



به نام خداوند جان و خرد

کزین برتر اندیشه برنگذرد

پژوهش تقاضامحور و تجاری سازی فناوری

زیربنای اقتصاد مقاومتی

معاونت پژوهش و فناوری دانشگاه فردوسی مشهد

آذرماه ۱۳۹۵



برگزیدگان



فرآیند انتخاب پژوهشگر برتر:

۱. استخراج اسامی یک صد نفر از اعضای هیات علمی دارای بالاترین تعداد مقاله های نمایه شده در فهرست JCR در سال های ۲۰۱۲ تا ۲۰۱۶ با نشانی دانشگاه فردوسی مشهد

۲. گروه بندی موضوعی به قرار زیر:

الف شیمی و مهندسی صنایع غذایی

ب- مهندسی

پ- علوم پایه

ت- کشاورزی و دامپزشکی

ث- علوم انسانی

۳. محاسبه امتیاز با توجه به شاخص های زیر:

الف- تعداد مقاله JCR

ب- مجموع استنادات غیر خودی

پ- متوسط استنادات غیر خودی

ت- مجموع IF نشریه ها

ث- متوسط IF نشریه ها

ج- شاخص H با ضریب ۲

نکته:

۱- اعضای هیات رییسه دانشگاه و برگزیدگان سه سال قبل مشمول دریافت جایزه نمی شوند.

۲- در گروه علوم انسانی ملاک انتخاب، تعداد مقاله کیفی و امتیاز پژوهش می باشد.



جناب آقای دکتر سید محمد علی رضوی

پژوهشگر برتر کشوری گروه کشاورزی در سال ۱۳۹۵

منتخب یک درصد دانشمندان و نخبگان برتر دنیا در سال ۲۰۱۵ میلادی

انتشار بیش از ۳۰۰ مقاله علمی - پژوهشی و ارائه ۱۰۰ مقاله همایشی

سردبیر نشریه پژوهش های علوم و صنایع غذایی

گروه شیمی و صنایع غذایی :



دکتر محمدحسن انتظاری

پژوهشگر برتر سال ۱۳۹۳



دکتر حسین عشقی



دکتر محمد رضا حسین دخت



جناب آقای دکتر حسین عشقی

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دکتر محمد منفرد

پژوهشگر برتر دانشگاه سال ۱۳۹۴



دکتر جواد ابوالفضلی اصفهانی



دکتر مجید بنی آدم



جناب آقای دکتر جواد ابوالفضلی اصفهانی

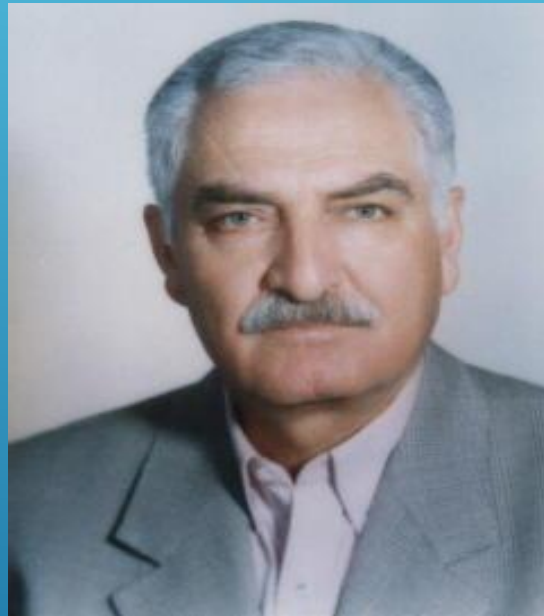
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پژوهشگر برتر دانشگاه

گروه علوم پایه:



دکتر احمد رضا بهرامی
معاون پژوهش و فناوری دانشگاه



دکتر سید رضا موسوی حسینی
پژوهشگر برتر کشوری سال ۱۳۹۳



دکتر سهراب عفتی



جناب آقاي دكتور سهراب عفتي

استاد دانشكده علوم رياضي

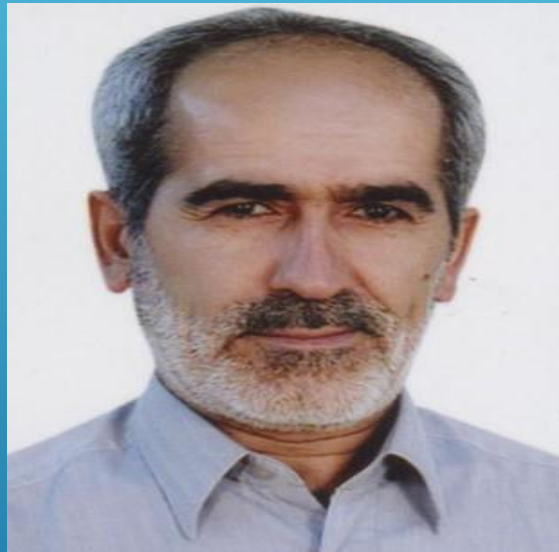
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گروه کشاورزی و دامپزشکی :



دکتر ابوالقاسم گلیان

پژوهشگر برتر دانشگاه سال ۱۳۹۴



دکتر عباسعلی ناصریان



دکتر رضا ولی زاده



جناب آقای دکتر رضا ولی زاده

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گروه علوم انسانی:



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استاد دانشکده الهیات و معارف اسلامى

پژوهشگر برتر دانشگاه

شاخص های انتخاب فناوری برتر :

۱. ثبت اختراعات یا کسب جوایز بین المللی
۲. حجم قراردادهای پژوهشی برون دانشگاهی
۳. توسعه زیر ساخت های فناورانه

گروه مهندسی و معماری :



دکتر رضا لطفی



دکتر حمیدرضا
پوررضا



دکتر محسن کاهانی



جناب آقای دکتر محسن کاهانی

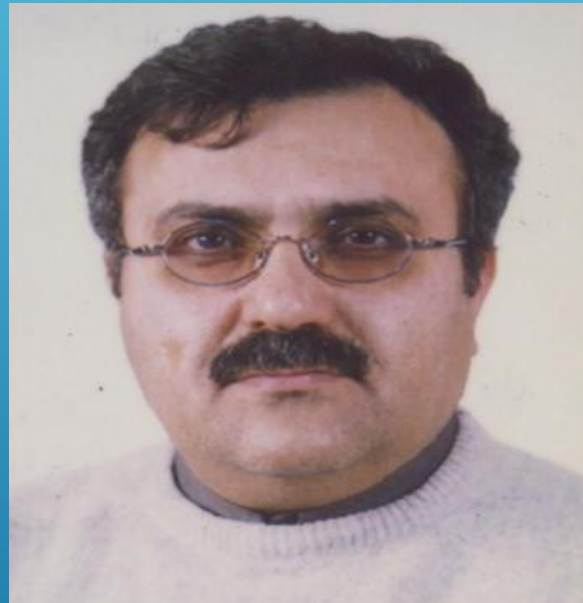
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فناور برتر دانشگاه

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دکتر حسین انصاری



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فناور برتر دانشگاه

دانشجوی منتخب پژوهشی





سرکار خانم محبوبہ حدادیان

دانشجوی دکتری دانشکده علوم

دانشجوی منتخب پژوهشی دانشگاه

Ionic Liquid Control Crystal Growth to Enhance Planar Perovskite Solar Cells Efficiency

Ji-Youn Seo, Taisuke Matsui, Jingshan Luo, Juan-Pablo Correa-Baena, Fabrizio Giordano, Michael Saliba, Kurt Schenk, Amita Ummadisingu, Konrad Domanski, Mahboubeh Hadadian, Anders Hagfeldt, Shaik M. Zakeeruddin, Ullrich Steiner, Michael Grätzel, and Antonio Abate*

Perovskite solar cells (PSCs) have had a lasting impression on the scientific community because of their fast progress as high efficient and low cost technology. Starting from the seminal work of Koijima et al. in 2009, in only seven years power conversion efficiencies above 22% have already been reported and certified.^[1-4] In aspect of economic and technological analysis, one promising route to industrialization of PSCs is to take advantage of the complementary band gaps of perovskite and silicon solar cells, i.e., to create a perovskite-silicon tandem. In a tandem architecture the perovskite can be deposited on the top of bottom cell to potentially overtake the Shockley Queisser limitation for a single junction device.^[5] This strategy is promising, but it requires low-temperature processing (100 °C) to avoid damaging of the bottom silicon cell. Currently, the highest efficient PSCs employ a mesoscopic TiO₂ electron contact, which is processed at temperature above

400 °C and thus not compatible with the preparation of tandem devices. Although there are strategies to prepare mesoscopic TiO₂ at low temperature, the easiest approach would be to use a planar perovskite device without mesoporous layer.^[6] We recently demonstrated low temperature processed SnO₂ as electron contact in planar PSCs for tandem silicon-perovskite solar cell.^[7] Although the efficiency of our tandem device was one of the highest reported, the top planar PSC was poorly performing compared to a mesoscopic TiO₂-based device. Therefore, to profit from using perovskite in tandem with other photovoltaic materials, planar devices need to be improved.

In planar PSCs, the crystallinity, morphology, thickness, and surface coverage of perovskite film are critical for the device performance.^[8] Several methods have been proposed to prepare high-quality perovskite layer, such as spin-coating, two-step sequential deposition, and vacuum vapor deposition.^[9-12] Even though the one-step spin-coating method enabled among the highest efficiencies, the perovskite films frequently showed poor surface coverage, which resulted in a reduced cell performance.^[13] To overcome these issues, control of perovskite crystal growth and morphology has been widely investigated using several additives in the perovskite precursor solution.^[14-18] Shahiduzzaman et al. made use of the low vapor pressure ionic liquid (IL) 1-hexyl-3-methylimidazolium chloride to control the film morphology by forming a uniform distribution of perovskite nanoparticles.^[16] Moore et al. demonstrated that methylammonium formate can be used as an additive to produce higher quality, crystalline perovskite films.^[19] Although these studies suggested that adding ILs in the perovskite precursor solution may help to prepare better solar cells, there are currently no reports that implemented this strategy to improve state-of-the-art planar PSCs.

In this work, we demonstrate that ionic liquids enable the highest ever reported stabilized power conversion efficiency for a planar perovskite solar cell. We show that compact perovskite films with larger crystalline domain can be prepared from solution by adding particular ionic liquids, such as methylammonium formate, to the precursors. We demonstrate that larger crystalline domains result in a more effective charge collection and thus better photovoltaic performances. We propose an IL-driven mechanism of crystallization as a new strategy to prepare high-efficiency planar perovskite solar cell.

ILs are well known for their extremely low vapor pressure, which makes them nonvolatile liquids. If added in small

Constructive Effects of Alkyl Chains: A Strategy to Design Simple and Non-Spiro Hole Transporting Materials for High-Efficiency Mixed-Ion Perovskite Solar Cells

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Organic-inorganic metal halide perovskite solar cells (PSCs) have attracted a great attention in the field of photovoltaics by demonstrating power conversion efficiencies (PCEs) soaring from 3.9% to above 21% during the past few years.^[1-7] The remarkable photovoltaic performance of PSCs is resulting from the unique properties of the organic-inorganic trihalide perovskite semiconductors, such as the direct bandgap, high extinction coefficient, ambipolar charge transport, as well as the large diffusion length of free charge carriers.^[8,9] In order to enhance the photovoltaic performance of PSCs, a large number of publications have been extensively devoted to the optimization of perovskite deposition methods,^[10-17] perovskite composition engineering,^[18] interface engineering,^[19-26] etc.

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Therein, hole transporting materials (HTMs), as an important interface contact between the perovskite crystals and the metal electrode (back contact), have been desirably developed and investigated. The structures of the HTM play crucial roles in determining the hole transfer kinetics at the interface between HTM and perovskite, as well as affecting the rate of hole transport through the HTM to the metal contact. These in turn affect the interfacial charge recombination and the charge collection efficiency.^[11,12] Therefore, a good HTM should possess the following features: (1) high solubility in organic solvents (such as chlorobenzene, toluene) is favorable to the spin-coating process; (2) the highest occupied molecular orbital (HOMO) of the HTM must be above the valence band of the perovskite in order to achieve efficient hole injection; (3) high conductivity is required to reduce the charge transport resistance; (4) excellent thermal and photochemical stability. In this respect, organic small molecular HTMs have attracted great attention due to their large availability of solution-processing and the ease of structural modification, although many conducting polymer^[27] and inorganic semiconductor^[14,15] were reported to be efficient HTMs for PSCs. Nevertheless, the state-of-the-art organic small molecule, spiro-OMeTAD, is the most commonly used and efficient HTMs in PSCs by showing high PCEs of more than 19% in many cases. However, its known features, such as the complex synthesis, high cost, and low conductivity, could impede its large-scale application in PSCs.^[28] Therefore, many types of small molecule HTMs without spiro motif have been designed, synthesized and investigated in PSCs, such as carbazole,^[29-31] phenoxazine,^[32] acene derivatives,^[33] azobenzene,^[34] triazirane,^[35] etc. However, most of the reported HTMs without spiro motif are either chemically very complex,^[31-33] or give insufficient photovoltaic performance (PCE: 10%–15%) in PSCs.^[31,32-34] To the best of our knowledge, there is little work devoted to a systematic study on the influence of alkyl chains on the properties of the HTMs in PSCs although the alkyl chains have been found to be highly important in the hole mobility of polymer transistors,^[36] charge transfer kinetics in dye sensitized solar cells (DSSCs),^[37] and the electrochromic properties of metal complexes in light-emitting cells.^[38] Therefore, it is highly desirable to develop an effective design strategy of HTMs for PSCs with high efficiency and long term stability in view of future potential commercialization.

Here we designed and synthesized four simple, non-spiro, triphenylamine-based, organic HTMs, namely X2, X21, X22,

Enhancing Efficiency of Perovskite Solar Cells via N-doped Graphene: Crystal Modification and Surface Passivation

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Thin-film photovoltaics (PVs) are some of the most cost-effective approaches to convert sunlight directly into electric power. Over the past few years, perovskite solar cells (PSCs) of general formula ABX₃ (where A is an organic/inorganic cation, B is a metal cation, and X is a halide anion), have emerged at the forefront of thin-film PVs due to their high power conversion efficiency and low-cost fabrication.^[1-5] Since the pioneering work of Miyasaka and co-workers in 2009,^[6] PSCs have witnessed impressive advances with the solar-to-electrical power conversion efficiency (PCE) improving from 3.8% to a certified value of 22.1% on laboratory-scale cells in 2016.^[7] Such a high value in PCE can be attributed to the unique properties of the material, including tunable optical band gap, long charge diffusion length, low exciton binding energy, and low charge recombination rate.^[8,9] The dominant architecture of the PSC consists of a perovskite light-absorbing layer sandwiched between a hole-transporting material (HTM) such as Spiro-OMeTAD

(2,2',7,7'-tetrakis[N,N'-bis(p-methoxyphenyl)amino]-9,9'-spirobifluorene) and an electron-transporting layer, often TiO₂. Remarkably, by removing the HTM^[10] or by coating perovskite onto an electronically inert alumina mesoporous scaffold,^[11] the perovskite layer was found to function not only as a sensitizer but also as an ambipolar charge transporter.^[12]

Morphology, grain size, and thickness are all key factors that contribute to high performance.^[13-15] Thick perovskite layers with large grains are more desirable in order to reach the maximum light-harvesting following the trend of making a single crystal perovskite layer more similar to silicon PVs.^[16] Several works have recently been published, highlighting the importance of controlling the perovskite crystal morphology towards larger grains in order to achieve high-efficiency PSCs.^[17-19] In our recent work, we showed that large crystals are necessary to achieve state of the art photovoltaic metrics and stabilized power output.^[16] In addition, Bi et al.^[17] reported that the poor perovskite film quality with small grain sizes is due to the quick reaction between lead halide and the cations during crystallization of perovskite from the blended precursor solution. Therefore, controlling the nucleation and crystallization process of the perovskite layer is an important route towards improving perovskite film morphology. On the other hand, due to the perovskite crystalline nature, the perovskite interfaces also influence the device performance. This has encouraged the study of passivation of surface charge trap states of the perovskite and corresponding grain boundaries by using different passivating agents such as thiophene and pyridine Lewis bases,^[20] the organic molecule iodopentafluorobenzene,^[21] fullerene,^[22] and even PbI₂^[23]

One way to improve the optoelectronic properties of perovskite materials is introducing graphene derivatives to the perovskite structure. For example, He et al.^[24] developed an in situ solution method for chemical decoration of CH₃NH₃PbI₃ perovskites with reduced graphene oxides (RGO) to significantly improve the photodetector performance. Owing to its exceptional electrical, optical, and physical properties as well as its low-cost solution-phase production techniques, graphene has risen as a promising candidate for optoelectronic applications.^[25-27] Recently, RGO has been used in the mesoporous TiO₂^[28] or as a HTM in planar PSC.^[29] Furthermore, the functionalization of graphene through the introduction of functional groups and chemical doping with N, B, or S atoms opens wide opportunities to manipulate graphene properties. In particular, nitrogen is considered to be the most frequently used element for regulating the electronic and chemical properties of graphene.^[30,31]

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کارشناس پژوهش و فناوری برتر





کارشناس برتر دانشگاه:

سرکار خانم زهرا مجدی

کارشناس پژوهش و فناوری دانشگاه

حمایت تشویقی از گروه های دارای
رشد نسبی فعالیت های پژوهش و فناوری

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