Sn-based high capacity electrodes for all-solid-state metal-ion batteries

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The standard Li-ion (or Na) batteries use carbonate-based solvents that are very flammable and would catch fire immediately with a short circuit or an overcharge. These safety-based issues can be eliminated by developing an all-solid-state battery (ASSB) using solid electrolytes (SE) instead of liquid carbonate-based electrolytes. In ASSB, all cell components i.e., anodes, cathodes, and electrolytes are solid. ASSBs have gained great attention over the past few years as they may provide higher energy densities (300-600 Wh kg^{-1}) and better safety compared to Li-ion batteries (LIBs) with liquid electrolytes. A wide range of electrode materials and SEs are therefore being researched at the moment. Regarding SEs, the main aim is to combine the properties of high ionic conductivity, suitable mechanical properties, good processability, and sufficient anodic/cathodic stability. While research on cathode materials (positive electrodes) largely focuses on intercalation and conversion reactions, research on anode materials (negative electrodes) largely addresses the use of lithium. However, Li has poor compatibility with many solid electrolytes due to its high reactivity. Graphite has been accepted as the state-of-the-art anode for Lithium-ion batteries (LIB) from the beginning of its commercialization. An important limitation of ASSB has been. However, graphite is found to be more reactive against SEs. As an alternative, many nanostructured materials have been proposed as an anode. Among them, Sn is more attractive due to its very high capacity ($Li_{4.4}Sn$, 992 mAh g^{-1}) combined with a very suitable redox activity range (0.40 V vs. Li^+/Li). However, it will undergo large volume expansion (259 %) at a fully lithiated state ($Li_{4.4}Sn$), leading to battery failure. So far, the ASSLiB research field is dominated by the development of SEs as well as cathodes, while the development of anode materials has hardly been explored, and the research efforts are still at an early stage. In the first part of my talk, the consequences of using liquid electrolytes and the need for a solid-state battery will be discussed. Subsequently, the synthesis and Li storage characteristics of various high-capacity electrode materials for ASSB applications will be discussed.

References:

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