Integration of Photodiode and Memristor (1P-1R) for In-Sensor Computation

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The rapid growth of Internet-of-Things (IoT) applications and data-intensive artificial intelligence workloads is driving the need for energy-efficient, edge-based computing architectures. The ability to process large volumes of unstructured, image-sensed data locally is becoming increasingly important. However, conventional von Neumann systems remain fundamentally constrained by the memory–compute bottleneck, motivating the exploration of in-memory and neuromorphic approaches for image sensing applications. [1][2]

In this context, hybrid photodiode–memristor (1P–1R) architectures offer a promising route toward compact, low-power, and massively parallel in-sensor processing. Here, we demonstrate a 1P–1R device that integrates a TaO_X-based memristor with a GaAs-based photodiode. The device directly senses and stores pixel intensity by using the light-modulated reverse-bias current as compliance current during the SET process, enabling multilevel resistance states. Furthermore, by programming the memristor to predefined states, the same unit can perform first-layer computation on the input light signal. This unified functionality enables direct encoding and processing of optical inputs, providing a scalable pathway toward efficient in-sensor computing for next-generation edge AI systems.

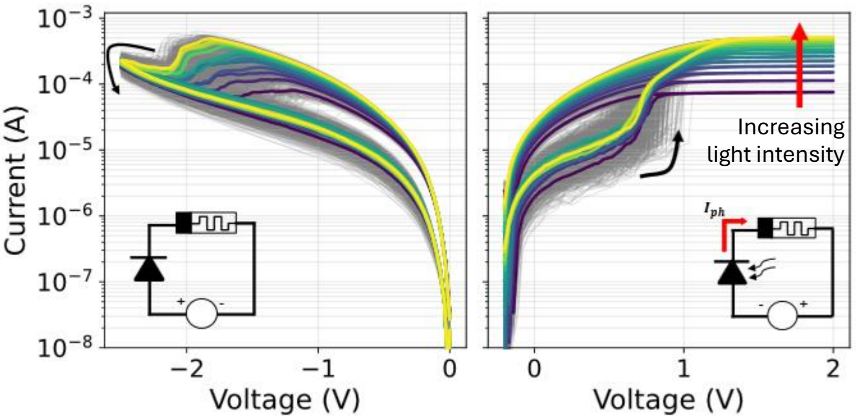

Figure 1: Multilevel switching implemented in 1P-1R devices using light modulated reverse bias current as compliance.

[1] N. Farmakidis *at al. Nat Rev Electr Eng* **1**, 358–373 (2024).

[2] B.J. Shastri *et al. Nat. Photonics* **15**, 102–114 (2021).