SS18A : International Ceramic Society Symposium

SS18A-1 | Near-complete charge separation in tailored $BiVO_4$-based heterostructure photoanodes toward artificial leaf

*JANG Ho Won[1]
[1]Seoul National University

As an artificial leaf, a tandem device for zero-bias solar water splitting is a capable solution for practical hydrogen production. Despite a promise, poor charge transport of $BiVO_4$ hampers photoelectrochemical performances under front-side illumination, which is a hindrance to the tandem system. Herein, we design a new photoanode comprising nanoporous $BiVO_4$ and SnO_2 nanorods focused on the charge separation via structural and interfacial engineering. $BiVO_4/SnO_2$ photoanode exhibits not only remarkable charge separation efficiency of 97% but also, by loading NiFe as a co-catalyst for water oxidation, high photocurrent density of 5.61 mA cm^{-2} at 1.23 V versus the reversible hydrogen electrode under front-side 1 sun illumination. Consequently, a tandem cell comprising NiFe/$BiVO_4$/SnO_2 photoanode and perovskite/Si tandem solar cell generates an operating photocurrent density of 5.90 mA cm^{-2} with a solar-to-hydrogen conversion efficiency of 7.3% in zero-bias. This work would be a significant step to develop spontaneous solar hydrogen production.

SS18A-2 | Preparation of Janus-type surface-modified niobate nanosheets

*SUGAHARA Yoshiyuki[1]
[1]Waseda University

Inorganic nanosheets have attracted enormous attention, and they are typically prepared from layered materials via exfoliation. Since interlayer surfaces of some layered metal oxides undergo grafting reactions, it is possible to prepare metal oxide nanosheets where functional groups and polymer chains are immobilized via robust bonds. Among inorganic nanosheets, Janus-type inorganic nanosheets have been developed in recent years.[1] It is possible to prepare Janus-type inorganic nanosheets via regioselective grafting reactions at interlayers and subsequent exfoliation, and the unique structure and interlayer surface reactivity of potassium hexaniobate, $K_4Nb_6O_{17} \cdot 3H_2O$, which consists of niobate layers, [Nb6O17]4-, and interlayer potassium cations, are very attractive for regioselective grafting reactions; two different interlayers with different reactivities for ion exchange reactions, highly reactive interlayer I with hydrated potassium cations and anhydrous interlayer II with potassium cations exhibiting low reactivity, appear alternately in the stacking direction of niobate layers. It is known that intercalation compounds which contain guest species only at interlayer I can be obtained via regioselective ion-exchange reactions with bulky organoammonium ions.[2] Since expansion of interlayers by ion-exchange reactions with organoammonium ions is required for grafting reactions in interlayers, surface modification at interlayer I can regioselectively proceed by using this type of intercalation compounds and phosphorus-containing coupling agents.[3] By exfoliating this such an organic derivative at both interlayers I and II, Janus-type nanosheets where one of two surfaces is modified can be prepared. When initiator groups for atom transfer radical polymerization were immobilized at interlayer I and thermoresponsive polymer chains were grown at interlayer I, the resultant nanosheets were dual-functional; one function was ion-exchange capability of unmodified surface and the other one was thermoresponsiveness.[4] It is also possible to modify interlayer II of organic derivatives with grafted interlayer I by introducing smaller organoammonium ions and subsequent grafting reactions at interlayer II.[5] Exfoliation at both interlayers I and II leads to the formation of Janus nanosheets, and individual nanosheets possess two different groups separately on two sides. By selecting appropriate immobilized groups, water-dispersible Janus-type nanosheets, which can stabilize an o/w emulsion, were prepared, indicating that they acted as a two-dimensional surfactant.[6]

References

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SS18A-3 | Pb-free perovskite nanocrystals for various applications

*IM Won Bin[1]
[1]Hanyang University

This talk explores the potential applications of machine learning (ML) in synthesizing lead-free perovskite nanocrystals. Despite the efficiency and eco-friendliness of lead-based perovskites in optoelectronic devices such as solar cells and light-emitting diodes, concerns regarding lead toxicity and stability have imposed limitations.

Novel approaches employing machine learning techniques were used for component synthesis to address issues related to lead-based perovskites. The aim was to retain the inherent advantages of lead-free perovskites while exploring more environmentally sustainable alternatives. The talk also investigated the suitability of synthesized lead-free perovskite nanocrystals as scintillators. These nanocrystals showed promise for applications like X-ray imaging, particularly in medical imaging and high-energy physics. The findings provide valuable insights for researchers in the fields of optoelectronic devices and medical imaging.

SS18A-4 | Is LK-99 the Holy Grail of Room Temperature Superconductor?

*LOW It-Meng[1]
[1]Curtin University

The dream of holy grail room temperature superconducting ceramics has recently attracted a frenzy attention since the discovery of YBCO superconductor more than 3 decades ago. In March 2023, a team of scientists from the University of Rochester claimed to show evidence of near-ambient superconductivity in a N-doped lutetium hydride. This material exhibited superconductivity with a maximum T_c of 294 K at 10 kbar. Then, in July 2023, South Korean researchers, Sukbae Lee et al. claimed to have successfully demonstrated atmospheric superconductivity of a modified lead apatite crystal (LK-99) with composition ($Pb_9Cu(PO_4)_6O$) at room temperature. They claimed that the synthesized LK-99 materials exhibit the Meissner levitation phenomenon of superconductors and have a superconducting transition temperature (Tc) higher than 400 K. A month later, a team of Chinese researchers from HUST also claimed to have verified and synthesized the LK-99 crystals which could magnetically levitate with larger levitated angle than Sukbae Lee's sample at room temperature. This material has been hailed as the first-ever room-temperature ambient pressure superconductor, a claim that was met with much healthy skepticism and excitement. But after weeks of feverish speculation and frantic attempts worldwide to make and test the new material, many experts in the normally recondite field of solid-state physics now think the claims were almost certainly wrong. However, computational theorists and other scientists believe that the LK99 structure is real and have discovered ways to improve its structure. This talk will present a cautious but balanced view on the pros and cons of this break-through claims and counter-claims.