Exciton physics in organic-inorganic 2D perovskites

Jean-Christophe Blancon[a]
Hao Zhang [a], Wenbin Li [a], Siraj Sidhik [a], Jacky Even [b], Andreas Stier [c], Arky Yang [d], Harry A. Atwater [d], Mercouri Kanatzidis [e], Claudine Katan [f], Aditya D. Mohite [a]
[a] *Department of Chemical and Biomolecular Engineering, Rice University, Houston, TX 77005, USA.*
[b] *FOTON, INSA de Rennes, CNRS, UMR 6082, 35708 Rennes, France.*
[c] *Technical University of Munich, D-85748 Garching, Germany.*
[d] *California Institute of Technology, Pasadena, CA, 91125, USA.*
[e] *Northwestern University, Evanston, Illinois 60208, USA.*
[f] *Université de Rennes 1, CNRS, Ecole Nationale Supérieure de Chimie de Rennes, UMR6226, 35042 Rennes, France.*
jrb21@rice.edu

Organic-inorganic (hybrid) 2D perovskites is a new class of 2D layer materials that feature unique structural characteristics related to their hybrid nature, which includes soft and dynamic lattice structure and organic-inorganic interfaces. There is still little knowledge of the interplay between, on the one hand, their photo-excited states and electronic properties and, on the other hand, their structural characteristics. Here, using optical spectroscopy and magneto-absorption, coupled with structural probes, we report the dependence of the formation, dynamics, and recombination of exciton states on the structural and compositional details of hybrid 2D perovskites [1]. Our work reveals the changes in the exciton properties due to the tuning of the thickness of the 2D perovskites and the size of the organic molecules in the lattice (Fig. 1a). The exciton characteristics are explained by an advanced model which includes quantum and dielectric confinement. Moreover, we demonstrate the existence of unique electronic states located at the edge surfaces of the 2D perovskite layers (Fig. 1b), which promote the dissociation of the strongly bound excitons and possibly result from local distortions of the lattice at the edges [2]. By controlling the orientation of the 2D perovskite crystals in thin films we also fabricated thin films solar cells with >12% power conversion efficiencies (Fig. 1c) [3]. Finally, we will discuss the hetero-coupling between 2D perovskites and transition metal dichalcogenides, which yield photoluminescence enhancement by more than one order of magnitude as compared to their constituent [4].

References

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[3] H. Tsai *et al.*, Nature, 536 (2016), 312.
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Figures

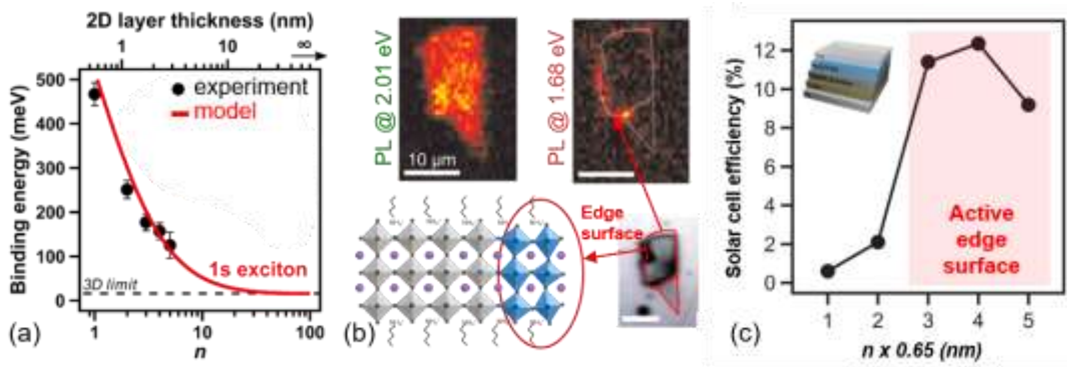

Figure 1: (a) Scaling of the exciton binding energy with the perovskite layer thickness. *n* represents the thickness of the perovskite layers in terms of number of octahedra PbI_6 units in the out-of-plane direction, where the perovskite real thickness is about n times 0.65 nm. (b) Observation of active edge-surface states in certain hybrid 2D perovskite due to local distortions at the edge of the perovskite layers. The top colour pictures are maps of the photoluminescence (PL) detected at two wavelength. The bottom images sketch the location of edge-surfaces in 2D perovskite layers. (c) Proof-of-concept of efficient thin film solar cells with hybrid 2D perovskite as absorber.