Energy Conversion at Solid/Liquid Interfaces -Development of Electrocatalysts and Evaluation of Reaction Mechanism

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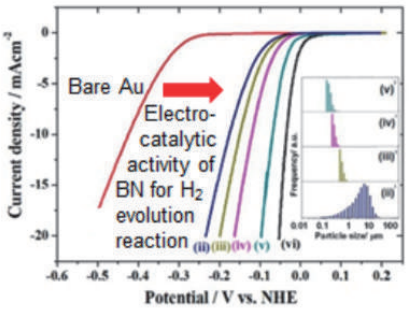
Background To realize sustainable society based on renewable energy, it is essential to establish efficient energy conversion/storage system. This is a fundamental research on energy conversion at solid/liquid interfaces (electrochemical energy conversion) such as fuel cells and secondary batteries.

Aim Important targets of energy conversion at solid/liquid interfaces include higher reaction rates and longer life time. To realize these targets, we are developing highly efficient electrocatalysts and clarifying reaction mechanisms at the interfaces. In particular, development of electro-catalysts without Pt group metals based on theory-experiment fusion research and clarification of mechanism of Li-air battery reactions by novel characterization techniques are carried out.

Advanced Research Topics

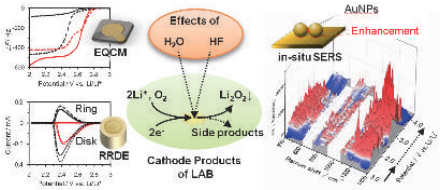
1. Development of highly efficient elctrocatalysts by theory-experiment fusion research

Demands for higher efficiency and lower cost of fuel cells are still very high and developments of electrocatalysts for oxygen reduction reaction (ORR), which is the most serious cause of lower efficiency, and water electrolysis to generate hydrogen as a fuel are required. We have theoretically predicted and experimentally proved that BN, which has the same structure as graphene but is an insulator, can act as electrocatalysts for ORR and hydrogen evolution reaction (HER). Furthermore, electrocatalytic activities are increased drastically by BN size control as shown in the top figure.



2. Clarification of mechanisms of energy conversion reactions at solid/liquid interfaces

Only limited methods are applicable to monitor processes at solid/liquid interfaces because methods with electron probe, which are very powerful in vacuum, cannot be used in solution. We have developed various methods to be applicable to the solid/liquid interfaces.Recently, we demonstrated that products distribution at positive electrode of Li-air battery, which has very high theoretical energy density, is very strongly affected by impurities in electrolyte solutions such as water and HF by using EQCM, RRDE, and SERS (bottom figure).



Publications

- K. Uosaki et al., BN on Au as an Electrocatalyst for ORR, *JACS*, 136, 6542 (2014).
- K. Uosaki et al., BN on Au as an Electrocatalyst for HER, *Sci. Rep.*, 6, 32317 (2016).
- K. Uosaki, In situ, Real-Time Monitoring at Solid/Liquid Interfaces, *JJAP*, 54, 030102 (2015).
- K. Tomita et al., Impurity Effect on Product Distribution at Li-O_2 Cathode, *ACS Appl. Energy Mat.*, in press (2018).

Summary

- Highly efficient elctrocatalytic activies of insulating BN for ORR and HER are theoretically predicted and experimentally proved.
- Effects of impurities in electrolyte solutions on product distribution at Li-O_2 cathode are clarified by using various characterization techniques.

Research outcome

- Electrocatalysts for Fuel Cell
- Electrocatalysyts for Water Electrolysis
- Novel Techniques for Solid/Liquid Interfaces
- Understanding of Reaction Mechanisms of Energy Conversion Processes