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Enhancing the Power of E-Mobility: A New Anode Material Accelerating Development

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Summary:
A new anode material is developed under the name Silumina Anodes ©, which is promising enhancements for the e-mobility in several aspects. The minimization of initial capacity losses, increased number of fast-charge cycles and improved safety regarding the risk of catching fire are just some of its positive effects. This is enabled by a special coating on the basic anode material produced in a facile and cost-efficient way.

Keywords: anode material, e-mobility, battery

Background, Motivation and Objective

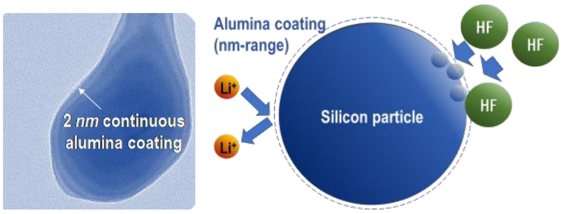
Batteries are one important tool to reduce CO_2 emissions and fight climate change. They provide a long-term energy storage solution where there are variances in energy production and consumption, specifically relevant for weather or day-light dependent renewable energy sources or give the option to carry your energy with you instead of needing a power plant.

Lithium-Ion Batteries are mostly used in transportable items providing the currently highest energy densities on the market. Current improvements to lithium-ion batteries, however, continue to rely on the storage capacity of graphite as an anode material. Major advances in the energy capacity or storage capacity for lithium ions are hardly to be expected on this basis. It is therefore logical to investigate the suitability of other materials. Silicon has long been known as a promising anode material, as it has 10 times the capacity of graphite. [1] However, the handling of the material also poses problems, as the disadvantages of graphite, which are easy to handle, are many times more significant. These disadvantages can be reduced by coating the individual particles. [2]

Results of the New Method

Via our facile and cost-efficient method, the anode material particles are coated with an ultra-thin ceramic layer. The procedure is performed in a liquid with an industrially feasible approach resulting in an evenly distributed amorphous ceramic layer of about 2 nm thickness. This coating prevents lithium-ions from simply attaching to the surface and reacting irreversibly with surface groups while the ion-conductivity of the particles is kept high to let ions pass through the coating layer and bind to the inner of the anode particle (Fig. 1). For silicon particles the thin alumina coating of only 2 nm thickness can prevent the breaking of the particles from breathing behavior during lithiation and de-lithiation. The contact loss of silicon particles with the conducting electrode materials due to particle breakage is one of the main blocking points for the use of high amounts of silicon in batteries. Preventing the breakage of the particles enables continued electrical contact of the silicon to the electrode, which results in full utilization of the silicon's capacity up to high cycle numbers [3]. Another beneficial effect of the alumina coating is the lowered initial capacity loss together with the prevention of the breakage resulting in enhanced cycle life as well as higher energy density of the battery.

The coating is further able to bind fluoric acid which is formed during the cycling of most lithium-ion batteries and can harm the whole battery from irreversibly capturing lithium-ions to degrading the components of the battery casing.



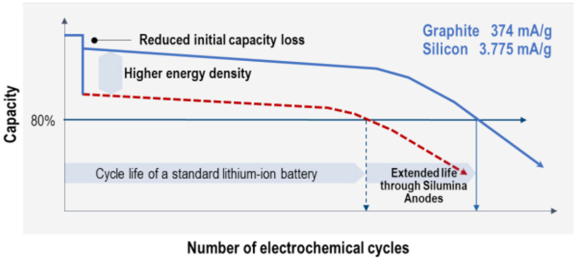


Fig. 1. TEM image of an anode material particle with 2 nm of the alumina coating (a), scheme of the effects of the coating including the prevention of irreversible reaction of lithium ions with surface groups of the particle and binding of the fluoric acid (HF) build during cycling of the cell (b) and the positive effect on the cycling behavior of the coated anode material with reduced initial capacity loss and higher resulting energy density.

In graphite application the alumina coating has been shown to prevent the chain reaction going on in nail penetration tests when the battery materials get in contact with ambient air. [2] The normal behavior during this chain reaction causes severe increase of the temperature, which normally results in the battery catching fire. Preventing this highly discussed safety issue of lithium-ion batteries is one of the main obstacles to be solved for broader use of lithium-ion batteries in the electric vehicle market.

Another potential advantage of the alumina coating is the improvement of the fast charge ability of the silicon due to its inhibiting effect on the particle breakage during lithiation and delithiation. [4]

Overall, we can state that our anode material coating method is a cost-efficient and facile solution to improve cycle life and duration of silicon materials, safety of graphite's and silicon anodes, enhances the ability to fast charge and reduces the capacity loss during the first cycles which results in a higher total energy density of the cells.

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