Abstract #26, 224th ECS Meeting, © 2013 The Electrochemical Society

Capacity and Energy Densities of Rechargeable MH/Air Battery using A_2B_7 Type Hydrogen Storage Alloy

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Air batteries use oxygen in air as the active mass of the positive electrode, so that the positive electrode theoretically has unlimited discharge capacity and the air battery is expected to show high power density and energy density. Despite such promising properties, currently commercialized air batteries are all primary ones, and many works have been done to develop rechargeable air batteries. We have been also developing a novel rechargeable air battery, which consists of a nickel-based gas diffusion electrode using pyrochlore-type oxide catalyst, $Bi_2Ir_2O_{7-z}$, an alkaline electrolyte, and an MH negative electrode, as shown in Fig. 1. Our previous studies have demonstrated that the developed MH/air secondary battery shows high output performance such as 308 Wh/L of energy density and can operate more than 300 charge-discharge cycles [1-3]. This rechargeable air battery has further revealed that the discharge capacity depends only on the capacity of the MH electrode, suggesting that the improvement in the capacity density of the negative electrode directly induces those in the capacity and energy densities of the battery. Here, we report the output performance of the MH/air secondary battery with the negative electrode, in which A_2B_7 type hydrogen storage alloy is utilized, substituting AB_5 type hydrogen storage alloy in our previous studies. We also modified the composition of the negative electrode to increase the weight ratio of MH and to improve the capacity density of the negative electrode.

The positive electrode used nickel as the conducting matrix, $Bi_2Ir_2O_{7-z}$ as a bi-functional catalyst, and PTFE as a binder. $Bi_2Ir_2O_{7-z}$ powders were prepared through co-precipitation in the solution dissolving H_2IrCl_6 and $Bi(NO_3)_3$ followed by calcination of the precipitates at 600 ^oC for two or three hours. $Bi_2Ir_2O_{7-z}$ powders, Ni powders, and PTFE dispersion were mixed, pressed on a nickel mesh, and heated at 370 ^oC under nitrogen atmosphere. The composition was Ni:$Bi_2Ir_2O_{7-z}$:PTFE = 70:20:10 wt%, and the dimensions of the positive electrode were 45 mm×43 mm. The negative electrode was prepared and supplied by FDK Twicell Company and comprised porous nickel matrix, hydrogen storage alloy ($Mm_{0.83}Mg_{0.17}Ni_{3.13}Al_{0.17}$), and binder. The capacity of the obtained negative electrode was *ca.* 1770 mAh, and the dimensions were almost the same as those of the positive electrode. The electrolyte was 5 mol/L KOH solutions and was used with a membrane separator. The cell components shown in Fig. 1 were PTFE. The cell was operated with constant current at ambient temperature without air or oxygen blow to the positive electrode.

The capacity density of the new negative electrode in this work was about 1776 Ah/L, which was 2.4 times as large as that of our previous works using AB_5 type hydrogen storage alloy. The polarization behaviors of the negative electrode were examined and the results showed that the resistance of the new negative electrode was almost the same as that of previous one, indicating that the increase in the capacity density of the negative electrode has been achieved without the resistance increase. The output performance of the MH/air battery at various currents was obtained and the maximum discharge current was 810 mA. The output power was found to be 198 mW (124 W/L as power density), which is 1.7 times as high as our previous works. Constant current discharge was also performed, and the typical discharge curve is shown in Fig. 2 together with the previous one. The battery developed in this work showed a stable discharge voltage of about 0.7 V for 10 hours, and the utilization of MH was more than 80 %. The cell voltage of this work is smaller than that of previous work in Fig. 2, because the discharge current in this work was 100 mA while that in previous work was 50 mA. The energy density obtained in this work was 601 Wh/L, which implied that the MH/air battery is possible to operate with higher energy density than present lithium ion secondary battery.

This work was financially supported by "Advanced Low Carbon Technology Research and Development Program (ALCA)" of Japan Science and Technology Agency (JST).

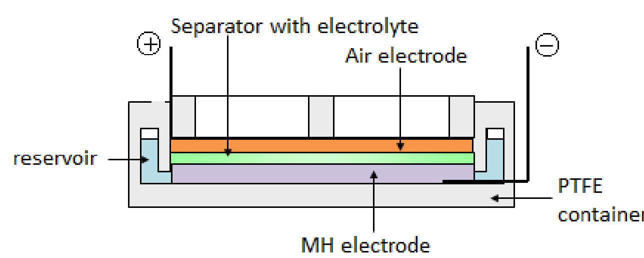

Fig. 1 Configuration of MH/air secondary battery.

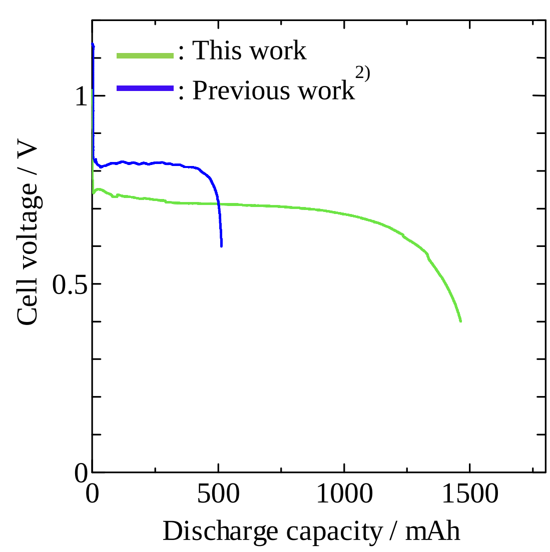

Fig. 2 Comparison of the discharge curves of the MH/air secondary batteries with A_2B_7 type MH electrode (this work) and AB_5 type MH electrode (previous work).

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