Chemistry and Devices from Halide Perovskites Semiconductors

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Two-dimensional (2D) metal halide perovskites have made an impressive entry in the field of solar cells and LEDs as highly promising semiconductors. They feature a high degree of structural flexibility and tunable optoelectronic properties. They have a general formula of (A’)2(A)n-1MnX3n+1, where A = Cs+, CH3NH3+ (MA), HC(NH2)2+ (FA), M = Ge2+, Sn2+, Pb2+ and X = Cl-, Br-, I-, are the perovskite components and A’+ = RNH3 is an organic spacer. There are four kinds of 2D organic inorganic hybrid perovskites so far: Ruddelsden-Popper, Cation-ordered, Jacobson-Dion and Diammonium Cation. These vary from one another in ways the inorganic slabs stack and the way the spacer cations interact with the inorganic slabs. Generally, 2D perovskites form from solution via the bottom-up self-assembly of individual, semiconducting perovskite sheets having an adjustable slab thickness of up to few nanometers, separated by insulating bulky organic molecules. As a result, they behave as natural multiple quantum wells (QWs) with the semiconducting perovskite layers representing the wells and the insulating organic spacers representing the barriers. The width of the barrier is fixed and depends only on the length of the A’ cation, while the width of the well can be adjusted by varying the thickness of perovskite slabs, which is defined by the n variable in (A’)2(A)n-1MnX3n+1. It is critical to understand the thermodynamic and chemical limitations of the maximum layer thickness that can be sandwiched between the organic bilayers while retaining the structural integrity of the 2D perovskite.