Application Note

Poseidon™

Understanding Degradation Processes in Automotive Fuel Cells

Problem Statement

Fuel cells have two major obstacles to adoption by the automotive industry. The first is the initial cost due to the materials used. The second, which is the subject of this case study is the rapid degradation of charge efficiency, or the ability to continue to discharge and charge at the required performance levels. Current fuel cells will degrade within five years to the point where replacement is required in an automotive application. The goal for auto manufactures in commercial applications is a minimum ten-year healthy life cycle. The root causes of degradation are thought to be understood, but previously have been unobservable.

Background

The plug-in hybrid is the automobile industry's opening foray into low emission electric vehicles. The battery, currently the most cost effective form for storing energy, will soon be replaced with a more powerful and efficient fuel cell. The promise of the fuel cell is readily demonstrable, with current models producing a 300-mile range on a single charge. However, those fuel cells make the autos cost prohibitive and their rapid degradation renders them unusable half way through the life of the chassis. Automakers, government, and commercial researchers are conducting large amounts of research focused on increasing this lifespan.

Methods

Understanding at a nanoscale the mechanisms of degradation will provide a path to the answers to increase the lifetime of fuel cells. Dr. David Muller's research group utilized the Poseidon 500 system within an FEI Titan transmission electron microscope to image *in situ* the degradation mechanisms as they occurred. Throughout the process the researchers gathered quantifiable analytical data paired to visual observations.

Conclusions

Previously, degradation was believed to be an effect of Ostwald ripening, where larger nanoparticles steal atoms for smaller nanoparticles. Secondarily it was viewed that coalescence, a process where nanoparticles move in bulk brought about the remainder of

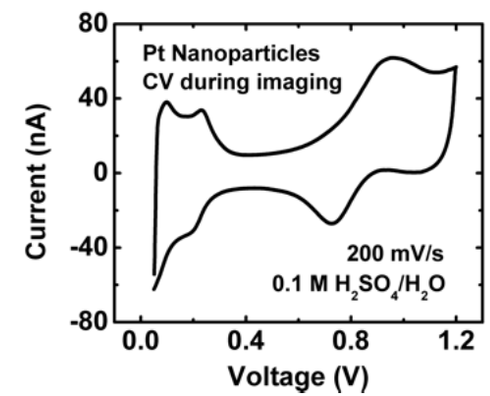

Figure 1: Cyclic voltammetry of Pt on a carbon support *in situ*.

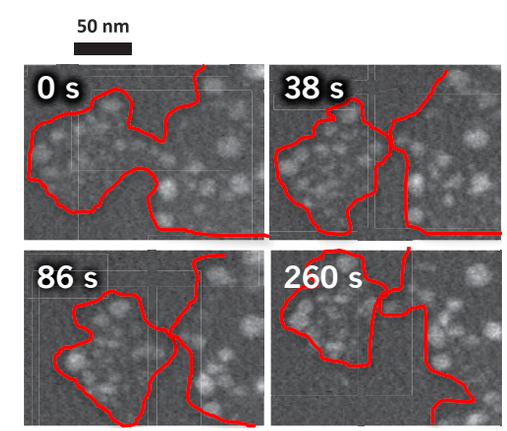

Figure 2: Carbon support degradation when 1.9 V is applied after 0 s, 38 s, 86 s and 260 s.

the degradation. Coalescence, while very difficult to model, is easily observable within a transmission electron microscope. Through observation it was determined that both Ostwald ripening and coalescence have about an equal effect on degradation of the cell. In addition both mechanisms have a cooperative effect that leads to coarsening within the cell. Due to the cooperative nature of the mechanisms, a plan to reduce coalescence is also a plan to reduce Ostwald ripening. Dr. Mueller discovered and confirmed through observation with the Poseidon 500 that he could reduce the degradation mechanisms by a reduction in the loading of particles on the catalyst. This spatial distribution reduced coalescence by enabling particles to travel a longer distance before colliding with another particle. The future of stored automotive energy is the fuel cell and continued research in the degradation mechanisms is essential for commercial success. Contact us to discuss the full range of capabilities of Poseidon. We can be reached at (919) 377-0800 or at contact@protochips.com.