Abstract

Metallic materials reversibly absorb hydrogen in recent years, are gaining interest in both the scientists and the industrial sector in the context of the broadly developed hydrogen economy. It is expected that hydrogen will be a long-term solution to ensure a secure energy future and eventually largely replace traditional fossil fuels. However, for this to be possible it is necessary to develop new materials and systems allowing to increase the productivity of hydrogen conversion into electricity while maintaining high safety standards. Hydrogen-based methods are clean and safe, as the only by-product of its combustion or conversion to electricity is water.

The main applications of metallic materials for reversible hydrogen storage materials are: hydrogen storage, hydrogen batteries, but also hydrogen sensors in hydrogen-powered devices or smart (switchable) mirrors in electronics. In the case of hydrogen storage, magnesium is the most studied material, mainly due to its low cost. In the case of hydrogen sensors and smart mirrors, materials are sought that provide faster hydrogen absorption kinetics and higher light transmittance coefficients.

This PhD thesis presents the results of research on the reversible absorption of hydrogen in thin-film systems based on two rare earth metals, yttrium and gadolinium. The use of a strong correlation of changes in optical transmission and the resistance of rare earth metals during hydrogen absorption is the basis for using them as materials for sensors or smart mirrors. However, in many cases it is necessary to increase and optimize the hydrogen absorption kinetics. This can be accomplished by using an additional, very thin catalyst layer in a rare earth metal/palladium system. As a result of this work, thin-film Y/Pd and Gd/Pd systems were prepared and studied, also a very thin layers of Ti and Ni were used to create Y/Ti/Pd and Gd/ Ni/Pd systems showing significantly faster hydrogen absorption kinetics. Using X-ray photoelectron spectroscopy, the alloying effect in the area of the interfaces of individual layers was investigated in detail, which allowed to present the mechanisms responsible for increasing the kinetics of hydrogen absorption in these systems. The obtained results confirmed the significant role of the additional Ti and Ni catalytic layer in increasing the kinetics of hydrogen absorption in the Y / Ti / Pd and Gd / Ni / Pd three layers. The alloying effect at the interface of the optically active layer (Y or Gd) and the additional catalytic layer also turned out to be

important. Using additional Ti layer allowed to tailor the optical properties of the Y layer, to obtain a more color-neutral state (constant transmittance in the visible range).

Research results presented in the doctoral thesis extend the current state of knowledge on hydrogen absorption in layered structures based on yttrium and gadolinium. Moreover, the obtained results can be used to create new hydrogen-absorbing thin-film systems characterized by faster hydrogen absorption kinetics, high transmittance and repeatability of the hydrogenation process at room temperature.

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