Novel Nano-Silicon / SiOC Composites as Anode Material for Li-Ion Batteries

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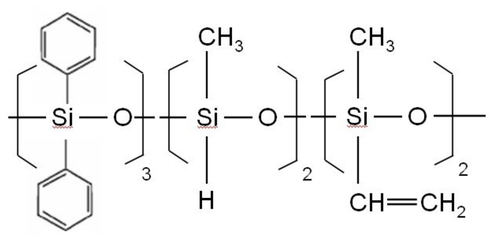
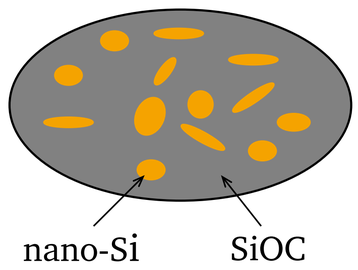
Synthesis



Polyramics RD-684a, Starfire Systems Inc., USA

+ nano-Si, (30-50 nm) 15, 25, 33 wt-%

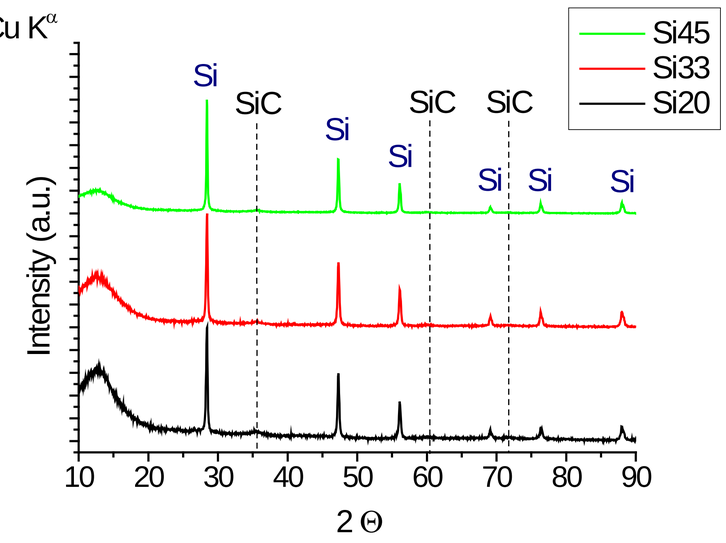
Nanostructured & Amorphous Materials Inc., USA



Crosslinking (400 °C, 3h, Ar)

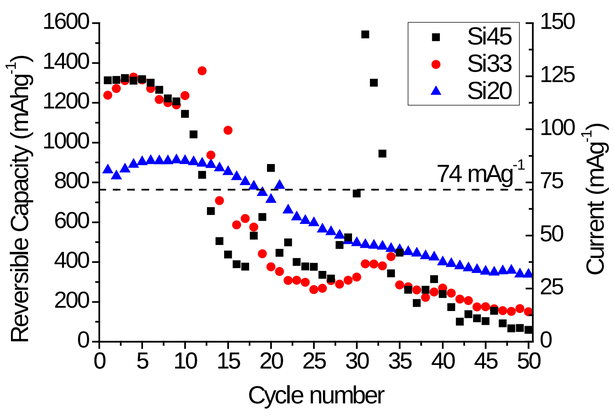
Pyrolysis (1100 °C, 3h, Ar)

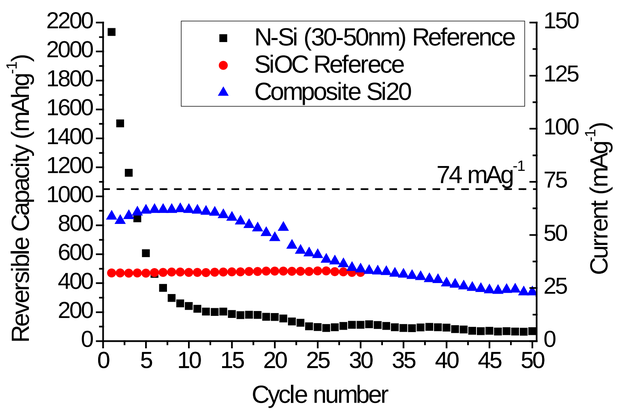
Sample	Starting ratio n-Si : Precursor	Final ratio n-Si : SiOC
Si20	15 : 85	20 : 80
Si33	25 : 75	33 : 67
Si45	33 : 67	45 : 55



- Strong reflexes of n-Si particles
- Crystallization of SiC

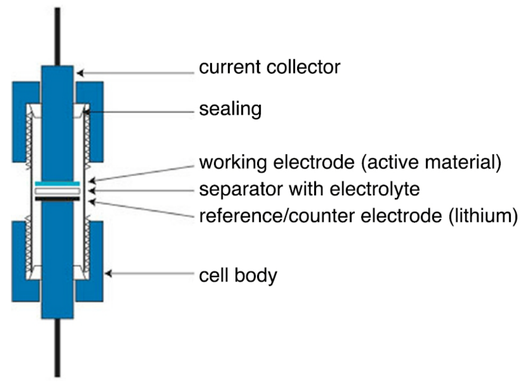
Galvanostatic Cycling with Potential Limitation

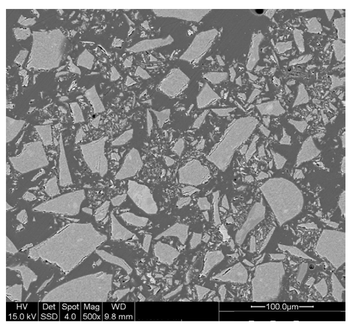


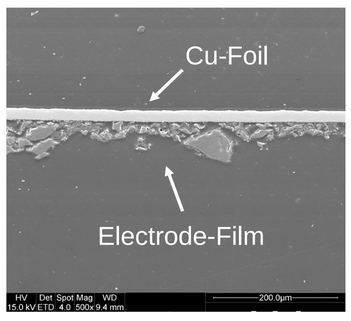


- Initial capacity enhancement
- Capacity fading and material degradation with ongoing cycling
- 20 wt-% n-Si sample more stable than 33 and 45 wt-%

Electrode Preparation and Cell Assembly

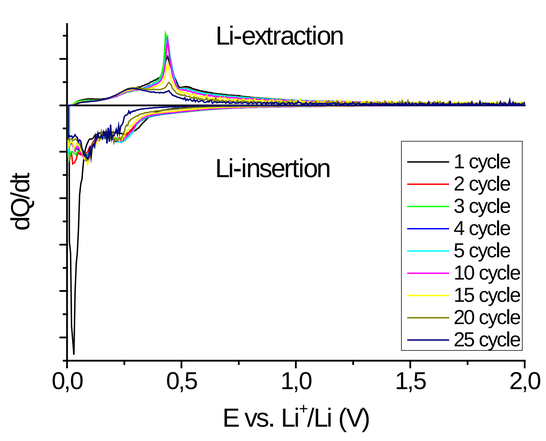


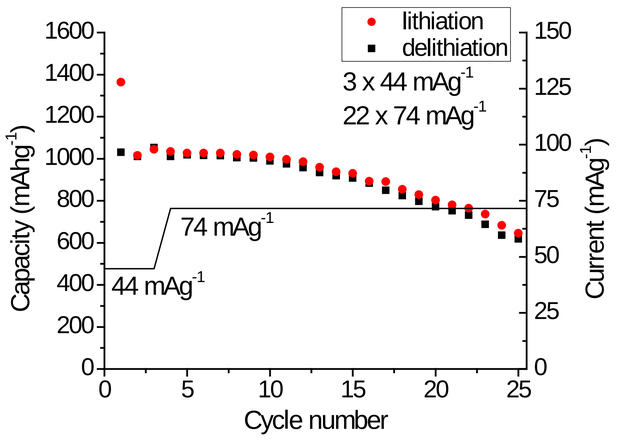




- 85 wt-% composite (active mass)
- 5 wt-% carbon black
- 10 wt-% PVDF binder, solved in NMP
- Tape casting on copper foil
- Loading of active mass: 3.3 mg/cm²
- Electrolyte: $LiPF_6$ in EC : DMC 1 : 1
- Separator: QMA Whatman™ glass-fiber filter

Potentiodynamic Cycling with Galvanostatic Acceleration





- Li-insertion: Si-activity at 0.23 and 0.03 V
- Li-extraction: Si-activity at 0.44 and 0.52 V
- Diminution of signals intensity with ongoing cycling
  → Loss of Si-activity
- Capacity fading correlates with Si-activity loss

Conclusions

- Nano-Silicon / SiOC composites
  → New approach to prepare silicon-based anodes
- Initially increased capacities compared to pure SiOC
- Improved cycling performance compared to pure n-Si
  → Stabilization of n-Si in SiOC matrix
- Reduced Si degradation in SiOC matrix
  → Restriction of large volume changes and/or support of particle breathing

Outlook

- Identify and overcome the degradation processes
- Examine the beneficial role of the matrix and its present stabilization function
- Analyze the microstructure and phase development during continuous cycling
- Improve the composites cycleability by optimizing the matrix

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