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13th PSI 'Tagessymposium Elektrochemische Energiespeicherung'

On July 2, 1997, the 13th PSI 'Tagessymposium Elektrochemische Energiespeicherung' was held at the Paul Scherrer Institute in Villigen. The meeting was attended by over 60 participants from universities and industries including participants from Germany and Austria. The symposium was dedicated to batteries and fuel cells for electric vehicles. Due to the increasing pollution in urban regions new clean energy conversion and storage systems are urgently needed for public and individual transport systems. Electrochemical storage (batteries) and conversion (fuel cells) systems are important components for these transport systems.

After the welcome by Prof. Dr. *A. Wokaun*, head of the General Energy Research Program at PSI, Dr. *O. Haas*, PSI, gave an overview of the electrochemical research at PSI. He showed the results of the 200 and 700 W membrane fuel cell stack built at PSI and mentioned the high energy density of the Zn/air and Li-ion battery systems the PSI is working on. With rechargeable Zn/air batteries a specific energy between 60 and 120 Wh/kg can be reached and with Li-ion batteries 100 Wh/kg could also be demonstrated. He then presented some data of the supercapacitor stack with which up to now a power density of 17.4 kW/l could be reached. Its specific energy, however, is much lower than the one in batteries. *O. Haas* pointed out that Zn/air and Li-ion batteries as well as a hybride system containing fuel cells and supercapacitors would be an attractive solution to be used as a power source for electric vehicles.

Dr. *P. Urban, Daimler-Benz AG*, Ulm, spoke about 'Membran-Brennstoffzellen für die Elektrotraktion' and impressed the audience with the results of the fuel cell program *Daimler-Benz* and *Ballard Power Systems*, Canada, are working on. A life time of more than 5000 h at constant power could be demonstrated with this system. A 40 kW stack with a specific power of 740 W/kg was built for Neckar II (fuel cell powered minivan) where the whole fuel cell system had a specific power of 170 W/kg. The minivan is fuelled with compressed hydrogen. For a practical application, however, the fuel should rather be methanol or hydrocarbon. This means that an on-board transformation by steam-reforming or by a partial oxidation process would be necessary. For this option, however, the catalyst should work in presence of some CO residues. Together with *Johnson Matthey*, *Daimler-Benz* is, therefore, developing new catalysts based on Pt/Ru which have a CO tolerance of up to 100 ppm. The efficiency of the fuel reformer process should be *ca.* 85%.

Dr. *H. H. Schönfelder, VARTA Batterie AG*, Kelkheim, spoke about 'Lithiumionen-Batterien für Elektrofahrzeuge'. In the framework of the USABC program (United States Advanced Battery Consortium) *VARTA* is developing together with Duracell a 40 kWh Li-ion battery system for electric vehicles. This consists of cells with a capacity of 65 Ah with a specific energy of 110 Wh/kg and a specific power of 500 W/kg for 30 s and *ca.* 50 W/kg for continuous power. *VARTA* could already demonstrate 600 cycles with these modules, where the negative electrode is a carbon Li insertion electrode and the positive a $LiMnO_2$ electrode. Dr. *Schönfelder* thinks that it will be possible to increase the specific energy up to 170 Wh/kg. With these batteries it would be possible to drive an electric car for *ca.* 350 km before the battery would have to be recharged.

In the afternoon session Dr. *H. Böhm, AEG Anglo Batteries GmbH*, Ulm, spoke about 'Die ZEBRA-Batterie, Hochenergiebatterie für Elektrostrassenfahrzeuge'. The ZEBRA battery is working with liquid Na as the negative electrode and $NiCl_2$ as the positive electrode material whereas (β-alumina and $NaAlCl_4$ melt are used as electrolyte system. The battery works at *ca.* 300° and is kept at this temperature with a sophisticated thermal insulator. The high temperature is a disadvantage, but it has also some advantages since the large ΔT offers a much more compact cooling system at high power. In the last year the specific power of the battery could be increased by a factor of two with the introduction of slim line monolith cells with which the internal resistance of the cell could be decreased considerably. ZEBRA batteries have already a very advanced state and could be tested in more than 100 cars. A cycle life of up to 1700 cycles could be reached, which means that one battery could be used for more than 100000 km. The specific energy of the whole system including insulation and cooling system is 87 Wh/kg, for 30 s the battery can deliver 220 W/kg. At a 12 h charge and 5 h discharge rate the battery has an energy efficiency of 91% which is really considerable. *AEG Anglo Batteries* would like to lower the price of the battery to near 500 DEM/kW.

In the last presentation of the afternoon session, Dipl.-Ing. *R. Nast, TÜV Automotive GmbH*, Garching, spoke about 'Zink/Luft-Batterie, Feldversuch der Deutschen Post'. *TÜV Automotive GmbH* Garching tested the Zn/air battery system developed by *Electric Fuel Ltd. (EFL)*, Israel. In this system the Zn electrodes have to be replaced mechanically to recharge the battery and the Zn electrode is regenerated by an external electrochemical Zn deposition process. The system has a very high specific energy (more than 200 Wh/kg), but its cycle energy efficiency is not as good as it is for the electrically rechargeable Zn/air battery developed at PSI. However, the large specific energy of the mechanically rechargeable Zn/air battery offers the possibility to drive more than 400 km, which was tested by the German post with the *Opel Corsa Combo*. Such a vehicle powered by the Zn/air battery has already successfully crossed the Alps.

As a conclusion of the symposium, it was obvious that the presented batteries and fuel cell systems advanced considerably. The specifications which are necessary for electric vehicle applications can now be reached. However, in most systems considerable price reduction has to be achieved to penetrate in the marke and only mass production can help to overcome these difficulties.

The documentation handed out at the symposium can be obtained from Ursula Grütter at PSI (Phone +41 56 310 29 19, E-Mail: ursula.gruetter@psi.ch).

Otto Haas
Paul Scherrer Institut
Electrochemistry Section

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