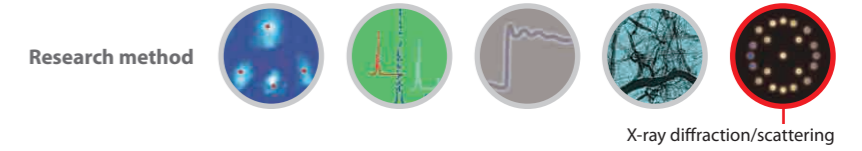


Improvement of Capacity of Nickel-Metal Hydride Battery

Clarification of the optimal composition of the electrode



Beamline used at SPring-8: Engineering Science Research I (BL19B2)

Award for this research: The 7th Hyogo SPring-8 Award (2009)

Achievements

- Clarification of the relationship between the crystal structure of electrode materials used in **nickel-metal hydride batteries*** and changes in the discharge capacity with repeated charging and discharging
- Optimization of the composition of the alloys in the electrodes, and development of a product with at least 20% increased discharge capacity

R&D facility: GS Yuasa Corporation

***Nickel-metal hydride battery:** A type of secondary battery that can be reused after charging. This type of battery is characterized by the use of environmentally friendly hydrogen storage alloys (metal hydride that stores hydrogen atoms in the interstitial position of its crystals) without the use of lead or cadmium. Nickel-metal hydride batteries are used in various devices, such as cameras, PCs, and mobile phones, because their energy density is higher than that of Ni-Cd batteries.

Role of SPring-8

Background

The discharge capacity of nickel-metal hydride batteries depends on the reaction rate of hydrogen storage by the anode alloy and on the amount of hydrogen reversely released from the alloy (amount of hydrogen storage). Therefore, hydrogen storage alloys based on various new elements are being actively studied. In particular, **La-Mg-Ni-type alloys** are drawing much attention. However, La-Mg-Ni-type alloys, which can store a very large amount of hydrogen, have a disadvantage in the sense that their performance deteriorates with repeated charging and discharging. To optimize their composition, it is necessary to clarify their crystal structure, but conventional methods were unsatisfactory to observe the crystal structure, which contains various stacking structural phases.

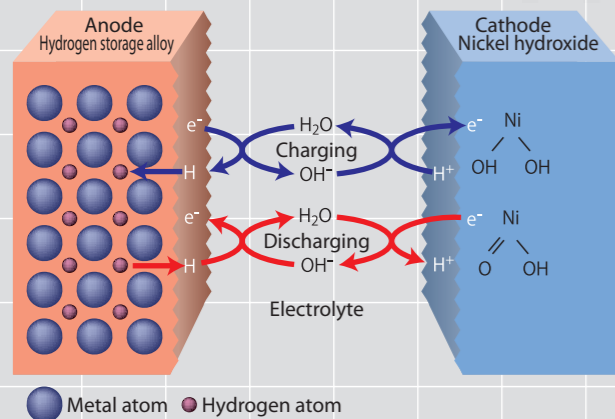
Results

By observing La-Mg-Ni-type alloys by X-ray diffraction using the synchrotron radiation of SPring-8, it was clarified how the various crystal structures of the alloy, which contains various elements, change depending on the percentage of the metals added (manganese and aluminum). Moreover, we analyzed the discharge capacity and changes in the performance due to repeated charging and discharging for different crystal structures. We found the optimal crystal structure that can maintain high capacity in a stable manner from among the various possible phases. From the above result, we successfully obtained guidelines for designing electrode materials.

Publication: T. Ozaki et al.; Journal of Alloys and Compounds **446-447**, 620-624 (2007) T. Ozaki et al.; ITE Letters **8**(4), B24 (2007)

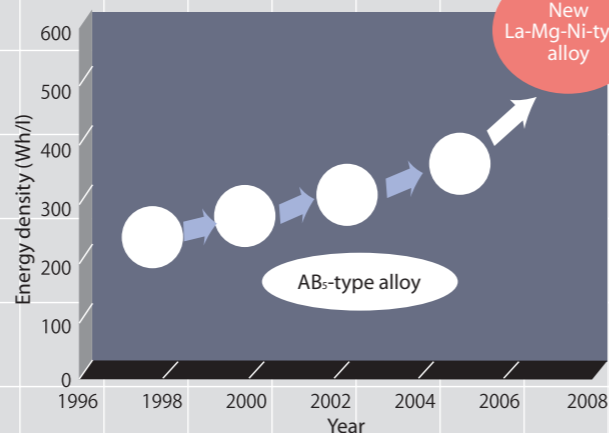
Principle of nickel-metal hydride battery

Nickel hydroxide and a hydrogen storage alloy are used as the cathode and anode, respectively. Hydrogen atoms move from the hydrogen storage alloy towards the nickel hydroxide cathode during discharging.



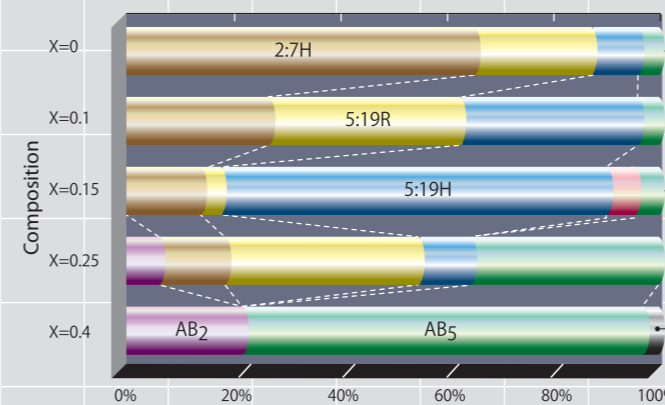
Change in energy density in AA-sized nickel-metal hydride battery

Battery performance depends on the quality of the hydrogen storage alloy used as the anode material, and its improvement has been promoted. The discharge capacity of a battery that uses a rare earth-nickel-based alloy (AB₅-type alloy) as the anode material is at least 85% of the theoretical value; therefore, the further improvement of the capacity is difficult.



Phase structure of La_{0.8}Mg_{0.2}Ni_{3.4-x}Co_{0.3}(MnAl)_x alloy

The crystal structures of alloys are dependent on the percentage of the manganese and aluminum added, (MnAl)_x. In particular, at x=0.15, Mn and Al substitute specific Ni sites that are sandwiched between rare-earth elements, leading to the stabilization of a 5:19 phase.



Relationship between number of repetitions of charging and discharging and discharge capacity

The discharge capacity of the alloy that contains a large amount of the 5:19 phases (x=0.15) hardly decreases even with repeated charging and discharging. This is because the degree of expansion and contraction due to the absorption and release of hydrogen, respectively, is small in the 5:19 phase.

