

**Section of  
Public Affairs**Mi-Yeon Kim  
Section Chief  
(+82) 62-715-2020Nayeong Lee  
Senior Administrator  
(+82) 62-715-2024**Contact Person  
for this Article**Young-jae Kim, Ph.D. Student  
School of Electrical Engineering  
and Computer Science  
(+82) 62-715-2658**Release Date**

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## **Professor Young Min Song's research team fabricates high-efficiency photoelectrode using a truncated cone structure**

- Korean researchers have confirmed that the optical design of nanostructures can improve the efficiency of photoelectrodes \* to produce environmentally-friendly hydrogen energy. GIST (President Seung Hyeon Moon) – Professor Young Min Song of the School of Electrical Engineering and Computer Science discovered that the absorption of light varies with the geometry of the gallium nitride \*\* photoelectrode (cone ratio, period, diameter and height) and that the nanostructure of the truncated cone is the most suitable structure for efficient hydrogen production.

\* Photoelectrode: A semiconductor material that absorbs sunlight from the outside and generates electrons and holes.

\*\* Gallium nitride: A semiconductor that is a III-V semiconductor and uses nitrogen as a group V element. It is possible to control the absorption wavelength band of light by changing the concentration of indium or aluminum, and it is chemically very stable.

- To produce hydrogen efficiently, it is important that the generated charges are transferred to the interface between the photoelectrode and the electrolyte. However, existing photoelectrode materials have

high refractive index characteristics, which interfere with charge formation due to reflection of light on the semiconductor surface. To solve this problem, it is necessary to design an optical structure capable of maximizing light absorption efficiency and efficiently collecting light by introducing a nanostructure.

- In this study, the nanostructure of gallium nitride, which is the most popular photoelectrode material, was designed through optical simulation. The truncated cone structure of the cylinder, truncated cone, and cone is the optimal structure for improving photoelectrode efficiency.
- For the truncated cone nanostructures, the structure is gradually inclined from the surface, and the refractive index gradually increases from the surface. The reflection of light is caused by the refractive index difference between the media, so the reflection of light can be reduced to improve the absorption. The truncated cone nanostructures are focused at the center of the nanostructure, and the light in the cone nanostructure is absorbed by the gallium nitride. The generated charges have a limited travel distance, which is advantageous as the light is condensed into a nanostructure close to the electrolyte.
- A thermal dewetting technique \* and dry etching technique were used to manufacture the photoelectron electrode for the truncated cone nanostructure. The result of this research is that the photoelectrode can be fabricated without using an expensive lithography process. It was confirmed that the absorption rate of the fabricated gallium nitride nanostructure was improved, and that the photocurrent \*\* density was increased three times as much as the conventional structure.

\* Thermal dewetting technique: when a silver nano-silver thin film is heated to a high temperature, the silver particles come together to form a nano-island of various sizes

\*\* Photocurrent: When a semiconductor is irradiated with light, the current generated by the formation of electron hole pairs

- Professor Young Min Song said, "In this study, we designed and fabricated nanostructures optically solving the high refractive index and limited charge transfer distance, which are intrinsic properties of photovoltaic materials and cause solar photocatalytic degradation. It can be applied to a large area and is expected to be widely used in solar photolysis devices in the future."
  
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