Large Surface Area Graphene-Si anodes for Li-ion Batteries

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Nanoscale materials are increasingly being pursued as electrochemically active materials for improving the rate of lithium insertion and extraction in batteries. Silicon is one of the most promising anode materials for lithium-ion batteries due to its very high theoretical capacity of 4200 mAh/g.[1] However, its large volume change during charge-discharge cycling with lithium usually results in material cracking and deterioration, leading to capacity fade. The combination of silicon with carbon coatings and CNTs is an active area of research, as carbon can act as a buffer for the volumetric changes of Si during cycling. Graphene offers an excellent advantage over other materials due to its high theoretical specific surface area of 2600 $m^2 g^{-1}$ and good electrical conductivity.[2]

The focus of this study was to combine multilayer graphene with laser deposited silicon films as the active anode material. Graphene layers were deposited on to a porous nickel substrate by chemical vapor deposition, using methanol as a liquid precursor. This was followed by the deposition of silicon, in high-vacuum, using pulsed laser deposition (PLD) from a crystalline silicon target, at 248 nm with a KrF excimer laser. This material combination was directly fabricated into an anode and tested in a half-cell configuration.

The optimized Si-graphene films display stable cycle life, and show a significant increase in specific capacity (factor of 4 to 5) relative to graphite. The combined effects of silicon and graphene on electrochemical performance will be discussed. Electrochemical cycling results will be presented for PLD Si films and PLD Si-on-graphene films. Extensive characterization of these materials using FESEM, cross-sectional TEM, Raman spectroscopy, and chemical analysis will be discussed to provide insight into the film properties and cycling performance.

References

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2. M.D. Stoller, S. Park, Y. Zhu, J. An, R.S. Ruoff, *Nano Lett.*, 8, 3498 (2008).