Project HC-10. Fabrication of hydrogen storage alloys and composites employing vapor deposition technologies

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The general conclusions of our work at the end of 2003 are as follows:

– thin film hydrogen storage materials, based on alanates as the most promising materials corresponding to the targets of the Project, were synthesized employing physical vapor deposition and hydrogenation by plasma technologies;

– further advances are required for these materials to achieve their practical application in low-power micro fuel cell energy devices.

The specific conclusions are as follows:

1. Physical vapor deposition technologies exhibit promising features for the production hydrogen storage thin film materials as follows:
   - strict control of composition,
   - fabrication of nanocrystalline materials,
   - low temperature synthesis of hydrides.

Thin films of Mg, Al and AlMg have been fabricated and their plasma hydriding behaviors in hydrogen has been investigated.

2. Syntheses of alanates AlH_x (x = 1-3) and $Mg(AlH_4)_2$ were investigated in two stages: (i) during the vapor phase deposition of Mg and Al atoms in the reactive hydrogen plasma, and (ii) employing technology of hydriding of deposited Mg, Al and AlMg films with hydrogen ions extracted from $(Ar+H_2)$ plasma irradiation. Experimental results show that there is the window of experimental parameters (substrate temperature and intensity of hydrogen ion irradiation) for the synthesis of alanates. $Mg(AlH_4)_2$ compounds were registered in AlMg films under high flux hydrogen ion irradiation at temperatures about 370 K.

At temperatures above 400K the first step of decomposition of $Mg(AlH_4)_2$ takes place as $Mg(AlH_4)_2 \rightarrow MgH_2+2Al+3H_2$.

3. The X-ray reflections of the synthesis products indicated that the alanates produced employing physical vapor decomposition technologies are nanocrystalline material with a mean grain size of 30-40 nm.

4. Plasma hydriding proved to be an efficient method for saturation of thin films with hydrogen atoms. This method is promising and can be considered for practical applications after further studies of the hydriding and dehydriding properties in accordance to industrial requirements.

5. The disadvantage of the use of thin films as storage material is the short life of adherence of films to the substrate. The changes of the material volume during hydriding tend to lift the film from the substrate.

6. The role of surface barrier layer (oxides) has to be considered.

7. Focus of the future work has to be (i) the fabrication of thin nanocrystalline films for hydrogen storage on flexible substrates to avoid film debonding effects; (ii) the hydrogenation of thin film hydrogen storage materials employing plasma immersion hydrogen ion implantation technology to increase the efficiency of the hydriding.