

A New Generation of Layered Hybrid Perovskites

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Hybrid organic-inorganic halide perovskite semiconductors emerged as one of the most promising materials for optoelectronic applications. These materials combine excellent optoelectronic properties with the ease of solution-processing and low material costs. However, their instability towards oxygen and moisture continue to pose substantial challenges. Unlike three-dimensional (3D) perovskites, their layered two-dimensional (2D) analogues have demonstrated promising stability against environmental factors. They are defined by the general formula $S_2A_{n-1}M_nX_{3n+1}$ or $S'A_{n-1}M_nX_{3n+1}$ (S or S' are mono and divalent organic spacer cations, respectively), which represents a layered structure of 3D perovskite slabs separated by the organic spacer layers (Figure 1). The nature of the spacer cation results in structural differences that affect the optoelectronic properties and consequently, the photovoltaic performance. In general, 2D perovskite solar cells suffer from rather low efficiencies mainly attributed to the charge transport inhibition by the organic cations that act as insulating layers, which is particularly pronounced since commonly employed organic spacers feature long alkyl chains that jeopardize the material crystallinity. Moreover, 2D perovskites feature larger exciton binding energies and band gaps that lead to decreased photovoltaic performance, accompanied by limited vertical charge transport. To address these challenges, we have relied on the unique advantage of tunability of the material properties based on the design of organic spacer cations by fine-tuning the noncovalent interactions and their structural adaptability to ensure stability of the 2D perovskites without compromising their performance. Following the development of the first prototypes, an in-depth investigation of the optoelectronic properties of these and other materials is required to provide fundamental understanding and advancement of 2D perovskites, which will be the main subject of this project. The student will be trained in the material synthesis and characterization at LPI.

For more information, the interested students are welcome to contact us.

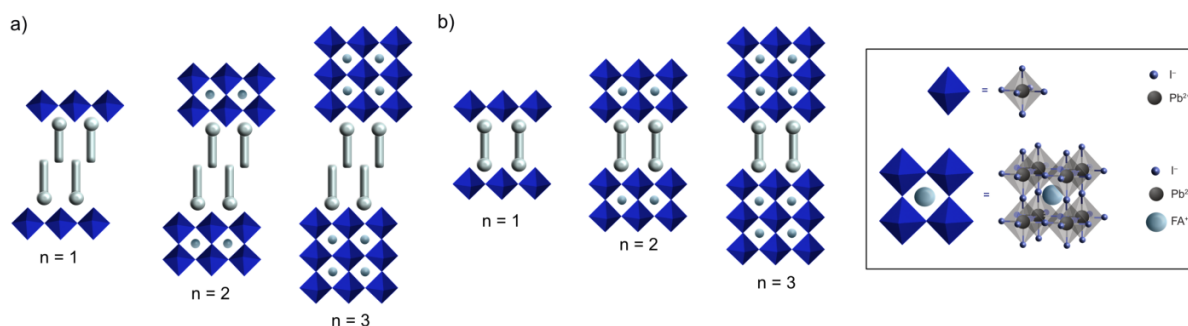


Figure 1. Structural characteristics of 2D layered perovskites. Schematic representation of the structure of (a) Ruddlesden-Popper ($S'_2A_{n-1}Pb_nI_{3n+1}$ composition with monovalent spacers S') and (b) Dion-Jacobson phases ($SA_{n-1}Pb_nI_{3n+1}$ composition with divalent spacers S) with different number of inorganic layers (n). Grey rods represent the spacers (S' or S).

Reference: [1] *Adv. Mater.* **2017**, 131, 1703487; [2] *J. Am. Chem. Soc.* **2019**, 141, 1171; [3] *Nature Commun.* **2018**, 9, 4482; [4] *Nano Lett.* **2018**, 19, 150; [5] *Adv. Energy Mater.* **2019**, 1900284.