Structural changes of various faces of Pt single crystalline surfaces induced by potential cycling in acid solutions

Faridah binti Sonsudin and Kohei Uosaki
Division of Chemistry, Graduate School of Science, Hokkaido University

Introduction: Platinum is the most important catalyst in many applications including polymer electrolyte fuel cells (PEFCs). It is however, a major contributor to a high cost and low reliability and durability in the fuel cell. In recent years, much effort has been put to overcome the loss of the active area of platinum catalyst during fuel cell operation. The electrochemical oxidation-reduction cycle is considered to be one of the main factors to accelerate the degradation process. In this study, the effects of potential cycling on the structural change of various faces of Pt single crystalline surfaces were investigated.

Experiment: A Pt single crystal bead was prepared according to the Clavilier method. The bead was cut along the preferable plane (111) and (110), followed by polishing with 3 μm and 0.5 μm diamond slurries. The substrate was annealed by an induction heater for 10 hours at 1600 °C under Ar/H2 flow. Prior to each series of electrochemical experiments, the electrode was treated similarly but only for 30 minutes, followed by quenching in a pure H2O saturated with Ar/H2 after cooled in Ar/H2 flow for 2 minutes. The electrochemical measurements were carried out in the hanging meniscus configuration.

Result: Figure 1 shows a cyclic voltammograms (CVs) for Pt(111) in 0.1 M H2SO4 solutions, during potential cycling between 0.07 V and 1.4 V vs. RHE, with a scan rate of 50 mV/s. The first potential cycling shows a typical CV profile of Pt(111) where anion adsorption/desorption peaks appeared at 0.5 V, oxygen adsorption peak at 1.40 V and desorption peak at 0.73 V. During the continuous potential cycling, peaks at 0.5 V disappeared, while new peaks appeared at 0.14 V. The decrease and increase of oxygen adsorption and desorption peak, respectively, suggest that the structural change of Pt(111) occurred and the surface became rough. This phenomenon was not observed when upper potential limit was negative than 1.2 V. Experiment on Pt(110) electrode in the same condition did not show a drastic change of CV profile in contrast to the results at Pt(111) electrode. There was almost no shifting of the peaks during potential cycling. Therefore, it can be concluded that Pt(110) surface is much more stable than Pt(111) surface during the electrochemical oxidation-reduction reaction.

Fig 1. CVs of a Pt (111) surface during potential cycling between 0.07 V and 1.4 V in 0.1 M H2SO4 solutions, with a scan rate of 50 mV/s.
Name: Faridah Sonsudin

Position and Affiliation: 2nd Year PhD Student, Division of Chemistry, Graduate School of Science, Hokkaido University
Postal Address: Sapporo 060-0810, Japan
Phone/Facsimile: +81-11-706-2708
Email: sfaridah@pchem.sci.hokudai.ac.jp

Research Interest and Keywords: Electrochemistry