The influence of thermal annealing on the topography and structure of carbon nanocomposite films containing palladium nanograins

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Summary: In this paper we present studies of an influence of an annealing process on a topography and morphology of nanocomposite carbonaceous film containing Pd nanograins. These films were obtained by PVD method and modified by deposition of DLC layer. Topographical and morphological properties of such films studied by SEM while applying two SEM modes ; SE and LABE. Changes due the temperature growth in topography of carbon matrix and in sizes of Pd grains were found.

Keywords: carbonaceous-palladium films, PVD method , DLC films

Introduction

The synthesis of Pd nanoparticles and their properties attract attention because of their application in many devices such as hydrogen sensors and hydrogen storage systems.

Hydrogen is stored interstitially in the octahedral vacancies of fcc-Pd nano-crystalline material with the possibility of an anisotropic lattice expansion in [111] and [100] directions [1]. Formation of $PdH_{0.706}$ due to hydrogen charging leads to an expansion of the lattice constant to 0.4049nm instead of 0.3906nm in bulk-Pd [2].

Pd nanoparticles may be obtained in many ways such as PVD method, CVD method or decomposition of organometallic precursors.

In this paper we present method for preparation of Pd nanograins placed in carbonaceous films. Such films can be obtained on various substrates and can be used in many applications.

Results

Carbon nanocomposite films containing palladium nanograins (NC films) were obtained by physical vapor deposition method. These films were obtained on Si substrate covered with diamond-like carbon layer. The topography and morphology of these films were studied by SEM and AFM methods. These films are of low surface roughness and palladium nanocrystals are disperse in their volume. Our previous TEM studies showed that size of palladium nanocrystals are between 2 and 8 nm depending on the PVD process parameters [3]. In Fig. 1 SEM image of NC film is presented. White objects seen in this image are fullerite nanograins.

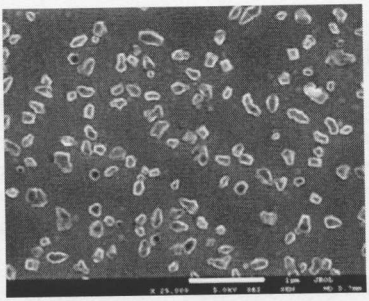

Fig.1. SEM image of NC film

Thermal annealing of such films lead to the modification of film topography and to agglomeration of small nanocrystals of palladium into a bigger objects protruding from the film surface. These effects are important because of the superficial properties of such films and affect on the film sensitivity toward hydrogen.

In Fig. 2a,b SEM images in SE (secondary electron) and LABE (low angle backscattered electron) modes are shown.

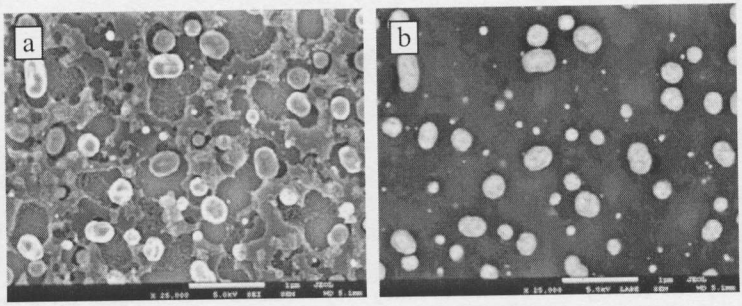

Fig 2. SEM image of NC film after annealing in a) SE mode and b) LABE mode

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References

[1] Toshiro Kuji, Yoshihito Matsumura, Hirohisa Uchida, Tatsuhiko Aizawa, Hydrogen absorption of nanocrystalline palladium, J. Alloys and Compounds, 330-332 (2002) 718-722

[2] J.E. Worsham, M.K. Wilkinson, C.G. Shull. Neutron-Diffraction observations on the Palladium-Hydrogen and Palladium-Deuterium Systems, J. Phys.Chem. Solids Vol. 3 (1957) 303-310

[3] M.Kozłowski, R.Diduszko, K.Olszewska, H.Wronka, E.Czerwosz, Nanostructural palladium films for sensor applications, Vacuum , 82 (2008) 956-961