

**P10****Positive plate morphology changes during cycle life testing of gelled-electrolyte VRLA batteries**

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Gelled-electrolyte valve-regulated lead–acid (VRLA) batteries have the advantage of low gassing and high performance in deep-cycle applications but during cycling the structure of the positive active material ( $\text{PbO}_2$ ) changes, and this could limit cycle life.

This change in morphology of the positive active material during charge–discharge cycling with different charging currents has been observed in VRLA batteries. A charge–discharge cycling test has been carried out on two battery modules, each composed of six series-connected cells. The nominal capacity of the cells was 200 A/h at the C/10 rate.

The discharge current was the C/5 rate to 100% depth of discharge and the charging voltage was 2.4 V per cell, with the maximum current set at 40 or 20 A.

Every fifty cycles, one cell from each module was disassembled, to analyze the composition and morphology changes to the positive electrode using XRD and SEM. After 300 cycles, the changes in morphology of the positive active material were different, depending on the charging current and the location of the electrode. The sulfate, formed in the early stages of the cycling test, was converted to lead dioxide with cycling. The morphology of the active material under the higher charging current was observed to be well structured, and this could give rise to a longer cycle life.

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**P11****A new lithium-ion battery system with a remarkably high capacity**

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Lithium-transition metal hydrides represented by the formula of  $\text{Li}_{3-x}\text{M}_x\text{N}$  have been studied, particularly  $\text{Li}_{2.6}\text{Co}_{0.4}\text{N}$ , as active materials for negative electrodes in lithium-ion cells.

$\text{Li}_{2.6}\text{Co}_{0.4}\text{N}$  has a large reversible capacity of 700 mA h  $\text{g}^{-1}$  when compared with carbon as the active material for negative electrodes. On the other hand, lithium nickel oxide ( $\text{LiNiO}_2$ ) also has a large reversible capacity of 180 mA h  $\text{g}^{-1}$  as a positive active material in comparison with  $\text{LiCoO}_2$  when used in a conventional lithium-ion battery.

This new lithium-ion battery system, employing  $\text{LiNO}_2$  and  $\text{Li}_{2.6}\text{Co}_{0.4}\text{N}$ , has a remarkably large capacity, owing to the multiplying effect of replacing both positive and negative electrodes with new, superior, types. This new system can provide double the capacity of the conventional carbon/ $\text{LiCoO}_2$  lithium-ion system.

This battery provides an average voltage of about 3.0 V, which is lower than that of the conventional type; however, the energy density is improved remarkably owing to the large capacity of the electrodes.

The electrochemical behaviour of  $\text{Li}_{2.6}\text{Co}_{0.4}\text{N}$  as a negative electrode, and the behaviour of trial batteries have been evaluated. As a result, not only the larger capacity but also the superior rate performance and good cycling ability have been demonstrated.

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**P12****Studies of nanocrystalline AB<sub>2</sub> alloys for nickel/metal hydride batteries**

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Due to the booming demand for mobile telephones and portable computers, intensive study is being conducted on nickel/metal hydride (Ni/MH) batteries, especially in order to reduce the weight of the alloys in the negative electrode. So, it would be extremely interesting to discover alloys with higher mass capacities, as this would mean batteries with better performances.

In the work presented here, we attempted to lighten an industrial alloy by partially substituting zirconium with magnesium. Magnesium was introduced in the AB<sub>2</sub> alloy

via mechanical alloying and thermal treatments. Monophased Zr-based alloys containing substantial amounts of magnesium were obtained. A planetary ball mill was used and different milling times and rotational speeds of the discs and vials were considered. Different heat treatments were also studied. The alloys were characterized by XRD, EPMA, SEM and TEM. A special effort was given to the TEM analysis, as the alloys obtained were nanocrystalline. It was observed that the alloys were actually grains of micron sizes made up of agglomerated nanocrystallites. Hydrogen absorption isothermal curves and kinetics were measured at different temperatures. Electrochemical measurements were also performed. The properties were then related to the structural and morphological observations. It was shown that nanocrystallinity could enhance the activation rate of the alloys as well as their absorption kinetics. However, the introduction of magnesium into these alloys did not improve their mass capacities.

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### P13

#### **Advanced nickel/zinc batteries for consumer and mobile applications**

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This poster discusses rechargeable nickel/zinc battery development for both small size consumer cells and mobile applications such as electric bicycles, electric scooters

and hybrid and electric vehicles. Nickel/zinc battery performance has been improved through the development of a reduced solubility zinc electrode and a patented sealed cell design. Deep cycle capability has been increased to 700 cycles while maintaining a high specific energy up to  $70 \text{ W h kg}^{-1}$ . Battery cost has been reduced through the use of patented plastic-bonded nickel and zinc electrodes. Cycle life performance has been improved by the use of a reduced solubility zinc electrode and a unique patented sealed cell design. The nickel/zinc battery represents the next technological plateau to replace lead-acid batteries for many applications. Nickel/zinc can also replace environmentally unacceptable nickel/cadmium and costly nickel/metal hydride batteries with a safer, more energetic and less expensive system. This patented nickel/zinc technology is currently being licensed to several commercial entities for a variety of applications.

The nickel/zinc system is ideal for mobile applications such as electric bicycles and scooters, electric and hybrid vehicles. The nickel/zinc battery, with a specific energy greater than  $60 \text{ W h kg}^{-1}$ , is capable of providing a vehicle range of 200 km total energy cost of 3 to 4 cents/km for a 25 kW h battery that would cost about US\$4000.00 in large-volume production. Other battery systems currently under development for electric vehicles are focused on technologies that are either too expensive, too heavy or contain environmentally undesirable materials. The nickel/zinc battery will provide electric vehicles with sufficient range and economy to satisfy most vehicle requirements. Several demonstration electric vehicles have been tested with 12 kW h batteries and additional programmes are currently underway.

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