文章编号: 1000-324X(2023)09-0989-02 **DOI:** 10.15541/jim20232000

徐徐展开新型钙钛矿光电材料的神秘画卷

赵晋津[1], 张文华[2]

(1. 河北师范大学 化学与材料科学学院, 石家庄 050024; 2. 云南大学 材料与能源学院, 昆明 650500)

在国家双碳目标的引领下, 新型钙钛矿材料在众多领域受到广泛关注。国家部委针对钙钛矿太阳能电池产业陆续出台了多个相关政策, 为新型钙钛矿材料与光电器件的发展提供了有力支撑[1-2]。新型钙钛矿材料(如卤化物钙钛矿材料)具有光吸收系数大、带隙可调、光生电子能力强、载流子扩散距离长、双 p/n 型、高光致发光量子产率、发光半峰全宽窄等特点, 也兼具铁电性、离子迁移可控和维度可调等显著优势[3-4], 在光-电转换、电-光转换、光-光转换(全光转换)等领域呈现出广阔的应用前景[5], 尤其是在太阳能电池、发光显示、阻变器、忆阻器、射线探测、示踪纳米药物等领域具有巨大的发展空间[6-7]。

钙钛矿是一种具有 ABX_3 结构的材料, 由德国矿物学家 Gustav Rose 首先发现并命名为 Perovskite, 以纪念俄罗斯矿物学家 Lev Perovski[8]。2009 年杂化钙钛矿作为光电转换材料首次应用于太阳能电池[9], 发展至今, 全球认证的单结钙钛矿太阳能电池转换效率已高于 25%, 从电池效率角度来看，钙钛矿太阳能电池在如此短的时间里走过了晶体硅太阳能电池近七十年的发展历程。我国科学家不仅对钙钛矿太阳能电池在各应用领域的发展做出了卓越贡献[10-11], 而且对钙钛矿材料的多铁性、离子迁移、稳定性等材料机理开展了深入而卓有成效的研究[12-13]。新型钙钛矿材料的研究涉及多个学科领域, 包括无机材料、光电子学、有机合成、物理化学、力学、生物医学等。钙钛矿材料及器件性能的不断突破和发展得益于各个学科的专家学者在材料制备、性能调控、微纳制造、工程应用、材料机理等方面的通力合作[14]。

新型钙钛矿材料的研究依然充满诸多未知, 无论是材料、界面和器件研究, 还是能量转换应用研究, 乃至其深层次的物化机理研究, 都还有待进一步探索与挖掘。基于此, 《无机材料学报》编辑部邀请云南大学张文华教授和河北师范大学赵晋津教授共同担任特邀编辑, 组织复旦大学、南京理工大学、兰州大学、中国工程物理研究院、中国科学院上海硅酸盐研究所等多家单位, 出版“新型钙钛矿材料与光电器件”专辑。本专辑致力于多方面展示本领域的最新研究成果和应用进展, 内容涉及材料合成与调控、器件设计与优化、性能测试与应用等关键领域, 旨在为读者展开钙钛矿光电材料的神秘画卷。

Unfolding the Mysterious Scroll of Novel Photoelectric Perovskite Step by Step

ZHAO Jinjin[1], ZHANG Wenhua[2]

(1. School of Chemistry and Materials Science, Hebei Normal University, Shijiazhuang 050024, China; 2. School of Materials and Energy, Yunnan University, Kunming 650500, China)

Under the guidance of achieving the national dual carbon goal, novel perovskite has drawn great concern in multiple fields. Various national policies related to the perovskite solar cell industry in China have been continually released, providing strong support for the development of novel perovskite materials (*e.g.* halide perovskite) and their photoelectric devices[1-2]. Owing to the advantages of large optical absorption coefficient, tunable band gap, strong photo-induced electron ability, long carrier diffusion distance, dual p/n type, high photoluminescence quantum yield, narrow full width at half maximum, ferroelectricity, tunabilities of ion migration, and dimensionality[3-4], novel perovskites are promising in the fields of photoelectric conversion, electro-optical conversion and photo-photo conversion (all-optical conversion)[5], especially for solar cells, luminescent displays,

resistive transformers, memristors, ray detection, nanomedicine tracer *etc*[6-7].

Perovskite (PVK) is the mineral with crystal structure of ABX_3, discovered by German mineralogist Gustav Rose in memory of Russian scientist Lev Perovski[8]. Novel organic-inorganic hybrid perovskite materials were firstly applied to solar cells as the photovoltaic conversion materials in 2009[9]. Up to now, conversion efficiency of certified single-junction perovskite solar cells has exceeded 25%, comparable to that of crystalline silicon solar cells which have developed for nearly seven decades. Chinese scientists have not only made remarkable contributions to the development of various perovskite applications including photovoltaics[10-11], but also carried out in-depth and fruitful research in their mechanisms as ferroelectricity, ion migration *etc*[12-13]. The study on novel perovskite materials involves interdiscipline such as inorganic material, optoelectronics, organic synthesis, physical chemistry, mechanics, and biomedicine. The collaboration of researchers from interdiscipline for material preparation, property modulation, micro- and nano-fabrication, applications, and mechanisms is required to achieve more breakthroughs in perovskites[14].

Research of halide perovskites is still full of unknowns, including material manufacturing, interfaces and devices, applications for energy conversion, and deep mechanisms, which needs more researchers to dedicate in. Therefore, the editorial board of *Journal of Inorganic Materials* invites Prof. Zhang Wenhua from Yunnan University and Prof. Zhao Jinjin from Hebei Normal University as contribution editors to organize articles of Fudan University, Nanjing University of Science and Technology, Lanzhou University, China Academy of Engineering Physics, Shanghai Institute of Ceramics of Chinese Academy of Sciences *etc*., and publish a special issue on the topic of Novel Perovskite Materials and Photoelectric Devices. This special issue is dedicated to presenting the latest research progress in multiple domains in this field, involving key areas of synthesis and regulation of materials, design and optimization of devices, and performance testing and applications, aiming to unfold a comprehensive and in-depth scroll of novel photoelectric perovskite.

参考文献:

[1] 中华人民共和国工业和信息化部. 三部门关于促进光伏产业链供应链协同发展的通知. [2022-08-24]. https://www.miit.gov.cn/zwgk/zcwj/wjfb/tz/art/2022/art_d799b68c80e64159ad818166b743a539.html.

[2] 中华人民共和国工业和信息化部. 工业和信息化部等六部门关于推动能源电子产业发展的指导意见. [2023-01-03]. https://ythxxfb.miit.gov.cn/ythzxfwpt/hlwmh/tzgg/sbfw/qyshzr/art/2023/art_e908d7f1315941a39e13fa4cd6460d55.html.

[3] LI Y, CHEN Z, YU B, *et al*. Efficient, stable formamidinium-cesium perovskite solar cells and minimodules enabled by crystallization regulation. *Joule*, 2022, **6(3):** 676.

[4] GUO H, YI S, YANG S, *et al*. Structural symmetry impressing carrier dynamics of halide perovskite. *Adv. Funct. Mater.*, 2023, **33(17):** 2214180.

[5] JIAO Y, YI S, WANG H, *et al*. Strain engineering of metal halide perovskites on coupling anisotropic behaviors. *Adv. Funct. Mater.*, 2021, **31:** 2006243.

[6] ZHANG F, HAN B, ZENG H. Perovskite quantum dot photovoltaic and luminescent concentrator cells: current status and challenges. *J. Inorg. Mater.*, 2022, **37(2):** 117.

[7] YANG S, XU Y, HAO Z, *et al.* Recent advances in high-efficiency perovskite for medical sensors. *Acta Phys.-Chim. Sin.*, 2023, **39(35):** 2211025.

[8] TANAKA H, MISONO M. Advances in designing perovskite catalysts. *Curr. Opin. Solid State. Mater. Sci.*, 2001, **5(5):** 381.

[9] KOJIMA A, TESHIMA K, SHIRAI Y, *et al.* Organometal halide perovskites as visible-light sensitizers for photovoltaic cells. *J. Am. Chem. Soc.*, 2009, **131(17):** 6050.

[10] ZHAO Y, MA F, QU Z, *et al.* Inactive $(PbI_2)_2RbCl$ stabilizes perovskite films for efficient solar cells. *Science*, 2022, **377(6605):** 531.

[11] CAI B, XING Y, YANG Z, *et al.* High performance hybrid solar cells sensitized by organolead halide perovskites. *Energy Environ. Sci.*, 2013, **6(5):** 1480.

[12] YUAN Y, CHAE J, SHAO Y, *et al.* Photovoltaic switching mechanism in lateral structure hybrid perovskite solar cells. *Adv. Energy Mater.*, 2015, **5(15):** 1500615.

[13] LI B, JIAO Y, QIN S, *et al.* Photoinduced strain in organometal halide perovskites. *J. Phys. Chem. Lett.*, 2023, **14(5):** 1343.

[14] YI S, ZHAO J. Preface to the special issue on interdisciplines. *J. Cent. South Univ.*, 2022, **28(12):** 3639.

张文华, 云南大学研究员, 博士生导师, 云南大学高层次引进人才(第二层次), 中国科学院相关人才计划, 德国洪堡学者, 中国可再生能源学会光伏专委会委员(理事), 中国材料研究学会太阳能材料专委会副秘书长。长期从事无机功能材料与新型太阳能电池的研究, 主要研究方向: 钙钛矿太阳能电池, 电催化材料与光伏电解水制氢。E-mail: wenhuazhang@ynu.edu.cn

赵晋津, 河北师范大学教授, 博士生导师, 全国青联委员, 河北省杰出青年, 省青年拔尖人才, 获得中国电介质物理优秀青年奖、中国新锐科技卓越影响奖、河北省青年科技奖、河北省三八红旗手、河北省青年五四奖章提名奖、两次获省优秀硕士毕业论文指导教师等荣誉与称号。长期从事钙钛矿能量转换材料及器件研究。E-mail: jinjinzhao2023@hebtu.edu.cn