In-situ AFM Observation of SEI Formation on Si-Thin-Film Negative Electrodes with an Artificial Surface Coating

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Silicon is regarded as the most promising negative electrode material for next-generation lithium-ion batteries because of the high theoretical capacity. We have developed a Si powder with a flake shape (Si LeafPower®, Si-LP, OIKE & Co., Ltd.) that is 100 nm thick with a 3-5 μm lateral dimension.[1-3] The Si-LP electrode demonstrates a superior cyclability because the unique flake structure resists pulverization during charge and discharge cycling. For further improvement of cycle performances, inhibition of reductive decomposition of electrolytes on the Si negative electrode is necessary. We tried to suppress the electrolyte decomposition by an artificial surface coting on Si thin films and observed SEI formation by an in-situ atomic force microscopy (AFM) coupled with a potential sweep.

An amorphous Si thin film with the thickness of 100 nm was deposited by RF magnetron sputtering on a mirror polished Cu substrate. After that, LiF layer was coated by the RF magnetron sputtering on the Si thin film. AFM observations coupled with cyclic voltammetry were performed in a liquid immersion sample stage equipped with electrochemical connectors. The Si thin film as a working electrode and Li wires as a counter and a reference electrodes were immersed in the electrolyte of 1 M LiTFSI/EC+DEC (1:1 by vol.). AFM scan was conducted with a conventional contact mode at a room temperature in an Ar-filled glovebox. The sweep rate of the potential was 0.5 mV s^{-1}.

In the first cycle of the cyclic voltammetry for the Si thin film without LiF coating, a reductive current peak arose around 0.9 V, which was originated from the electrolyte decomposition. In the AFM image coupled with the potential sweep, surface deposits emerged from 0.9 V corresponding to the potential of the electrolyte decomposition. On the other hand, a reductive current peak and surface deposits caused by the electrolyte decomposition were not observed in the Si thin film with LiF coating. We found that LiF is one of the important components to inhibit the electrolyte decomposition on the Si negative electrodes.

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References:

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