Substitutional Effect of Cr and Ti on Hydrogen Desorption from Mg_2Ni-Based Alloy

LI Fa-bing, JIANG Li-jun, DU Jun, WANG Shu-mao, LIU Xiao-peng, ZHAN Feng
(Institute for Energy Material Science and Technology, General Research Institute for Nonferrous Metals, Beijing 100088, China)

Abstract: Mg_2Ni alloys have been synthesized through the solid state diffusion method. The effect of substitutions of Cr for Ni and Ti for Mg on hydrogen storage properties was studied. In the case of $Mg_2Ni_{0.8}Cr_{0.2}$, $Mg_{1.8}Ti_{0.2}Ni_{0.8}Cr_{0.2}$, the desorption pressure increased after the substitutions of Cr for Ni and Ti for Mg. The hydrogenation properties of Mg_2Ni can be improved by tailoring the effect of cell volume using Cr and Ti elements.

Key words: solid state diffusion; hydriding/dehydriding; Mg-based hydrides
CLC number: TG139.7 Document code: A Article ID: 0529-6579 (2007) Sl-0250-02

1 Introduction

Mg and Mg-based alloys as hydrogen-storage materials have been carried out intensively worldwide because of the high storage capacity. However, the high dissociation temperature and slow reaction kinetics limit its practical application[1−2]. Mg_2Ni alloy has relatively high hydrogen storage capacity (3.6% H_2 as Mg_2NH_4) and lower desorption temperature than MgH_2[3]. Here we developed the solid state diffusion method[4−6] and investigated the effect of substitutions of Cr for Ni and Ti for Mg in Mg_2Ni on hydrogen desorption properties.

2 Experimental Procedures

The magnesium, nickel, titanium and chromium powder (>99% purity, 200 mesh), corresponding to a composition of Mg_2Ni, $Mg_2Ni_{0.8}Cr_{0.2}$ and $Mg_{1.8}Ti_{0.2}Ni_{0.8}Cr_{0.2}$, were ground in a crucible by hand for 1 h. The mixture was cold pressed into pellets under a pressure of 30 MPa. The pellets were sintered at 873 K under argon atmosphere in a stainless steel furnace for 5 h, then were crushed to powders below 200 mesh in air.

3 Results

3.1 Microstructure change

The X-ray spectrum of Mg_2Ni-based alloys before and after the solid state diffusion was shown in Fig. 1.

Solid state diffusion produces a single Mg_2Ni phase. All the peaks of raw materials disappear, which indicates that the element chromium and titanium solution-ize in Mg_2Ni. The stable hexagonal structure after substitution implied that Ti probably held the atom position of Mg and Cr took up the Ni atom position. Substitution of Cr for Ni resulted in an increase of the unit cell constant and volume for $Mg_2Ni_{0.8}Cr_{0.2}$ because the atom radius of Cr is bigger than that of Ni. The unit cell constant and volume of $Mg_{1.8}Ti_{0.2}Ni_{0.8}Cr_{0.2}$ slightly decreased comparing with that of $Mg_2Ni_{0.8}Cr_{0.2}$ because the atom radius of Ti was less than that of Mg, but still was bigger than that of Mg_2Ni.

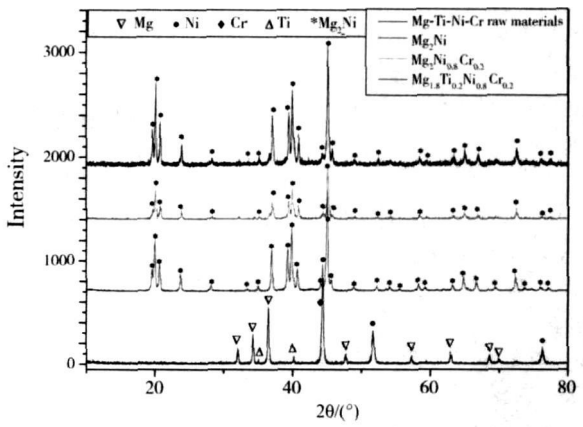

Fig. 1 The X-Ray diffraction pattern of Mg_2Ni-based alloys

①收稿日期: 2007-01-10
基金项目: 国家 "863" 计划资助项目 (2006010521001)
作者简介: 李法兵 (1974年出生), 男, 博士研究生, 工程师; E-mail: lfbm@yahoo.com.cn
(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

3.2 Hydrogen storage properties

The powder sample weighed 0.5 g was put into the reactor, pumped for 30 min, then heated to 573 K for activation. The first hydriding rate was slow, taking more than 1 h fully hydrided under a hydrogen pressure of 5.0 MPa. The second and third absorptions were faster. After five absorption-desorption cycles, the hydriding/dehydriding capacity and rate remained almost same. The dehydriding Pressure-Composition-Temperature curves at 529 K were shown in Fig. 2. The desorption plateau pressure of Mg_2Ni, $Mg_2Ni_{0.8}Cr_{0.2}$ and $Mg_{1.8}Ti_{0.2}Ni_{0.8}Cr_{0.2}$ was respectively 1.08, 1.136 and 1.321 atm at 529 K. Substitution of Ti for Mg and Cr for Ni increased the desorption equilibrium pressure, slightly decreased the hydrogen storage capacity and inclined the plateau zone at the same time.

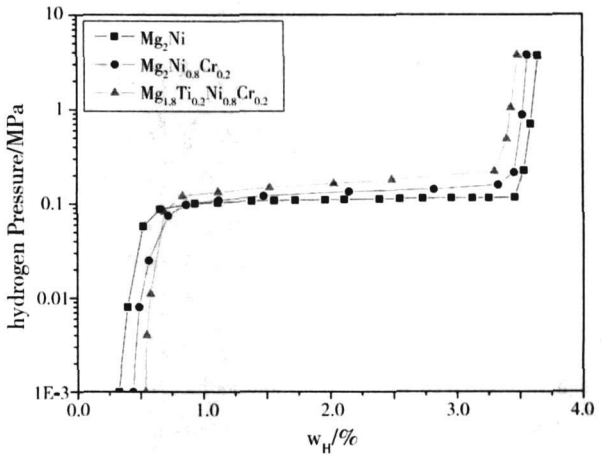

Fig. 2　Dehydriding PCT curves of alloys prepared by the solid solid diffusion method Mg_2Ni-based alloys at 529 K

References:

[1] SCHLAPBACH L, ZUTTEL A. Hydrogen storage materials for mobile applications [J]. Nature, 2001, 414: 353.

[2] ZUTTEL A. Materials for hydrogen storage [J]. Materials Today, 2003, 6: 24.

[3] REILLY J J, WISWALL R H. Reaction of hydrogen with alloys of magnesium and nickel and the formation of Mg_2NiH_4 [J]. Inorg Chem, 1968, 7: 2254—2256.

[4] REILLY J J, WISWALL R H. Reaction of hydrogen with alloys of magnesium and copper [J]. Inorg Chem, 1967, 6: 2220—2223.

[5] SB J. Dispersion strengthened supperalloys by mechonical alloying [J]. Met Trons, 1970, 8: 2943.

[6] TN, AI, KM. Hard magnetic propertions of Nd-Fe-B alloy powders prepared by mechanial alloying [J]. J Mater Scilett, 1989, 8: 13.

Cr和 Ti的元素替代对 Mg_2Ni基合金放氢性能的影响

李法兵，蒋利军，杜　军，王树茂，刘晓鹏，詹　锋

(北京有色金属研究总院能源材料研究所，北京 100088)

摘　要：应用扩散烧结工艺合成出 $Mg_2Ni_{0.8}Cr_{0.2}$和 $Mg_{1.8}Ti_{0.2}Ni_{0.8}Cr_{0.2}$合金，Cr和 Ti对 Mg_2Ni合金 A侧和 B侧的替代均导致放氢平衡压力升高。Mg_2Ni基合金的储氢性能可以通过元素替代改变晶胞体积来加以改善。

关键词：固态扩散；吸氢/放氢；镁基氢化物

中图分类号：TG139.7

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved.　http://www.cnki.net