Investigations of Raman Spectroscopy of C-Pd films for hydrogen sensor application

J.Kęczkowska[1], M. Suchańska[1], E.Czerwosz[2]

[1] Kielce University of Technology, al. 1000–lecia P.P. 7, 25-314 Kielce, Poland, *e-mail: j.keczkowska@tu.kielce.pl*
[2] Tele &Radio Research Institute, 11 Ratuszowa, 03-450 Warsaw, Poland

Abstract

The work presents the results of Raman studies of carbon nanofilms containing Pd nanostructural films.

Experimental setup

The technology of obtaining C-Pd thin films by a two-phase method (PVD/CVD) was developed in the Tele & Radio Research Institute in Warsaw (Poland). In the first step of the process (PVD method) the films constituting the matrix for structures obtained in the second step (CVD method) are created. Details of technological process are described in [1–3]. Schema of CVD reactor are shown in Fig. 1. In the first zone the maximum temperature was of 180° C (T_1). In zone II temperature changes between 500 and 750° C (T_2).
The molecular structure of films was studied by using Raman spectroscopy (Nicolet Almega XR spectrometer, excited with 532 nm line). The spectra were recorded in the range from 100 to 4000 cm^{-1}. The beam of a relatively small power, equal to 0.25mW, was focused in the area of 1µm x 1µm by using the microscopic lens x50.

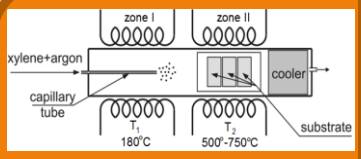

Fig.1. Schema of experimental CVD set-up

Fig.2. Raman spectrometer Nicolet Almega XR

Raman study

PVD samples

The typical Raman spectra of PVD samples are presented in Fig. 3.
The spectrum is not similar to the fullerene spectrum. It may be related to the greater degree of structure deformation. However, for each spectrum it is possible to isolate all 10 modes observed in C_{60} fullerene in every spectrum [4].

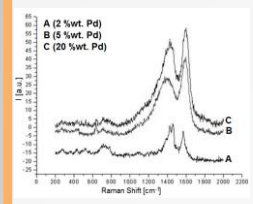

Fig.3. Raman spectra of C-Pd films with different contents Pd (%wt) obtained in PVD method

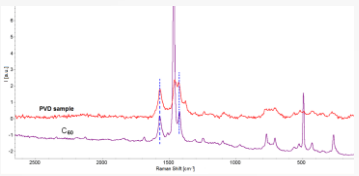

Fig. 4. Raman spectra of C-Pd films obtained in PVD process

Project deteH

C-Pd films containing Pd nanocrystals can be applied as active layers in proposed gas sensor applications. Sensing process by C-Pd film:

1. **H_2 is catalysed by Pd to atomic hydrogen**
2. **Atomic hydrogen is absorbed into Pd film**
3. **Resistance of film changes due to formation of PdH_x**

A new sensor of hydrogen and its compounds prepared within the deteH Project.

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CVD samples

In the Raman spectra of samples obtained:

- **at lower process temperatures (500, 550 and 600°C), characteristic C_{60} fullerene spectra can be found [4].**
- **in 600°C the additional G and D bandwidths are observed, characteristic for amorphous graphite [5]. This can prove existence of both fullerene and amorphous carbon in the carbonaceous matrix.**
- **at higher temperatures of CVD process (>600°C), bandwidths with peaks at about 1350 cm^{-1} and 1585 cm^{-1} are observed. These bandwidths are identified to be D and G.**
- **The increase of process temperature (T_2) facilitates degradation of C_{60} fullerene.**

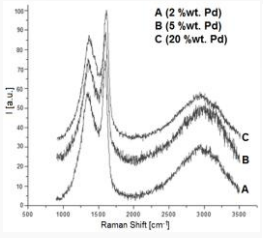

Fig.5. Raman spectra of C-Pd films with different contents Pd (%wt) obtained in CVD method

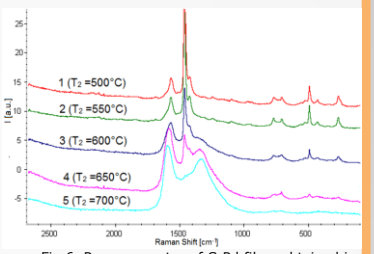

Fig.6. Raman spectra of C-Pd films obtained in CVD process (various temperatures T_2)

References

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