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Editorial

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Consolidation and Expansion of Perovskite Solar Cell Research

Hysteresis, band transport, polaron transport, balanced charge transport, diffusion length, vacancies, ion migration, defects, doping, traps, exciton binding energy, luminescence, hot carrier cooling, lasing, amplified spontaneous emission, fluorescence intermittency, semitransparent, colored, band gap tuning, precursors, sequential deposition, compositional engineering, solvent engineering, aging, pinholes, organic contacts, stabilization with cesium, crystallization control, grain boundaries, moisture, degradation, ecotoxicity, ferroelectric, phase transitions, glassy dynamics, dielectric constant, dipoles, cage tilting, giant capacitance, single crystals, nanowires, nanoplatelets, nanoclusters, quantum dots, plasmonic particles, flexible, upscaling, tandem...

These are just a fraction of possible keywords that show active research topics in hybrid organic−inorganic perovskite solar cells. In about three years, the field has consolidated large efficiencies, now certified above 20% for small area, and shown the production of the first modules with significant efficiencies. The organic−inorganic perovskite material has an ABX_3 structure and is typically comprised of an organic cation A = (methylammonium, formamidinium), a divalent metal B = (Pb^{2+} ; Sn^{2+}), and an anion X = (I^-, Br^-, Cl^-, BF_4^-). The hybrid organic−inorganic perovskite materials display a range of fascinating properties that support the extraordinary photovoltaic performance. The plethora of physical phenomena that have emerged in the study of this new photovoltaic technology have practically given rise to a scientific field of its own. The size, diversity, and inventiveness of this scientific community continue to increase with no bounds on sight so far. But despite exciting advances in the field, there are many question marks on the principles of photovoltaic and photophysical operation of perovskite photovoltaic devices. A number of key issues hindering further developments need be investigated thoroughly and solved, especially when the complex structure−property relation is to be maintained in upscaling.

A rich variety of fabrication methods have been reported with the aim toward large-scale production, focusing on robust deposition methods that provide consistency of results. Optimal preparation methods need to be established in order to obtain a precise control of crystallinity and morphology, which is a key element of high performance and stability. Two major sources of doubt exist about the future success of the technology. The first is instability, both intrinsic instability to PbI_2 separated phase as well as exposure to degradation by attack of moisture. Second, the presence of lead as a key component for the large photovoltaic response raises concerns due to toxicity, even though the Pb content is extremely low. Increasingly broad types of compositions are being investigated to engineer the bandgap, electronic, and optical properties of the perovskites, modifying the known materials, aiming to finding new ones. According to Sang Il Seok, that pioneered the combinations of cations in the perovskite layer, the entire periodic table should be scanned for optimal compositions.

This issue of the Journal of Physical Chemistry Letters attests to the impressive development of perovskite research with a series of very interesting Perspective articles that summarize the research field from different angles. Nazeeruddin and co-worker present an overall view of the knowledge gained on chemical, electronic and device properties. They also show a number of alternative configurations, and they express the view that perovskite will play a major role in future photovoltaic technologies. Jen and co-workers explain the main challenges for the perovskite solar cell to enter the photovoltaic market, which needs to address upscaling, toxicity and degradation. Giorgi and Yamashita describe the consequences of reduction of dimensionality, toward small nanoclusters, based on ab initio methods of calculation.

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Notes

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