NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Block Copolymer Templated Halide Perovskite Memristors

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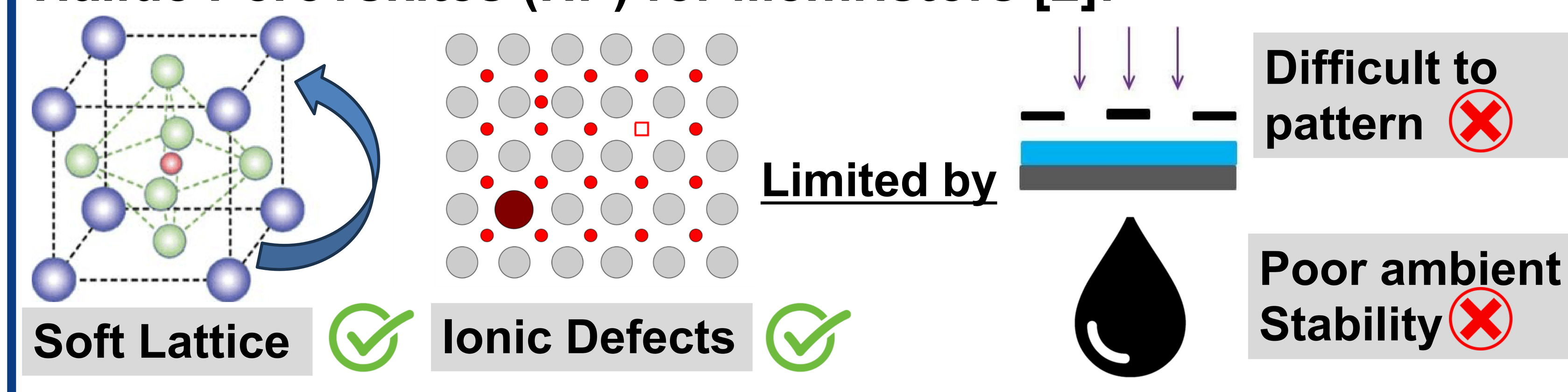
Introduction

The advent of new technologies such as AI and IoT creates a demand for faster integrated circuits and **smaller** transistors [1], which are currently **difficult to scale down** further due to adverse **quantum effects** and the **Von-Neumann bottleneck**. **Memristors** are a promising alternative, with the ability to emulate **synaptic** and **learning** characteristics of the brain.

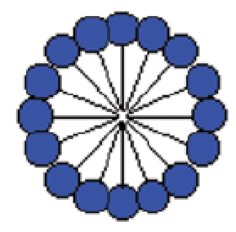
Halide Perovskites (HP) for Memristors [2]:



Objectives

1) Investigate the effects of **$MAPbBr_3$** on the **self-assembly** of PS-b-P2VP
2) Fabricate **memristors** based on the composite $MAPbBr_3$/PS-b-P2VP film.
3) Study the **structure-performance relationship** of the films as memristors.

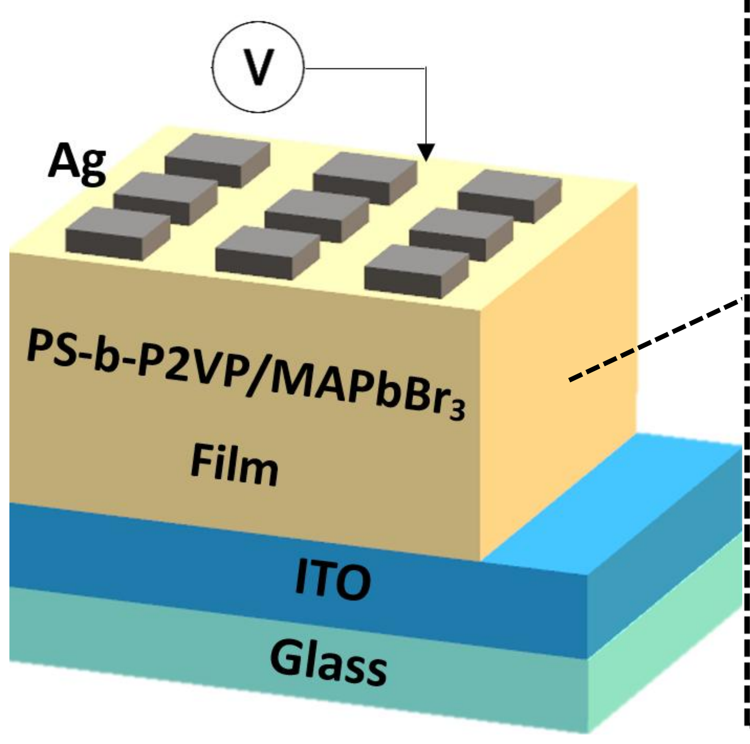
Novel Solution

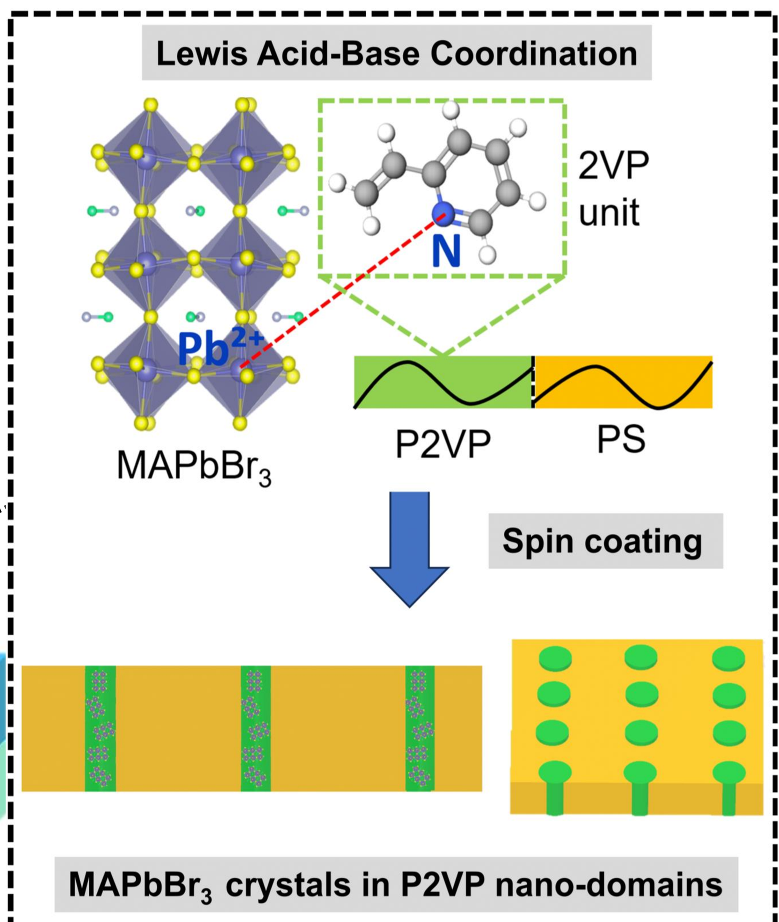


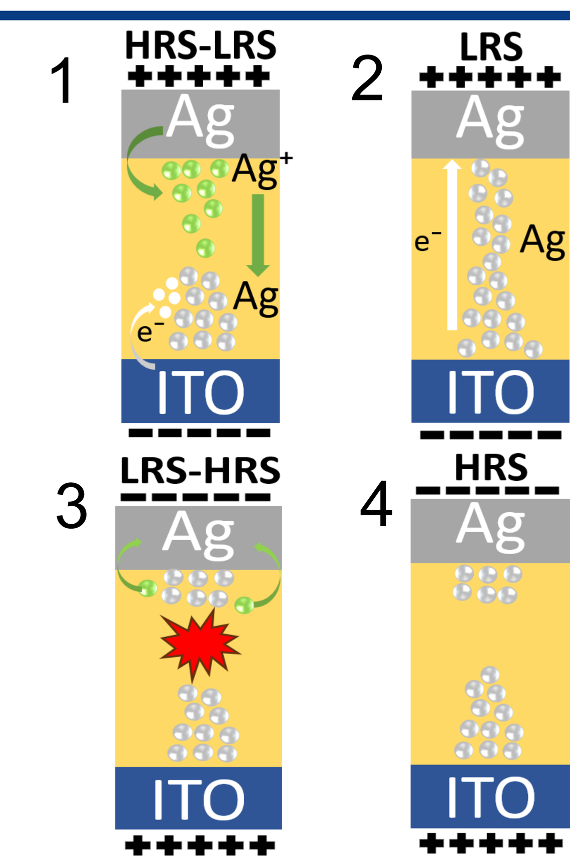
Leverage **self-assembly capability** of **block copolymers** to **pattern** (template) and **encapsulate** HPs in memristors.

Methodology

Device Structure

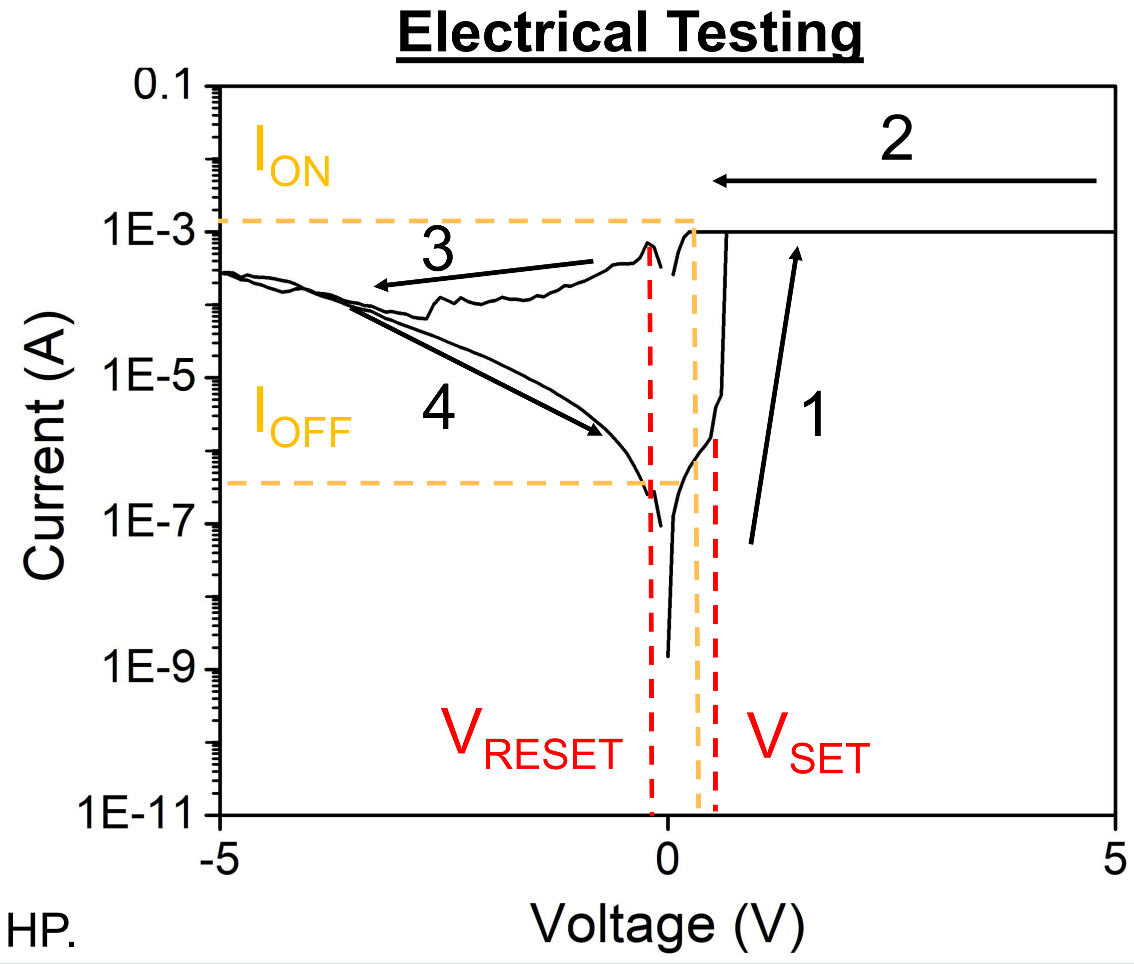






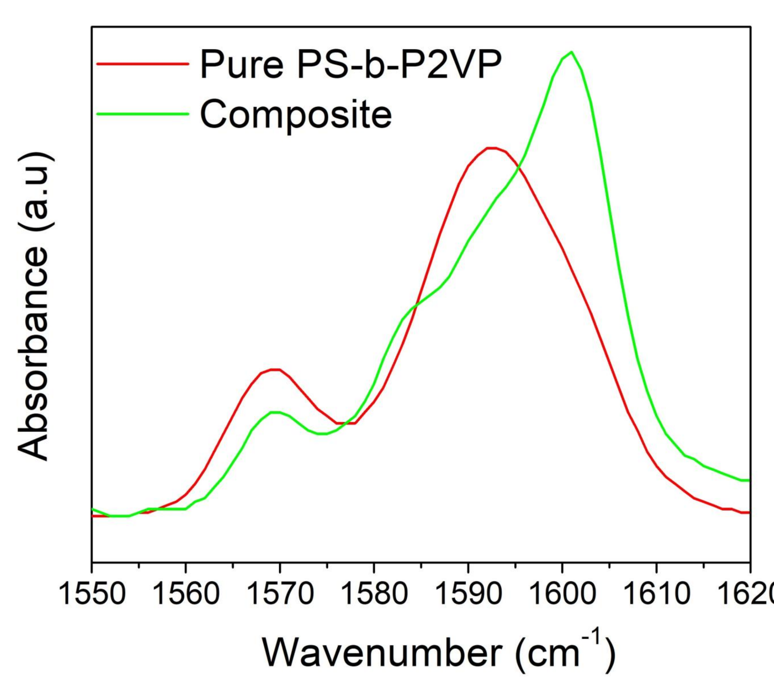
Ag electrodes: Low oxidation potential, easily migrates through HP.

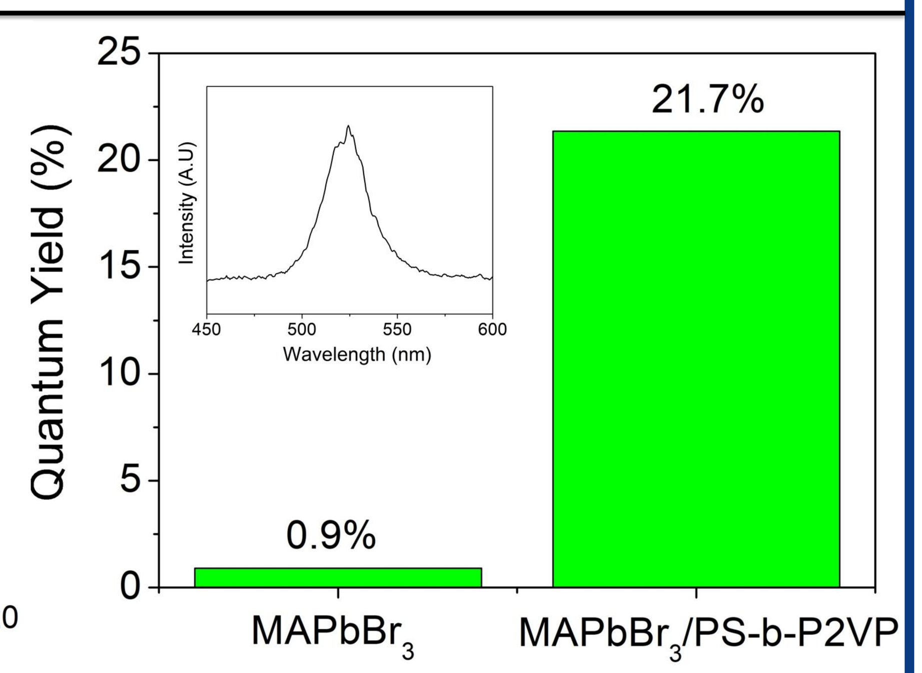
Electrical Testing



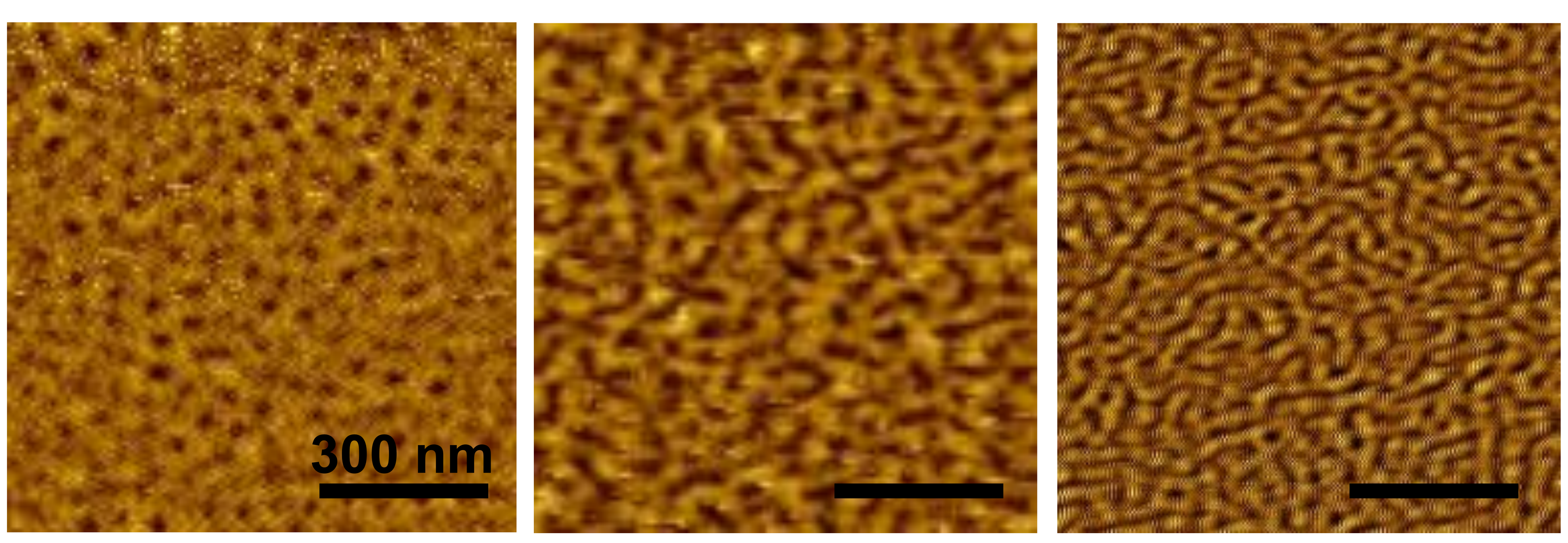
Results and Discussion

1. Selective Crystallization of $MAPbBr_3$ in P2VP





- FTIR Spectra shows **blue-shift** of **pyridine ring deformation** peak in composite vs a pure BCP film.
- **Enhanced PLQY** in the composite film vs pure $MAPbBr_3$

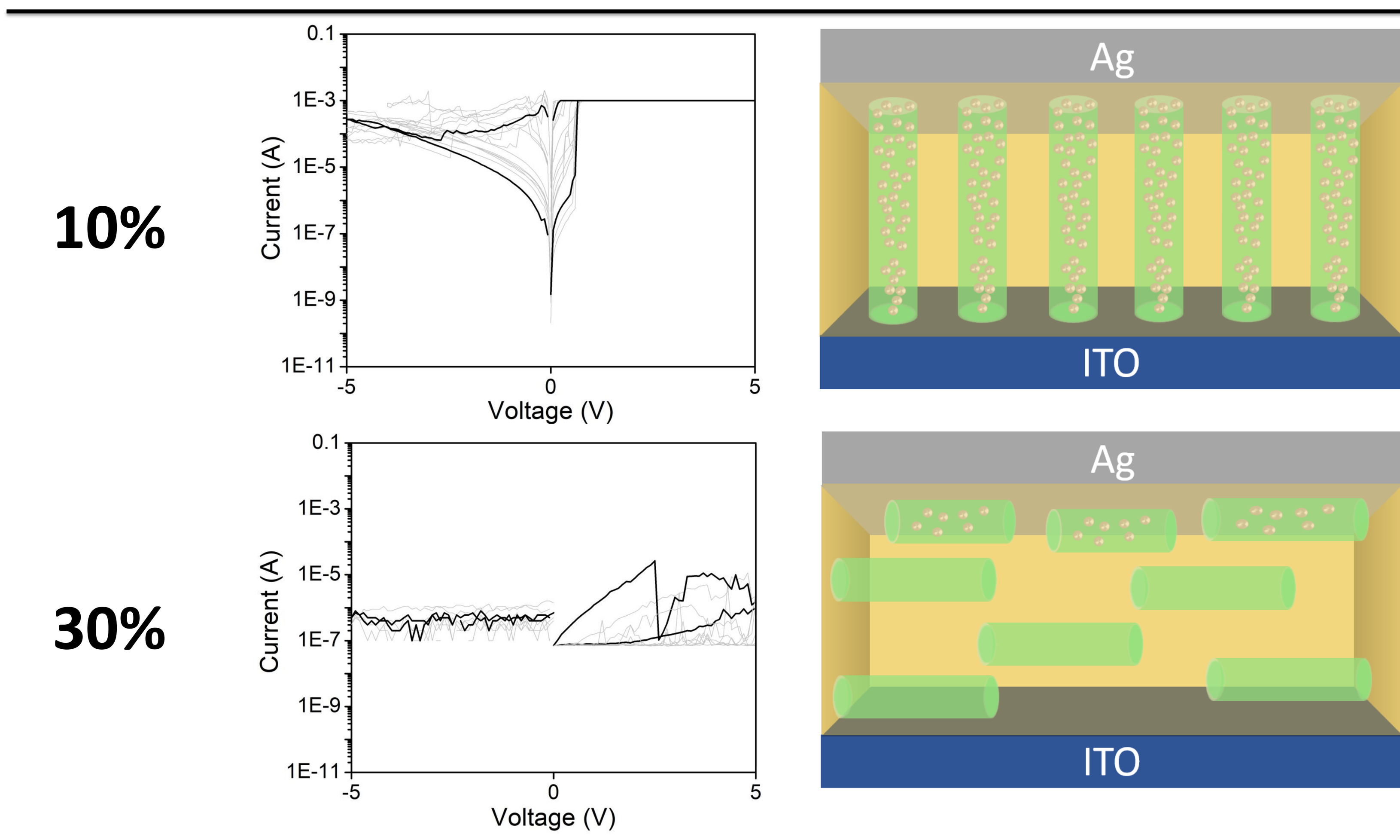


10% $MAPbBr_3$ | 20% $MAPbBr_3$ | 30% $MAPbBr_3$

- NC-AFM: **Changes in nanostructure** as $MAPbBr_3$ loading is increased consistent with **selective swelling of P2VP** phase by $MAPbBr_3$ crystals.

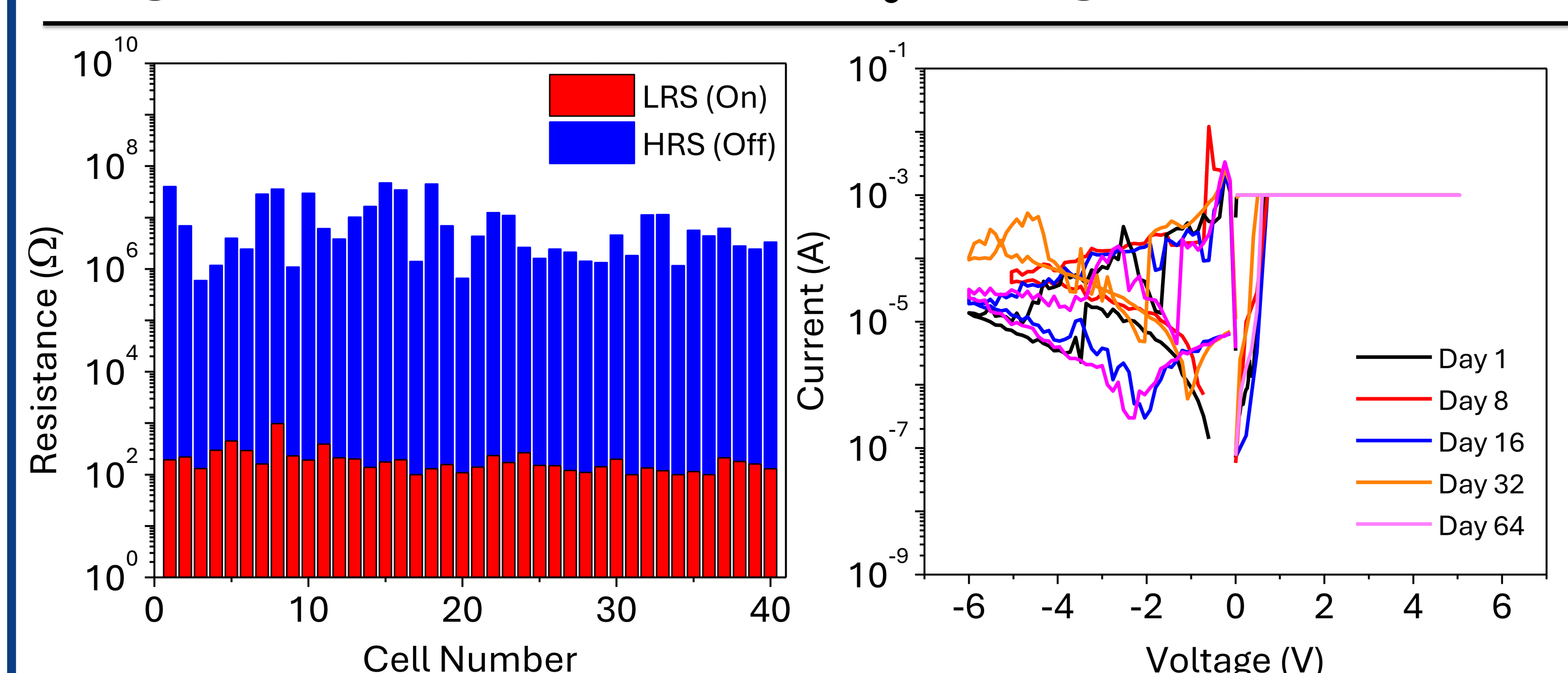
Results from characterization show that $MAPbBr_3$ successfully **crystallized selectively** within the P2VP phase of PS-b-P2VP

2. Film Structure – Performance Relationship



- **10% $MAPbBr_3$** loading yields **best performance.**
- Proposed mechanism: Conductive Filament **(CF) formation is confined** within P2VP phase

3. Figures of Merit – 10% $MAPbBr_3$ loading



- **CF confinement** translates to **tangible benefits** in device performance
- High on/off ratio, low D2D variation, and enhanced ambient stability

Conclusion and Future Work

- We fabricated and studied the **first ever HP memristors templated in a block copolymer system.**
- Characterisation data showed that the $MAPbBr_3$ was **successfully patterned** via **selective crystallization** within the P2VP phase.
- Fabricated devices show **enhanced ambient stability** and **good reliability** as a result of the patterning.
- Further **pulsed-voltage** could be done to test for **synaptic characteristics. Manuscript in the works** which will incorporate these additional data.

References

[1] X. Zou, S. Xu, X. Chen, L. Yan, and Y. Han, "Breaking the von Neumann bottleneck: architecture-level processing-in-memory technology," *Sci. China Inf. Sci.*, vol. 64, no. 6, pp. 1–10, Jun. 2021
[2] H.-L. Park and T.-W. Lee, "Organic and perovskite memristors for neuromorphic computing," *Organic Electronics*, vol. 98, p. 106301, Nov. 2021