Development of flexible Lithium-Ion Battery on a stainless steel substrate by radio frequency magnetron sputtering

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Abstract

Flexible rechargeable all solid-state lithium ion battery was fabricated on 70µm thick, flexible stainless steel substrates with the cell composition of LiMn$_2$O$_4$ thin films. The cell includes thin film electrode of Lithium metal as an anode, LiMn$_2$O$_4$ as a cathode and LiPON as a solid electrolyte. Fabrications of LiMn$_2$O$_4$ thin film on the flexible stainless steel substrates (SS304) were demonstrated using a radio frequency magnetron sputtering technology in room temperature. The as-deposited films were amorphous and could be crystallized into a spinel structure by rapid thermal process (RTP) in the atmosphere. The structure and surface morphology of heat-treated films were investigated as a function of post-deposition process. The phase transformation from amorphous to crystalline phase was observed at temperature of around 700°C for one-minute annealed. No conducting additives and binders were used. Moreover, it can form high-temperature (HT) annealed electrodes on flexible stainless steel substrates for lithium ion batteries. Thus, the charge-discharge and cycles life property can be clearly verified and studied.

The performances of flexible lithium-ion battery shows discharge capacity of 17 µAh/µm·cm$^2$ between 4.3V and 3V at a current density of 1 µA/cm$^2$. And the flexible lithium-ion battery exhibits the best capacity retention over 90% at 200 charge-discharge cycles between 4.2V and 3V at a current density of 3 µA/cm$^2$.

Keyword: Flexible, All solid state, Lithium-ion Battery, LiMn$_2$O$_4$

Reference


Figure 1. Demonstration of 1 cycle fatigue test: (a) flat and (b) bent state of the flexible rechargeable all solid-state lithium ion battery.

Figure 2. (a) Cross-sectional diagram of a flexible rechargeable all solid-state lithium ion battery on a flexible stainless steel substrate. (b), (c) a photograph showing an a flexible rechargeable all solid-state lithium ion battery.

Figure 3. Charge and discharge behavior of a flexible rechargeable all solid-state lithium ion battery at the first three cycles.

Figure 4. Cycle-life performance of the flexible rechargeable all solid-state lithium ion battery.