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Encapsulation of $La_{1.5}Mg_{0.5}Ni_7$ nanocrystalline hydrogen storage alloy with Ni coatings and its electrochemical characterization

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Abstract

Nanocrystalline $La_{1.5}Mg_{0.5}Ni_7$ alloy has been synthesized by mechanical alloying and heat treatment (850^{o}C) and a 20 - 50 μm fraction of its particles has been encapsulated with three kinds of Ni-based coatings: (i) electroless Ni-P, 1 μm thick, (ii) magnetron sputtered Ni, 0.087 μm thick and (iii) magnetron sputtered Ni, 0.29 μm thick. The electrochemical charge/discharge multicycling of powder composite electrodes has been carried out in view of material potential usefulness for Ni/MH_x batteries. The nanocrystalline $La_{1.5}Mg_{0.5}Ni_7$ alloy exhibits four times lower capacity fade as compared to a microcrystalline $LaNi_5$ reference compound. Modification of $La_{1.5}Mg_{0.5}Ni_7$ particle surface with comparatively thick layer of electroless Ni-P coating deteriorates electrode corrosion behavior and worsens kinetics of hydrogen electrosorption due to unsatisfactory adhesion of the coating to the Mg-containing substrate. Corrosion protection of the $La_{1.5}Mg_{0.5}Ni_7$ nanomaterial by magnetron sputtered Ni films depends on average film thickness. Relatively thick (0.29 μm) sputtered Ni film limits corrosion degradation and stabilizes exchange current density of H_2O/H_2 system. Particle modification by Ni encapsulation does not affect the hydrogen diffusivity. Effective diffusion coefficient of hydrogen for $La_{1.5}Mg_{0.5}Ni_7$ nanocrystalline material, irrespectively of surface modification, is close to $2 \cdot 10^{-10}$ $cm^2 s^{-1}$.