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Mechanical properties of lithium-ion battery electrode
車載リチウムイオン電池電極劣化の機械的特性評価

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1. Introduction

Seven years passed after it began to be released the public, and a mind car appeared to the electric car which became the used junk car in one of the world. The reuse means of this battery is an important theme, and, in these days when an energy problem, lack of resources are demanded, a study is performed flourishingly. Even if there is it in such inside, there are many uncertain points and stays about "the deterioration" of LiB (Lithium ion Batteries).

As for the deterioration of LiB, elucidation is difficult to be generated in various materials while various changes, reactions give interaction at the same time. Only with an electrode, the deterioration of the binder, corrosion of collector, many changes including the deterioration of the quality of flower arrangement happen at the same time. Therefore there is the consequent rating system as the whole battery that electric capacity is how much, but it is the present conditions that there is not an effective method to pursue a factor where is as for the neck and the material that it is why it was in this performance.

Therefore, for a battery electrode of various a charge/discharge frequency counting, I measure the mechanical characteristic that is sensitive to a change of the internal structure by plural methods. Deepen understanding about the deterioration properties of the electrode and the characteristic of the assay from the result and is intended to choose an assay suitable for this experiment.

2. Experimental

I show the mechanical characteristic assay of the electrode sample in figure 1. I fix one end of the sample to the copper blocks in a vacuum chamber. And I give another becoming free an electrostatic force by VAC and have a convulsive fit. I let you rebel in the power of restitution of the sample and let you vibrate by repeating this. I change a temperature condition by heaters and find frequency to become the resonance frequency each time. In addition, from reply properties of frequency provided by the measurement, it is Q-1 figure 1 experimental device diagrammatical view of the internal discord
I calculate a value. I perform the vibration lead measurement by the decrement method and the half bandwidth method in the domain in the frequency domain at time.

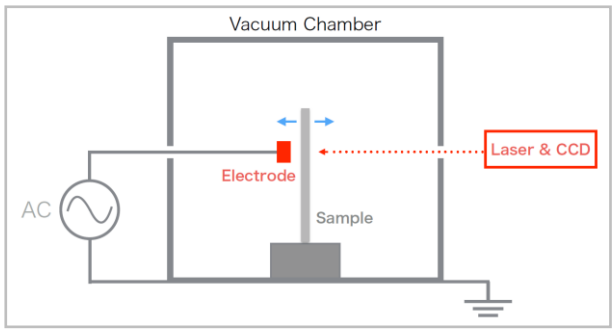

Fig. 1 Schematic diagram of measurement system.

3. Results and Discussion

I show resonance frequency temperature-dependent result of a measurement of the anode in the frequency domain in figure 2. It is revealed that a resonance frequency decreases by performing discharge and chargerepeatedly. And I understand that sudden decrease happens near 150K and 240K. These tendencies were seen in all sample length.

I show internal discord temperature-dependent result of a measurement in figure 3. Near temperature same as sudden decrease having been seen in a resonance frequency, an internal discord peak is observed. This tendency was seen in the cathode equally, and a similar tendency appeared even if I changed method for measurement and sample length. From this, as a

result of the peak being regarded as the thing by the component of the electrode, and having pushed forward a guess from constitution materials, it was revealed that it was a thing by the phase transition of PVdF which was a binder.

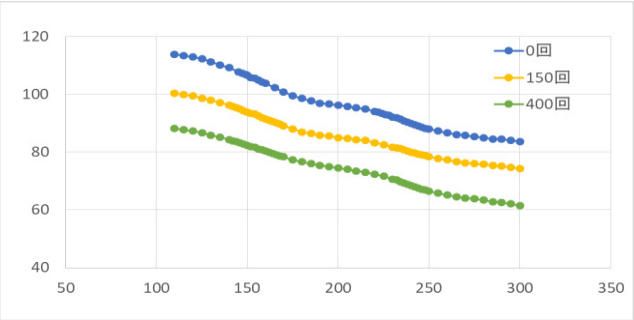

Fig. 2 Temperature dependence of the resonance

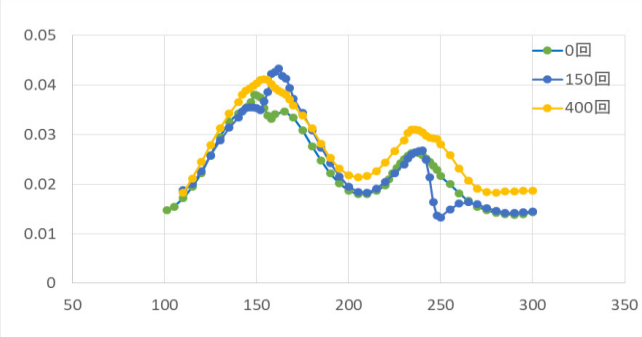

Fig. 3 Temperature dependence of the internal

The resonance frequency showed a change with Increase in discharge and charge when I watched the change of the value by discharge and charge. About a resonance frequency, I show the rate of change of the value by discharge and charge in figure 4.

I understood that this laboratory finding conformed to "route rule" used as a rating system of the battery cell. Route rule expresses Remaining life of the battery in $y = 100 - \beta\sqrt{N}$, and coefficient, N where β is demanded by an experiment are discharge and charge.

Based upon the foregoing, it was revealed that a life evaluation using route rule was enabled by measuring a resonance frequency as an electrode.

For the same sample, I show the resonance frequency temperature dependence that I got by the decrement method and the half bandwidth method in figure 5.

The differences between decrement method and resonance frequency that I got by the half bandwidth method were 4.5Hz on the average. The error of the sample length for this frequency error was 0.68mm.

Because there was the error of this length within the artificial error at the time of the sample manufacture, the result of a measurement of the decrement method and the half bandwidth method was good and knew that I agreed.

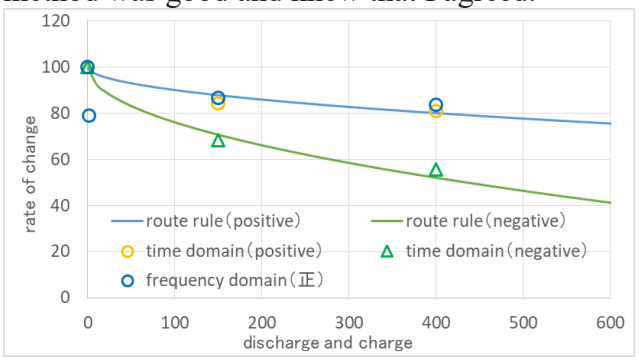

Fig. 4 Rate of change of the resonance frequency

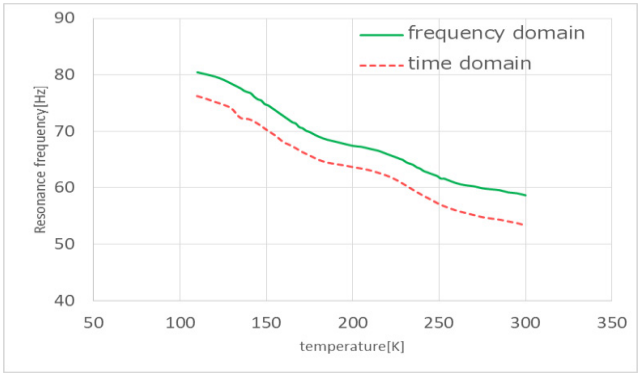

Fig. 5 Temperature dependence of the resonance

4. Conclusions

I measured the mechanical characteristic of the LiB electrode of discharge and charge time using vibration lead law. It is thought that the rigidity of the electrode decreased by deterioration of PVdF from the decrease in resonance frequency with discharge and charge. And I understood that a life evaluation by route rule was possible as an electrode by using a resonance frequency as a parameter. In addition, the measurement accuracy by the half bandwidth method is equal to the decrement method, and the measurement in the frequency domain is suitable for automatic measurement.