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New method for intercalation and ion exchange utilizing solid state electrochemical reaction

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Due to the development and improvement of synthesis apparatus and techniques, materials science and design have advanced drastically. Recently, we have developed a new synthesis method available for intercalation and ion exchange, utilizing a solid-state electrochemical reaction under ambient hydrogen pressure. This synthesis method is called proton-driven ion introduction (PDII). The protons (H+) generated by the electrolytic dissociation of hydrogen, drive other monovalent cations along a high electric field in the solid state. This phenomenon can be thought of as 'ion billiards'. Such a liquid-free process of ion introduction allows the application of high voltage around several kilovolts to the sample. This high electric field strongly accelerates ion exchange. Actually, compared to conventional solid-state reaction, PDII introduced 15 times the amount of K ions into Na super ionic conductor (NASICON)-structured Na3−xKxV2(PO4)3 as shown in figure 1. Powdered Na3V2(PO4)3 as host material was put in a shallow alumina cylinder and placed on a carbon cathode stage. Then, a potassium-containing phosphate glass was also placed on the alumina cylinder as a K ion source material. When a voltage was applied, protons replaced K ions in the glass and drove these ions into Na3V2(PO4)3. K ions continuously migrated and formed Na3-xKxV2(PO4)3. The obtained compound exhibited a thermodynamically metastable phase, which has not been reported so far. At the current stage, H+, Li+, Na+, K+, Cu+ and Ag+ can be used as guest ions. Furthermore, various compounds with nanospaces can be candidates for host materials in this method. In this conference, details of PDII and obtained materials will be presented.

Recent Publications

1. Fujoika M, et al. (2017) Proton-driven intercalation and ion substitution utilizing solid-state electrochemical reaction. Journal of the American Chemical Society 139:17987–17993.
2. Caglieris F, et al. (2017) Quantum oscillations in the SmFeAsO parent compound and superconducting SmFeAs(O,F). Physical Review B 96:104508
3. Fujioka M, et al. (2016) Discovery of the Pt-based superconductor LaPt5As. Journal of the American Chemical Society 138:9927–9934.
4. Fujioka M, et al. (2014) High-Tc phase of PrO0.5F0.5BiS2 single crystal induced by uniaxial pressure. Applied Physics Letters 105:052601.
5. Fujioka M, et al. (2014) The effect of exceptionally high fluorine doping on the anisotropy of single crystalline SmFeAsO1-xFx. Applied Physics Letters 105:102602

Biography

Masaya Fujioka is an Assistant Professor at Hokkaido University and Member of the Laboratory of Nanostructured Functional Materials in Research Institute for Electronic Science. He got his BSc, MSc and PhD in Science at Keio University. After finishing a Doctorate, he was engaged in fabrication of new superconducting materials and improvement of those properties at National Institute for Materials Science. Currently He has been focusing on materials with nano-spaces.

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