PAUL SCHERRER INSTITUT

ELECTROCHEMISTRY LABORATORY

BATTERIES

MSn_2 (M=Fe) intermetallics as anode materials for Na-ion batteries

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Motivation

Na-ion electrode materials underexplored, conversion materials promising, reaction mechanism yet unknown

Sn Anode

Pros and Cons of Sn?

\+ High theoretical specific charges for Intermetallics (Sn, Sb, P)

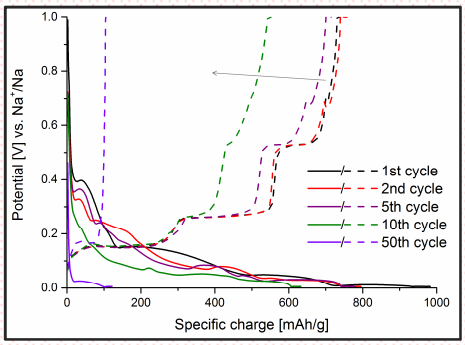
– Volume expansion up to 400% leads to fast fading of specific charge

$FeSn_2$ Anode

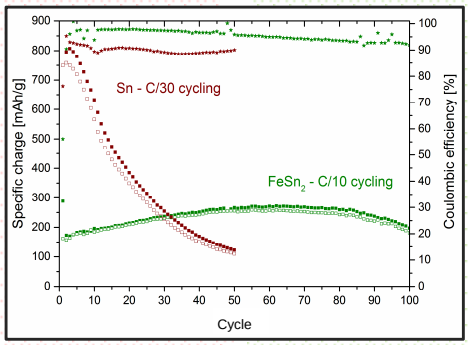
Why $FeSn_2$?

- No Fe-Na alloys known, fully sodiated state, $Na_{15}Sn_4$, is identical as for Sn
- Despite inactivity of Fe a different reaction pathway than for Sn anodes

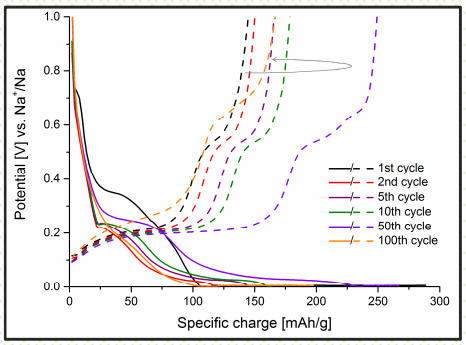
Electrochemical Properties



- No consistent sodiation plateaus → material changing drastically
- Upon de-sodiation consistently 4 plateaus 150, 240, 520, 680 mV
- De-sodiation plateaus shorten and finally disappear with cycle number



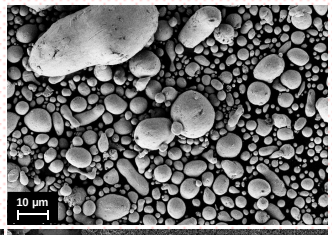
- Sn: High initial specific charge (> 800mAh/g) strong fading (<20% after 40 cycles)
- $FeSn_2$: Specific charge increases < 60 cycles cracking exposes fresh, previously inaccessible domains slight fading above 70 cycles

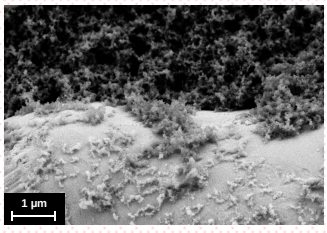


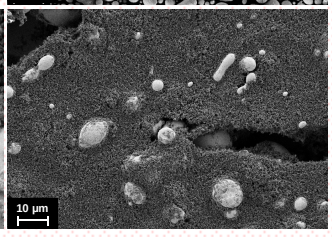
- Electrolyte decomposition at 0.4 V in initial cycle
- 1st potentiostatic step activates sodiation plateaus at 250 mV & 50 mV which grow with cycle number initially
- Polarization increase at 100th cycle

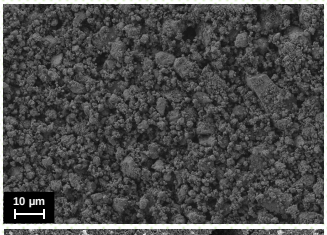
Morphology

- Particle size up to 50 µm
- Very round
- Integration in carbon and binder matrix difficult due to smooth morphology

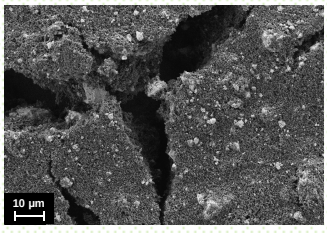


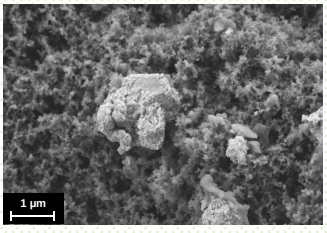






- Smaller particles (10 µm max)
- Rough, ragged surface
- Dimension and morphology allow for better integration in carbon and binder matrix





Conclusions

Two promising negative electrode materials

- High initial specific charge
- Poor capacity retention, probably due to unfavourable morphology of starting powder for integration in the electrode matrix

- High cycling stability due to good integration in carbon/binder matrix
- Initial specific charge < half of theoretical specific charge → further tests needed in modified systems (ex. other electrolyte, nanoparticles)

This work is a part of the SCCER Heat and Electricity Storage

Storage Swiss Competence Centers for Energy Research