

# 3-D hierarchically porous nanostructured catalyst helps efficiently reduce carbon dioxide

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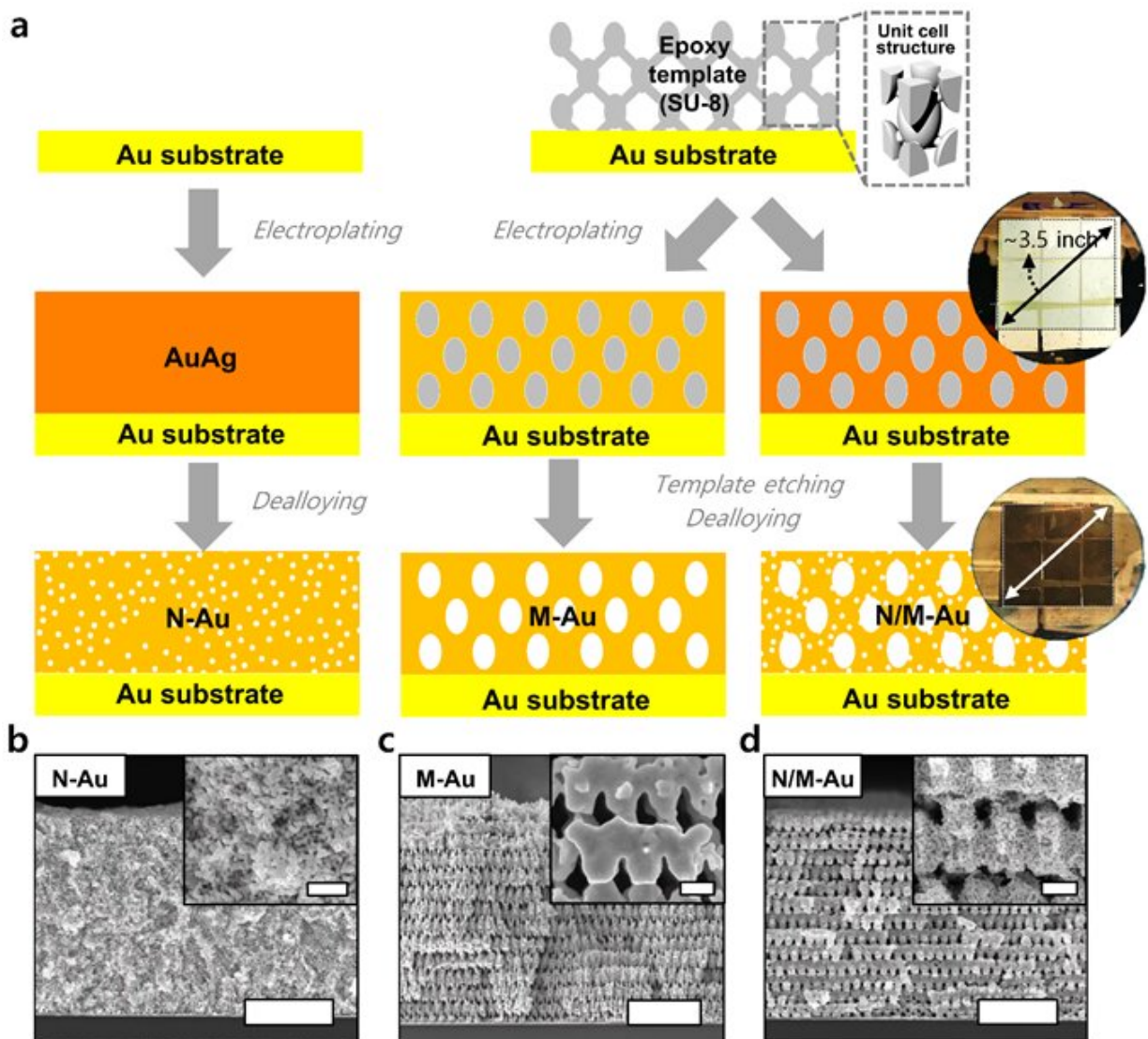


Figure 1. Fabrication procedures of various gold nanostructures through proximity-field nanopatterning (PnP) and electroplating techniques. Credit: The Korea Advanced Institute of Science and Technology (KAIST)

KAIST researchers developed a three-dimensional (3-D) hierarchically porous nanostructured catalyst with carbon dioxide ( $\text{CO}_2$ ) to carbon monoxide (CO) conversion rate up to 3.96 times higher than that of conventional nanoporous gold catalysts. This new catalyst helps overcome the existing limitations of the mass transport that has been a major cause of decreases in the  $\text{CO}_2$  conversion rate, holding a strong promise for the large-scale and cost-effective electrochemical conversion of  $\text{CO}_2$  into useful chemicals.

As  $\text{CO}_2$  emissions increase and [fossil fuels](#) deplete globally, reducing and converting  $\text{CO}_2$  to clean energy electrochemically has attracted a great deal of attention as a promising technology. Especially due to the fact that the  $\text{CO}_2$  reduction reaction occurs competitively with hydrogen evolution reactions (HER) at similar redox potentials, the development of an efficient electrocatalyst for selective and robust  $\text{CO}_2$  reduction reactions has remained a key technological issue.

Gold (Au) is one of the most commonly used catalysts in  $\text{CO}_2$  reduction reactions, but the high cost and scarcity of Au pose obstacles for mass commercial applications. The development of nanostructures has been extensively studied as a potential approach to improving the selectivity for target products and maximizing the number of active stable sites, thus enhancing the energy efficiency.

However, the nanopores of the previously reported complex nanostructures were easily blocked by gaseous CO bubbles during aqueous reactions. The CO bubbles hindered mass transport of the

reactants through the electrolyte, resulting in low CO<sub>2</sub> conversion rates.

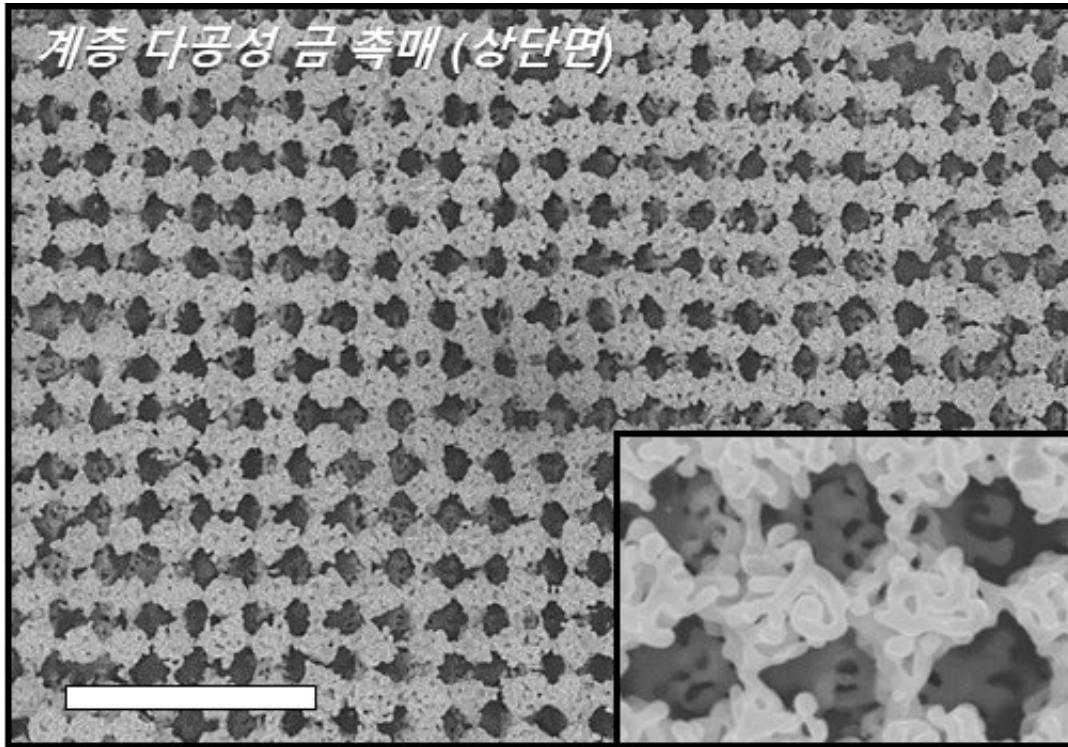


Figure 2. Top view of scanning electron microscope (SEM) images of the hierarchically porous gold nanostructure (Scale bars, 3  $\mu\text{m}$ ). Credit: The Korea Advanced Institute of Science and Technology (KAIST)

In the study published in the *Proceedings of the National Academy of Sciences* of the U.S. (*PNAS*) on March 4, a research group at KAIST led by Professor Seokwoo Jeon and Professor Jihun Oh from the Department of Materials Science and Engineering designed a 3-D hierarchically porous Au nanostructure with two different sizes of macropores and nanopores. The team used proximity-field nanopatterning (PnP) and electroplating techniques that are effective for fabricating the 3-D well-ordered nanostructures.

The proposed nanostructure, comprised of interconnected macroporous channels 200 to 300 nanometers (nm) wide and 10 nm nanopores, induces efficient mass transport through the interconnected macroporous channels as well as high selectivity by producing highly active stable sites from numerous nanopores.

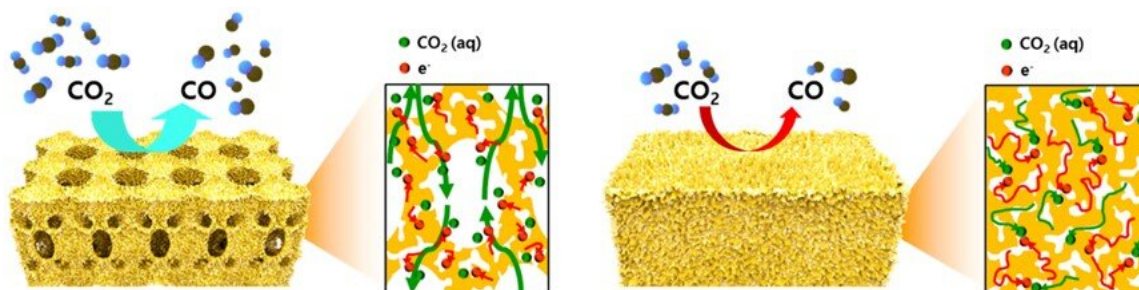


Figure 3. Schematic illustration and the cross-sectional view with the expected reaction pathway for the hierarchically porous gold and nanoporous gold electrodes. Credit: The Korea Advanced Institute of Science and Technology (KAIST)

As a result, its electrodes show a high CO selectivity of 85.8% at a low overpotential of 0.264 V and efficient mass activity that is up to 3.96 times higher than that of de-alloyed nanoporous Au electrodes.

"These results are expected to solve the problem of [mass](#) transfer in the field of similar electrochemical reactions and can be applied to a wide range of green energy applications for the efficient utilization of electrocatalysts," said the researchers.

**More information:** Gayea Hyun et al. Hierarchically porous Au nanostructures with interconnected channels for efficient mass transport in electrocatalytic CO<sub>2</sub> reduction, *Proceedings of the National Academy*

*of Sciences* (2020). [DOI: 10.1073/pnas.1918837117](https://doi.org/10.1073/pnas.1918837117)

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