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A plenary talk

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Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Yue, Y., Zhang, Y., He, W., Qiao, A., Wang, Z., & Tao, H. (2018). *Role of Glass in Enhancing the Li/Na-Ion Battery Performances: A plenary talk*. 3-4. Abstract from The 10th China Symposium on Functional Glasses and International Forum on New Optoelectronic Materials, Kunming, China.

Role of Glass in Enhancing the Li/Na-Ion Battery Performances

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Further enhancement of the electrochemical performances of Li/Na ion batteries (LNB) has become a challenge when using the existing technical approaches. Under this background, we have chosen a different route, that is, the disorder/ordering engineering concept[1] to develop high performance cathode/anode/electrolyte materials for fabricating full solid batteries or even full glass/glass ceramic batteries. The disorder/order engineering concept refers to the following aspects. The disordered or amorphous structure in cathode/anode materials is created via sol-gel or biotemplating[2] or melt-quenching or ball-milling, and afterwards the ordered nano-domains in the glass matrix are generated through heat-treatment or other means. Conversely, long-range order solids are transformed into disordered or amorphous ones, and thereby enhancing ionic/electronic conductivities. In this talk, we present three case studies, which deal with cathodes, anodes, and fast conductors, respectively, concerning the effect of the order/disorder tuning on the electrochemical performances of Li/Na-ion batteries.

First, a series of glass ceramic cathode materials, which consist of Li-Na-V-Fe phosphates and carbon, were developed through bio-templating and calcination.[3] The ordered phase (nano-crystals), disordered phase and disordered carbon network were found to have different functions in facilitating ion intercalation/deintercalation and electron conduction. The partially ordered materials exhibit better electrochemical performances than the purely glassy or purely crystalline materials.

Second, a series of vanadium-tellurite glasses with various V/Te ratios were synthesized by melt-quenching,[4,5] and the glass powder was mixed with carbon to fabricate Li-ion battery anodes. Then, the anodes underwent the charging/discharging cycles. During these cycles, a fascinating phenomenon was observed, i.e., nanocrystals formed in the glass matrix without any thermal treatment.[1] Consequently, the cycling stability of the anodes was enhanced. The mechanism of the nanocrystal formation was partly revealed through structural analysis and electrochemical tests.

Third, the crystalline Ag_3PS_4 was transformed into amorphous state via a chemo-mechanical milling process. We found that the Ag^+ conductivity of the amorphous sample is about three orders of magnitude higher than that of the crystalline counterpart. The amorphous sample exhibits lower activation energy (E_a) for the Ag^+ migration. By performing structural characterizations, we explored the origin of the enhanced Ag^+ conductivity of the amorphous sample.

Keywords: Li/Na Ion Battery; Order/Disorder Engineering; Glass; Cathode; Anode; Nano Crystals.

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