Nanostructured negative electrodes for rechargeable lithium batteries

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In a recent work we showed the high and long cycle capacity together with the high rate capability of Si[1] and Ge[2] nanostructured anodes. In these materials, the volume expansion that accompanies lithium alloying doesn't lead to the particles decrepitation as known to occur in bulky powders. We attributed these results to the lithiumshort diffusion path, which reduces the strain field within the nanoparticles and allows fast alloying and de-alloying.

Nanostructured electrodes based on a single layer element (Ge, Sb, Sn, Au and Co) or double layer elements (Co + Ge) were obtained by vapor deposition. The electrodes were used in Li/EC-DMC-$LiPF_6$ based coin cells. The later were cycled between 0 mV and 1500 mV under different C-rates.

The cycle capacity of the single deposited layer electrodes is showed in figure 1. The Ge based electrode gives the highest and stable capacity under C/4 rate, whereas the Sn and Sb electrodes have poor cycling as the capacity dropped dramatically after a few cycles, probably due to particles size effect.

Noteworthy is the relatively high capacity achieved with nanostructured Au (~ 250 mAh/g). This corresponds to ? x of about 1.84 in the Li_xAu composition variation. Au forms a series of phases with lithium including Au_5Li_4, $AuLi_3$ and Au_4Li_{15}[3]. The latter should yield a capacity of 510 mAh/g.

Co shows lower yet stable cycle capacity (<100 mAh/g). The lack of alloying with Li at ambient temperature may explain such behavior[4].

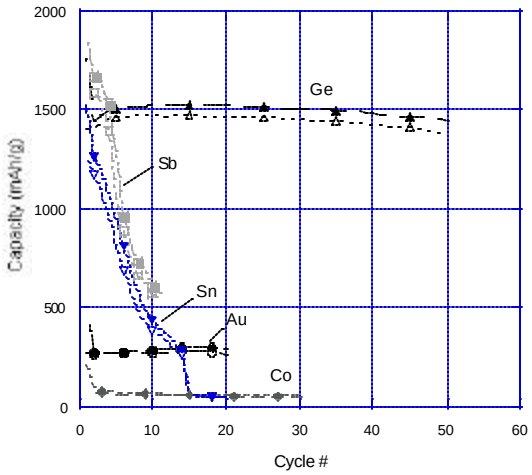

Figure 1: cycle capacity of single element nano-structured electrodes under C/4 rate.

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[2] J. Graetz et al. J. Electrochem. Soc. 151(2004)A698
[3] A. D. Peleton, Bull. Alloy Phase Diagrams, 7(1986)228
[4] Binary Alloy Phase Diagrams, 2nd ed. T. B. Massalkski, H. Okamoto, P. R. Subaramanian and L. Kacprzak, ed. ASM International, Materials Park, OH, 1201, 1203-1204 (1990)