Technology Offer: Nano-structured Silicon Anode

Lithium-Ion batteries are incredibly popular nowadays. They can be found in products ranging from laptops to smartphones and from Electrical Vehicles ('Evs') to lawnmowers. The main reason for their popularity is that Li-Ion has a much higher energy density than other battery types such as lead-acid. A Li-Ion battery consists of 3 main components: the positive electrode ('cathode'), the negative electrode ('anode') and the 'electrolyte layer' in between that connects the cathode to the anode. ECN has developed a novel high capacity anode material that could significantly improve the energy density of Li-Ion batteries and range for EVs.

Key words: Lithium-ion; Li-Ion; Battery; Storage; Anode; Silicon; Nano technology; Nano structured materials; PECVD; Microwave PECVD; Roll-2-roll.

Description

- ECN has developed a silicon anode material with a capacity 10 times higher than graphite anodes, which are the current industry standard.

New and innovative aspects

- It is well known that silicon anodes have a much higher capacity than graphite anodes (372 mAh/g vs 4200 mAh/g), but the problem with silicon anodes is that they swell 400% when charged with lithium ions (somewhat like a balloon). This expansion leads to breaking and crumbling of the material. ECN has developed a novel production method based on Microwave PECVD to create a nano-structured silicon material from SiH_4 and H_2. The material has high porosity, which accommodates the charging with lithium ions and prevents swelling and degradation of the anode.

Main advantages of its use

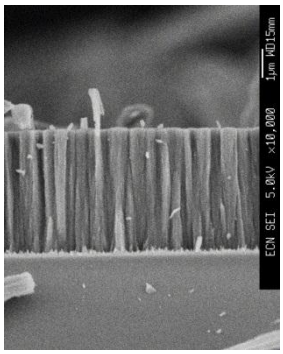
- Measurements show that the anode has a capacity of 3800 mAh/g, which is 10 times more than the theoretical capacity of graphite. At the level of the battery a 30% increase in gravimetric energy density (Wh/l) is expected, if all other components of the battery remain unchanged. This means >30% more range for EVs.
- Potential shorter time-to-market than other silicon based anodes that are being developed. ECN uses modified Microwave PECVD equipment that has been developed for the solar industry and is designed for mass production.
- Expected cost price per m^2 is comparable with conventional graphite anodes.
- Easy scalable roll-2-roll manufacturing process.

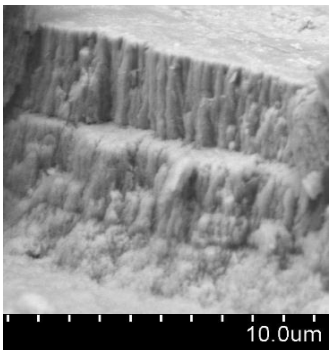
Specifications

- With this production method silicon can be grown on a foil in self-organized small columns (width 10's of nm). The spacing between the columns and the porosity of the columns give the silicon the space to swell without degradation.
- Based on a 0,1µm layer thickness, a capacity of 3800 mAh/g has been demonstrated with a long cyclic stability of 100 cycles and at a Coulombic efficiency of nearly 100%.

Potential applications

- Conventional Li-Ion batteries, Solid-state batteries, thin film batteries.





▲ Fig. 1 & 2*: The material consists of small silicon columns. The spacing between the columns accommodates the volume expansion during lithiation and prevents cracking of the anode. In the most recent experiments (right picture) it has been demonstrated that it is possible to deposit thicker layers of 10*µ.

► Fig. 3: *The modified Microwave PEVCD machine is at pilot scale, but can easily be scaled up. It is a continuous process and current foil width is 30 cm.*

State of development

- ECN is currently testing on half-cells, with 10 micron thick layers (right picture). We would like to extensively test the thicker material at 100 cycles, assess the volume expansion, and determine the potential for enhanced power density by charging / discharging at 2C, 3C and higher.
- Next steps: produce full cells , cycle testing on full cells and different battery chemistries.

Transaction type and partner profile

- Spin-off and/or (exclusive) license.
- ECN kindly invites large battery or anode manufacturers as well as highly experienced entrepreneurs with a proven track record in battery manufacturing to respond to this Tech Offer. The deadline to receive your proposal is the 27th of January 2016.

IP

- Patent pending and confidential know-how.

For more information, please contact: Sjoerd Wittkampf, Technology Transfer Manager
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