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Solution-processed nanomaterials for advanced optoelectronic and energy applications

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Abstract: I will review our recent advances in low dimensional hybrid nanomaterials such as quantum dots, quantum-dot-in-perovskite and layered perovskites for optoeletronic and energy applications.

OCIS codes: (160.0160) Materials; (250.0250) Optoelectronics; (350.6050) Solar Energy; (280.4788) Optical sensing and sensors.

Summary

Nanoscale materials are building blocks that, with programmable functionalities from the atomic level, unfold unprecedented energy manipulation for more efficient optoelectronic devices. I will show how using low-dimensional materials such as quantum dots, quantum-well perovskites or quantum-dot-in-perovskite solids leads to the realization of more efficient light sensors, light sources, and solar cells.

I will present our latest results in colloidal quantum dot solar cells, where we achieved certified power conversion efficiencies (PCE) beyond 12% using novel ink, all-solution exchange strategy [1]. I will also introduce our latest efforts in panchromatic solar energy harvesting beyond crystalline silicon photovoltaics, where we exploit the spectral tunability of the quantum dots to top up the performance of silicon technology [2].

Novel materials, such as quantum-dot-in-perovskite, open the door to the realization of quantum confined devices previously only attainable through high-temperature epitaxy. I will present a field-emission photodiode that, based on this material, achieves high sensitivity in the short-wavelength infrared [3]. I will show under which conditions charges photogenerated in the quantum dots can be emitted and transported through the perovskite matrix, and demonstrate it with in operando ultrafast transient absorption measurements. This system combines the remarkable charge transport properties of organohalide perovskites with the strong, tunable absorption, of quantum dots.

I will present our latest advances in quantum-well low-dimensional layered perovskite for efficient light-emitting diodes and luminescent solar concentrators [4]. I will show how a judicious manipulation of the energy transfer in layered perovskites led to the realization of conductive perovskite films with high quantum yields and how these properties translate into efficient and stable green LEDs with 14% EQE. I will introduce luminescent solar concentrators that, based on a similar material platform, present a dramatically reduced reabsorption and a maximized outcoupling of solar energy to the edges of the device. To conclude, I will give a grasp of my recent work in CO_2 remediation by the design of catalysts that efficiently transform renewable electricity to fuels and chemicals.

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