

# **Designing solid-state electrolytes for safe energy-dense batteries**





## Overview

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Over the past 10 years, solid-state electrolytes (SSEs) have re-emerged as materials of notable scientific and commercial interest.

SSEs generally possess high ionic conductivities ( $>0.1 \text{ mS cm}^{-1}$  at RT), high moduli (for example,  $>1 \text{ GPa}$  for oxides), wide and high electrochemical-stability windows ( $>4.0 \text{ V}$ ).

Ion-transport mechanisms Ion transport in electrolytes is driven by chemical and electrochemical potential gradients in the system. The Nernst-Planck equation relates  $t$ .

The main failure modes of SSEs (Fig. 4) are caused by their decomposition, owing to the electrochemical and interfacial instability at high and/or low voltages, volume changes.

There are numerous strategies that can be employed to optimize SSEs for high-density energy storage and practical applications. For SSEs, these strategies include increasing the ionic conductivity.

Are solid-state electrolytes a high-priority material?

Abstract | Solid-state electrolytes (SSEs) have emerged as high-priority materials for safe, energy-dense and reversible storage of electrochemical energy in batteries.

Can solid-state electrolytes be used for electrical energy storage in batteries?

3These authors contributed equally: Qing Zhao, Sanjuna Stalin, Chen-Zi Zhao. Over the past 10 years, solid-state electrolytes (SSEs) have re-emerged as materials of notable scientific and commercial interest for electrical energy storage (EES) in batteries.

Are solid-state electrolytes safe?

Nature Reviews Materials 5, 229–252 (2020) Cite this article Solid-state electrolytes (SSEs) have emerged as high-priority materials for safe, energy-dense and reversible storage of electrochemical energy in batteries.



What are solid-state electrolytes?

Over the past 10 years, solid-state electrolytes (SSEs) have re-emerged as materials of notable scientific and commercial interest for electrical energy storage (EES) in batteries.

Are solid-state batteries safe?

Solid-state batteries based on electrolytes with low or zero vapour pressure provide a promising path towards safe, energy-dense storage of electrical energy. In this Review, we consider the requirements and design rules for solid-state electrolytes based on inorganics, organic polymers and organic-inorganic hybrids.

What is a high-energy-density solid-state battery (SSB)?

Nature Energy 6, 227–239 (2021) Cite this article The widespread adoption of high-energy-density solid-state batteries (SSBs) requires cost-effective processing and the integration of solid electrolytes of about the same thickness as the polymer-membrane separators found in conventional lithium-ion batteries.



# Designing solid-state electrolytes for safe energy-dense batteries

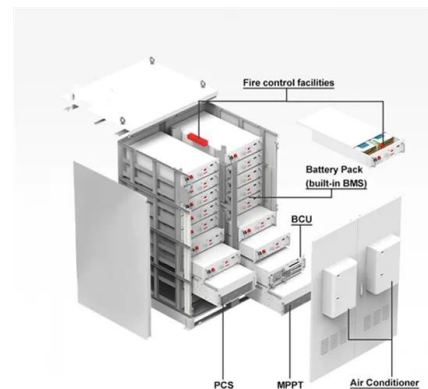


## Designing solid-state electrolytes for safe, energy-dense batteries

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## Sci-Hub , Designing solid-state electrolytes for safe, energy-dense

Zhao, Q., Stalin, S., Zhao, C.-Z., & Archer, L. A. (2020). Designing solid-state electrolytes for safe, energy-dense batteries. Nature Reviews Materials. doi:10.1038



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## Designing biomass-integrated solid polymer electrolytes for safe

DOI: 10.1039/d3ee01173a Corpus ID: 259056711  
Designing biomass-integrated solid polymer electrolytes for safe, energy-dense lithium metal batteries @article{Sheng2023DesigningBS,



title={Designing biomass-integrated solid polymer electrolytes for safe, energy-dense lithium metal batteries}, author={Ouwei Sheng and Chengbin Jin and T. Yang and Zhijin Ju and Jianmin Luo ...



### Solid-state electrolytes for safe rechargeable lithium metal batteries

In this context, solid-state electrolytes (SSEs) arise as the preferred replacement of alkyl carbonate-based liquid electrolytes due to their intrinsic safety and the foreseen higher energy density of solid-state Li metal batteries (SSLMBs) [6, 7].

### Advanced inorganic/polymer hybrid electrolytes for all-solid-state

Solid-state batteries have become a frontrunner in humankind's pursuit of safe and stable energy storage systems with high energy and power density. Electrolyte materials, currently, seem to be the Achilles' heel of solid-state batteries due to the slow kinetics and poor interfacial wetting. Combining the merits of solid inorganic electrolytes (SIEs) and solid polymer electrolytes ...

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### Batteries , Special Issue : Solid-State Electrolytes for Safe

Solid-state electrolytes are the most promising materials for energy-dense and safe energy storage in batteries. Replacing organic liquid electrolytes with solid-state electrolytes eliminates the risk of inflammation at elevated temperatures and/or the battery damage, including that as a result of a short circuit.

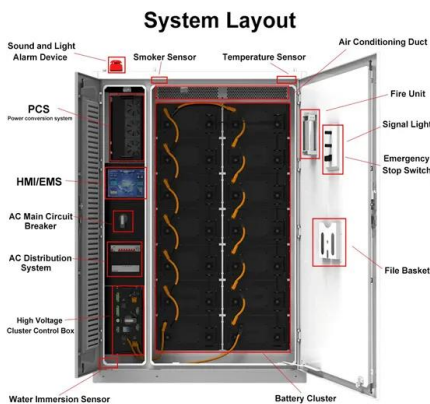


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### Designing electrolytes with high solubility of sulfides/disulfides for

Alkaline metal sulfur (AMS) batteries offer a promising solution for grid-level energy storage due to their low cost and long cycle life. However, the formation of solid compounds such as  $M_2S_2$



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Liquid phase therapy to solid electrolyte-electrode interface in solid-state Li metal batteries: A review. Energy Storage Materials, 2020, 24, 75. 11. Q Zhao, S Stalin, CZ Zhao, LA Archer\*. Designing solid-state electrolytes for safe, energy-dense batteries. 12. XB

### Solidification of polymer-based electrolytes for energy-density solid

This review is helpful to further understand the solidification technologies associated with a polymer-based electrolyte in energy-density solid-state batteries. Further, the review is expected to promote mass production of polymer-based electrolytes and ...





### Research Progress on Solid-State Electrolytes in Solid-State

2 ???· Solid-state lithium batteries exhibit high-energy density and exceptional safety performance, thereby enabling an extended driving range for electric vehicles in the future. ...



### Designing solid-state electrolytes for safe, energy-dense batteries

Solid-state batteries based on electrolytes with low or zero vapour pressure provide a promising path towards safe, energy-dense storage of electrical energy. In this Review, we consider



### Fundamentals of inorganic solid-state electrolytes for batteries

Solid-state batteries are attractive due to their potential safety, energy-density and cycle-life benefits. Recent progress in understanding inorganic solid electrolytes considering multiscale ion

### Designing solid-state electrolytes for safe, energy-dense batteries

Solid-state electrolytes (SSEs) have emerged as high-priority materials for safe, energy-dense and reversible storage of electrochemical energy in batteries. In this Review, we assess recent ...

**INTEGRATED DESIGN**  
EASY TO TRANSPORT AND INSTALL,  
FLEXIBLE DEPLOYMENT





### Processing thin but robust electrolytes for solid-state batteries

High-performance solid-state electrolytes are key to enabling solid-state batteries that hold great promise for future energy storage. The authors survey the fabrication process of



### Design of thin solid-state electrolyte films for safe and energy ...

Designing and fabricating thin solid-state electrolytes (SSEs) are crucial to achieve high energy densities and boost the practical application of ASSLBs. However, the ...



### Recent advances and perspectives on thin electrolytes for high-energy

Solid-state lithium batteries (SSLBs) are promising next-generation energy storage devices due to their potential for high energy density and improved safety. The properties and physical parameters of the solid-state electrolyte (SSE), as a critical component of the battery, have a significant effect on the



### Electrochemical Compatibility of Solid-State ...

As shown in Figure 1, to meet the ever-growing demands for high-safety and high-energy-density batteries, Yoshima et al. fabricated a 12 V-class bipolar solid-state battery with an LLZO electrolyte, a Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> (LTO) anode, and ...





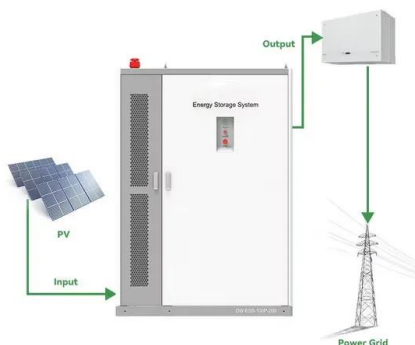
### Solid-state electrolytes for beyond lithium-ion batteries: A review

Safe energy storage technique is prerequisite for sustainable energy development in the future. Designing Solid-State Electrolytes exhibiting high ionic conductivity, good electrochemical performances, high mechanical/thermal stability, compatible electrolyte



### Designing solid-state electrolytes for safe, energy-dense batteries

Solid-state electrolytes (SSEs) have emerged as high-priority materials for safe, energy-dense and reversible storage of electrochemical energy in batteries. In this Review, we assess recent progress in the design, synthesis and analysis of SSEs, and identify key failure modes, performance limitations and design concepts for creating SSEs to meet requirements ...



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### From nanoscale interface characterization to sustainable energy ...

The recent discovery of highly conductive solid-state electrolytes (SSEs) has led to tremendous progress in the development of all-solid-state batteries (ASSBs). Though promising, they still face





### Designing biomass-integrated solid polymer electrolytes for safe

Solid-state polymer electrolytes are an important factor in the deployment of high-safety and high-energy-density solid-state lithium metal batteries.

### Designing All-Solid-State Batteries by Theoretical Computation: A

All-solid-state batteries (ASSBs) with solid-state electrolytes and lithium-metal anodes have been regarded as a promising battery technology to alleviate range anxiety and address safety issues due to their high energy density and high safety. Understanding the fundamental physical and chemical science of ASSBs is of great importance to battery ...



### Designing composite solid-state electrolytes for high performance

such as lithium-ion batteries and all-solid-state batteries. ajiangsu Key Laboratory of Electrochemical Energy-Storage Technologies, College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China. E



### Designing solid-state electrolytes for safe, energy-dense batteries

Solid-state electrolytes (SSEs) have emerged as high-priority materials for safe, energy-dense and reversible storage of electrochemical energy in batteries. In this Review, we assess recent progress in the design, synthesis and analysis of SSEs, and identify key failure modes, performance limitations and design concepts for creating SSEs to meet requirements for ...



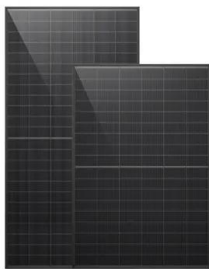


### Designing Solid Electrolytes for Rechargeable Solid-State Batteries

generation batteries with better safety, higher energy density, and longer cycle life have been actively investigated. In this thesis, works on polymer and ceramic solid electrolytes to improve safety and energy density of rechargeable solid-state batteries are

### Design of thin solid-state electrolyte films for safe and energy-dense

DOI: 10.1016/j.mattod.2023.11.016 Corpus ID: 266391886 Design of thin solid-state electrolyte films for safe and energy-dense batteries @article{Wang2023DesignOT, title={Design of thin solid-state electrolyte films for safe and energy-dense batteries}, author={Caoyu Wang and Cheng Wang and Mingnan Li and Shilin Zhang and Chao Zhang and Shulei Chou and Jianfeng Mao ...



### Designing biomass-integrated solid polymer electrolytes for safe ...

The solid polymer electrolyte (SPE) as a key battery component promises advances in solid-state lithium (Li) metal batteries (SSLMBs). Biomass, with a naturally derived structure design, composition and physical/chemical properties, exhibits advantages over the traditionally synthesized polymers in SPE. Biom

### Designing Solid Electrolytes for Rechargeable Solid-State Batteries

Lithium-ion battery (LIB) is an indispensable energy storage device in portable electronics, and its applications in electric vehicles and grid-level energy storage are increasing dramatically in recent years due to high demands. To meet



energy demands and address fire hazards, next generation batteries with better safety, higher energy density, and longer cycle life have been actively



### **Designing solid-state electrolytes for safe, energy-dense batteries**

Designing solid-state electrolytes for safe, energy-dense batteries. Qing Zhao 1,3, Sanjuna Stalin 1,3, Chen-Zi Zhao 1,2,3 and Lynden A. Archer 1\* Abstract , Solid-state electrolytes

### **Designing solid-state electrolytes for safe, energy-dense batteries**

Design Strategies, Practical Considerations, and New Solution Processes of Sulfide Solid Electrolytes for All-Solid-State Batteries Park, Kern Ho; Bai, Qiang; Kim, Dong ...



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