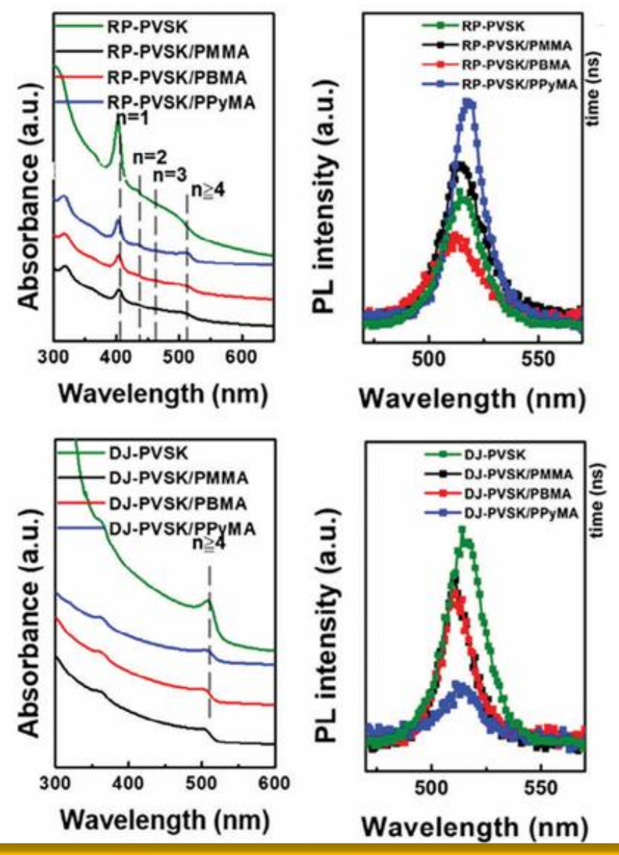
Abstract

Quasi-2D perovskites have great potential for photomemory applications, but the effects of ligand structures and polymer matrices remain unclear. In this work, RP- and DJ-phase perovskites based on PEABr and PDMA were combined with methacrylate polymers containing benzene or pyrene groups to investigate ligand–polymer interactions. The RP-phase perovskite with a pyrene-functionalized polymer showed improved crystal orientation, fewer grain boundaries, and better charge transport, leading to a high ON/OFF ratio of 2.68×10^4, low operating voltage of −0.1 V, fast response of 0.1 s, and good thermal stability. These results demonstrate that ligand and polymer engineering can effectively optimize perovskite microstructure and photomemory performance.



UV, PL



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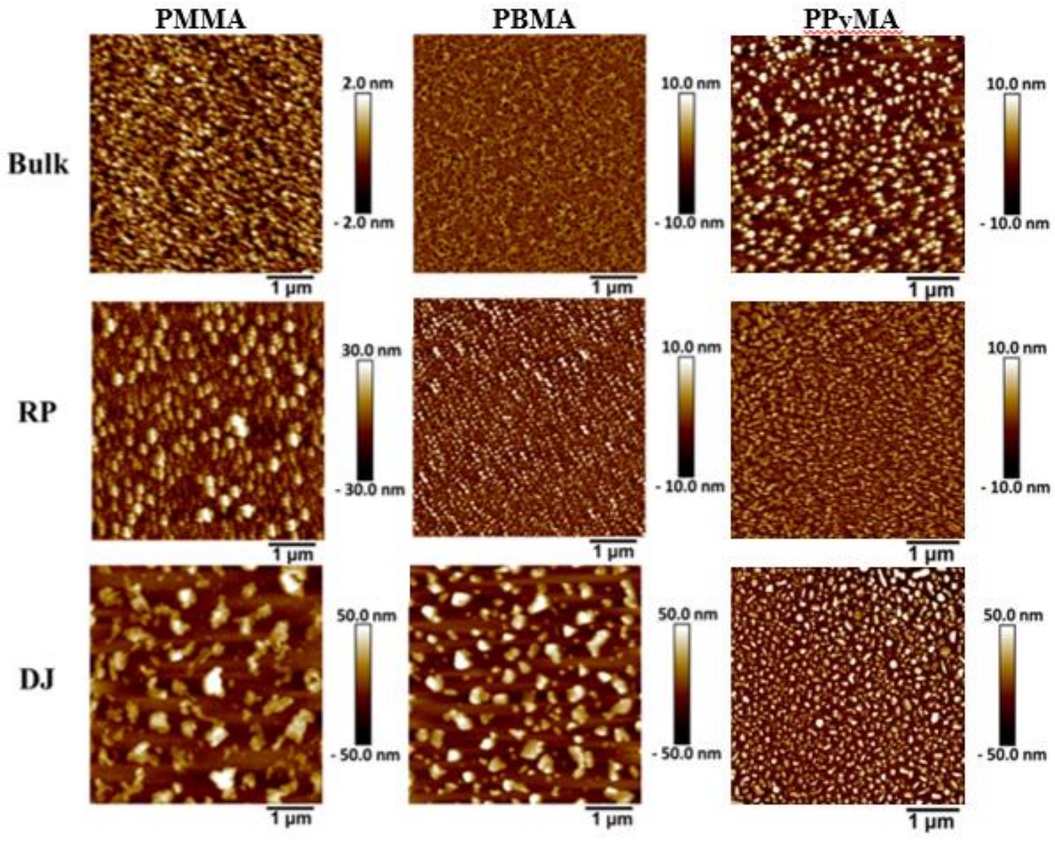

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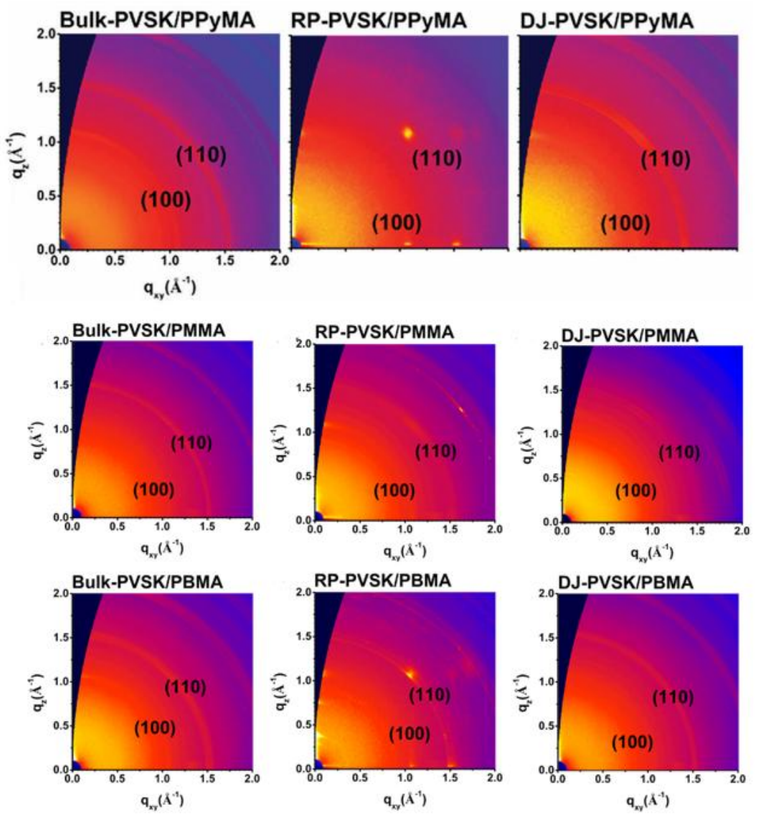
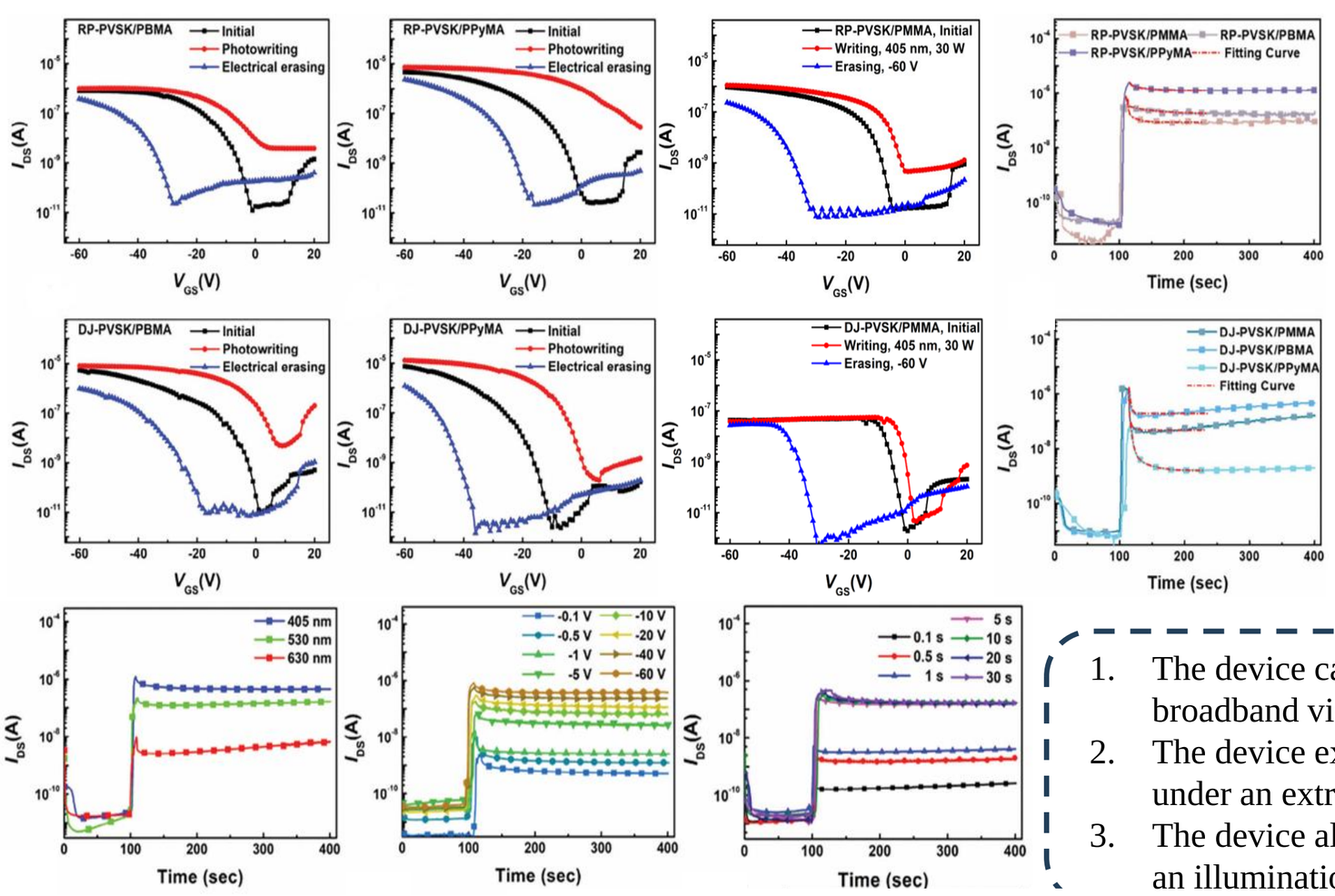


Device performance



RP-RT	PMMA	PBMA	PPyMA
μ_{avg} ($cm^2 V^{-1} s^{-1}$)	3.32×10^{-3}	4.14×10^{-3}	1.53×10^{-2}
$V_{th,\ write}$ (V)	0.73	0.66	16.28
$V_{th,\ erase}$ (V)	-36.85	-34.08	-24.60
ΔV_{th} (V)	37.58	34.74	40.88
I_{ON}/I_{OFF}	8.37×10^{2}	3.36×10^{3}	2.68×10^{4}

DJ-RT	PMMA	PBMA	PPyMA
μ_{avg} ($cm^2 V^{-1} s^{-1}$)	2.25×10^{-3}	2.73×10^{-2}	2.51×10^{-2}
$V_{th,\ write}$ (V)	6.04	5.61	-3.63
$V_{th,\ erase}$ (V)	-34.17	-30.98	-45.73
ΔV_{th} (V)	40.21	36.59	42.10
I_{ON}/I_{OFF}	1.27×10^{3}	7.51×10^{3}	3.24×10^{2}

1. The device can be successfully activated by different wavelengths, enabling broadband visible-light writing.
2. The device exhibits high electric-field sensitivity, operating effectively even under an extremely low drain bias.
3. The device also shows high photosensitivity, responding successfully with an illumination time as short as 0.1 s.

Result

Devices integrating RP-phase perovskite with PPyMA deliver outstanding performance, including **a high ON/OFF ratio (~10^4)**, **wide ΔVth (43 V)**, **broadband response (405–650 nm)**, **low operating voltage (−0.1 V)**, and **fast switching (0.1 s)**. These enhancements stem from the stable PEA ligand and strong π–π interactions between pyrene groups and the perovskite, promoting improved crystal orientation and nanocrystal dispersion.

The devices also show good retention, cycling endurance, and thermal stability, highlighting the effectiveness of ligand–polymer engineering for high-performance photomemory.