AlkaSuSi – ALKALIMETAL, SULFUR AND SILICON

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TARGET

Development of new concepts for lithium-silicon/ sulfur cells

- Cathode: Carbon nano tubes (CNT)-electrodes as conductive carrier for sulfur or Li_2S
- Anode: Silicon or Li22Si5-wire array
- Electrolyte: organic liquid, ionic liquid, gel-polymer, solid state glass ceramic + organic liquid support

Development of demonstrator cells with energy densities above 400 Wh/kg

- Selection, combination and balancing of the new materials in
- demonstrator cells (pouch-design)
  Safety tests: Overcharge, squeezing, external short cut, temperatures > 100 °C
- Demonstration of scalability and cost efficiency of the production methods

BINDER FREE CNT-SULFUR CATHODES

Carbon nanotubes are coated vertically on a metal or carbon current collector by a CVD process at atmosphere pressure. Process duration is dependent on working temperature and desired CNT mass and lies within a range of 5 to 20 minutes. The carbon nanotube electrodes are binder free and can contain a sulfur mass fraction of up to 90 %. The achieved capacities per cm² electrode are between 4 and 20 mAh/cm² dependent on the utilized current collector structure. Li-ion and Li-S slurry electrodes in comparison only achieve values between 2 and 4 mAh/cm². Additionally it is examined whether a metal current collector in small cells (e.g. for cell phones) can be waived in order to increase the energy density. In this case the CNT coated carbon structure works as current collector and electrode.

SILICON FIBRE ARRAY ANODE

Silicon fibre arrays are produced through an etching process. Every fibre has a defined diameter and distance to its neighbour. Stabilizing planes prevent the "stiction" of the fibres and allow a controlled lift off from the silicon substrate. The copper current collector is added electrochemically before lift off. As a result the silicon anode contains no binder and is out of 100 % active material. Through the defined distance of the silicon fibres the electrode can breathe during lithiation and delithiation leading to an uncomparable cycle stability regarding graphite silicon slurry electrodes.

IN COOPERATION WITH

Fraunhofer IWS
Fraunhofer ICT
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Projektträger Jülich Forschungszentrum Jülich
Bayer MaterialScience
SCHOTT glass made of ideas

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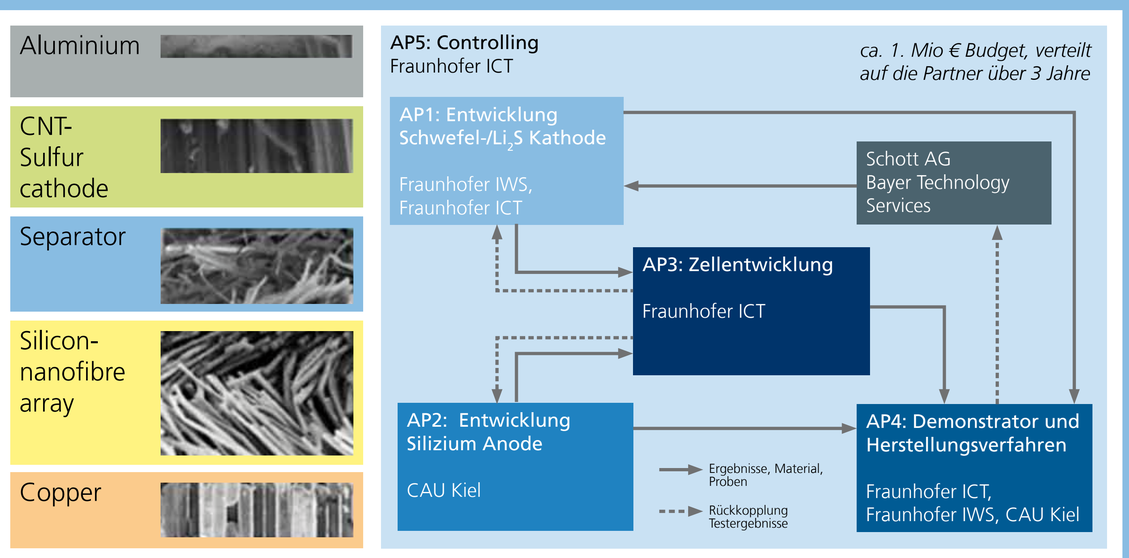
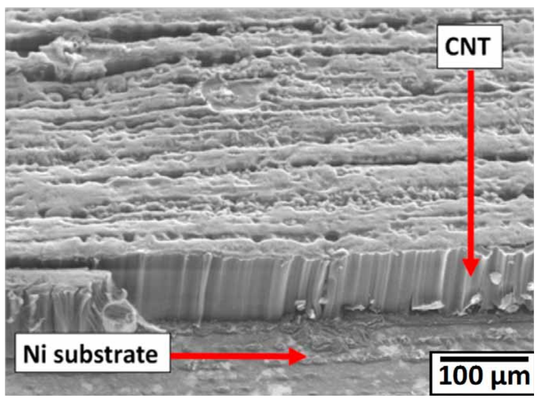
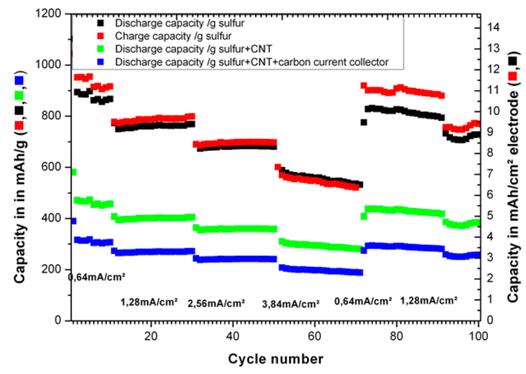
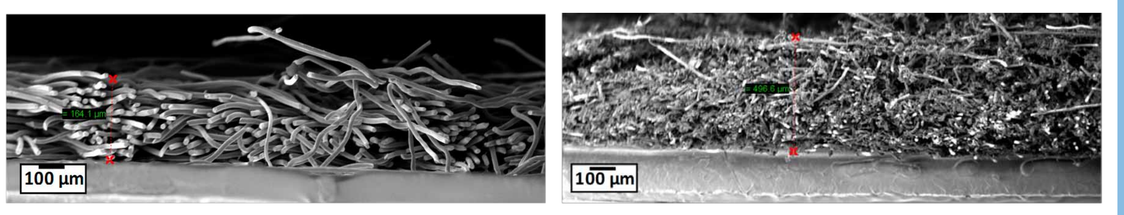




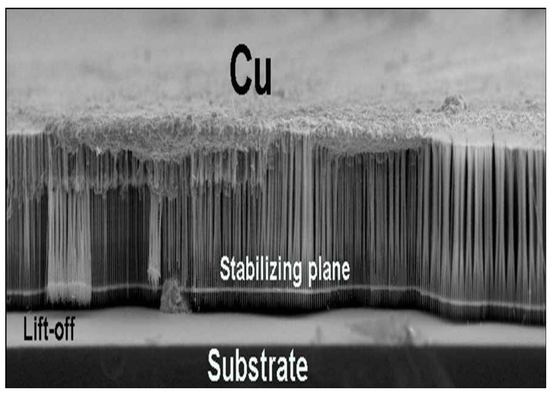
SEM: CNT coated on Ni-current collector (side view)



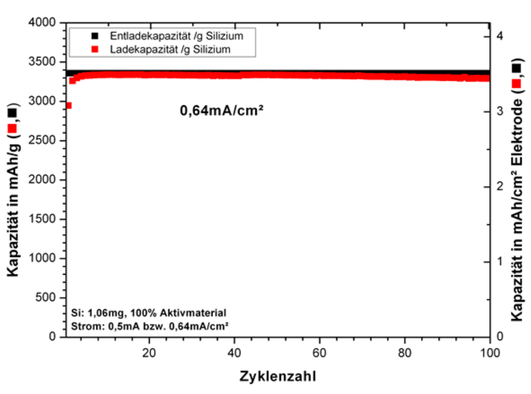
CNT coated carbon structure with sulfur (12,2 mg/cm²) vs. lithium at various currents



C-structure without CNT (left) and with CNT (right) before sulfur infiltration. The binder free electrode is ideal in compensating the volume change during charge and discharge ($S_8 \rightarrow Li_2S$)



SEM: Etched silicon wire array with stabilizing plane and galvanized Cu current collector before lift off the silicon substrate



Capacity Si vs Li: The discharge capacity was capped at 80 % of the theoretical capacity

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