# Ultra-Low-Power $MoSe_2$ Quantum Dot Hybrid Memristors for Neuromorphic Synaptic Emulation

**Anjala Jayaraj** Aldrin Antony [1,2*]
[1]Department of Physics, Cochin University of Science and Technology,
Kochi - 682 022, Kerala, India.
[2]Centre of Excellence in Advanced Materials, Cochin University of Science and Technology,
Kochi - 682 022, Kerala, India.
*aldrin@cusat.ac.in

Molybdenum diselenide ($MoSe_2$) quantum dots (QDs) have emerged as promising nanoscale building blocks for next-generation neuromorphic devices due to their tunable electronic structure and efficient charge trapping characteristics. In this work, we report a hybrid memristive device based on an Ag/PMMA–$MoSe_2$ QDs/ITO architecture that demonstrates ultra-low power synaptic operation and stable resistive switching behavior. The incorporation of $MoSe_2$ QDs within the polymer matrix introduces discrete electron trapping and de-trapping centers, enabling controlled modulation of conductive pathways and improved switching stability.
Electrical characterization reveals repeatable bipolar resistive switching with stable endurance over 100 cycles (fig.1a). The device exhibits exceptionally low operating power, with set and reset energies on the order of nanowatts, significantly lower than many previously reported quantum-dot-based memristors. Synaptic functionality is demonstrated through potentiation behavior under pulsed electrical stimulation, where conductance modulation follows a logistic trend analogous to nonlinear learning processes in biological synapses. [2] These results highlight the potential of $MoSe_2$ QD-integrated hybrid memristors as energy-efficient artificial synapses for scalable neuromorphic computing systems. The set and reset power consumption of the Ag/$MoSe_2$ QDs/ITO device are $P_{set} \sim 7$ nW and $P_{reset} \sim 10$ nW respectively, which are much lower than many reported QDs-based memristors[1]. The device potentiates, indicating that it exhibits good learning behaviour.

## References

[1] Z. Wang *et al.*, *Research*, 2022, (2022),9654876,
[2] M. Asif, Y. Singh, and A. Thakre, RSC Adv, 13(2023) 13292.

## Figures

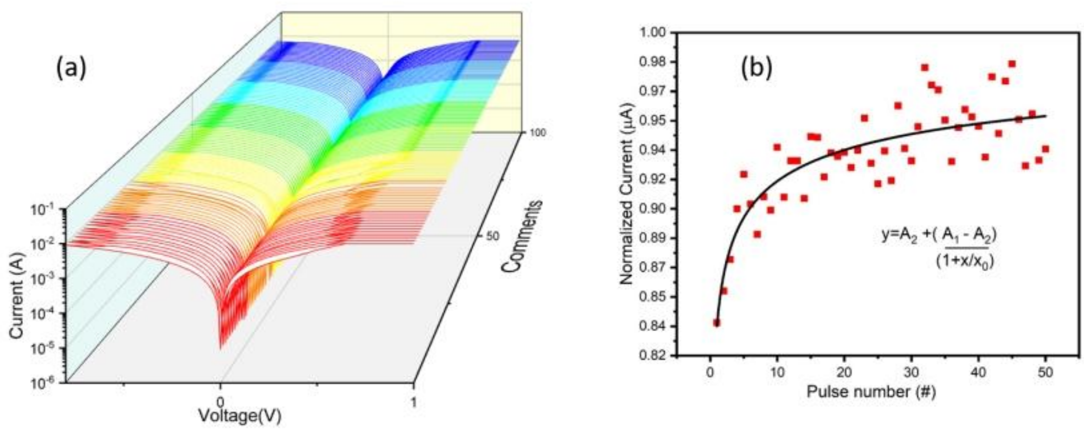


**Figure 1. (a)**Pinched hysteresis loop showing the device retracing the same set and reset voltages in each cycle. **(b)** The potentiation for the device is examined with 50 input pulses of amplitude 500mV width 100 ms and interval 100 ms.