Alkaline air battery

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Lithium ion battery is a key enabling technology for the transition of society from the use of fossil fuels towards increased use of renewable energy sources which is essential to meet ambitious emissions targets. Although lithium ion batteries are widely used in portable electronics and electric vehicles their further development towards longer cycle-lifetimes and improvements in energy density is rather limited. The metal-air battery is a possible candidate for the next generation of the battery system comprising advantages of batteries and fuel cells. The metal-air battery typically suffers from lack of efficient electrocatalyst for ORR/OER which could be commercially applicable for the positive electrode in the battery system.

The project proposal targets limitations in our basic understanding of operation of metal air battery. For a better understanding of processes occurring in the electrochemical cell we seek techniques for an in-situ observations of reactions upon charging/discharging processes that influence the performance of new energy materials. Our research is focused on electrochemical synthesis of self-organized nanostructures such as nanotubes and nanopores by means of anodizing which we aim to implement into the components of the battery system.

Oxygen evolution reaction (OER) and oxygen reduction reaction (ORR) are the primary electrochemical reactions operating in metal–air secondary batteries as well as regenerative fuel cells and water splitting devices. The current limitations of the air-batteries arrive from relatively slow kinetics of ORR and OER and therefore efficient electrocatalysts are required to accelerate these reactions and improve the efficiency of the metal–air batteries and fuel cell systems. The electrochemistry of electrocatalyst in strongly alkaline electrolytes having pH in the range of 13.0 ~ 15.7 appears to be particularly attractive as the ORR in alkaline media may either follow a direct four-electron ($4e^-$) pathway or a series of pathways in which peroxide intermediate (HO_2^-) is formed. In contrast to the ORR in acidic media, which occurs at a reasonable rate only on noble metal electrodes, the ORR in alkaline media is catalyzed by a wider range of materials, including oxides and carbon materials.

Our concept assumes development of air battery in alkaline electrolyte including implementation of 1-D vertical nanotubes as the negative electrode and brownmillerite electrocatalyst combined with carbon containing graphene loop structure in order to boost ORR. The in-situ technique will allow direct observations of structural changes on gas diffusion electrode which is purged with air for battery operation.