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Effect of cold rolling on hydrogen storage behavior of BCC and Mg-based alloys

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Abstract – The effect of repetitive cold rolling on magnesium and titanium-based BCC alloys on hydrogen storage properties have been investigated. Rolling of magnesium with 2.5 at.% of palladium leads to a materials that is easier to activate (first hydrogenation) and has a better air resistance that the same composition synthesized by ball milling (Fig. 1). In the case of BCC alloys, rolling induce a preferred orientation in the crystal structure (Fig. 2). Unfortunately for titanium-based BCC rolling, as ball milling, seems to have a detrimental effect on hydrogen capacity. Other magnesium-based and titanium-based BCC alloys are discussed and possible mechanisms explaining the effect of rolling will be discussed.

Recently, various methods of severe plastic deformation techniques such as repeated cold rolling (CR) equal channel angular pressing (ECAP) and high pressure torsion (HPT) have been applied to process hydrogen storage alloys, mainly magnesium and magnesium-based alloys but also alloys with body-centered-cubic (BCC) structures. In the present work, we investigated the effect of multiple cold rolling on the hydrogen sorption properties of titanium-based BCC solid solution and magnesium. We found that when pure magnesium is mixed by cold rolling with 2.5 at.% of palladium the first hydrogenation is much faster than the same composition mixed by ball milling [1]. Moreover, the laminated sample has better air resistance that the milled counterpart (Fig.1). Results of Mg-Pd, Mg-Ni, and commercial magnesium alloys will also be presented. In the case of titanium-based BCC we first studied the parent alloy $TiCr_2$. We found that, unlike ball milling, cold rolling of $TiCr_x$ (x = 2, 1.8, 1.5) did not lead to the formation of metastable BCC phase. Cold rolling was found to be effective to form nanocrystalline $TiCr_x$ alloys. Hydrogen absorption and desorption experiments showed that cold rolled and ball milled alloys have similar hydrogen sorption properties despite their different crystal structures. The composition $TiV_{1.6}Mn_{0.4}$ was also studied [3]. For this alloy, rolling produced a reduction of crystallite size and lattice parameters but no change in the crystal structure. However, the rolled alloy is highly textured as seen in fig.2. Unfortunately, after rolling the alloy could not absorb hydrogen. Therefore, it seems that rolling could have a beneficial or detrimental effect according to the alloy crystal structure and composition.

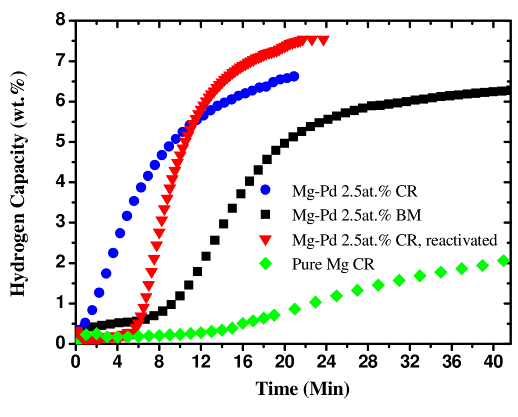

Figure 1: Activation curve of ball milled Mg-Pd2.5at.%, cold rolled Mg-Pd2.5at.%, and cold rolled pure magnesium. Activation temperature 623K, pressure 1.3 MPa. CR=Cold Rolled, BM = Ball-milled.

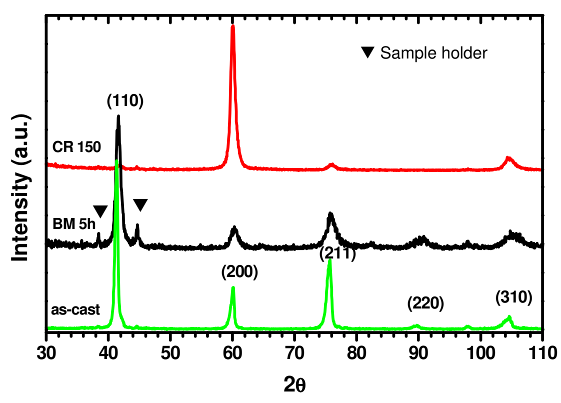

Figure 2: X-ray powder diffraction patterns of $TiV_{1.6}Mn_{0.4}$ after casting, after ball milled for 5 hours (BM 5h), and after 150 cold rolls (CR150). Miller indices of each Bragg peak is indicated.

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