

# SURFACE INVESTIGATION OF AMORPHOUS SI THIN FILMS CYCLED AS ANODES FOR LI-ION BATTERIES

Giulio Ferraresi<sup>a</sup>, Lukas Czornomaz<sup>b</sup>, Petr Novák<sup>a</sup>, Claire Villevieille<sup>a</sup>, Mario El Kazzi<sup>a</sup>

<sup>a</sup> Paul Scherrer Institut – Electrochemical Energy Storage Section – CH-5232 Villigen PSI, Switzerland

<sup>b</sup> IBM Research-Zürich – Säumerstrasse 4 – CH-8803 Rüschlikon, Switzerland

giulio.ferraresi@psi.ch

The search for alternative negative electrodes to replace graphite in Li-ion batteries is ongoing. So far, silicon is one of the most promising candidates due to its availability and its high theoretical specific charge of ca. 4200 mAh g<sup>-1</sup> (up to 4.4 Li per Si), the highest value among the already known candidates. However, its commercial application is still very limited because of its large volume change upon lithiation (up to 300%) and its low electronic conductivity [1]. To overcome those issues, one can both decrease the thickness of the electrodes, thus increasing the cycling stability, and also insert a dopant to enhance the conductivity. Moreover the investigation of Si thin film can be of great interest for the application in all-solid-state Li-ion batteries.

In this context, we investigated amorphous Si thin films deposited by sputtering or chemical vapour deposition techniques on two different substrates: copper and titanium. Those thin films, which can also be doped to increase their conductivity, were electrochemically characterized in test cells vs. Li metal (Figure 1a-b). Remarkable results were obtained for the thin films prepared by chemical vapour deposition on copper substrate which show high stability and reversible specific charge of ~ 4000 mAh g<sup>-1</sup> after 30 cycles. After 500 cycles more than 50% of the initial specific charge was maintained. The surface evolution during the early stages of lithiation and delithiation was probed by scanning electron microscopy (SEM) and in-house x-ray photoelectron spectroscopy (XPS). Combining ex situ XPS characterization analysis (Figure 1c) with post mortem SEM surface morphology we were able to develop a model describing the mechanism behind the SEI evolution as well as the Li-Si alloy reaction.

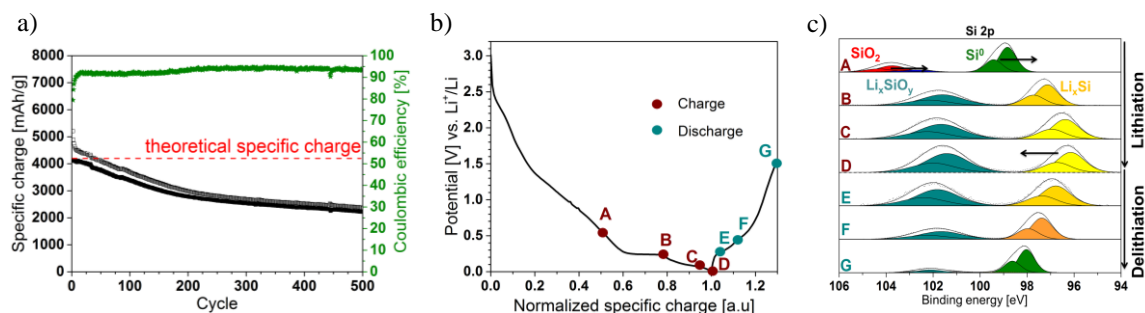


Fig. 1 - a) Cycling stability of Si thin films cycled vs. Li at 1C rate; b) Galvanostatic profile of the first cycle of Si thin films in LP30 electrolyte; c) Evolution of the XPS Si2p core level during first lithiation and delithiation.

## References:

1. J.O. Besenhard, J. Yang, M. Winter, J. Power Sources 68 (1997) 87