MS14-2-7 Real structure of magnetron sputtered Pt-based nanocrystalline thin films
#MS14-2-7

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Abstract
Due to high energy-conversion efficiency, low operation temperatures, and environmental sustainability, proton exchange membrane fuel cells (PEMFCs) are among the most promising candidates for future green-energy systems. However several drawbacks hinder its wide commercialization. A high platinum price is a serious problem. Extensive studies have been performed to find the oxygen reduction reaction (ORR) catalyst, which is more active, less expensive and more stable than pure platinum. The promising strategy is the alloying of platinum with relatively cheap transition metals. It has been reported in literature that Pt alloyed with Ni, Co and Fe enhances the electrocatalytic activity toward ORR, while simultaneously lowers the catalyst cost due to reduction of used platinum quantity.
In our work the series of Pt, Pt-Ni, Pt-Cu, Pt-Y and Pt-CeO_2 nanocrystalline films were prepared by the magnetron co-sputtering process. The microstructure and the real structure of coatings were investigated in as-deposited as well as in as-treated - after the electrochemical treatment, simulating the real function of fuel cell (accelerated durability tests), using the combination of X-ray scattering methods (X-ray reflectivity, X-ray diffraction, GISAXS), SEM, TEM/HRTEM, and in situ electrochemical AFM and XPS.
A special emphasis was focused on detailed description of the real structure of the layers – its thickness, roughness, the phase composition, size of coherently diffracting domains – crystallite size, the defects of the crystal lattice, the preferred orientation of crystallites – the texture, the presence and the magnitude of the residual stress in layers, because of its undisputable role and influence in the deterioration processes occurring during the materials operation as a cathode in the PEMFCs. The results of microstructural investigations were correlated with the activity loss, dealloying and morphological changes induced by catalysts aging processes. Our study showed that the real structure of layers has an essential influence on the deterioration processes, significantly influencing the life time of PEMFCs cathodes.

References
[1] I. Khalakhan, M. Vorokhta, P. Kúš, M. Dopita, M. Václavů, R. Fiala, N. Tsud, T. Skála, V. Matolín, Electrochim. Acta 245, 2017, 760–769
[2] R. Brown, M. Vorokhta, I.Khalakhan, M. Dopita, T. Vonderach, T. Skála, N. Lindahl, I. Matolínová, H. Grönbeck, K. M. Neyman, V. Matolín, B. Wickman, ACS, Appl. Maters. and Interfaces, Volume 12, Issue 4, 2020, 4454-4462.
[3] I. Khalakhan, M. Bogar, M. Vorokhta,P. Kúš, Y. Yakovlev, M. Dopita, D.J.S. Sandbeck, S. Cherevko, I. Matolínová, H. Amenitsch, ACS App. Maters. and Interfaces, Volume 12, Issue 15, 2020, 17602-17610.
[4] X. Xie, I. Khalakhan, M. Vorokhta, Y. Yakovlev, T. N. Dinhová, J. Nováková, P. Kúš, M. Dopita, K. Veltruská, I. Matolínová, Adv. Mater. Interfaces, 8, 2021, 2100122.