Type of presentation: Oral

ID-12-O-1778 In situ SEM observation of electrode reactions in ionic liquid-based lithium-ion secondary battery

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Ionic liquid (IL) generally exhibits attractive physical and chemical properties, e.g., negligible vapor pressure, relatively-high ionic conductivity, wide electrochemical window. We have focused on IL's negligible vapor pressure to create novel technologies and analytical methods combined with vacuum technology and ILs.[1)] Based on our first report that IL can be observed by a common SEM,[2)] we have established several novel SEM observation and EDX analysis methods using ILs.[3)] The aim of this study is to directly observe electrode reactions in IL-based lithium-ion secondary battery (LIB), which is expected to be a next generation energy storage device.

IL-based LIB used in this investigation was composed of a Si negative electrode, a $LiCoO_2$ positive electrode, a glass fiber membrane, and an IL electrolyte with lithium bis(trifluoromethanesulfonyl)amide ($Li[(CF_3SO_2)_2N]$). We mainly used 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)amide ($[C_2mim][(FSO_2)_2N]$) as the IL electrolyte because the cell performance of the LIB with the $[C_2mim][(FSO_2)_2N]$ electrolyte is comparable to present LIB system using organic electrolytes.[4)] Figure 1a shows a photograph of an IL-based LIB cell employed for in situ SEM observation. The LIB configuration is basically the same as commercially-available LIB cells. The detailed information on the configuration is given in Figure 1b. Silicon micro/nanoparticles, which have extremely-high theoretical capacity (4199 mAh g^{-1}) compared to graphite electrode (372 mAh g^{-1}) widely used in common LIBs, was exploited as the active material for the negative electrode. Si particle volume become up to 4.0 times when the electric energy is fully stored. Although the deterioration of the Si negative electrode is believed to be due to the drastic volume variation, there is insufficient information on the deterioration mechanism. Figure 2 shows typical SEM images of the Si negative electrode in the IL-based LIB during charge/discharge process. We could directly observe the variation in the Si electrode by our in situ SEM observation technique. The detailed results and discussion will be given in our presentation.

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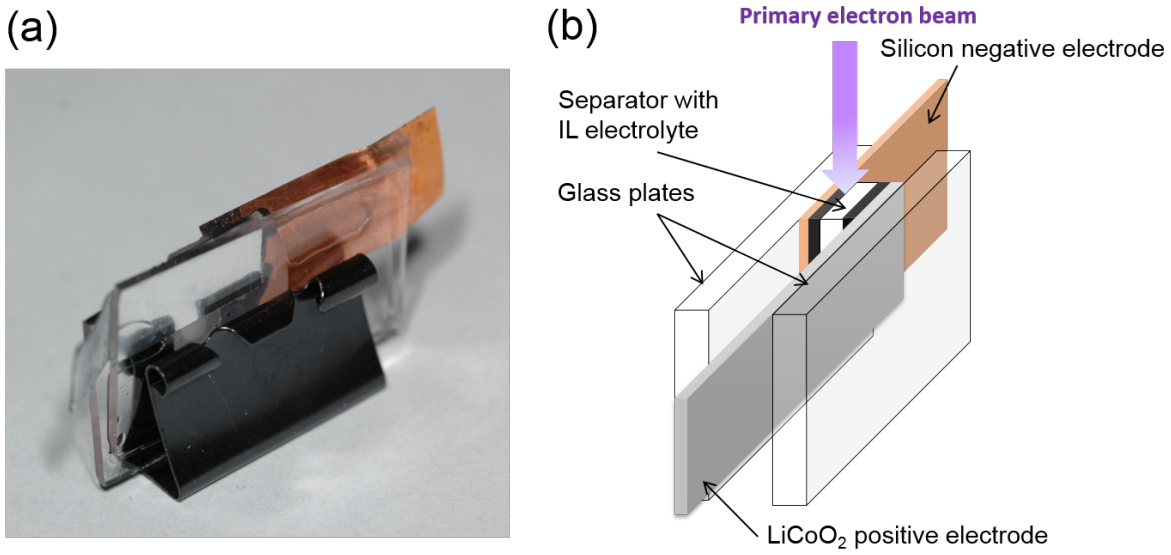

Fig. 1: (a) Photograph of one of IL-based LIB cells used for in situ SEM observation and (b) explanation of the cell depicted in Fig. 1a.

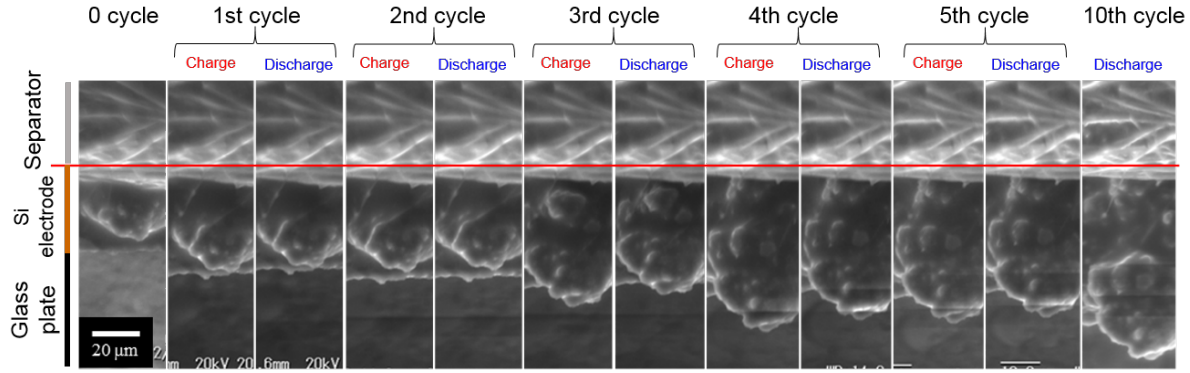

Fig. 2: Variations in morphology of the Si negative electrode observed by the in situ SEM observation system during charge/discharge processes at 0.2 C in the IL-based Li-ion secondary battery prepared in this study. The used IL was [C_2mim][$(FSO_2)_2$N].