Properties of the carbon-palladium nanocomposites studied by Raman spectroscopy method

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ABSTRACT

In this paper, the results for thin carbon-palladium (C-Pd) nanocomposites obtained by PVD (Physical Vapour Deposition) and PVD/CVD (Chemical Vapour Deposition) method, carried out using Raman spectroscopy method are presented. Studies reveal the dominance of fullerene-like structure for PVD samples and graphite-like structures for CVD samples. The type of substrate and metal content have great impact on spectra shapes.

Keywords: carbon-palladium nanocomposites, fullerene, Raman spectroscopy,

1. INTRODUCTION

The carbon-palladium (C-Pd) nanocomposites with the carbon matrix made from fullerenes or nanoporous graphite-like carbon materials are a promising object of studies as they are likely to be used in hydrogen sensors and containers. It is connected with fact, that both carbon nanostructure and palladium has uncommon ability to absorb hydrogen [1-4]. This analysis is focused on hydrogen sensors based on composites containing nanoclusters of palladium. In that case metal nanograins are obtained from palladium compounds which significant reduces costs.

The Pd nanograins embedded in carbon-based matrix look especially promising. Such structures are obtained using e.g. a Physical Vapour Deposition method (PVD) from the precursors in the form of fullerene and palladium acetate and then can be optionally modified in CVD process [5-7]. Due to the catalytic properties of palladium, its presence may have a significant influence on the structure of the deposited carbon matrix. The aim of this article is to analyse the structure of the obtained carbon-palladium nanocomposites using the Raman spectroscopy method.

2. RAMAN SPECTROSCOPY OF CARBON NANOMATERIALS

Raman Spectroscopy (RS) is a non-invasive method of studying the molecular structure of compounds and chemical substances basing on the inelastic scattering of a photons [8-9]. The Raman spectrum is an appropriately converted energy distribution of photons scattered in an inelastic way by the sample. The energy of scattered photons depends on the energy of the exciting photons, while the energy difference (the so-called Raman shift) is generally independent from this parameter and represents the energy of molecule oscillation.

The Raman spectroscopy was selected for studying carbon-palladium nanostructures because of its popularity for characterising various types of carbon materials. Carbon structures can be characterized taking into consideration the hybridization type of carbon atoms included in them [10]. The sp^3 hybridization is characteristic of structures where particular atoms are connected by single bond of σ type which applies to diamond-like carbon structures, that is diamond, DLC or lonsdaleite [11-13]. On the other hand, sp^2 hybridisation, distinguished with the presence of π bonds, is characteristic of graphite-like carbon structures, such as Highly Ordered Pyrolitic Graphite (HOPG), nanocrystalline graphite, pyrolitic graphite, glassy carbon, as well as carbon nanotubes and graphene [14-19]. There are also structures characterized with the presence of both phases, e.g. carbon nanofoams [20].

In the Raman spectrum of carbon, there are bands derived from graphite-like phases [21-28]. The presence of π bonds leads to increasing the changes of polarizability in the presence of oscillations, and consequently the Raman signal of