



Colloquium on Advanced Materials

Hybrid Perovskites – ‘Novel’ Semiconductors for Optoelectronic Applications

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Organo-metal halide perovskites have overwhelmed the area of thin film photovoltaics with efficiencies skyrocketing to levels of >20%.^[1] while concerns about stability are still intimately linked to the field.^[2] Recently, we designed ultra-stable inverted perovskite cells, where an impermeable electron extraction layer based on tin oxide grown by ALD affords devices with an outstanding resilience.^[3] The SnO_x functions as an ultra-dense yet electrically conductive permeation barrier which protects the perovskite against moisture from ambient air. At the same time, the SnO_x shields the cathode metal against halide compounds that may eventually leak out of the perovskite. The resulting devices are stable over more than 4500 hours even when exposed to elevated temperatures.^[4] The use of SnO_x as a replacement for TiO_x in conventional perovskite cells will also be discussed. As a result of a favorable electronic structure at the interface SnO_x/perovskite, we achieve a remarkably high V_{oc} of up to 1.186 V.^[5] Note, with a typical bandgap of 1.55 eV for the MAPbI₃ we derive a voltage loss of only 0.36 V, which is among the lowest values reported for PVSCs and rivals that of commercial silicon cells.

Perovskites also state an intriguing platform for applications beyond solar cells. As of yet, their tremendous potential for photonic applications has not been unlocked because of a lack of suitable patterning techniques to create resonator structures, waveguides etc. directly into these perovskites. Crystal binding in these perovskites includes significant contributions of van der Waals interactions among the halide atoms and hydrogen bonding.^[6] The formation enthalpy per unit cell is only about 0.1 eV in MAPbI₃.^[7] We took advantage of the “soft-matter properties” of organo-metal halide perovskites and demonstrated that photonic nano-structures can be prepared by direct thermal nano-imprint lithography in MAPbI₃ and MAPbBr₃ at low temperatures (<150°C). The resulting periodic patterns provided distributed feedback resonators, which afforded lasing in MAPbI₃ with ultra-low threshold levels on the order of 1 μJ/cm².^[8] I will discuss the applicability of thermal imprinting for perovskite solar cells and LEDs.

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Place:
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