SW6 : 차세대이차전지기술 연구회

SW6-1 | 포스트-리튬이온전지를 위한 유기 물질 디자인

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Lithium-ion batteries (LIBs), composed of lithium-containing oxide cathodes and graphite anodes, have powered the most mobile devices due to their high power and energy density compared to other battery types. Since the advent of LIBs, there is growing demand for even higher energy density to power mobile devices with increased power consumption and to extend the driving mileage of electric vehicles (EVs). Although battery suppliers have endeavored to increase the energy density of LIBs for past decades, the practical energy density of LIBs is reaching the theoretical limit based on the active materials. A dramatic increase in the energy density requires new redox chemistries beyond the conventional 'intercalation' mechanism. The redox behaviors caused by new chemistries are distinct from those in the conventional host materials, leading to uncontrolled side reactions and short lifetime. The primary factors responsible for the low reversibility are instabilities during the redox reaction of active materials and uncontrolled side reactions at the electrode/electrolyte interface. I have focused on the development and analysis of novel organic materials for post Li-ion batteries. In this presentation, the concepts of organic molecules and their working principles in Li metal and Al batteries will be discussed.

SW6-2 | 고에너지밀도와 고출력 리튬이온전지 양극재 개발

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Cathode materials have been developed toward having high energy density and low cost with decreasing cobalt and increasing nickel. However, as Ni content increases, structural and electrochemical stabilities become poor. Cathode materials exhibit trade-off relation between capacity and stability. It is very challenging to break the trade-off relationship since high-capacity accompanies high structural and volumetric change. However, both properties are important to utilize materials. In this presentation, recent approaches to solve the issues will be introduced. Firstly, single crystal cathode will be introduced. Single-crystal cathodes are emerging as the solution to have both high capacity and stability. Its advantages and challenges will be presented. Secondly, polyanion structured cathodes have high safety-cathodes compared to layered structure. However, its energy density is very low. It will be addressed some design of the polyanion structured materials with high energy density.

SW6-3 | 차세대 이차전지 개발을 위한 프러시안블루 유사체 합성 연구

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Next-generation batteries are being studied intensively and impressive improvements have been developed in their energy/power densities and life-time. To further improve the performance, relentless research efforts have been invested in the development of new electrode active materials and optimizing the electrode formulation. Among different strategies, my research interests thus far have looked at nanostructuring electrode materials to improve both ionic and electronic transport as well as to alleviate mechanical stress. In this presentation, I will present my recent research topics on i) structuring of Prussian blue analogues for the development of intercalation materials and ii) applying these materials into various energy storage devices including sodium ion batteries and seawater batteries.

SW6-4 | 전고체 전지의 기계적 안정성 향상을 위한 멀티스케일 설계

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전고체 배터리(ASSB)는 기존 리튬 이온 배터리에 비해 높은 화학적 안전성과 내구성을 제공하는 잠재력을 가지고 있지만, 활물질과 고체 전해질 사이의 물리적 접촉 유지 문제로 인한 고체-고체 계면의 기계적 불안정성이 주요 과제로 남아 있다. 본 연구에서는 이 문제를 해결하기 위해 대조적인 부피 변화 경향을 가진 바이모달 전극인 LCO-NMC811을 도입하였다. 연구 결과, LCO의 수축/팽창 역학이 NMC811의 팽창/수축을 효과적으로 상쇄하며, 무게 비율 40%의 LCO 전극은 순수 NMC 전극에 비해 인터페이스 접촉 손실을 97%까지 줄이는 데 성공하였다. 추가적으로, 양극에 LCO 층을 배치한 이중층 전극 설계를 통해 LCO의 무게 비율이 20%인 전극은 인터페이스 손상을 99%까지 줄이는 효과를 보였다. 이 연구는 ASSB의 성능 향상과 안전성 증대를 위한 중요한 단계로 평가될 수 있다.

SW6-5 | 고성능 수계아연이차전지를 위한 금속유기골격체

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Aqueous Rechargeable Zinc Batteries (ARZBs) have been greatly increasing in interest for application to large scale energy storages (ESSs) owing to their advantages in terms of high power, low cost, and safety. Despite such high interest, there are still limitations in improving the performance of ARZBs due to the absence of high-performance cathode materials and dendrite growth of Zn anodes. To solve this problem, we paid attention to Metal-Organic Frameworks (MOFs) for developing a high-performance cathode and controlling an anode-electrolyte interfaces. For the cathode material, high capacity and high output characteristics were realized through the development of $Cu_3(HHTP)_2$, a conductive 2D MOF cathode. In addition, UiO66-(Zr)-$(COOH)_2$ and supramolecular MOF was introduced to effectively control dendrite growth on the Zn anode during battery operation. Therefore, it was possible to present key insights for high performance ARZBs.

SW6-6 | 계면 안정화를 통한 고성능 전고체 전지 개발

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All-solid-state batteries are considered a promising technology due to its enhanced safety and high energy density compared to the current Li-ion battery. Despite such advantages, achieving high performance all-solid-state batteries is challenging due to poor interfacial properties at solid electrolyte/electrode interfaces. To address challenges related to poor interfacial contact, we use the strategy of modifying the interface by employing highly concentrated solvate electrolyte as an interlayer material at the electrolyte/electrode interfaces. The incorporation of interlayer enhances the cyclability of the solid-state cell compared to the bare counterpart. The incorporation of solvate interlayer enhances the cyclability of the solid-state batteries by forming favorable ionic contact at battery interfaces. Another way to modify the solid-state battery interfaces is to employ thin-film deposition techniques to apply Li-ion conducting thin films at the solid electrolyte/electrode interfaces. We demonstrate the incorporation of thin film coating on solid electrolyte enhances the chemo-mechanical- electrochemical stability of the cell.

SW6-7 | 차세대 박막 이차전지 소재 개발 연구

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A thin-film lithium-ion battery belongs to the family of solid-state lithium-ion batteries and has been specifically designed for thin-film manufacturing systems and advanced semiconductor processes. Sometimes referred to as 'microbatteries,' these batteries can be seamlessly integrated into microchips to serve as power sources for a range of applications, including smart cards, intelligent textiles, and medical sensors. While they may appear similar to traditional bulk lithium-ion batteries, thin-film batteries differ significantly in terms of electrode materials, fabrication processes, evaluation methods, and electrochemical behaviors. Numerous scientific and technical challenges must be overcome to make these batteries practical for real-world applications. This paper explores recent developments and innovations in the field of thin-film lithium-ion batteries. Specifically, we examine various unexpected phenomena and discuss how to design an optimized architecture for electrodes and electrolytes at the thin-film scale to achieve high-performance batteries.

SW6-8 | 활성산소종에 의한 리튬공기전지 부반응 및 비가역성 극복 연구

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리튬공기전지 구동 중 형성되는 활성산소 종에 의한 거동 메커니즘 및 관련 열화 반응에 대한 연구들이 최근 해당 시스템에 대한 주요 연구 주제로 진행되고 있습니다. 이번 발표를 통해 활성산소종으로 대표되는 일중항산소 및 초과산화물의 형성, 촉진, 제거에 대한 이해를 돕고 어떻게 이러한 문제를 극복해 나갈 것인지, 더 나아가 보다 안정적이고 가역적인 리튬산소전지를 개발하기 위한 향후 전략에 대해 말씀드리고자 합니다.