Manufacturing technology

Miniature fuel cell with monolithically fabricated Si electrodes – Multi-layer catalyst by electrochemical atomic layer deposition –

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Purpose of Research

There are increasing expectations regarding compact power sources for the industrial use of drones and utilization of various types of robots. However, despite the clean energy image of fuel cells, they are fueled by hydrogen produced mainly from fossil fuel. In light of this situation, we are developing miniature fuel cells that can be fueled by biomass-derived hydrogen. In this research, we have, in order to achieve compatibility with biomass-derived hydrogen, developed a catalyst that is highly resistant to carbon monoxide and requires little platinum.

Summary of Research

In order to miniaturize fuel cells using MEMS technology, catalytic layers were previously formed by depositing porous platinum on silicon substrates. Although this achieved high power density fuel cells, reducing the amount of platinum used remained a problem. At the same time, the search continued for a catalyst that is highly resistant to carbon monoxide, a large quantity of which is contained in biomass-derived hydrogen. Excellent properties were obtained by depositing a small amount of platinum on porous palladium, but it was found that hydrogen absorbed into and discharged from the palladium caused the catalytic layer to break. This research aims to create a catalytic layer using electrochemical atomic layer deposition, with palladium and platinum being precisely deposited on the superficial layer of a core made of porous gold.

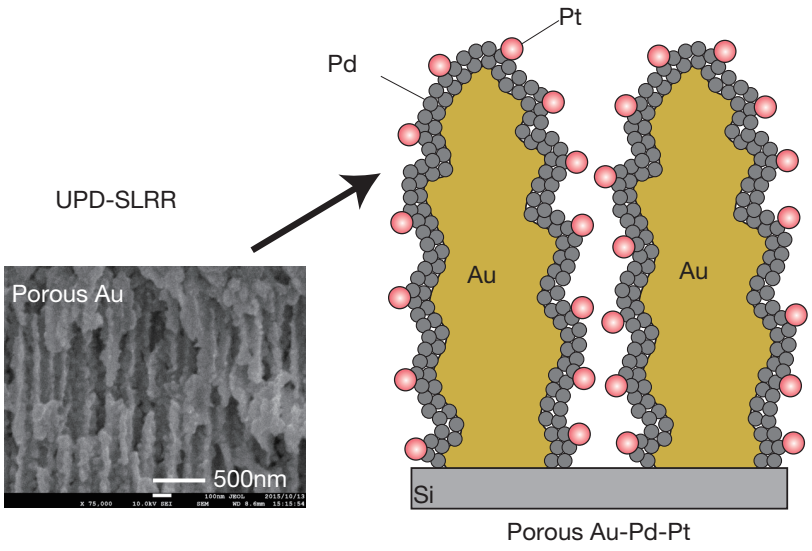

Figure: Third-generation Au-Pd-Pt catalyst

Points

- **Reduction in amount of platinum used (approx. 5 μg/cm²)**
- **High resistance to carbon monoxide**
- **High-power MEMS fuel cells**

Comparison with Conventional or Competitive Technology

- This is a unique technology that forms high-performance catalyst using a porous gold structure—suitable for MEMS fuel cells—as a base.
- In our previous research, a core shell structure was formed on metal microparticles through electrochemical atomic layer deposition.
- There is little research that uses porous gold as a base.
- Using porous gold as a base allows precise electrochemical atomic layer deposition to be achieved.

Expected Applications

- Portable power sources
- Moderately quiet power sources for drones and robots
- Promotion of use of biomass-derived hydrogen

Challenges in Implementation

- It is currently unclear how competitive this technology is with respect to the performance and cost of fuel cells for general-purpose devices.
- Optimization of the catalytic layer structure (number of UPD-SLRR processes, porous Au layer)

What We Expect from Companies

- We would like companies to offer popular products that use biomass hydrogen fuel cells.

Future Developments

Until 2018: Prototyping cells prepared with Au-Pd-Pt catalyst
Until 2019: Increasing power of fuel cells (demonstration with smartphones)
Until 2020: Studying combination with fuel tanks and other accessories
From 2018: Seeking partners and venture companies

■ Intellectual Property: Japanese Patent Application No. 2016-159735 "Silicon substrates with catalytic layer, fuel cells, and method for manufacturing silicon substrates with catalytic layer"
■ Prototype: Available
■ Sample: Samples of cells prepared with Au-Pd-Pt catalyst

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