Reykjavik solid-state batteries

(a) Academic efforts. The variation of published research articles related to solid-state batteries (SSBs). Source: Data acquired from webofscience . (b) Industrial efforts. Representative companies (Toyota, Mercedes, Ford, CATL, etc.).

Structure schemes of different types of all-solid-state batteries (ASSBs): (a) solid-state (SS) Li-ion batteries; (b) SS Li-metal batteries; (c) SS Li-S batteries; and (d) SS Si-based batteries. SSE, solid-state electrolyte. (Microscale interphases are not illustrated in figures.)2

Solid-state ionic conductors, as an indispensable component in ASSB structure, play a significant role in determining the cyclability and performance of cells. Generally, SE materials can be divided into inorganics, polymers, and composites. Among them, inorganic SEs have gained intensive research interests and a variety of materials have been developed,18,19,20,21 including oxides, sulfides, halides, and borohydrides.

There are several inorganic SE materials to achieve ionic conductivity competitive with that of LEs. A major milestone was the report in 2011 of Li10GeP2S12 (LGPS)25 sulfide with RT ionic conductivity of 12 mS cm-1 and a later report in 2016 on a LGPS-type solid solution (Li9.54Si1.74P1.44S11.7Cl0.3) shows an ionic conductivity of 25 mS cm-1.26 Other representative inorganic SE materials include garnet-type oxide (Li7La3Zr2O12, LLZO),21,27 NASICON-type (e.g., Li1.3Al0.3Ti1.7(PO4)3, LATP),28 sulfides such as argyrodites (Li6PS5X), Li3PS4,29 and halides, such as Li3InCl6.30

Interface issues (anode/solid electrolyte [SE], bulk SE, cathode/SE) in all-solid-state batteries (Chemical reaction: 1, 6; void: 5, 7, 8, 9, 10, 12; electrochemical reaction: 2, 3, 6, 13; grain boundary: 4, 11).37

(a) Mechanisms for x-rays and neutrons interacting with the outer electron shells of the atoms. (b) Sketch of the x-ray and neutron total cross sections of several atoms.51

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Web: https://www.hollanddutchtours.nl/contact-us/
Email: energystorage2000@gmail.com
WhatsApp: 8613816583346