Coming Soon: Improved Lithium Ion Batteries?

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(PhysOrg.com) -- Rechargeable lithium ion batteries provide portable devices that require a lot of energy, such as mobile telephones, digital cameras, and notebook computers, with power. However, their capacity, and thus the running time of the devices, remain somewhat limited. A notebook computer thus usually runs only about two hours. The reason for this is the relatively small capacity of the graphite anode in these batteries to absorb lithium ions.

A team led by Jaephil Cho at Hanyang University in Korea has now developed a new material for anodes, which could clear a path for a new generation of rechargeable batteries. As reported in the journal *Angewandte Chemie*, their new material involves three-dimensional, highly porous silicon structures.

Lithium ion accumulator batteries produce current by moving lithium ions. The battery usually contains a cathode (positive electrode) made of a mixed metal oxide, such as lithium cobalt oxide, and an anode (negative electrode) made of graphite. While the battery is being charged, lithium ions migrate into the anode, where they are stored between the graphite layers. When the battery is being discharged, these ions migrate back to the cathode.

It would be nice to have an anodic material that could store more lithium ions than graphite. Silicon presents an interesting alternative. The problem: silicon expands a great deal while absorbing lithium ions (charging) and shrinks when giving them up (discharging). After several

cycles the required thin silicon layers are pulverized and can no longer be charged.

Cho's team has now developed a new method for the production of a porous silicon anode that can withstand this strain. They annealed silicon dioxide nanoparticles with silicon particles whose outermost silicon atoms have short hydrocarbon chains attached to them at 900 °C under an argon atmosphere. The silicon dioxide particles were removed from the resulting mass by etching. What remained were carbon-coated silicon crystals in a continuous, three-dimensional, highly porous structure.

Anodes made of this highly porous silicon have a high charge capacity for lithium ions. In addition, the lithium ions are rapidly transported and stored, making rapid charging and discharging possible. A high specific capacity is also attained with high current. The changes in volume that occur upon charging and discharging cause only a small degree of swelling and shrinking of the pore walls, which have a thickness of less than 70 nm. In addition, the first charging cycle results in an amorphous (noncrystalline) silicon mass around residual nanocrystals in the pore walls. Consequently, even after 100 cycles, the stress in the pore wall is not noticeable in the material.

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