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Non-volatile Memory in Large-area Junctions Comprising Self-assembled Fused Porphyrins

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Abstract:

The invention of next-generation computing primitives that keep up with the exponential increase in data storage and computing demand has become one of the greatest challenges in materials science and IT engineering.[1] Human brains outperform the best computers in the world in many complex problems, such as decision-making. This inspiration has led to the creation of inorganic/organic electrical materials and device architectures for neuromorphic computing to emulate the functions of human brains. However, their energy-efficiency, performance under working conditions and reproducibility for scalable production remain as the major bottlenecks.

Molecular self-assemblies, the ordered structures formed by spontaneous covalent/non-covalent interactions between molecules and substrates, have the solution to those challenges. When integrated into electronic devices, they display quatum-transport properties which can be fine-tuned by changes at atomic scale.[2] Pioneering work has demonstrated that charge-transport through molecular self-assemblies can be modulated by electric fields and ionic/molecular recognition at low power cost;[3-6] however, molecular self-assemblies that are responsive to multiple stimuli and operate in a stateless fashion, which is one of the key features of human brains, are yet to be developed.

During this lecture, we will present our recent progress in synthesizing non-volatile memory from large-area junctions comprising self-assembled monolayers of redox-active fused porphyrins.[7] These self-assembled monolayers exhibit reversible, multi-state switching in electrical conductance which is driven by (partial) oxidation/reduction under electric fields in "WRITE-READ-ERASE" operations. An investigation into the charge-transport mechanism reveals a complex picture in which resonant tunneling and thermally activated charge-transfer intertwine. The unique system is multi-responsive, enabling modulation of its conductance states from electrical bias and temperature, which can be trained to recognize stimulations retrospectively.

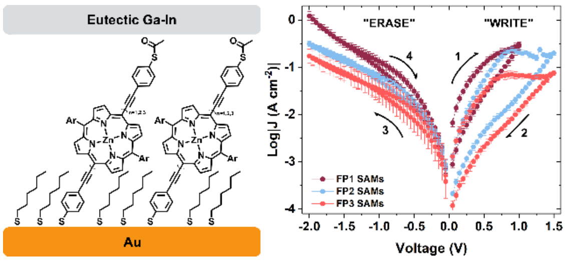

Figure 1. The schematic of the large-area junction comprising self-assembled fused porphyrins (FPn) and eutectic Ga-In top electrode (left), and the J-V curves during "WRITE-ERASE" operations (right).

References:

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