STRUCTURED SILICON ANODES FOR LITHIUM BATTERY APPLICATIONS

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Pillars arrays fabricated on silicon substrates have been tested as potential anodes for on-chip lithium batteries. The pillars are required to be sub-micron in diameter and high packing density, e.g. 0.4. We have used the novel, inexpensive, technique of Island Lithography to fabricate such structures. The electrode behaviour of pillar arrays whose characteristics are, diameter=580nm±150nm; fractional surface coverage=0.34; height=810nm, are reported here. Cyclic voltammetry and cyclic galvanostatic tests of alloying/de-alloying of electrochemically produced lithium with silicon were carried out, and results correlated with SEM studies. Aerial current densities in the low and fractional $mAcm^{-2}$, and voltage 25mV to 2V (vs. L/Li^{+}) were used. CV features correspond to various Zintl phase compounds (ZPC). Structured electrodes of Si pillars maintained their structural integrity throughout the cycling; planar Si electrodes showed cracks (2 micron features) after 50 cycles. A model is advanced in which lithium diffuses through a layer of ZPC to react with Si: growing ZPC plastically deforms where necessary. Upon lithium de-alloying vacancies coalesce to form voids at the ZPC/Si interface, Si rejoins the substrate, or precipitates out as nano-crystalline material, and the voids appear as a fine pattern of cracks, looking like dried mud. The extra surface area that a pillar structure can confer on Si electrodes is essential and makes it practical to consider the possible eventual use of such anodes in integrated battery structures.