Electrochemical performance of USPLD prepared Silicon anode electrodes

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Introduction

Secondary battery materials are in great demand of research and new high energy density materials are required for higher quality of batteries[1]. Silicon based anode is one of the most promising anode material for Li-ion batteries, because it has high theoretical capacity (4200 mAh/g, lithiated to $Li_{4.4}Si$) and low operating voltage (~0.3V versus Li/Li^+) [2,3]
Problems are capacity fading at first cycle and poor cycle performance.

Experimental

Si layers on copper foil were produced by Picodeon's ultra-short pulsed laser deposition (USPLD) technology. This technology utilizes pulsed lasers with pulse lengths in the picosecond range and high pulse repetition rates (MHz). The pulsed laser beam is delivered to the surface of the target, which is placed inside a vacuum chamber, through a scanner and a telecentric lens. With this beam delivery approach a focused scan line can be produced on the target. Material is removed by the laser pulses from the target material, and movement of the substrate through the material cloud generated by this line source enables straightforward deposition of uniform layers even on larger surface areas.
Cells with USPLD prepared Silicon anode and LiNi0.5Co0.2Mn0.3O2 cathode were prepared in humidity controlled dry room. Cathode thicknesses controlled to have different specific capacity for the silicon anode material. Different type of electrolytes and testing parameters tested to achieve better electrochemical results for USPLD silicon anodes.

Results and discussion

Results show that electrochemical testing parameter and materials used in tests have great influence on the electrochemical performance of silicon anode materials. Especially additives in electrolyte seems to have great influence on the cycle performance of silicon based anode material. Results also show that silicon material should not charge full, instead 1500mAh/g show much better electrochemical properties. Results also clarify problems with half-cell and full-cell tests.
We have demonstrate that USPLD prepared 10µm thick 100% silicon anode layer can replace 50µm graphite layer in Li-ion cell. Total energy density is higher for silicon-NCM cell than graphite-NCM cell for hundred cycles. Problem is poor cycle performance compared to graphite anode; however, results show that it is possible to improve properties by electrolyte additives and limiting charging capacity. Silicon based anode material is a good candidate for the next generation Li-ion battery.

References:

1. J.W Choi and D. Aurbach (2016) *Nature rewiew materials 1. (*2016) 16013
2. R.A Huggins (1999) Journal of Power Sources, Vol 81-82, pp.13-19
3. Hui Wu, Yi Cui (2012) Nanotoday, Vol 7, issue 5, pp 414-429

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