Pt-Cu Alloys as Catalysts for the Oxygen Reduction Reaction – A Thin-Film Study of Activity and Stability

A.K. Schuppert^{a)}, A.A. Topalov^{a)}, A. Savan^{b)}, A. Ludwig^{b)}, and K.J.J. Mayrhofer^{a)}

 a) Department of Interface Chemistry and Surface Engineering Max-Planck-Institut für Eisenforschung GmbH Max-Planck-Strasse 1, 40237 Düsseldorf (Germany)
b) Faculty of Mechanical Engineering Ruhr-Universität Bochum Universitätsstrasse 150, 44780 Bochum (Germany)

In order to replace fossil and nuclear power sources by renewable energies, long-time energy storage as well as timed and localized availability are necessary requirements. Hydrogen as a chemical energy carrier can be generated during peak-times and then be utilized in fuel cells to provide electrical energy e.g. for mobile applications.¹ An approach to increase the performance of polymer electrolyte membrane fuel cells is to use alloys of Pt with non-noble metals as catalysts, which are known to have increased activity towards the oxygen reduction in comparison to pure Pt.²⁻⁴ However, the stability of these catalysts is a crucial issue and especially the conditions for e.g. dissolution are still unclear.

To address this issue, we are utilizing an electrochemical scanning flow cell (SFC)⁵ connected to an inductively coupled plasma mass-spectrometer (ICP-MS) to measure in parallel the activity of a catalyst as well as the timeand potential-resolved dissolution of all component materials.⁶ Due to the automation of the setup,⁷ we can thus easily map the performance of different material compositions under various experimental conditions. We applied this combinatorial method on a thin-film material library of Pt-Cu with a Cu content ranging from 0 at% up to 60 at%, screening the different compositions concerning their activity as well as stability.

In the present work, we show how Cu dissolution is linked to Pt dissolution, e.g. that Cu keeps dissolving when cycling above the potential limit for Pt stability.⁸ This shows that the surface is not completely depleted of Cu and passivated by Pt, but constantly faces dissolution. This phenomenon gets critically enhanced above a certain composition threshold, i.e. the parting limit of the Pt-Cu system. At this point, the Cu dissolution increases drastically and porosity formation sets in. The critical potential above the parting limit is detected, which gives an indication of the stability region of highly alloyed Pt-Cu alloys.

Literature

1. H. A. Gasteiger and N. M. Markovic, *Science*, **324**, 48–49 (2009).

2. M. Oezaslan, F. Hasché, and P. Strasser, J. *Electrochem. Soc.*, **159**, B444 (2012).

3. S. Koh and P. Strasser, J. Am. Chem. Soc., **129**, 12624–12625 (2007).

4. V. R. Stamenkovic et al., *Nat. Mater.*, **6**, 241–247 (2007).

5. A. K. Schuppert, A. A. Topalov, I. Katsounaros, S. O. Klemm, and K. J. J. Mayrhofer, *J. Electrochem. Soc.*, **159**, F670–F675 (2012).

6. S. O. Klemm, A. A. Topalov, C. A. Laska, and K. J. J. Mayrhofer, *Electrochem. Commun.*, **13**, 1533–1535 (2011).

7. A. A. Topalov, I. Katsounaros, J. C. Meier, S. O. Klemm, and K. J. J. Mayrhofer, *Rev. Sci. Instrum.*, **82**, 114103 (2011).

8. A. A. Topalov et al., *Angew. Chem. Int. Ed.*, **51**, 12713–12615 (2012).

