Electrodeposition of Platinum Nanoparticles on High Oriented Pyrolytic Graphite (HOPG)

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Nanometer scale platinum particles on carbon surface constitute an interesting model system for supported electrocatalyst structure tested in polymer electrolyte fuel cells.[1] In particular, the possibility to electroplate onto well-defined surfaces and to quantitatively measure particle size distribution by AFM allows precise correlation between particle size, distribution and catalytic activity to be obtained. Catalytic activity for electrochemical reactions depends in fact on the size and distribution, structure and morphology of the crystal particles, and all these parameters can be precisely evaluated by using HOPG substrates.[2] Methods to electroplate Pt nanoparticles with narrow size distribution have been reported by several groups.[2,3]

In the present work, we investigate the effect of Pt electrodeposition conditions (pulse time interval, pulse potential, concentration of H_2PtCl_6 and supporting electrolyte) on the nucleation and growth of Pt nanoparticles on HOPG by electrochemical (i-t transient and cyclic voltammetry) and AFM/SEM imaging methods. These results, together with an evaluation of the electrocatalytic activity as a function of particle morphology will help to optimize particle size and morphology to achieve maximum electrocatalytic activity, thus providing a method to control the electrocatalytic activity of Pt nanoparticles on carbon surface.

Figure 1 shows potentiostatic current transients for the electrodeposition of Pt on HOPG at various potentials from 1mM H_2PtCl_6. No hydrogen evolution is observed at the potentials investigated. Non-dimensional i^2/i_m^2 vs. t/t_m plots of the data in Fig. 1 are shown in Fig. 2 and compared with theoretical data.[4] It is observed that with increasing the deposition overpotential, the nucleation mode of Pt on HOPG evolves from progressive nucleation to instantaneous nucleation.

Figure 3 shows a typical Tapping Mode AFM image of A HOPG surface with platinum nanoparticles. Particles with average size of about 25 nm and height of 1.5 nm can be obtained. There is an accumulation of particles at steps, where some particles are observed to coalesce. A relevant fraction of the nanoparticles also deposits at terraces.

References

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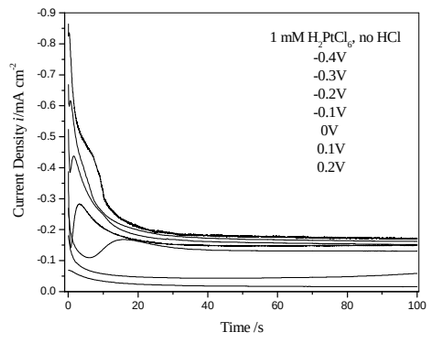

Figure 1. Potentiostatic current transients for the electrodeposition of Pt on HOPG at various potentials from 1mM H_2PtCl_6

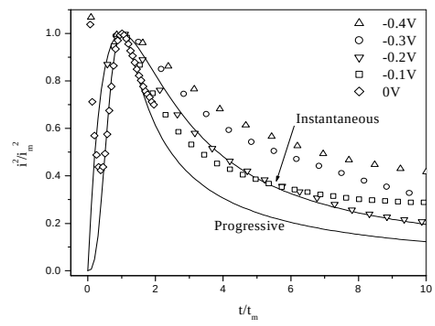

Figure 2. Non-dimensional i^2/i_m^2 vs. t/t_m plots of the data in Fig. 1. The continuous lines correspond to instantaneous and progressive nucleation, respectively.

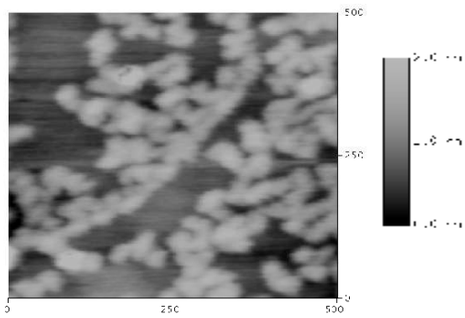

Figure 3. Typical Tapping Mode AFM image of HOPG surface with platinum nanoparticles (500×500 nm, height scale: 2 nm)