Performance of Si thin-film anode Li-ion battery with Ti-Nb-Zr alloy as a current collector

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1. Introduction

As technology has evolved, the increasing demand for power in portable electronic devices has led to the need for better performance batteries. Many researchers are devoting for much better the performance of batteries. Si has much attention as an anode active material(~4200mAh/g) of a high capacity Li-ion battery[1], but dramatic volume change(~320%) during Li intercalation and deintercalation produces high stress between the active material and current collector, so that it results in pulverization of active material and failure from current collector. In this study, the electrochemical properties of a half-cell were investigated by using a Ti-Nb-Zr alloy thin film with super-elastic properties as a current collector for a Si thin film anode material.

2. Results

Figure 1 shows the surface image of the $Ti_{60.7}Nb_{31.7}Zr_{7.6}$ thin film(TNZ) and the surface of the Si thin film deposited on the TNZ(Si/TNZ) deposited with the magnetron sputtering system respectively. The thicknesses of TNZ and Si are about 3.24μm and 800 nm, respectively. To calculate the amount of active material participating in the Li reaction, the density of Si was assumed to be 2.33 g/cm^3. Figure 2 shows the XRD analysis results of Si / TNZ. The TNZ thin film is in the beta phase and, it can be seen that the deposited Si is amorphous from the absence of the crystalline Si peak. The results of the constant current charge / discharge test(C-rate : 0.5C, Potential window : 0.01~1.5V) of the half cell assembled with Li foil as the counter electrode and 1M $LiPF_6$ EC/DEC(1:1) as the electrolyte are shown in Figure 3.

The weak adhesion between the Si active material and the current collector leads to a serious capacity fading during a series of cycles. [2] Annealing of the electrode may be a good method for increasing the adhesion. We annealed the Si/TNZ at 600℃ for 1 hour in quartz vacuum tube. Figure 4 shows the surface of the annealed Si/TNZ. The XRD pattern of the annealed Si/TNZ still showed only the β phase of the TNZ. In the half-cell CC test, the annealed Si/TNZ showed better cycle performance than the annealed Si/TNZ.

3. figures

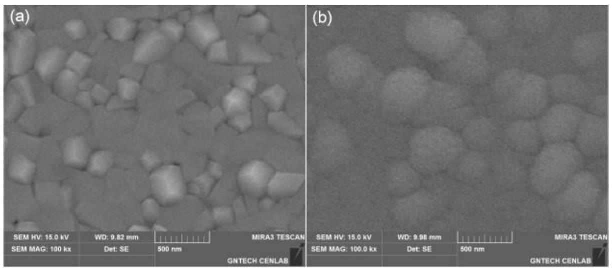

Figure 1. Surface SEM image of (a) TNZ (b) Si/TNZ.

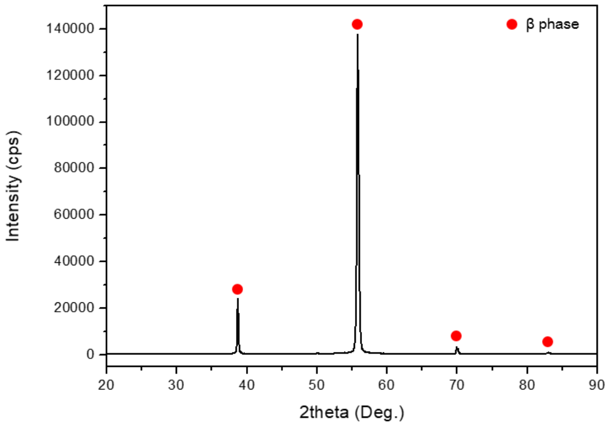

Figure 2. Result of XRD analysis of Si/TNZ.

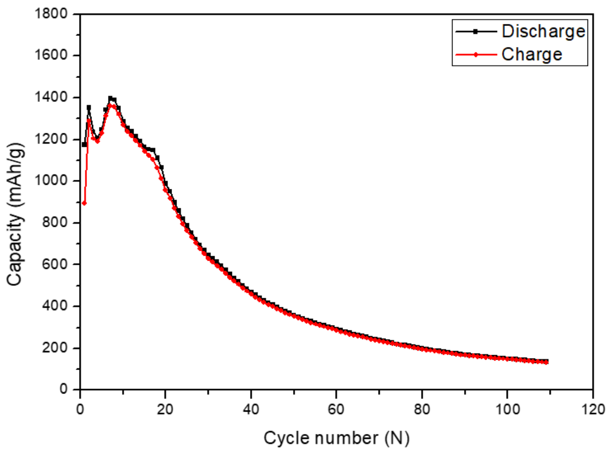

Figure 3. Result of CC test with Si/TNZ.

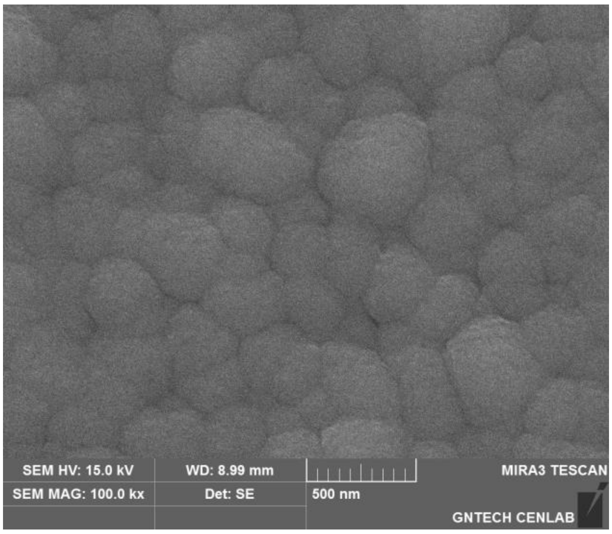

Figure 4. Surface SEM image of Si/TNZ annealed at 600℃ durung 1 hour.

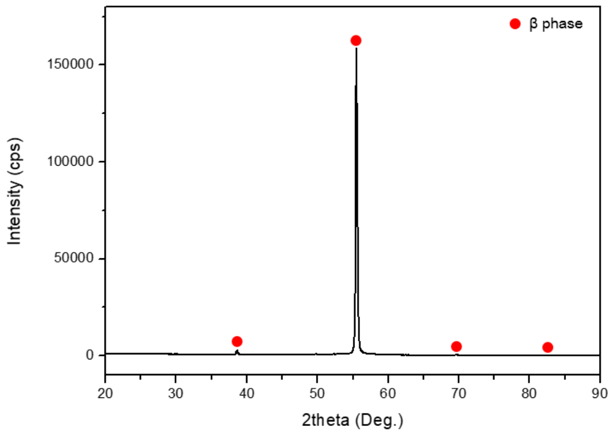

Figure 5. Surface SEM image of Si/TNZ annealed at 600℃ durung 1 hour.

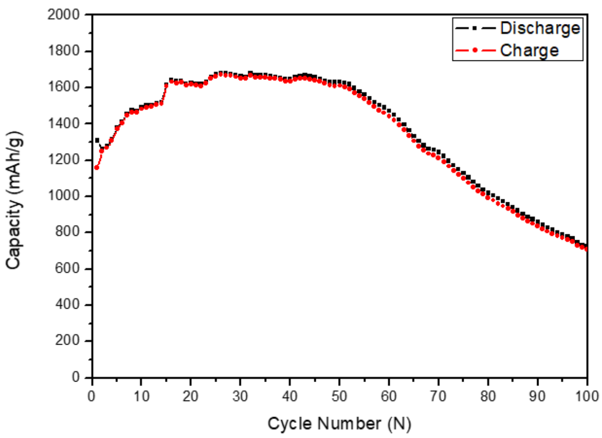

Figure 6. result of CC test with Si/TNZ thin film annealed at 600℃ durung 1 hour.

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