

Electrocatalytic Diamond Thin Film Electrodes with Incorporated Pt

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Electrocatalytic electrodes are often constructed by finely dispersing metal particles (ca. 5 nm diam.) on an sp^2 carbon support. One problem with sp^2 carbon supports is the oxidation/corrosion that can occur in aggressive solution environments and at elevated temperature.¹ The oxidation/corrosion leads to morphological and microstructural damage that can result in aggregation and or detachment of the catalyst particles. In some cases, fouling of the catalyst surface can occur. Conductive polycrystalline diamond thin-film electrodes possess several important properties: electrical conductivity, chemical inertness, morphological stability and corrosion resistance.²⁻³ These properties make the material a good candidate to serve as a catalyst support/host.

The incorporation of Pt particles into the surface of diamond thin-films is possible forming a highly dimensionally stable electrocatalytic electrode.^{4,5} The basic idea is to (1) grow a conductive and continuous diamond film on a conducting Si substrate, (2) then deposit a controlled amount of Pt or Pt/Ru metal on the surface and (3) follow this by short term growth of a conductive diamond film which deposits around the metal particles, thus incorporating them into the surface microstructure. Several approaches for depositing the metal particles are being explored including magnetron sputtering,^{4,5} electrodeposition, etc. We report herein the preparation of Pt incorporated diamond thin films via the electrodeposition method. A 3-5 μm thick boron-doped diamond thin-film was first deposited on Si. A Pt adlayer was deposited on the diamond film by galvanostatic electrodeposition in 1mM K_2PtCl_6 solution. The diamond growth was then continued on the Pt coated film for 3 additional hours. The following schematic demonstrates the concept.

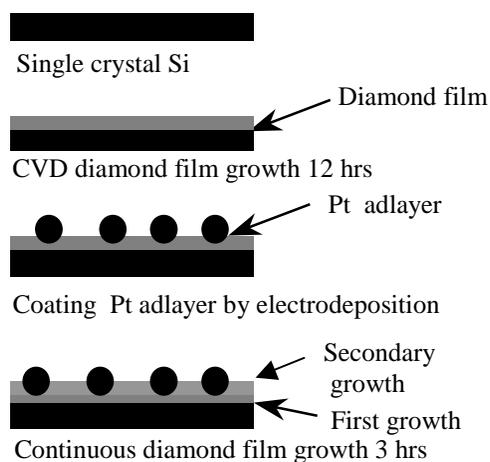
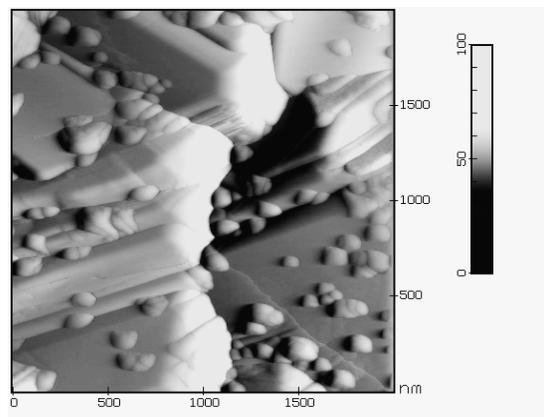
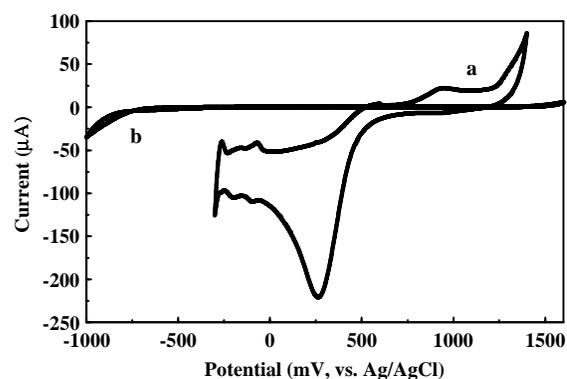


Figure 1 shows a $2 \times 2 \mu\text{m}$ AFM (force mode, air) image of the Pt incorporated diamond thin-film. The metal-containing electrode is well-faceted with dispersed Pt particles (10-200 nm diam.) incorporated into the surface. The Pt particles are strongly anchored to the electrode because of their location in the grain boundaries and the fact that the diamond film appears to grow around their base. Our electrochemical measurements indicate that the Pt particles are in electronic communication with the current collecting Si substrate through the boron-doped diamond matrix, and they are electroactive for the UPD of hydrogen. The Pt loading can easily be controlled by adjusting the electrodeposition current and time.



Pt incorporated diamond thin-film electrodes possess unique electrocatalytic activity. Figure 2 shows cyclic voltammetric i-E curves for diamond films with (a) and without (b) incorporated Pt in 0.1M HClO_4 saturated with dissolved oxygen. The increased reduction current and the reduction peak of ca. 250mV suggest the Pt-containing diamond film is electroactive toward O_2 reduction. The current density was dependent on the composition of the electrode materials and the electrolyte. The oxygen reduction reaction is strongly inhibited on the metal-free diamond film.



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