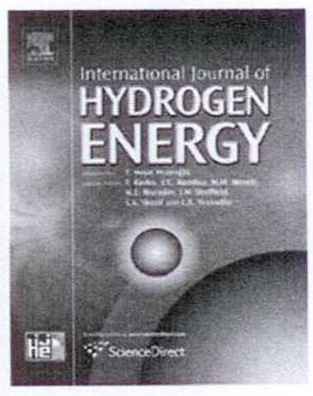
INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 37 (2012) 18556–18562

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/he



Transmission electron microscopy studies of the Pd–C films obtained by physical and chemical vapor deposition

Kamil Sobczak [a,*], *Piotr Dluzewski* [a], *Marcin T. Klepka* [a], *Boguslawa Kurowska* [a], *Elzbieta Czerwosz* [b]

[a] *Institute of Physics, PAS al. Lotników 32/46, 02-668 Warsaw, Poland*
[b] *Tele and Radio Research Institute, Ratuszowa 11, 03-450 Warsaw, Poland*

ARTICLE INFO

Article history:
Received 18 April 2012
Received in revised form
10 September 2012
Accepted 11 September 2012
Available online 6 October 2012

Keywords:
Nanoporous materials
Pd nanoparticles
Thin films
Detection hydrogen

ABSTRACT

Transmission Electron Microscopy (TEM) analysis of carbonaceous films that contain palladium nanoparticles were carried out. These layers will be used in next-generation hydrogen sensors. The investigated films were obtained in Physical Vapor Deposition (PVD) and followed in Chemical Vapor Deposition (CVD) processes. For TEM analysis, cross-sections specimen (lamella) of both samples (i.e. PVD and PVD/CVD) were prepared with the usage of Focus Ion Beam (FIB). TEM analysis of the cross-sections determined the films' thickness, which were ~200 nm and ~300 nm for PVD and PVD/CVD films respectively. The greater thickness of the PVD/CVD films was associated with xylene decomposition and consecutive formation of porous structure. Our studies allowed to obtain some information about the distribution of palladium crystallites and porous carbon in the both layers of Pd–C.

Furthermore, aggregation of small (~2 nm) Pd nanocrystallites around the larger ones was observed for PVD and PVD/CVD films. In the PVD/CVD films a polycrystalline palladium have been observed.

1. Introduction

The increased interest in films that contain metallic palladium crystallites embedded in a carbonaceous matrix is caused by the rapid development in the field of hydrogen-based energy sources. As a result, many new methods of obtaining hydrogen have been developed. Hydrogen can now be obtained in many new processes, not only in standard chemical methods such this [1] but also in the alternative ones, that is: alternative nuclear energy [2], geothermal energy [3,4], reaction based of aluminum/sodium [5], wind energy [6] or even energy from living organisms such as *Citrobacter freundii* [7]. Everything indicates that hydrogen will become one of the most important energy sources after the exhaustion of oil reserves. Hydrogen and its compounds are already widely used in many areas of technology, for example: in Haber–Bosch process – the nitrogen fixation [8], in food industry – hydrogenation [9].

The hydrogen and its compounds are not only used in the industry, but also needed to be monitored in science.

* *Corresponding author*. Tel.: +48 22 843 66 01; fax.: +48 22 843 09 26.
E-mail addresses: ksobczak@ifpan.edu.pl (K. Sobczak), dluzew@ifpan.edu.pl (P. Dluzewski), mklepka@ifpan.edu.pl (M.T. Klepka), kurowska@ifpan.edu.pl (B. Kurowska), elzbieta.czerwosz@itr.org.pl (E. Czerwosz).
0360-3199/$ – see front matter
http://dx.doi.org/10.1016/j.ijhydene.2012.09.073