Hybrid solid $Li_4Ti_5O_{12}/LiNi_{1-x-y}Co_xMn_yO_2$ bipolar batteries

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Development of Li-ion batteries for automotive applications such as EV and PHEV has been specially focused on the enhancement of battery energy density. For promoting the spread of EV applications, the size reduction of battery pack and fast-charge performance will be practically required to realize compact EVs with long driving ranges by fast-charging such as a few minutes. $Li_4Ti_5O_{12}$ (LTO) anode has no Li metal plating during fast-charging and long-term cycling, which leads to long-life and safety. However, LTO anode-based batteries have disadvantages of low voltage and small energy density. We have studied hybrid solid electrolytes for LTO anode-based bipolar battery operation without pressing by a heavy housing in order to develop small-size and light battery pack for automotive applications [1,2]. This paper reports the technologies and performance for hybrid solid bipolar batteries.

4.6 V-class LTO/$LiNi_{1-x}Co_xMn_yO_2$ (NCM) bipolar batteries (size:70 x 110 x 3.1 mm) using a thin hybrid solid electrolyte (thickness:<10 μ m) consisting of $Li_7La_3Zr_2O_{12}$ (LLZ) and a gel polymer were preliminarily fabricated for high-voltage system applications such as EV and PHEV. By using the LTO anode, the hybrid solid electrolyte, and Al anode current collectors, the bipolar batteries have simple structure and almost no voulme change, which will effectively reduce the volume and weight of battery pack with a light housing. Discharge curves of the bipolar battery at various rates exhibited 4.6 V output, a discharge capacity of 1.1 Ah at 0.2 C rate, and high capacity retention of 88% at 10 C rate as shown in Fig.1. The energy density and the output power density for 10 s were 95 Wh kg^{-1} and 1.7 kW kg^{-1}, respectively. These values were about 20% larger than those of 2.3 V LTO/NCM single battey. The capacity charged up 80% in 6 min by 10 C rate charging. Fig.2 shows cycle life performance by charge-discharge cycling test at 1 C rate without pressing bewtween 3.6 and 5.4 V. The capacity retention at 1000 cycles was 97%, indicating the excellent cycle performance. The 4.6 V-class hybrid solid LTO/NCM bipolar batteries are expected to be applied for compact battery pack in the high-voltage systems.

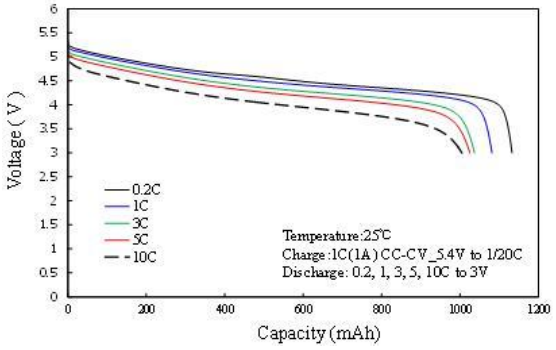

Fig.1 Discharge curves of hybrid solid LTO/NCM bipolar battery at various discharge rates and 25℃.

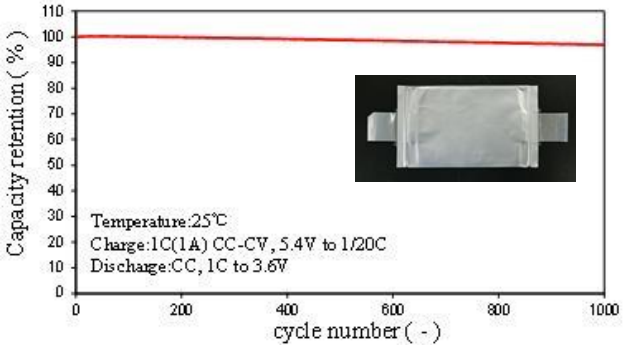

Fig.2 Capacity retention as a function of cycle of cycle number for hybrid solid LTO/NCM bipolar battery at 1 C rate and 25°C.

References:

[1]K.Yoshima,Y.Harada, and N.Takami, *J.Power Sources*,**302**,283(2016)
[2]N.Takami, K.Yoshima, and Y.Harada, *J.Electrochem.Soc*.,**164**,A6254(2017)