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ABSTRACT BOOK

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Development of a quasi-solid composite electrolyte for 3D-structured batteries

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So far, the development of lithium-ion batteries has been carried out in a layer-by-layer configuration, in which an electrolyte layer is sandwiched with anode and cathode layers. However, it is impossible to realize both high energy density and high power density in this configuration since the diffusion of Li^+-ions in the electrode becomes difficult as increasing the electrode thickness. As a result, the practical thickness of electrode is limited up to ~ 100 μm in current lithium-ion batteries. In order to overcome this limitation, we have focused on 3D-structured electrode configurations[1]. For example, an interdigitated electrode configuration is available (Fig. 1). This comfiguration can provide a constant distance (Li^+-ion diffusion length) between cathode and anode even if the electrode heights (the amounts of anode and cathode materials) are increased. Therefore, both high energy density and power density can be realized at the same time. However, it is difficult to use a conventional separator to avoid an internal short circuit between anode and cathode in this electrode configuration. Here, we developed a composite electrolyte composed of Li^+-ion conducting solid electrolyte powder ($Li_{0.35}La_{0.55}TiO_3$, LLT) and a nonvolatile liquid electrolyte (N,N-diethyl-N-methyl-N-(2-methoxyethyl)ammonium bis(trifluoromethanesulfonyl)imide including 0.32 mol kg^{-1} of lithium bis(fluorosulfonyl)imide) to solve the short circuit problem. When the volume content of LLT was 30%, an ionic conductivity of 1.7×10^{-3} S cm^{-1} was obtained at 30 °C, and the composite electrolyte had fluidity suitable to introduce into the gap beween anode and cathode and was then solidified after leaving to stand (Fig. 2). This quasi-solid-state property (thixotropy) improved not only the safety but also the cycle performance of 3D-structure battery. For further improvement, we also examined the composite electrolyte including methyl methacrylate as a gelling agent.

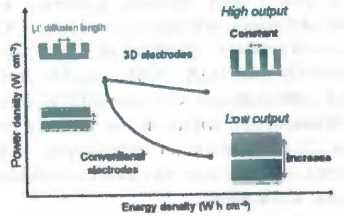

Fig. 1 Schematic relationships between energy density and power density in conventional and 3D-structured electrode configurations

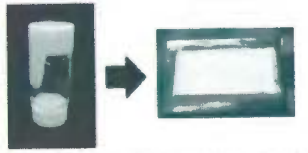

Fig. 2 The quasi-solid-state property of the prepared composite electrolyte

[1] K. Yoshima, H. Munakata, K. Kanamura, *J. Power Sources*, **208** (2012) 404

Experimental study of energy distribution in ion-beam lithography

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The paper reports two important results. Conducted a rigorous comparison of the sensitivity of the resist is polymethylmethacrylate (PMMA) to the irradiation of electron and ion beams. It is shown that, as in the case of electron irradiation, the resist shows both positive (at low doses) and negative (at higher doses) behavior of sensitivity. But compared with the electronic exposure, sensitivity of the resist is approximately a thousand times higher to the ion exposure, both the positive and negative areas.

The second series of experiments concerned the study of the etching depth (thick) of the resist depending on the dose. It was discovered that in contrast to irradiation by electrons, the energy distribution deposited by ions is strongly inhomogeneous in depth, which leads to strongly non-uniform dependence of the rate of etching to the depth and irradiation dose.

These data were the basis for attempts to quantitatively recover the spatial distribution of energy losses by fast ions in matter.

The process description is based on the formula (1), in which the dissolution rate of the resist V is associated with a density of absorbed energy $E_{exp}(z)$ irradiated with dose D and the contrast of the resist [3] the following relation:

$$\frac{V}{V_0} = \left(\frac{D\,E_{exp}(z)}{D_0}\right)^{\gamma} \qquad (1)$$

In ion-beam lithography compared to electron beam lithography, there is a strong dependence of the sensitivity of the resist thickness. When increasing the thickness from 10 nm to 70 nm sensitivity, measured in units of [μC / cm2], changes to the order, remaining, however, still high compared to the sensitivity to irradiation by electrons.

Thus, in addition to the practical significance of the measured characteristics (sensitivity, contrast), the technique presented by us opens an experimental way of studying the processes of interaction of fast ions with matter.

[1] Ya. Shabelnikova, S. Zaitsev. (ICMNE-2016) with the Extended Session "Quantum Informatics" (QI 2016) October 3-7, 2016, Moscow Region, Russia
[2] Ya. Shabelnikova, S. Zaitsev, Abstracts of MNE 2017, Sept 18-22, 2017, BRAGA, Portugal