Pt-based ORR Catalyst on Carbon-Supported Amorphous Niobium Oxide Support

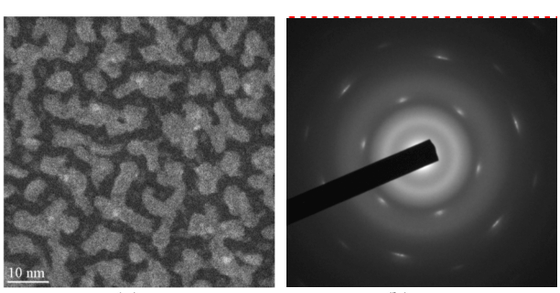
C. Xu[1], P. Pietrasz[1], J. Yang[1], R. Soltis[1], K. Sun[2], M. Sulek[1], R. Novak[1]

[1]Ford Motor Company Dearborn, MI 48124, USA
[2]University of Michigan, Electron Microbeam Analysis Laboratory, Ann Arbor, MI 48109, USA

The ORR catalyst for PEMFC needs to be improved in terms of catalytic activity, stability, and reduction of Pt loading to be viable for fuel cell vehicle applications. A drawback of state-of-the-art dispersed platinum nanoparticles on carbon is the corrosion of carbon in the PEMFC vehicle under operation conditions, which also exacerbates the agglomeration of Pt nano-particles. This results in a limited life of the vehicular fuel cell. Conductive metal oxide supported Pt-based ORR catalysts nanoparticles have been studied extensively and showed improved electrochemical stability and catalytic activity through d-band interaction [1,2,3]. However, crystalline conductive metal oxides such as NbO and NbO_2 are not stable in the fuel cell [1]. This work uses a carbon-supported amorphous conductive metal oxide as Pt-based catalyst support for ORR in PEMFC. Amorphous conductive metal oxides have neither grain boundaries, nor the long-range atomic order to be easily transformed into insulating crystalline structure, *i.e.* amorphous conductive metal oxides are resistant to oxygen incorporation, thus preserving the structural stability and electric conductivity.

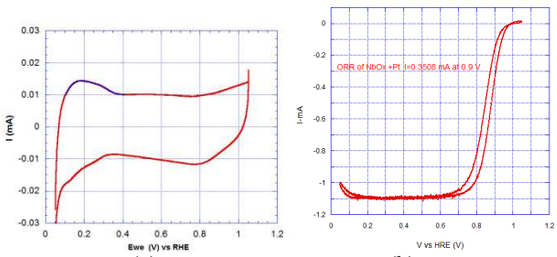
Amorphous NbOx conductive metal oxide is magnetron sputtered from either Nb_2O_5 in Ar or Nb in a gas mixture of 30 vol.% of O_2 in Ar onto a 5 mm diameter glassy carbon rod. The morphology of the obtained NbOx on glassy carbon is isolated amorphous island, with the value of x between 1 and 2 as shown in Figure 1 (a) and (b). When a 24Å of Pt is deposited onto the formed NbOx, the obtained ORR results are shown in Figure 2 for ECSA and ORR (a) and (b). The kinetic current is about 1900 $\mu A/cm^2$-Pt, close to the ORR activity of bulk Pt. The temperature, vacuum level, and gas composition used to generate the plasma are the control parameters for making the amorphous conductive metal oxides.

When the substrate temperature is appropriate, that is above 300°C but below the crystallization temperature of about 700°C, the Pt deposited on the amorphous conductive metal oxide forms a 2-D percolated Pt network. The obtained Pt based ORR catalyst on conductive amorphous metal oxide substrate exhibits bulk-like ORR activity.



(a) (b)

Fig. 1 The isolated island morphology and distribution sputtered NbOx (a), SAED confirms the NbOx is amorphous (b)



(a) (b)

Fig.2 The electrochemical surface area (ECSA) (a), the ORR at 1600 rpm, 0.1 M $HClO_3$ (b).

Introduction

References:

[1] Li Zhang, Liya Wang, Chris M. B. Holt, Titichai Navessin, Kourosh Malek, Michael H. Eikerling and David Mitlin, " Oxygen reduction reaction activity and electrochemical stability of thin-film bilayer systems of platinum on niobium oxide" *Journal of Physical Chemistry C* 114(2010)16434.

[2] Sheng-Yang Huang, Prabhu Ganesan, Branko N. Popov, "Electrocatalytic activity and stability of niobium-doped titanium oxide supported platinum catalyst for polymer electrolyte membrane fuel cells" *Applied Catalysis B: Environmental* 96(2010)224.

[3] Sheng-Yang Huang, Prabhu Ganesan, Branko N. Popov, "Titania supported platinum catalyst with high electrocatalytic activity and stability for polymer electrolyte membrane fuel cells" *Applied Catalysis B: Environmental* 102(2011)71.