Sustainable Resistive Switching Memories Enabled by Halide Perovskites

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Abstract

The solution-based processing of mixed halide perovskite (HP) devices at relatively low temperatures offers prospects of developing low-cost multifunctional devices developed at flexible substrates. Hereby, we present results on using HP for demonstrating efficient solar cells and optoelectronic synapses based on the same material stack.[1-2] These devices, however, exhibit variability in their switching characteristics, weak endurance, and retention, which limit their performance and practical use. To address this challenge, we applied low-dimensional perovskite capping layers onto 3Dmixed halide perovskites using two perfluoroarene organic cations, namely (perfluorobenzyl) ammonium and (perfluoro-1,4-phenylene)dimethylammonium iodide, forming Ruddlesden–Popper and Dion–Jacobson 2D perovskite phases, respectively.[3] The corresponding mixed-dimensional perovskite heterostructures were used to fabricate resistive switching memories based on perovskite solar cell architectures, showing that the devices based on perfluoroarene heterostructures exhibited enhanced performance and stability in inert and ambient air atmosphere. Notably, the substrate on which the perovskite active layer is developed has been reported to severely affect its quality and thus the overall device performance. Hereby, we demonstrate the sustainable manufacturing of memristive perovskite solar cells by replacing the expensive poly[bis(4- phenyl)(2,4,6-trimethylphenyl)amine] (PTAA) that serves as a hole transporting layer (HTL) with a self-assembled monolayer (SAM), namely [2-(3,6-dimethoxy-9H-carbazol-9-yl)ethyl]- phosphonic acid (MeO-2PACz).[4] Multiple sequential memristive current−voltage characteristics of single devices are reported, and average data of multiple reference and targeted devices are compared. Resistive switching memory devices based on SAM exhibit improved performance having reduced average SET voltage values and narrower statistical variation compared to reference devices with PTAA. It is shown that both PTAA and SAM based devices exhibit high ON/OFF ratio of about 10^3 operating at low switching electric fields. Replacing an expensive polymer-based HTL with this approach reduces fabrication costs compared to PTAA. Recent results on lead-free double perovskite based resistive memory devices will be presented toward achieving enhanced sustainability.

References

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