Mesostructured Multimetallic Thin Films as Electrocatalysts for Fuel Cells

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The main fundamental research effort in polymer electrolyte fuel cells is placed on platinum based materials, since platinum is the best monometallic catalyst for the anodic and cathodic reactions. Currently, an approximately fivefold reduction in Pt loading is necessary to meet cost requirements for automotive applications. Pt-based alloys may offer substantial benefits in fuel cell catalysts by decreasing the amount of platinum while improving activity and durability. For that reasons, these materials are at the focus of intensive fundamental and applied research. Ultimate goal in the catalyst design is linked to the possibility of achieving the unique structural and compositional profile of the $Pt_3Ni(111)$ alloy [1], which was established to be the best catalyst for the oxygen reduction reaction. These unique structure-function properties were obtained on extended surfaces by utilizing thermal annealing that facilitates segregation of Pt to form a pure ordered surface layer, so called Pt-Skin. The electronic and adsorption properties of Pt(111)-Skin are determined by the subsurface layer that is rich in Ni induces high ORR activity that is two orders of magnitude of the state-of-the-art Pt/C catalyst. Possibility to design catalyst with the compositional profile and structure of Pt-Skin in practical catalysts can bring desirable improvement to the ORR.

Recently we established a new class of catalysts based on mesostructured multimetallic thin films with adjustable structure and composition [2]. These thin films have been modified to mimic unique properties of the Pt(111)-Skin. In this work we designed catalysts that can link extended single crystalline surfaces and nanoscale materials with high specific surface area, in order to lower the content of Pt in practical catalysts. Our approach has targeted the mesoscale systems, which does not only imply a specific length scale, but a principle of operation. We will present that controlling the compositional profile and surface structure of thin metal films it is possible to achieve the level specific activities that were previously observed only on single crystalline bulk materials. Moreover, durability behavior of these systems is superior if compared to Pt/C catalyst

Considering that mesoscale materials chemistry is still in its infancy, it is expected that this approach may open novel pathways in electrocatalyst design that arise from the rational control of physicochemical properties and unique functionality of mesostructured systems.

[1] Stamenkovic et al. *Science* 315 (2007) 493.
[2] van der Vliet et al. *Nature Mat.* 11 (2012) 1051.