

All solid-state sodium battery with two-step sintering processes

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All solid-state battery with a solid electrolyte has attractive potentials of higher energy density, and higher safety under abuse condition than normal lithium battery with organic electrolyte^[1]. The battery with oxide solid electrolyte shows high chemical and thermal stabilities although it has an issue of device integration^[2]. Previously, Spark plasma sintering (SPS) method has been utilized for the good integration between a symmetrical cell of NASICON type electrode and electrolyte^[3]. However, it is not easy to obtain the battery with a good electrochemical contact between negative/positive electrodes with different structures because they have the different thermal stability and densification in the all solid-state battery. In this presentation, we talk the charge-discharge performance of all solid-state sodium battery with $\text{Na}_3\text{V}_2(\text{PO}_4)_3(\text{NVP})$ negative electrode^[3], $\text{Na}_4\text{Co}_3(\text{PO}_4)_2\text{P}_2\text{O}_7(\text{NCPP})$ positive electrode^[4] and $\text{Na}_3\text{Zr}_2(\text{SiO}_4)_2\text{PO}_4(\text{NZSP})$ solid electrolyte^[3] by two-step sintering processes and a good inorganic binder to clear the issue with the heterogeneous electrodes.

Negative or positive electrode mixtures are obtained using NVP or NCPP powders, NZSP, and carbon. Two pellets are obtained by SPS methods of 500°C and 900°C using the positive electrode and the negative electrode mixtures. Two half-cell pellets are jointed through NZSP layers using HBO_2 for a binder by heating at 500°C under SPS method.

NCPP can keep solid phase under 500°C of SPS method although it melts at 600°C. HBO_2 is found to work for a binder to joint two pellets. Figure 1(a) presents charge-discharge curves of all solid-state sodium battery at the various voltage ranges under C/10. The battery indicates 70 mAh g^{-1} (NCPP weight) between 0.5-3.9 V vs. NVP. The battery also has the rate performance of relative discharge capacity, 20% under C/3, in which the capacity under C/10 is regard as 100%. A combination of two-step sintering processes and HBO_2 binder can lead to good contact between two half-cell pellets of positive and negative electrodes, and excellent charge-discharge performance in the battery with NZSP oxide solid electrolyte.

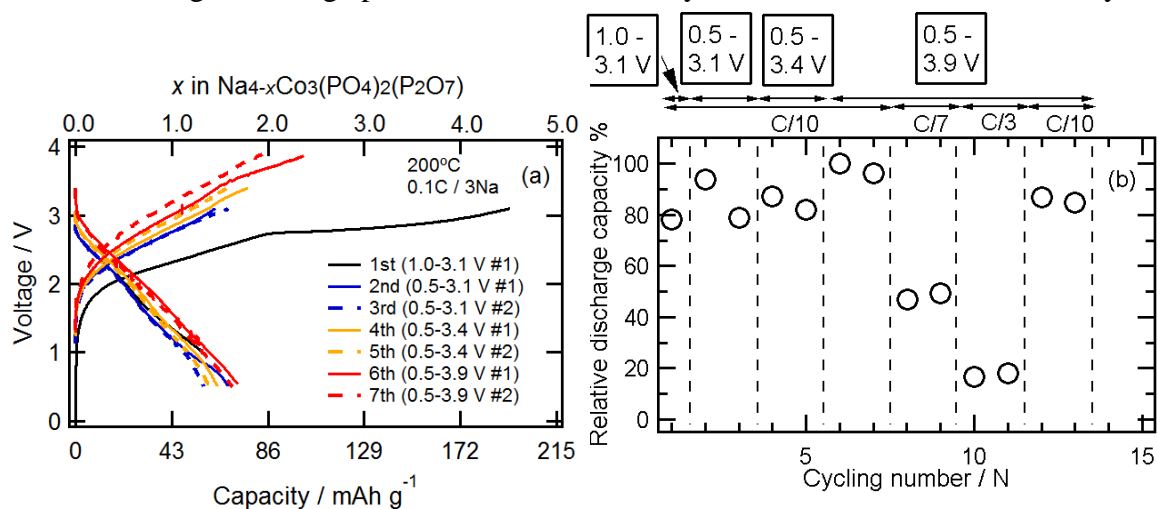


Figure 1 (a) charge-discharge curves and (b) rate performance of all solid-state sodium battery.

References:

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