

Optical properties of C-Pd films prepared on silica substrate studied by UV-VIS-NIR spectroscopy

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ABSTRACT

In this paper some optical properties of carbonaceous-palladium (C-Pd) thin films investigated using UV-VIS-NIR spectroscopy method are presented. Transmittance and reflectance spectra were measured in 200-3200 nm region. The shape of the spectra were depended on allotropic form of carbon (fullerene) matrix. The refractive coefficients and film thickness of studied materials has been determined based on Thin Film Interference and “envelope” methods. The optical band gap values were also estimated from absorption spectra using Tauc plot extrapolation. The results are in good agreement with experimental data obtained by spectroscopic ellipsometry.

Keywords: C-Pd film, fullerene, UV-VIS-NIR spectroscopy, Thin Film Interference, Tauc gap.

1. INTRODUCTION

Carbonaceous-palladium nanostructures (C-Pd) have been interesting materials both from scientific and practical points of view. This material can be useful for gas detection, in particular hydrogen detection [1-4]. One of the simple technology to produce such nanocomposites is Physical Vapour Deposition method (PVD), where C₆₀ fullerene and palladium acetate are used as a carbon and palladium sources respectively [5-6]. In effect, C-Pd nanocomposites are obtained, where palladium nanograins are embedded in carbon (fullerene) matrix. Due to the Pd content the material is hydrogen active and can be characterized by a change a some electrical and optical properties during of H₂ presence [4,7].

There have been many experimental and theoretical studies of physico-chemical properties of C-Pd layer performed using electron microscopy, X-ray diffraction and optical spectroscopy methods [8-13] as well as Effective Medium Theory and method of single expression analysis [14-15]. Performed Raman studies indicate a fullerene type of carbon matrix in considered films [10-11]. It has also been found that the presence of several percent of metal content results a clear modification of the Raman spectra of the C₆₀ fullerene. These changes are probably caused by intermolecular covalent bonds formation in fullerene in the Pd presence. Preliminary spectrometric measurements suggest the semiconducting properties of the C-Pd films. An ellipsometric studies [13] also indicate the presence of free carriers in the C-Pd films with a high metal content, which in turn results in the electrical conductivity. The mentioned above features of high transparency and electrical conductivity make the C-Pd as interesting material for optoelectronic applications (including photovoltaic industry) as transparent conductor.

In this paper, the analysis of optical properties of C-Pd layer deposited on silica substrate has been presented. Values of refractive, extinction and absorption coefficients and also optical band gap and film thickness have been estimated based on transmittance and reflectance spectra.

2. CALCULATION OF OPTICAL PARAMETERS OF THIN FILMS

Optical spectroscopy is well-known fundamental measurement technique used in the characterization and analysis of the optical properties of thin films [16]. Measurement of transmittance (absorbance) and reflectance spectra allows to obtain some important information regarding the value of the refraction (n) and absorption (α) coefficients as well as the presence of absorption centers, making the method useful for physical and chemical analysis. However, the