Electrical Engineering | Energy Technology | Batteries | Technology Offer

Battery electrodes made of silicon layers with optimized porosity and microstructure

Application area

Since the theoretical capacity of silicon-based anodes is significantly higher than that of conventional carbon-based anodes, methods are required which enable mass production of stable silicon anodes. The silicon-based electrode related to this invention is able to absorb a large amount of ions while maintaining a high level of mechanical stability. It can be produced in a cost-efficient manner and is designed to be used for both primary cells (e.g. silicon-air batteries) and secondary cells (e.g. Li-ion batteries).

State of the art

Using silicon as anode material in primary and secondary cells promises to enable high theoretical energy density. However, the silicon-based anode will increase in volume with the inclusion of ions. Such swelling causes mechanical stress on the anode structure, eventually leading to degradation and electrode breakdown.
Previous approaches have tried to prevent volume expansion by producing silicon electrodes with controlled porosity. However, they often cannot adequately solve the swelling issue and usually involve high manufacturing costs.

Innovation

Scientists at the Institute for Photovoltaics (*ipv*), University of Stuttgart, now succeeded in developing silicon-based anodes of porous and micro-stabilized semiconductor layers.
Microstabilization is based on a simple process – for example by producing differently doped areas by means of local laser irradiation. In particular p-doped areas on an n-doped semiconductor layer will act as support areas as they store a smaller amount of ions than n-doped areas. This will prevent volume expansion while improving the anode’s mechanical stability. The three-dimensional grid structure of the support areas can also be produced by crystallization, i.e. stabilization of the grid points.
The semiconductor layers are applied to a plastic or metal foil using a vacuum method. If necessary, several layers are deposited and microstabilized in order to increase material thickness. The coated film is metallized and contacted so that it can then be wound up with a second electrode, the electrolytes (e.g. gel on flexible, porous substrates) and, if necessary, the separator membranes to be encapsulated in a housing.
Initial experiments with a laboratory model have already shown that the capacity remains stable at approximately 950 mAh/g after 300 charge/discharge cycles.

Patent portfolio

EP3087630 granted; US 2016/0301068 A1 pending.

Your advantages at a glance

- ✓ High specific capacity by enhanced lithiation combined with improved mechanical stability
- ✓ Production of mechanically flexible batteries
- ✓ High energy density due to a large active surface: Stable charge capacity of 1650 mAh/g already shown in laboratory experiments
- ✓ Simple connection of individual cells in series or in parallel during the deposition process
- ✓ Cost-effective solution thanks to low material consumption and ease of manufacturing.

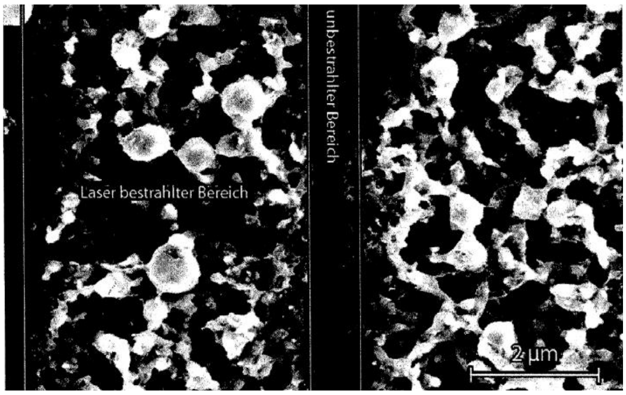

Figure1: SEM image of a silicon layer with a non-irradiated (right) and a laser-irradiated area (left).

Technology transfer

Technologie-Lizenz-Büro GmbH is responsible for the exploitation of this technology and assists companies in obtaining licenses.

Contact

Dr.-Ing. Hubert Siller
hsiller@tlb.de
Technologie-Lizenz-Büro (TLB)
der Baden-Württembergischen Hochschulen GmbH
Ettlinger Straße 25, D-76137 Karlsruhe
Phone 0049 - 721 79004-0, fax 0049 - 721 79004-79
www.tlb.de

Reference no.: 13/055TLB

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