

# Renewable Energy and Resources & Energy Materials and Fuel Cell Research

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## Photoelectrochemical materials for sunlight-driven water splitting devices

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Photocatalysis or photoelectrochemistry are attractive developing fields of engineering for building free-running sunlight-driven water splitting to generate H<sub>2</sub> and O<sub>2</sub>. We are surveying solar-spectrum-responding semiconductive materials as the candidates for the visible light absorbers in the H<sub>2</sub>+O<sub>2</sub> harvesting devices. We have been fabricating and testing water photo-splitting devices composed of a pair of photocathode (p-type, for H<sub>2</sub>) and photoanode (n-type, for O<sub>2</sub>) both decorated with catalysts for evolving those gases. As for photocathode, we developed H<sub>2</sub> evolving flat layered sheets based on chalcopyrite Cu(In, Ga)Se<sub>2</sub> (CIGS, the cutoff wavelength of absorption ~ 1100 nm) and its doped versions with Zn, S, etc. The photocurrent obtained by the solar simulator (AM 1.5G) can afford more than 10% of solar hydrogen conversion efficiency. The photoanode material is the remaining problem to solve. BiVO<sub>4</sub> (~540 nm), paired with CIGS, realized a stable operation for the stoichiometric faradaic evolution of H<sub>2</sub> and O<sub>2</sub>, however, the maximum solar-to-H<sub>2</sub> efficiency has been below 4 %. Obviously, we need n-type light absorbers with longer cutoff wavelength. We are also developing transition metal nitrides and oxynitrides for the sunlight absorbers. Ta<sub>3</sub>N<sub>5</sub> (~600 nm) has been the most intensively investigated, as particles embedded on metal layers (particle transferred sheets) and flat layered thin films, both of which can serve as photoanodes. Foreign materials can be assembled as the background layer or capping layer for the Ta<sub>3</sub>N<sub>5</sub> layer to improve the electronic properties and robustness as an electrode immersed in the electrolytic solution. We will discuss the best performance for Ta<sub>3</sub>N<sub>5</sub> and oxynitrides as O<sub>2</sub>-evolving photoelectrodes energized by solar irradiation.

### Biography

Hiroshi Nishiyama completed his Ph.D. at Nagaoka University of Technology, Japan in 2005. In 1998–2013, he was an assistant professor at the Analysis and Instrumentation Center at Nagaoka University of Technology. He is currently a principal project researcher in the R&D Laboratory of Artificial Photosynthetic Chemical Process (ARPCHEM) at The University of Tokyo. His research focuses on the development of high-performance photoanode electrodes and high-performance PEC systems.

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