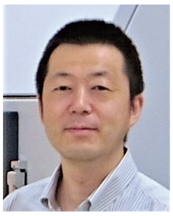
Nanoscale Mechanical Properties at Electrode/Electrolyte Interface during Energy Conversion Process Analyzed by Scanning Probe Microscopy

Instrument Center



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Physical properties and elementary processes at the interface between electrode and electrolyte are strongly related to the performance of energy devices.[1,2] Traditionally, the physical properties and elementary processes have been indirectly discussed based on the changes of the device performances. Developments of the techniques of spectroscopic measurements have analyzed the physical properties and elementary processes at the interface. In addition to the spectroscopic analysis, direct imaging and nano/atomic-scale analysis by microscopic measurements of the interface will reveal the real nature of the interface.

Historically, scanning probe microscopy (SPM) have been developed as the experimental technique to analyze the physical properties and elementary process in nano/atomic-scale in ideal conditions such as ultra-high vacuum and low temperature for single crystal samples. We have constructed SPM systems to analyze the physical properties and elementary process at electrode/electrolyte interface (Figure 1).

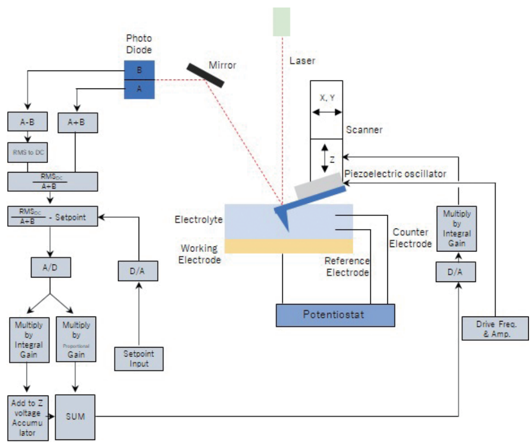

Figure 1. A schematic illustration of the electrochemical SPM systems to analyze the mechanical properties at the electrode/electrolyte interface.

At the interface between electrode and electrolyte of rechargeable battery during the charge and discharge reactions, solvent molecules, carrier ions and additives congregate and form specific states.[1–3] The properties of interface phases are related to the battery performances (capacity, cyclability, rate performance etc.), however, much is unknown at the interface.[4–6] We have investigated the mechanical properties at the interface. Figure 2 shows force curves obtained by the SPM with changing the electrode potential in an electrolyte for rechargeable battery. At open circuit potential (OCP), the adhesion force (negative force in the force curve) was negligible value. By changing the potential to −1.25 V (*vs*. Pt), the adhesion force was increased to ~60 nN. Further sweep of the potential to −2.0 V, the adhesion force was returned to negligible value. These changes of the mechanical properties are caused by the changes of the interface phases by applied electric fields that relate to the battery perforamance.

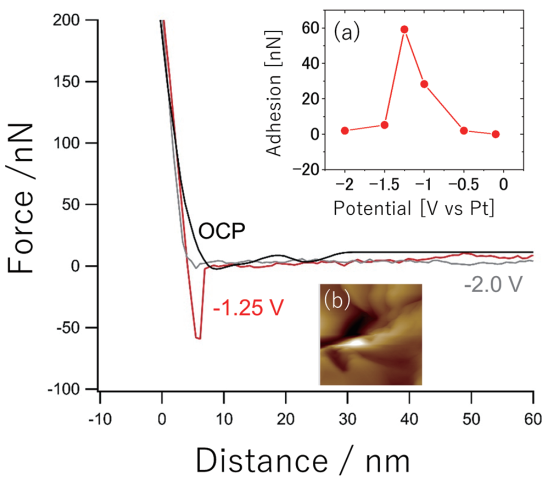

Figure 2. Force curves obtained by the electrochemical SPM systems at the interface between an electrolyte for rechargeable battery and the electrode with changing the sample potential. The black, red and gray curves were obtained at open circuit potential (OCP) = ~−0.1 V, −1.25 and −2.0 V, respectively. Inset (a); the change of the adhesion force obtained by the SPM by changing the potential. Inset (b); an SPM image at −1.25 V (300 nm × 300 nm in *xy* scales and 0 ~ 180 nm in *z* scale). All potential is defined from the difference from Pt.

References

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