Journal of Electrochemistry

Volume 25
Issue 1 *Special Issue of Next-Generation Secondary Batteries*

2019-02-28

Preface on Special Issue of Next-Generation Secondary Batteries

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Recommended Citation
Zhen Zhou, Quan-Feng Dong. Preface on Special Issue of Next-Generation Secondary Batteries[J]. *Journal of Electrochemistry*, 2019 , 25(1): 180540.
DOI: 10.13208/j.electrochem.180540
Available at: https://jelectrochem.xmu.edu.cn/journal/vol25/iss1/12

DOI: 10.13208/j.electrochem. 180540 **Artical ID**:1006-3471(2019)01-0001-02
Cite this: *J. Electrochem*. **2019**, *25*(1): 01-02 **Http**://electrochem.xmu.edu.cn

《下一代二次电池》专辑序言

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随着人类社会的迅速发展, 能源和环境问题逐渐成为人们关注的焦点. 化石燃料的过度依赖和使用所导致的全球变暖和环境污染日趋严重,国内大范围高频率的雾霾天气引起了民众的广泛担心,迫切要求加快能源技术创新,建设清洁低碳、安全高效的新能源体系.

风能、太阳能和潮汐能等清洁可再生能源在空间和时间上分布不均,电化学储能是实现其广泛应用的关键环节. 以锂离子电池为代表的二次电池技术一经出现就在数码产品等移动电源市场占据了主导地位, 然而长距离续航里程的电动汽车和发展新能源需要的智能电网等对储能技术提出了更高的要求. 因此,下一代二次电池储能体系的研究发展至关重要,对我国能源、交通、信息和国防等领域的高速发展和相关战略新兴产业的形成和壮大具有重要意义.

传统的锂离子电池被形象地称为“摇椅式电池”,摇椅的两端为电池的正负极,锂离子像运动员一样在摇椅的两端来回奔跑完成电池的充放电过程,但正负极活性材料有限的理论比容量限制了体系能量密度的进一步提升. 使用金属锂负极是下一代二次电池储能技术发展的重要方向, 在其基础上发展了全固态锂电池、锂硫电池和锂空气电池等. 全固态锂电池的电解质固态化,有助于克服锂枝晶的生长和避免锂枝晶穿透隔膜引发电池短路,使其具有能量密度高、安全性能好等优势. 为了匹配锂金属超高的理论能量密度, 陆续发展了以硫作为正极活性材料的锂硫电池和以氧气为活性材料的锂空气电池. 与传统锂离子电池的离子脱嵌机理完全不同,锂硫电池和锂空气电池的正极不仅物质结构与性质发生较大变化,而且还存在大幅变化的固固、固液、固气、气液等多相反应界面. 此外,由于全球锂资源的匮乏和分布不均衡,开发一种替代电池成为各国科学家努力的重要方向. 钠离子电池因其电化学储能机理与锂离子电池类似,并且地球上钠资源十分丰富,开采费用仅为锂的百分之一,相关研究发展受到了广泛关注. 上述二次电池储能体系无疑具有广阔的应用前景,在研发上已经取得一系列令人瞩目的进展,但各项技术均处在早期研发阶段,仍需进行大量深入的研究工作.

本专辑围绕下一代二次电池专题,收录了在相关研究领域具有丰富经验积累和影响力的团队所撰写的 9 篇相关研究进展的综述文章和研究论文. 希望借助此专辑的出版, 能使广大读者更好地了解当前新型储能体系研究领域的研究现状、研究趋势和存在的问题及挑战,以推动我国下一代二次电池研究的进一步发展.

最后,对本专辑的所有作者、审稿人及编辑部工作人员的辛勤工作和付出表示由衷的感谢!

Special Issue: Next-Generation Secondary Batteries

With the rapid development of human society, energy and environmental issues have gradually become the focus in the current society. The global warming and environmental pollution caused by vast use of fossil fuels have become increasingly serious. For instance, the widespread and high frequency of haze weather has aroused public concern nationwide. The development of a clean, low-carbon, safe and efficient new energy system is a major strategic need of our country.

Since clean renewable energy sources such as wind, solar and tidal energies are fluctuant and intermittent depending on the weather conditions, secondary batteries are often required in the development and utilization. Nowadays, rechargeable lithium-ion batteries have dominated in the portable power sources of electronic devices. However, long-distance range electric vehicles and large-scale energy storages in smart grids put forward higher requirements of new energy storage technologies. The research and development of next-generation secondary batteries has important strategic significance for the rapid developments in energy, transportation, information, national defense and other related fields.

Lithium-ion batteries (so-called rocking-chair batteries) generally consist of intercalation compounds for both cathodes and anodes, and the charge and discharge processes are completed by the migration of lithium ions between the two electrodes. However, the limited theoretical specific capacities of the cathode and anode materials impede the further enhancement in energy density. The use of lithium metal as an anode becomes an important direction for the development of next-generation secondary batteries. Accordingly, all-solid-state lithium batteries, lithium-sulfur batteries and lithium-air batteries have been developed. The solid electrolyte can suppress lithium dendrite growth and prevent cell from short-circuit caused by dendrite penetration. Thus, all-solid-state lithium batteries have the advantages of high energy density and good safety. In order to match the ultra-high theoretical energy density of lithium metal, lithium-sulfur batteries and lithium-air batteries have been successively developed. Different from traditional lithium-ion batteries with intercalation mechanism, the cathodes of lithium-sulfur batteries and lithium-air batteries are more like reaction places related to solid-solid, solid-liquid, solid-gas and gas-liquid reaction interfaces. Moreover, sodium ion batteries have been studied extensively as a prospective alternative to lithium-ion batteries because of the depleted natural resources and expensive prices of lithium. The above next-generation secondary batteries undoubtedly have broad application prospects, and a series of remarkable progress have been made. Nevertheless, all technologies are in the early stage of research and development, and more in-depth research work is still needed.

In this special issue, we collect 9 submissions including review and research articles from some leading research groups in next-generation secondary batteries in China. We hope that the publication of this special issue helps the broad readers better understanding the research statuses, future trends, problems and challenges in the above-mentioned types of batteries, as well as further promoting the development of next-generation energy storage systems in China.

We would like to take this opportunity to thank all the authors, reviewers, and editorial staffs of *Journal of Electrochemistry* for their excellent and professional contributions to this special issue.

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