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Non-conventional Pt-Cu alloy/carbon paper electrochemical catalyst formed by electrodeposition using hydrogen bubble as template

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HIGHLIGHTS

- A Pt-Cu alloy foam catalyst was synthesized directly on micro porous layer (MPL).
- A foam structure was prepared on MPL by Cu electrodeposition using bubble template.
- The Pt-Cu alloy was formed by Pt displacement following the electrodeposition.
- The Pt-C alloy/MPL catalyst showed superior durability to Pt/C in single cell test.

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ABSTRACT

With emerging stability issues in fuel cell technology, a non-conventional catalyst not supported on carbon materials has been highlighted because it can avoid negative influences of carbon support materials on the stability, such as carbon corrosion. The nanostructured thin film catalyst is representative of non-conventional catalysts, which shows improved stability, enhanced mass specific activity, and fast mass transfer at high current densities. However, the nanostructured thin film catalyst usually requires multi-step processes for fabrication, making its mass production complex and irreproducible. We introduce a Pt-Cu alloy nanostructured thin film catalyst, which can be simply prepared by electrodeposition. By using hydrogen bubbles as a template, a three-dimensional free-standing foam of Cu was electrodeposited directly on the micro-porous layer/carbon paper and it was then displaced with Pt by simple immersion. The structure characterization revealed that a porous thin Pt-Cu alloy catalyst layer was successfully formed on the micro-porous layer/carbon paper. The synthesized Pt-Cu alloy catalyst exhibited superior durability compared to a conventional Pt/C in single cell test.

1. Introduction

The remaining issues for commercialization of fuel cells include cost reduction and improvements in the durability of the fuel cell components [1,2]. Both issues mainly rely on a catalyst among various fuel cell components. Catalyst activity, once a main issue in fuel cell technology, has been greatly improved through extensive research [3–6]. However, cost and durability are still insufficient to meet the requirements for commercialization. A conventional catalyst has metal (or metal alloy) nanoparticle structures supported on porous conducting materials for maximizing the surface area and acquiring electric conductivity like Pt-supported on carbon (Pt/C) [7–9]. However, its structural characteristics degrade catalyst activity under continuous fuel cell operation, which is a big hurdle for commercialization. The intrinsic instability of nanoparticles leads to unwanted changes in catalyst composition, morphology, and size during fuel cell operation by their sintering and dissolution [10,11]. Furthermore, the corrosion of carbon support materials causes significant problems like nanoparticle detachment and other unexpected phenomena [12,13]. These degradation phenomena are directly related to fuel cell stability/durability issues.

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