Properties of carbonaceous-palladium hydrogen sensor

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ABSTRACT

In this paper we present studies of hydrogen sensors based on nanostructural C-Pd films deposited on alundum substrate with silver or titanium electrodes. These C-Pd films were prepared by PVD method. Films were characterized by SEM and EDS. Sensitivity of films toward hydrogen were measured in specially prepare experimental set-up with small chamber (50ml). Response time was also registered for different percentage of hydrogen / nitrogen mixture (up to 1% of hydrogen).

Keywords: carbonaceous-palladium films, hydrogen sensor, titanium electrodes, silver electrodes

1. INTRODUCTION

Hydrogen has long been known to adsorb and dissociate spontaneously on group VIII transition metals like palladium (Pd) and its alloys [1,2] and it was applied in a solid state form as hydrogen sensor [3]. Carbonaceous-palladium (C-Pd) materials were also used for the detection of hydrogen [4, 5]. To produce a fast, reversible and sensitive hydrogen detector nanostructured C-Pd films are used. In these films palladium is in the form of nanograins embedded in a carbonaceous matrix [6,7]. Carbonaceous matrix is used to stabilize the palladium atoms in the form of nanograins which do not aggregate into large grains. Depending on the PVD process parameters C-Pd films are composed of Pd nanograins with sizes ranging from 2 to 10 nm. These nanograins are embedded in a carbonaceous matrix, which is generally in the form of an amorphous carbon mixed with fullerite grains. The hydrogen sensing mechanism is based on the changes of resistance of the films in the presence of hydrogen due to a formation of hydrogen and palladium in the form of a solid solution (at low concentrations of hydrogen) or palladium hydride (at high concentrations of hydrogen). After removal of hydrogen from the environment, these compounds decompose and the process can be repeated in several cycles. Such hydrogen sensor does not require heating to return to its initial state [8]. The agglomeration of palladium particles is also not observed [9].

However, a number of problems related to the assembly have to be solved in order to application of such hydrogen sensors. One of these problems is a content, kind and deposition of electrodes on the substrate. Such electrode should assure a good contact to the films and it cannot react with the film.

Titanium and silver electrodes are used in many electronic solutions. Titanium anodes, like silver electrodes, have many advantages (are stable in terms of shape – they do not diffuse, have long-life, are not soluble in carbon, can improve the current density and they are resistant to corrosion). In contact with carbonaceous-palladium film, unexpected phenomena may occur, however it is a new problem and not described in literature.

In this paper we compare the results of hydrogen sensing measurements for C-Pd films deposited on alundum substrate with silver and titanium electrodes. We present the results of the influence of the electrode type on the sensitivity and response time of the C-Pd films in the presence of H_2/N_2 mixture. Our research shows that the type and preparation method of the electrodes affect sensing characteristics.

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