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Study of Hydrogen Sorption in Mg-Pd-Nb nano-oxide alloys

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Abstract – The aim of this work is to study the sorption and desorption kinetics and storage capacity of hydrogen in magnesium alloys (Mg-Pd and Mg-Pd-Nb nano-oxide). The alloys were cold rolled and ball-milled to produce nanocrystalline alloys.

Metal hydrides are promising candidates for hydrogen storage material used for energy application. However, to reach commercial utilization, many problems such as resistance to impurities and stability under cycling, must be solved. Magnesium and magnesium-based alloys are widely investigated as hydrogen-storage materials due to their high hydrogen storage capacity and low weight. To improve the sorption kinetics, different methods of synthesis have been investigated, for example additions of various catalysts and cold rolled materials [1].

In this work the effects of the addition of Pd and Pd-Nb nano-oxide were investigated on cold rolled and ball-milled magnesium alloys. Prior to and after hydriding, the samples were analyzed by means of x-ray diffraction (XRD), scanning electronic microscopy (SEM) and differential scanning calorimeter (DSC). The absorption and desorption kinetics were analyzed using pressure-composition isotherms (PCI) obtained with a Sievert's apparatus. At first, the recrystallization kinetics (Fig. 2) was determined by DSC, in order to establish a maximum temperature for the other experiments and prevent loss of properties of the cold rolled samples.

The palladium has a high hydrogen diffusivity and solubility and for this reason has been used as a promising catalyst in the magnesium based alloys. It was observed that the addition of palladium improves the hydrogen absorption kinetics, although the Pd is found as agglomerate and not finely dispersed in the Mg matrix (Fig. 1). An embrittlement behavior is observed when Nb nano-oxides are dispersed in the Pd matrix, which leads to a better distribution of this composite in the Mg matrix, improving even more the hydrogen uptake kinetics.

Cold rolled alloys produce a high density of dislocations and vacancies that can improve the sorption kinetic. In addition to this, the manipulation of the samples can be performed without a glove box with an inert gas because the oxide formation is very slow when compared with the magnesium powder.

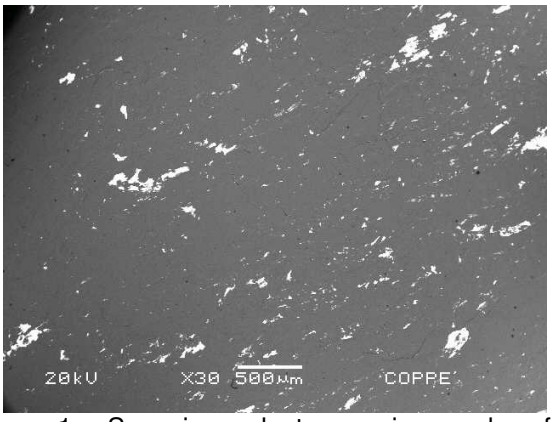

Figure 1: Scanning electron micrographs from backscattered electrons of Mg–Pd 2.5 at.%. The white marks are palladium particles.

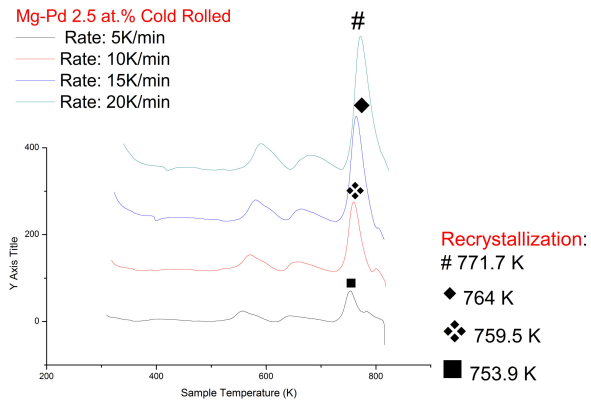

Figure 2: Differential Scanning Calorimeter (DSC) of Mg-Pd 2.5 at.% cold rolled for different rates.

[1] J. Dufour and J. Huot. Journal of Alloys and Compounds, 439, L5–L7 (2007).