In Situ Analysis for Cracking of Alloys in Charge-Discharge Processes by Acoustic Emission Method

Hiroshi Inoue, Ryosuke Tsuzuki, Tadahito Nakashima,
Shinji Nohara, and Chiaki Iwakura

Department of Applied Chemistry, Graduate School
of Engineering, Osaka Prefecture University,
Sakai, Osaka 599-8531, Japan

Introduction

A negative electrode mainly made of hydrogen storage alloy in nickel-metal hydride battery absorbs and desorbs hydrogen in charge and discharge processes, respectively. The volume expansion due to the hydrogen absorption leads to the cracking of the alloy particles. In the end of charge process or overcharge, hydrogen evolution displaces the hydrogen absorption. The structure change of the hydrogen storage alloys with the electrochemical reactions influences battery performance such as initial activation, cycle life and so on. Therefore, in situ analysis of the structure change is important, but there have been only a few researches.[1]

Acoustic emission (AE) method is a nondestructive one detecting elastic waves given by materials when they crack. The adhesion of an AE sensor with a material is enough to detect the cracking. We can basically obtain three kinds of data, i.e. rate of event, power spectrum and AE wave form, and from these data we can get information about when and how materials crack. In this study, the AE method was used for analyzing the change in structure of alloy electrodes on the way of charge and discharge processes.

Experimental

Hydrogen storage alloy with the composition of $MmNi_{3.6}Mn_{0.4}Al_{0.5}Co_{0.7}$ was prepared by arc melting. Pellet-type negative electrodes were prepared by cold-pressing the mixed powders of the alloy (106-125 μm) and Cu (mass ratio of alloy to Cu=1) at 2 MPa. An AE sensor was stuck on the back side of the alloy pellet and rate of event, power spectrum and AE wave form were measured during charge and discharge processes, respectively. The electrode was charged at 100 mA $g(alloy)^{-1}$ for 3h and discharged at the same current density to –0.6 V vs. Hg/HgO after resting for 10 min.

Results and Discussion

Figure 1 shows the change in rate of event with time in the first charge process. As soon as the charge process began, AE signals came to be detected. The rate of event was high in the former part of the charge process, but it began to decrease after 1 h.

Figure 2 shows the change in power spectrum with time in the first charge process. In the beginning of the charge process, AE signals with a wide range of frequency were detected. The AE signals with higher frequencies almost disappeared after 2 h, while those with lower frequencies still remained.

Figure 3 shows the change in AE wave form with time in the first charge process. In the beginning of the charge process, AE signals showed a burst-type decay that was characteristic of the cracking. After 2 h, the burst-type decay changed to a continuous one that was characteristic of gas evolution.

These results demonstrated clearly that in the beginning of the charge process the alloy cracked in some large pieces, and then each piece still cracked in smaller pieces. In the end of the hydrogen absorption, hydrogen evolution was dominant.

Reference

1. P.H.L.Notten, J. L. C. Daams, R.E.F. Einerhand, *J. Alloys Comp.*, **210**, 233 (1994).

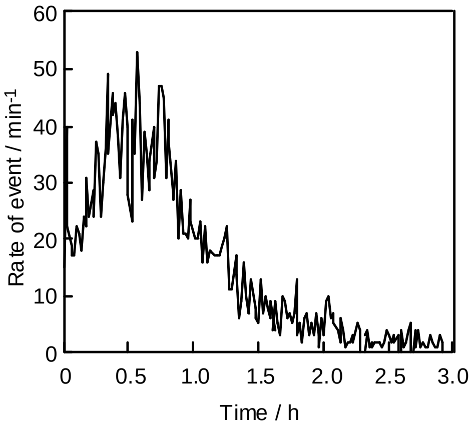

Fig. 1 Change in rate of event with time in the first charge process.

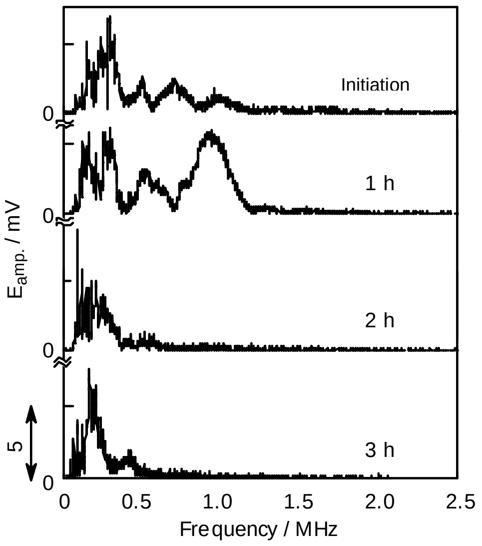

Fig. 2 Change in power spectrum with time in the first charge process.

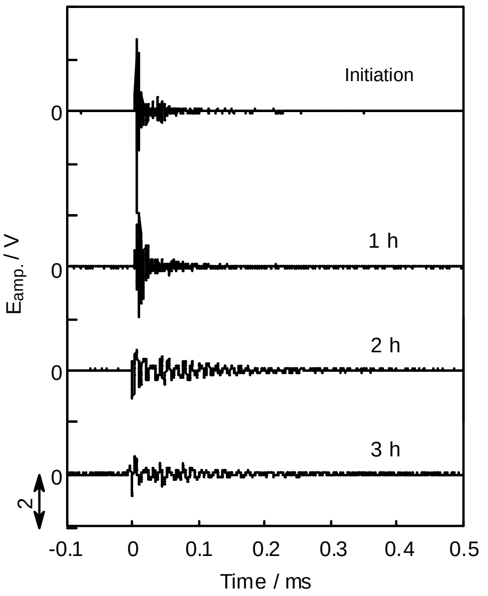

Fig. 3 Change in AE wave form with time in the first charge process.