Renewable Energy and Energy Storage
Room Naupaka Salon 4 - Session RE1-MoM

Electrochemistry and Photocatalysis I
Moderator: Craig Perkins, National Renewable Energy Laboratory

8:40am **RE1-MoM-3 Hot Carrier-Driven Plasmonic Photoelectrochemical Processes*, Jeong Young Park,*** KAIST, Republic of Korea **INVITED**

The detection of hot electrons and understanding the correlation between hot electron generation and surface phenomena are challenging questions in the surface science and catalysis community. Hot electron flow generated on a gold thin film by photon absorption (or internal photoemission) appears to be correlated with localized surface plasmon resonance. It has been found that the hot electron flux generated under photon absorption and exothermic chemical reaction is the major mediator of energy conversion process [1-3]. In this talk, I introduce the research direction to attempt to detect the surface plasmon driven hot carrier at the nanometer scale by using scanning probe microscopy. To detect and utilize the hot electron flows at the macroscale level, the metal-semiconductor nanodiodes were constructed. At the nanometer scale, we utilized photoconductive atomic force microscopy to observe photoinduced hot electrons on a triangular Au nanoprism on n-type TiO2 under incident light. This is the direct proof of the intrinsic relation between hot electrons and localized surface plasmon resonance. We observed surface plasmon induced hot hole by using the system of Au nanoprism on p-type GaN [4]. I will discuss the impact of hot carriers in the photocatalytic activity under photoelectrochemical water splitting by using Au-based plasmonic nanostructures [5].

References

[1] K. Song et al. Advanced Materials Interfaces, 2400273 (2024).

[2] H. Lee et al. of Chemical Research 55, 24, 3727 (2022).

[3] S. W. Lee et al. Surface Science Reports 76 100532 (2021).

[4] H. Lee et al. Advanced Science 7, 2001148 (2020).

[5] K. Song et al. ACS Energy Lett. 6, 4, 1333–1339 (2021).

9:20am **RE1-MoM-5 Next-Generation Electrocatalysts Derived from Metal-Organic Frameworks for Hydrogen Production and Conversion*, Di-Jia Liu,*** Argonne National Laboratory

Metal-organic frameworks (MOFs) have found their ever growing applications in today's economy and industrial applications. In this presentation, I will discuss some of the recent technological breakthroughs in applying MOFs for green hydrogen applications. I will focus on the discussion on our recent progresses in applying MOFs for a) platinum group metal free (PGM-free) and ultralow platinum metal cathodic catalysts in the proton exchange member fuel cell (*Science*, 2018) and b) new application of PGM-free catalyst as the replacement for iridium for hydrogen production operated in proton exchange membrane water electrolyzer (*Science*, 2023). The talk will cover rational catalyst design, electrocatalytic performance, understanding of the catalytic mechanism, and prospects of these emerging technologies in green hydrogen production and application.

9:40am **RE1-MoM-6 Defective Metal Oxides for Electrochemical Ammonia Synthesis *, Emma Lovell,*** University of New South Wales, Australia

There is a growing and urgent need to decarbonize large-scale industrial process, such as the Haber-Bosch process, used to synthesize ammonia. By using electricity to drive this process and avoiding the requirement for fossil fuel-derived hydrogen, the large scale production of fertilizers can be done sustainably.

Our recent work uncovered an approach to produce ammonia using air and water. By plasma activating air into water, an aqueous solution of NO_x (nitrate and nitrite) can be generated. This solution can then be electrocatalytically reduced to produce ammonia (NOxRR). This hybrid plasma/electrochemical approach can overcome the limitations of direct nitrogen reduction to ammonia (NRR), such as the relative insolubility and stability of nitrogen [1].

The development of active, selective and stable catalysts for NOxRR is essential for the application of this hybrid ammonia synthesis approach. In this talk, our recent work on designing metal oxide catalysts for NOxRR will be discussed [2-4]. By using flame spray pyrolysis (FSP) metal oxides with tunable properties were produced. For example, Ru-doped Co_3O_4 was produced with Ru being shown to be incorporated into the Co_3O_4 lattice. This doping resulted in an ease in generating oxygen vacancy defects during electrochemical preconditioning which facilitated nitrate adsorption and enhanced Faradaic Efficiency towards ammonia production [3].

[1] Sun et al., (2021) Energy & Environmental Science 14 (2), 865-872

[2] Bui et al., (2023) Advanced Materials 35 (28), 2205814

[3] Lim et al., (2024) Small, 2401333

[4] Rahman et al., (2021) Energy & Environmental Science 14 (6), 3588-3598

Author Index

Bold page numbers indicate presenter