Ultrafast lead-acid battery with nanostructured Pb and PbO_2 electrodes

Rosalinda Inguanta[1]
Maria Grazia Insinga[1], Roberto Luigi Oliveri[1], Carmelo Sunseri[1]

[1] Laboratorio di chimica Fisica Applicata, Dipartimento dell'Innovazione Industriale e Digitale, Università degli studi di Palermo, Viale delle Scienze ed. 6, Palermo, Italy

Contact@E-mail: rosalinda.inguanta@unipa.it

Lead-acid batteries (LABs) are still extensively used in the field of energy storage, owing to a well-known and reliable technology. LABs can deliver high power and store energy for a very long time. In addition, they are reliable and easy to produce. The raw materials for their manufacture are practically unlimited, and about 95% of the materials can be recovered and reused. However, the lower specific energy storage (about 30-40 Wh kg^{-1}), in comparison with other storage systems, limits their use in the most emerging and challenging applications, like electrical mobility, due to the high atomic weight of lead [1]. One of the principal limitations in the use of LABs in electric vehicles (EV) is related to the inadequacy of the negative plates in accepting high charge/discharge currents. Besides, LABs operate in EVs at high rate partial state-of-charge, which leads to rapid sulphation of the negative plates.

Many approaches were proposed in order to overcome these problems and make LABs suitable for emerging applications. A possible approach is based on electrodes with nanostructured active materials, which are progressively emerging as an alternative to the conventional plates because their high aspect ratio and consequent high superficial area allow to fabricate LABs with high specific energy and power density.

We have developed template electrodeposition as an easy and direct technique for fabrication of nanostructured electrodes, with very large active area, consisting of PbO_2 and Pb [2-3]. Both active materials (Pb and PbO_2) were electrodeposited using a nonporous template to obtain the regular arrays of nanowires shown in Figure 1, well attached to a compact film of the same material, acting as a current collector and mechanical support of the nanostructures.

Nanostructured PbO_2 and Pb electrodes were assembled and tested using aqueous 5 M H_2SO_4 solution in a zero gap configuration, and was discharged up to 90% of the gravimetric capacity to a cut-off voltage of 1.2 V.

In comparison to commercial LABs, which usually deliver about 30 mAh/g for only 15-20 cycles at 1C rate, our batteries are able to charge and discharge at very high rate without fading up to 1500 cycles with a cycling efficiency of about 90%. Besides, nanostructured electrodes show better performances without time-consuming curing and formation process. These performances are attributable to their large surface area (about 70 times higher than the geometrical one), leading to a new LAB with high specific energy and power density. Another interesting finding is the ability of our batteries to be cycled up to 30C [4].

References

[1] D. Pavlov, P. Nikolov, J. Electrochem. Soc. 159 (2012) A1215-A1225.

[2] C. Sunseri, S. Piazza, R. Inguanta et al. International Patent, WO/2012/117289.

[3] A. Moncada, M.C. Mistretta, S. Randazzo, et al. J. Power Sources 256 (2014) 72-79.

[4] A. Moncada, S. Piazza, C. Sunseri, R. Inguanta, J. Power Sources 275 (2015) 181-188

Figures

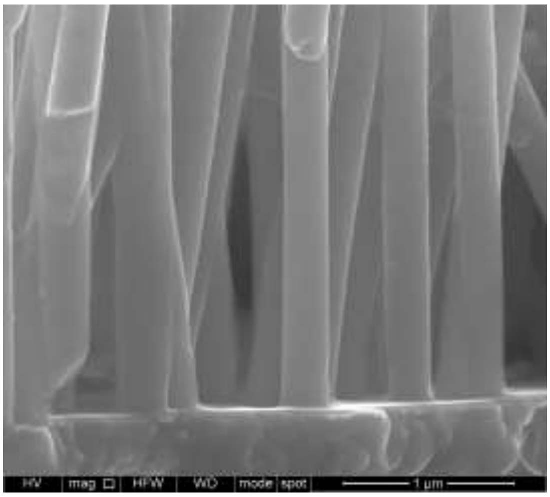

Figure 1. Cross-Sectional view of PbO_2 nanowires