Batteries

Na^+ Rechargeable Batteries using Novel Na_3PS_4 Glass-ceramic Electrolytes

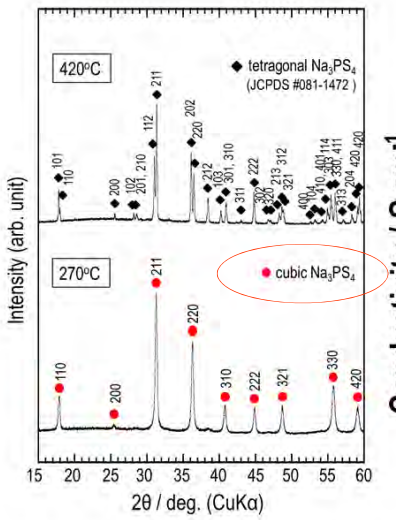
Associate Prof. Akitoshi HAYASHI (Osaka Prefecture University)

- We discovered a novel electrolyte of a cubic Na_3PS_4 with Na^+ superionic conductivity.
- The conductivity is over 10^{-4} S/cm obtained in a glass-ceramic structure.
- All-solid-state Na batteries, with a powder-compressed Na_3PS_4 electrolyte, functioned as a rechargeable battery at room temperature.

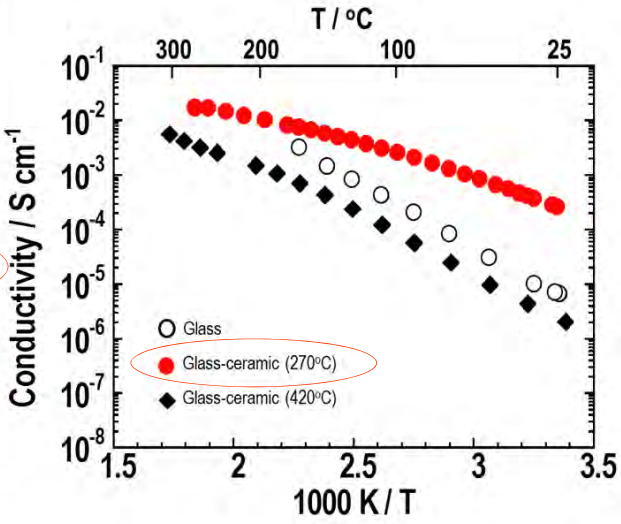
1. Novel Na_3PS_4 Electrolytes

- Cubic Na_3PS_4 phase is precipitated by the crystallization of the $75Na_2S \cdot 25P_2S_5$ (mol%) glass with heat treatment at 270℃ for 1Hr. The Na^+ conductivity is over 10^{-4} S/cm.
  (Tetragonal phase of Na_3PS_4 is known to be formed at 420℃, which has a low conductivity of 10^{-6} S/cm.)
- A higher conductivity is obtained by a partial substitution of Na_4SiS_4 for Na_3PS_4, which is (100-x) $Na_3PS_4 \cdot xNa_4SiS_4$.

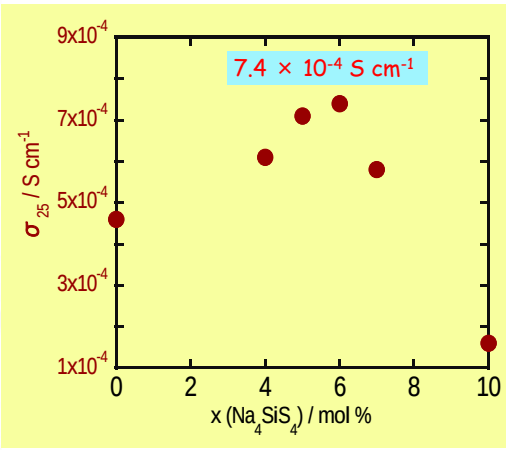
XRD patterns



Na^+ conductivity of Na_3PS_4



Na^+ conductivity of (100-x)$Na_3PS_4 \cdot xNa_4SiS_4$



2. Rechargeable Na^+ Battery (⊖ Na-Sn / Na_3PS_4 / TiS_2 ⊕)

- The Na^+ battery shows a capacity of ~90 mAh/g (theoretically 240 mAh/g for TiS_2) with V=1.7 volts (theoretically 1.9V). By a partial substitution of Na_4SiS_4 for Na_3PS_4, the higher capacity of 300mAh/g (theoretically 550mAh/g for amorphous TiS_3 active material) is obtained.

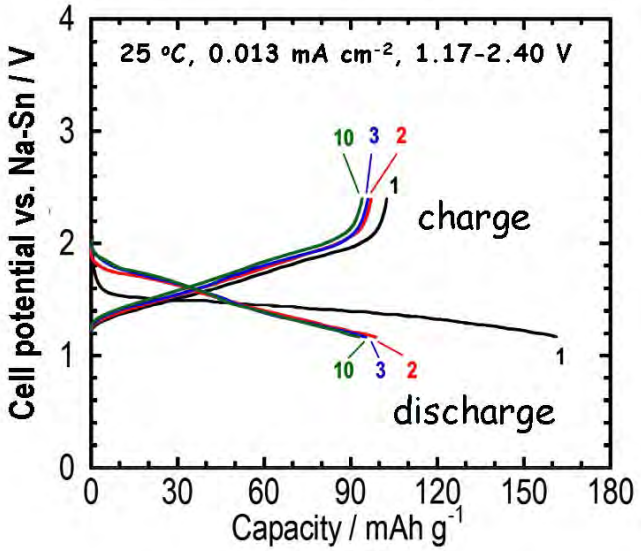
$$TiS_2 + Na_{15}Sn_4 \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} Na_xTiS_2 + Na_{15-x}Sn_4$$

Positive electrode: TiS_2

$$TiS_2 + xNa^+ + xe^- \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} Na_xTiS_2$$

Negative electrode: $Na_{15}Sn_4$ alloy

$$Na_{15}Sn_4 \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} Na_{15-x}Sn_4 + xNa^+ + xe^-$$



Patent Licensing Available

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JST/ IP Management & Licensing Group
Phone:+81-3-5214-8486, e-mail: license@jst.go.jp