TIP Project Brief – 090052/10H006

Manufacturing
Silicon Nanowire Production for Advanced Lithium-Ion Batteries

Develop a unique, high-throughput, continuous manufacturing process for producing a novel, nanostructured silicon-based anode material for lithium batteries.

Sponsor: Amprius, Inc.
Menlo Park, CA

- Project Performance Period: 2/1/2010 - 1/31/2012
- Total project (est.): $6,000 K
- Requested TIP funds: $3,000 K

Amprius, Inc., is working to develop a unique, high-throughput, continuous manufacturing process for producing a novel, nanostructured silicon-based anode material for lithium batteries. Higher energy density batteries would have a major impact on the development of electric vehicles by extending driving range and lowering costs. Over the 20 years since the introduction of the lithium ion battery, improvements in energy density have been largely driven by increasing utilization of the electrochemically active materials from which they are made. The materials themselves, however, have remained largely unchanged. Today, current active materials are utilized nearly to their theoretical limits; this means that new, higher energy density materials are required if we are to push the limits of energy density much further. Silicon offers more than 10 times the theoretical energy storage capacity of carbon, today's state of the art anode material, suggesting that batteries built with silicon-based anodes could offer significant increases in energy density, corresponding to better driving range and run-time in consumer electronics. Conventional approaches to utilize silicon in batteries, however, have been unsuccessful. Specifically, lithium-ion insertion causes silicon to swell up to 400% when charged. This swelling causes bulk silicon structures to fracture, diminishing battery life after just a few cycles. Structured as nanowires, however, Silicon is able to swell without breaking. Amprius has demonstrated anodes made of silicon nanowires that are tolerant of strains and can expand and contract without breaking for hundreds of cycles. A practical battery with a silicon nanowire anode could increase the energy density of today's lithium batteries by 40 percent, even at realistic levels of material utilization. Amprius currently makes silicon nanowires in a small-scale batch process using chemical vapor deposition (CVD), a process borrowed from the semiconductor industry. Mass consumer applications would require a far more efficient and low-cost manufacturing technique. The company hopes for a 1000-fold scale up of manufacturing capability, and the current project will explore two potential paths towards a large-scale process to produce silicon nanowire anodes "by the mile." After initial feasibility studies, the most promising approach will be developed. If successful, the process will represent the first continuous "roll to roll" process to deposit three-dimensional silicon-based nanostructures. In addition to the manufacture of advanced batteries, this continuous throughput technology would very likely benefit other industries including solar photovoltaic, energy storage and solid-state lighting industries.

For project information:

Ryan Kottenstette, (800) 425-8803
ryan@amprius.com