Facile synthesis of micro-sized silicon/carbon composites via rapid thermal process for lithium-ion battery anode

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Abstract
Micro-sized silicon/carbon composite anode is synthesized via rapid thermal process (RTP). The aqueous cross-linked binder PAA-PVA is partial carbonized and forms micro-sized silicon/carbon composite after rapid thermal process. This micro-sized silicon/carbon composite structure not only ameliorates conductive framework for silicon anode but also stabilizes the solid electrolyte interphases formation of micro-sized silicon particles. The micro-sized silicon/carbon composite anode shows a reversible capacity over 900 mAhg\(^{-1}\) after 200 cycles at 0.5 Ag\(^{-1}\), and superior rate capability. Furthermore, on the basis of these advantages, including low cost, facile manufacture, and high performance, this approach provides a pathway to achieve commercial high-capacity silicon/carbon composite anodes for Lithium-ion batteries.

Experimental Procedure
- **Advantage:**
  1. stronger conductive framework, more conductive paths
  2. No additional conductive material needed

Raman spectrum
- From Raman spectra, the G-band detected on RTP treated electrode.
  \((\text{C=C, sp}^2 \text{ bond existing} \rightarrow \text{making the carbon matrix conductive})\)
  \(I_d/I_g=0.92\) \(\rightarrow\) the amorphous state of carbon.

Electrochemical Performance
- Fig. 1 Electrochemical performance of RTP treatment electrode and bare electrode: (a) cycle test with 0.5Ag\(^{-1}\) charge/discharge rate; (b) rate test
- The “PAA/PVA RTP600,20min” shows higher and stable capacity than “PAA/PVA bare”.
- “PAA/PVA RTP600,20min” has superior rate capability.

Electrode after cycle test
- Fig. 5 (a) bare electrode and (b) RTP600°C, 20min treated electrode before and after 100 cycles
- After 100 cycle, no obvious cracking of the SEI on RTP treated electrode due to the protect layer from carbon matrix.

Conclusions
1. After rapid thermal process treatment, the micro-sized silicon anode exhibits excellent cycle performance and rate capability.
2. The amorphous carbon matrix is formed via partial carbonization of the binders during rapid thermal process, and this carbon matrix not only provides conductive paths for electrons but also forms more stable conductivity framework of silicon anode.

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