PRESS RELEASE

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Subject line: Powering the future with low-cost, high-performance all-solid-state batteries

(Tokyo, 14 July 2017) Researchers at Tokyo Institute of Technology have devised a low-cost approach to developing all-solid-state batteries, improving prospects for scaling up the technology for widespread use in electric vehicles, communications and other industrial applications.

Ever since batteries were invented over 200 years ago, there has been a drive to improve quality and performance at reduced costs. Compared to common lithium-ion batteries that contain lithium ion conducting liquids, all-solid-state batteries of the future promise a suite of advantages: improved safety and reliability, higher energy storage and longer life cycles.

The discovery of 'superionic' conductors — solid crystals that enable fast movement of ions — is spurring the development of such dream batteries, but promising designs have so far relied on the use of rare metals such as germanium, making them too expensive for large-scale applications.

Ryoji Kanno and colleagues at Tokyo Institute of Technology (Tokyo Tech) have now discovered a new material with a low-cost, scalable approach that involves substituting germanium for two more readily available elements: tin and silicon. The new material achieved an ionic conductivity[1] that exceeds that of liquid electrolytes. Reporting their findings in *Chemistry of Materials*, the team states: "This germanium-free lithium conductor could be a promising candidate as an electrolyte in all-solid-state batteries."

Due to its high chemical stability and ease of fabrication, Kanno says that the new material widens the possibilities of fine-tuning solid electrolytes to meet diverse industry and consumer needs.

In 2011, Kanno and his team, working in collaboration with Toyota Motor Corporation and Japan's High Energy Accelerator Research Organization (KEK), published a landmark paper in *Nature Materials* that introduced a solid electrolyte with the structure $Li_{10}GeP_2S_{12}$ (LGPS). This material became an important forerunner in the race to develop viable all-solid-state batteries. It exhibited an ionic conductivity of 1.2×10^{-2} S cm^{-1} at room temperature, a level comparable with — and even exceeding some — liquid electrolytes used in existing batteries.

The team went on to design other solid electrolytes based on the same LGPS crystal structure, with promising results. (See Solid electrolytes open doors to solid-state batteries.)

In their latest study, the researchers kept the same framework structure of LGPS, and finely adjusted the ratio and positioning of the tin, silicon and other constituent atoms. The resulting material *LSSPS* (composition: $Li_{10.35}[Sn_{0.27}Si_{1.08}]P_{1.65}S_{12}$ ($Li_{3.45}[Sn_{0.09}Si_{0.36}]P_{0.55}S_4$)) achieved an ionic conductivity of 1.1 x 10^{-2} S cm^{-1} at room temperature, almost reaching that of the original LGPS structure.

Although further work will be required to optimise performance for different usage purposes, the new material raises hopes for low-cost production without sacrificing performance.

Kanno envisions that in addition to meeting current battery needs across all sectors, all-solid-state batteries will expand the possibilities of responding to new user needs arising from the Internet of Things (IoT) and the shift towards smart systems, as well as powering robots, drones and space and aircraft technologies among others in future.

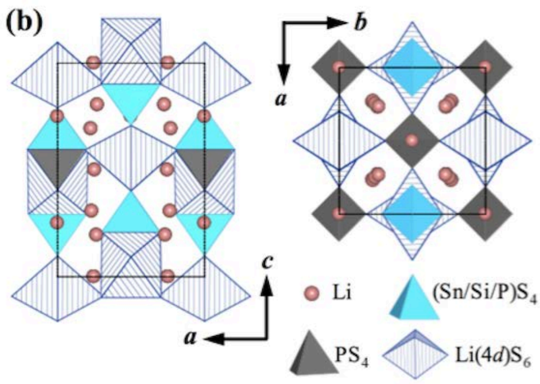

Figure 1. The atomic arrangement of the new material named *LSSPS*
Two representations of the new germanium-free material with the structure $Li_{10.35}[Sn_{0.27}Si_{1.08}]P_{1.65}S_{12}$ ($Li_{3.45}[Sn_{0.09}Si_{0.36}]P_{0.55}S_4$.

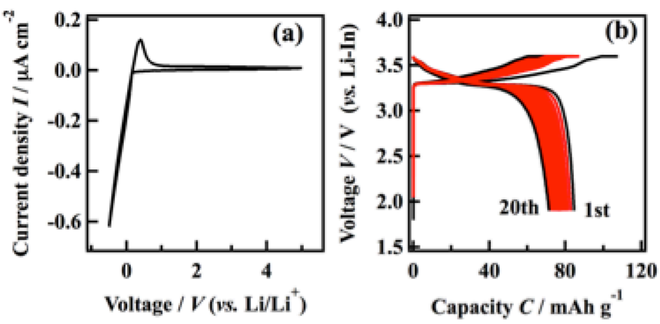

Figure 2. Cyclic voltammogram and charge-discharge curves
The material exhibits high stability and cycling ability, with good capacity retention during 20 cycles.

Technical terms

[1]Ionic conductivity: A measure of how easily lithium ions flow through a given material

Reference

Yulong Sun[a], Kota Suzuki[a,b], Satoshi Hori[b], Masaaki Hirayama[a,b] and Ryoji Kanno[a,b] *, Superionic Conductors: Superionic Conductors: $Li_{10+\delta}[Sn_ySi_{1-y}]_{1+\delta}P_{2-\delta}S_{12}$ with a $Li_{10}GeP_2S_{12}$-type Structure in the Li_3PS_4-Li_4SnS_4-Li_4SiS_4 Quasi-ternary System, *Chemistry of Materials,* DOI: 10.1021/acs.chemmater.7b00886
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