Long-term annealing of advanced lithium metatitanate breeder pebbles

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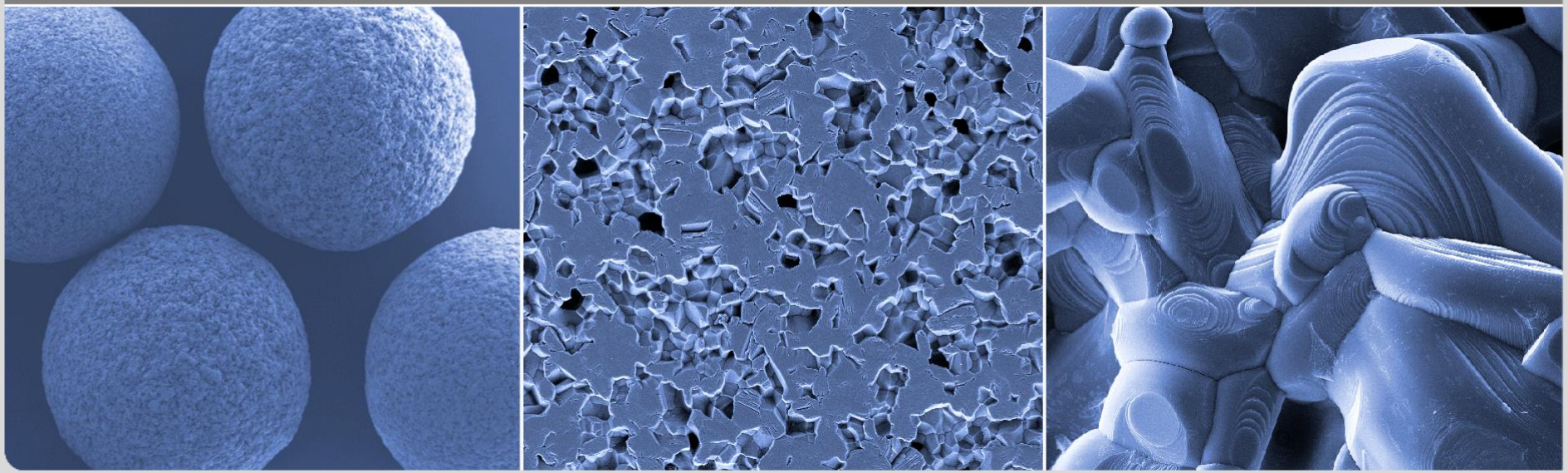
INSTITUTE FOR APPLIED MATERIALS



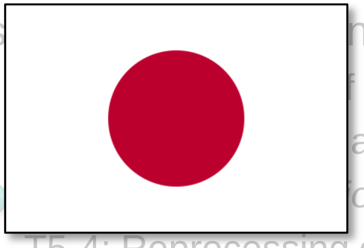
Broader Approach DEMO

- Agreement on a privileged partnership between Japan and EURATOM in support of ITER and an early realization of fusion energy
- 3 projects
  - IFMIF/EVEDA
  - STP (JT60/SA)
  - I

T5-3: Characterization of pebbles

- Study on the stability of advanced Li_2TiO_3 (JA) and Li_4SiO_4 (EU) pebbles during exposure to purge gas atmospheres
- Chemical and micro-structural characterization of exposed pebbles

  - Task 1..4
  - Tas … s for DEMO Blanket
    - T5-4: Reprocessing of breeder material



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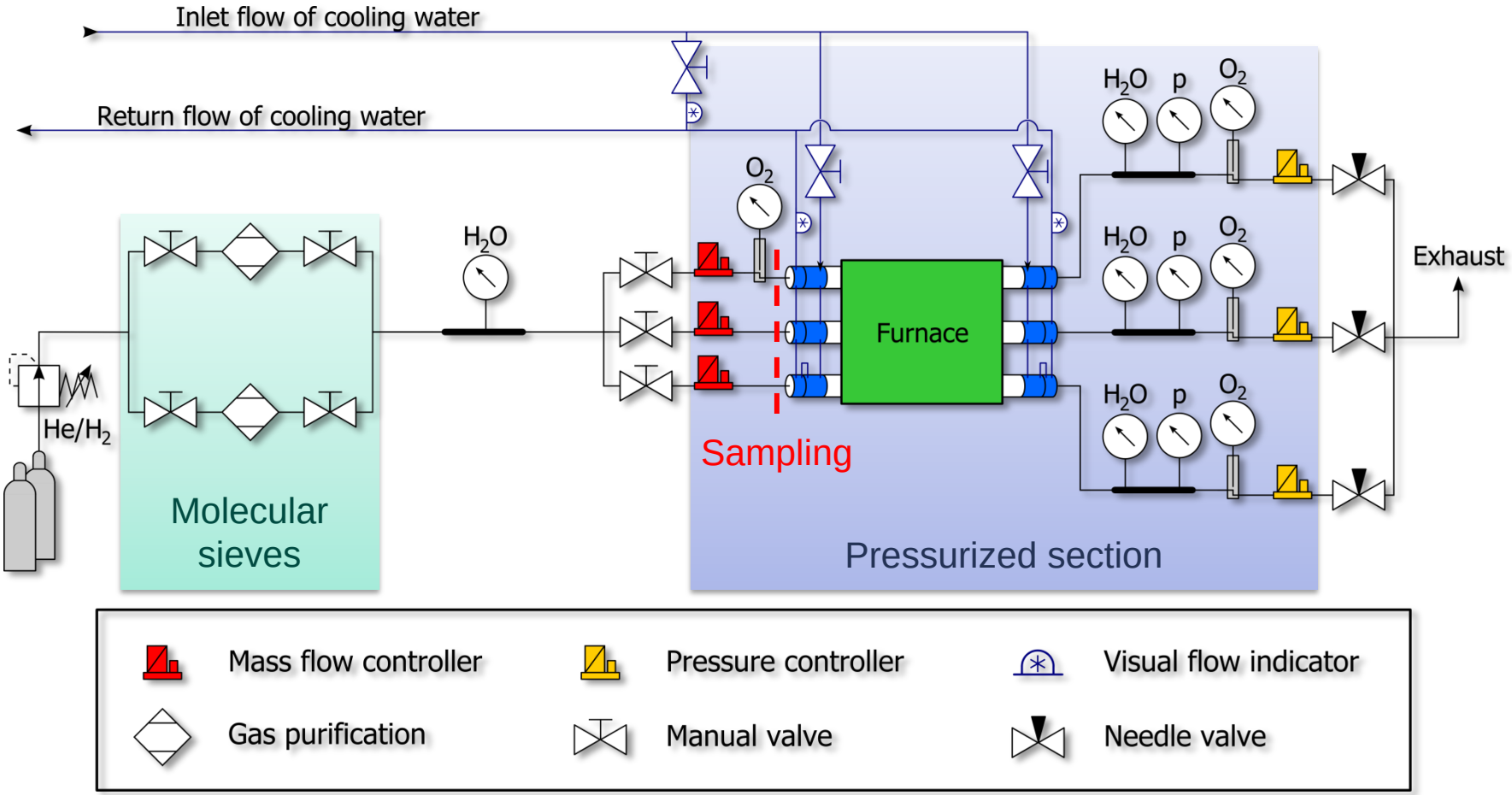
- Experimental
  - Annealing setup
  - Experimental conditions
- Results
  - Porosity & density
  - Microstructure
  - Chemical composition & impurities
  - Appearance
  - Mechanical strength
- Conclusions

Annealing setup & conditions

EXPERIMENTAL

Experimental setup

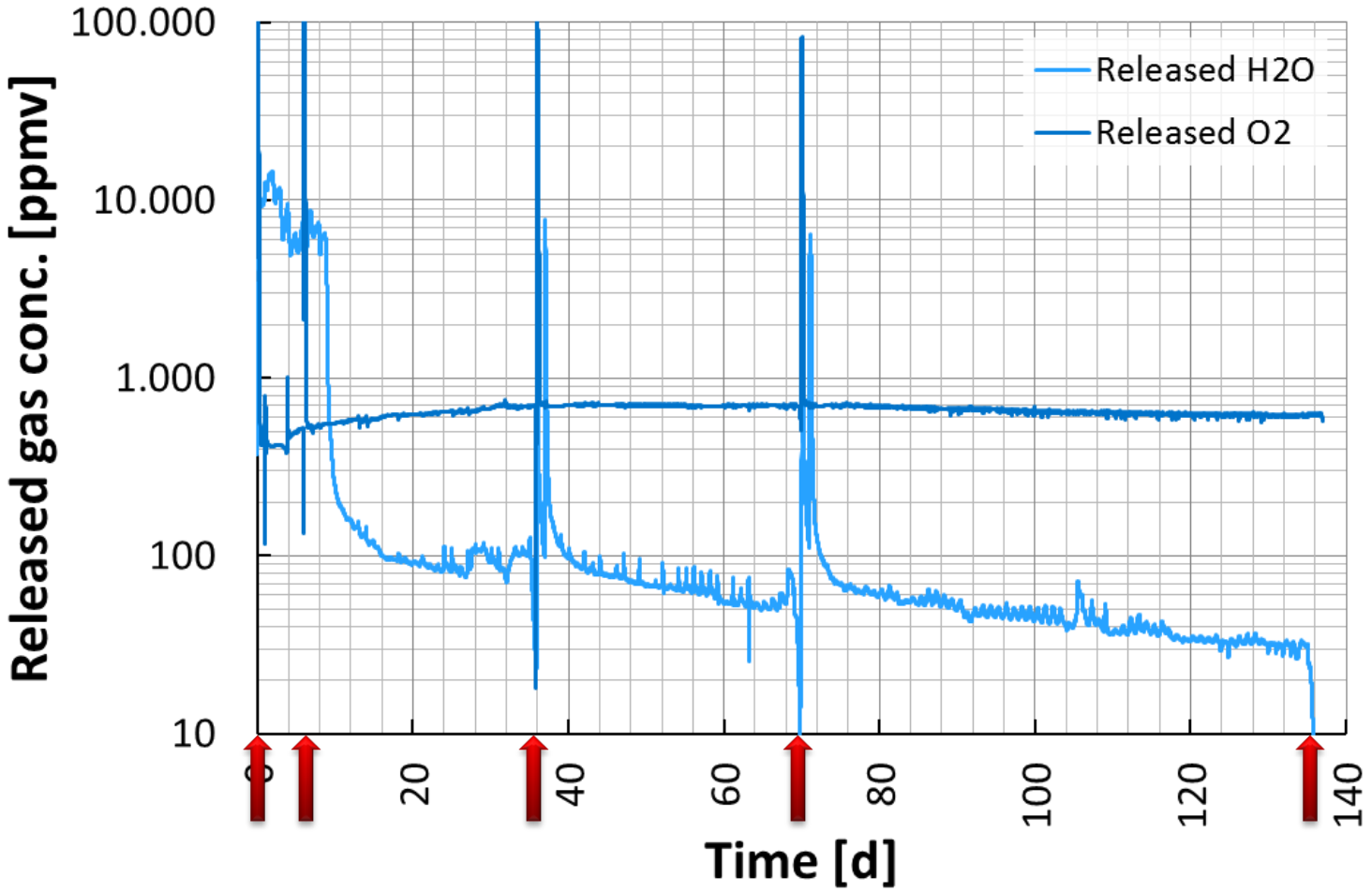


Experimental conditions

- Samples
  - Emulsion method pebbles $Li_{2.16}TiO_{3.08}$
  - Sol-gel method pebbles $Li_{2.11}TiO_{3.055}$
- Annealing temperature: 900° C
- Annealing for: 4, 32, 64, 128 days
  - Temperature during sampling: 300° C
  - Heating/cooling rate: 5 K/min
  - The period of sampling is not considered as annealing time
- Atmosphere: He with 0.1 vol.% H_2
  - Pressure: 1200 mbar, absolute
  - Flow rate: 1.2 l/h (reference: 8000 l/h)
- Sample preparation: 1 hour at 300° C in vacuum

Annealing atmosphere

- Released gases during the experiment

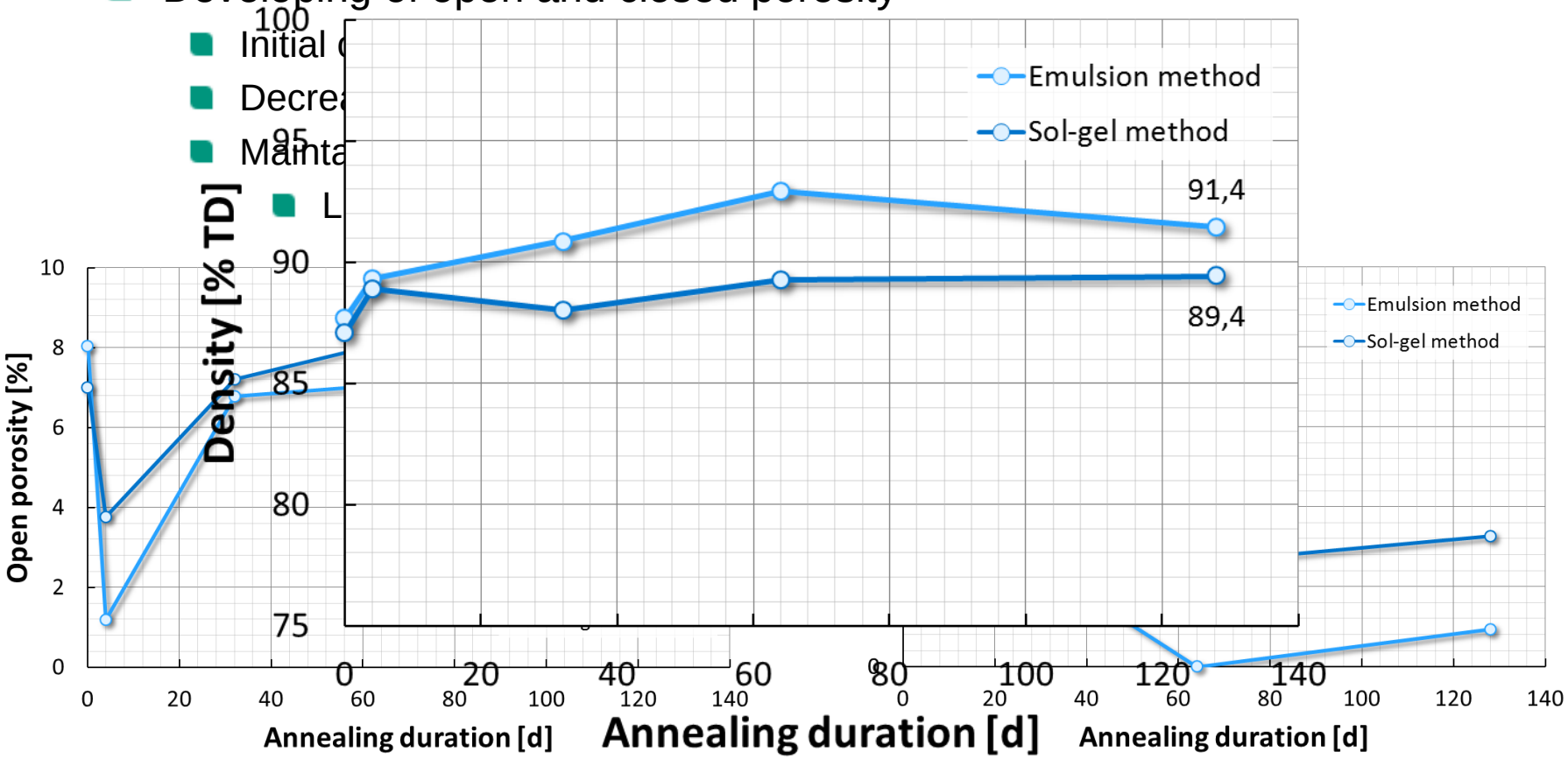


Morphological, mechanical and chemical characterization

RESULTS

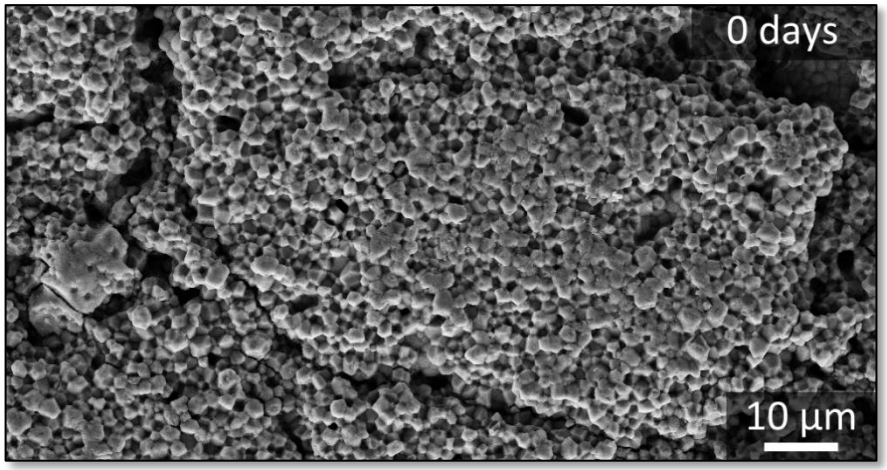
Porosity

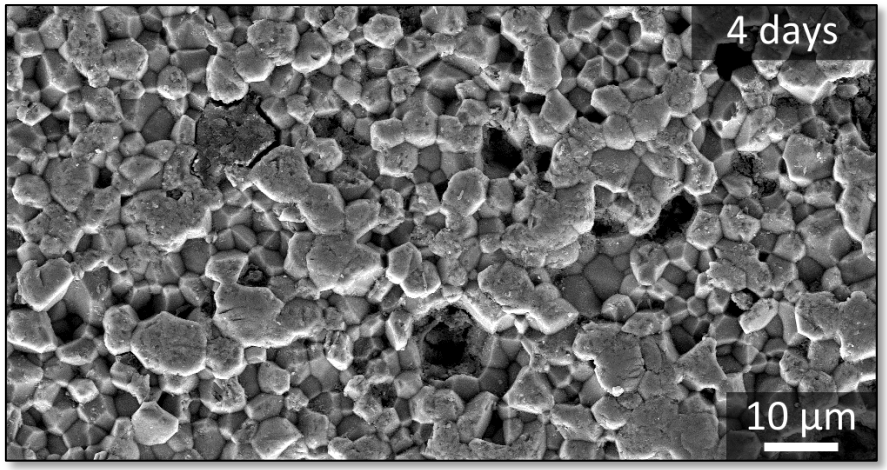
- Mild increase in density over annealing time
  - Post-sintering densification
  - Developing of open and closed porosity
    - Initial
    - Decrea
    - Mainta
    - L

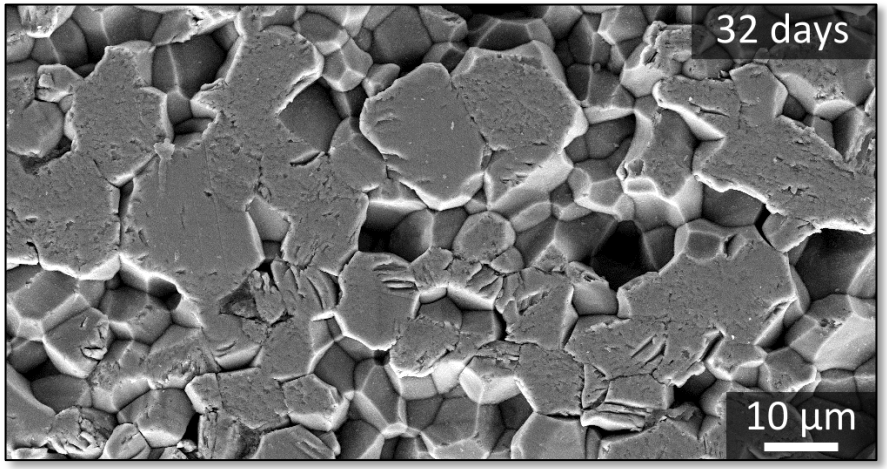


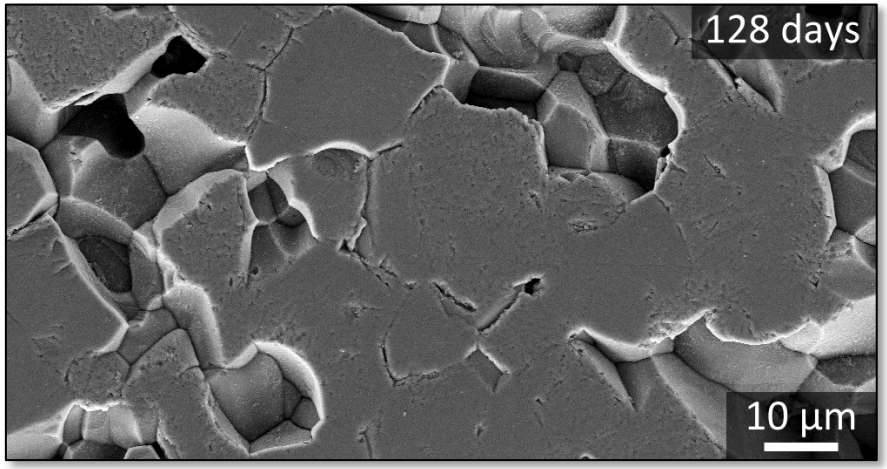
Microstructure

- Emulsion method pebbles



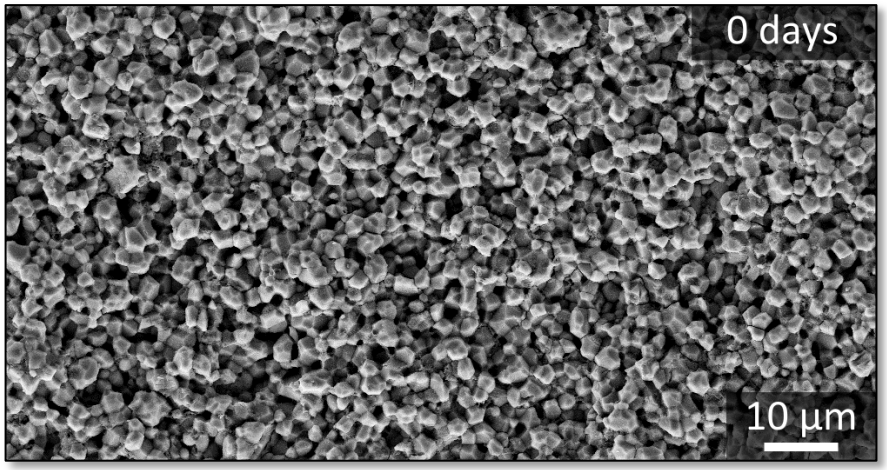


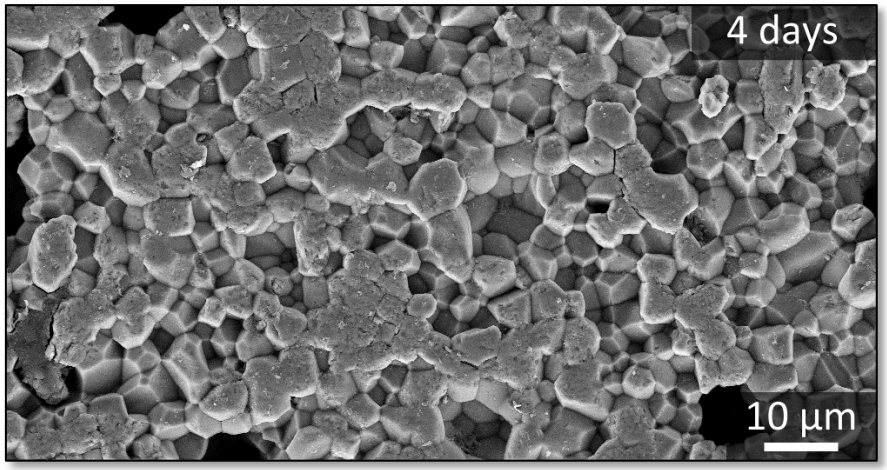


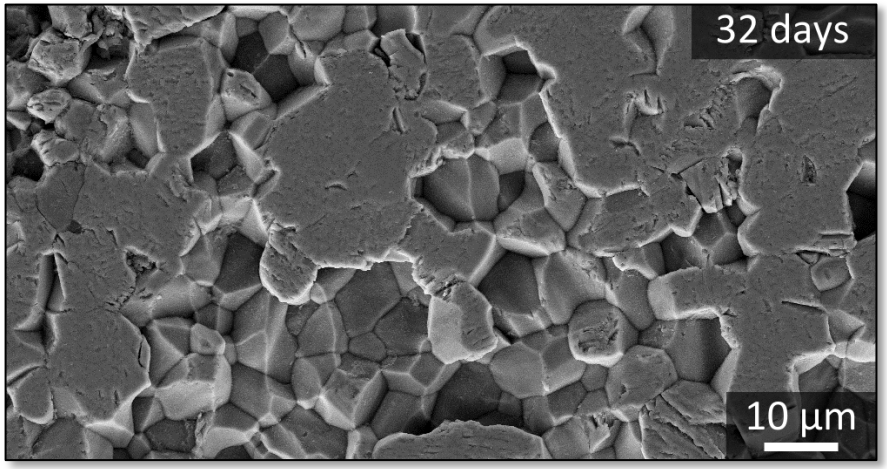


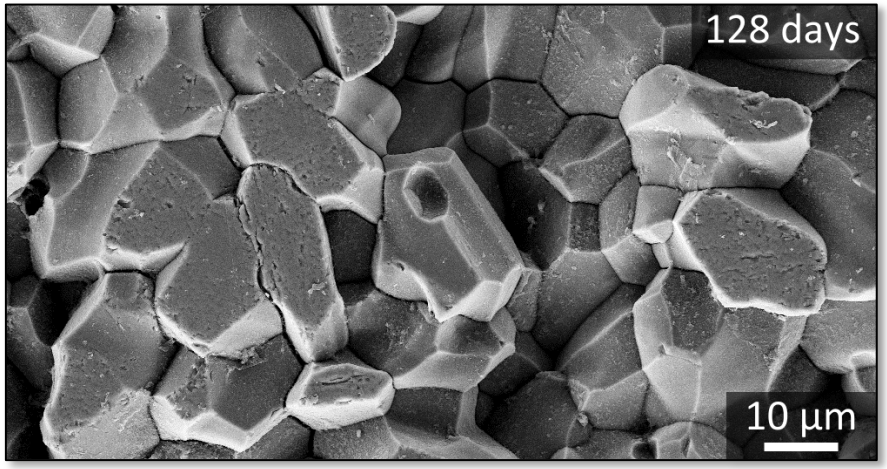
Microstructure

- Sol-gel method pebbles



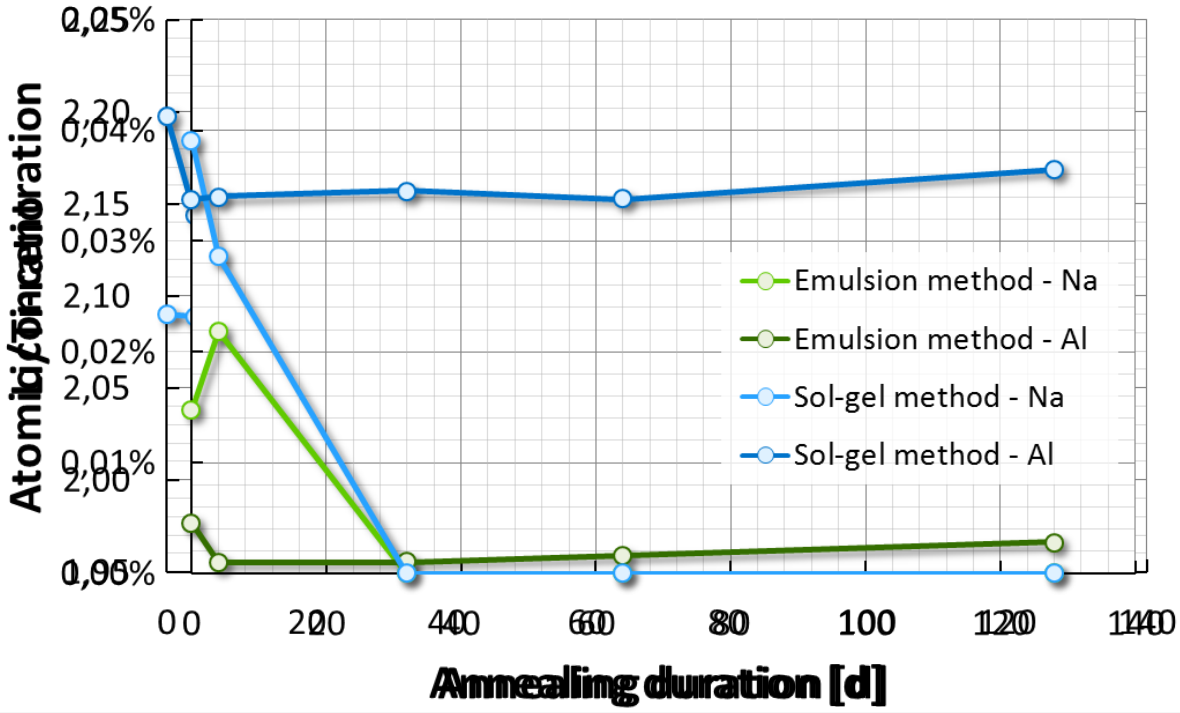


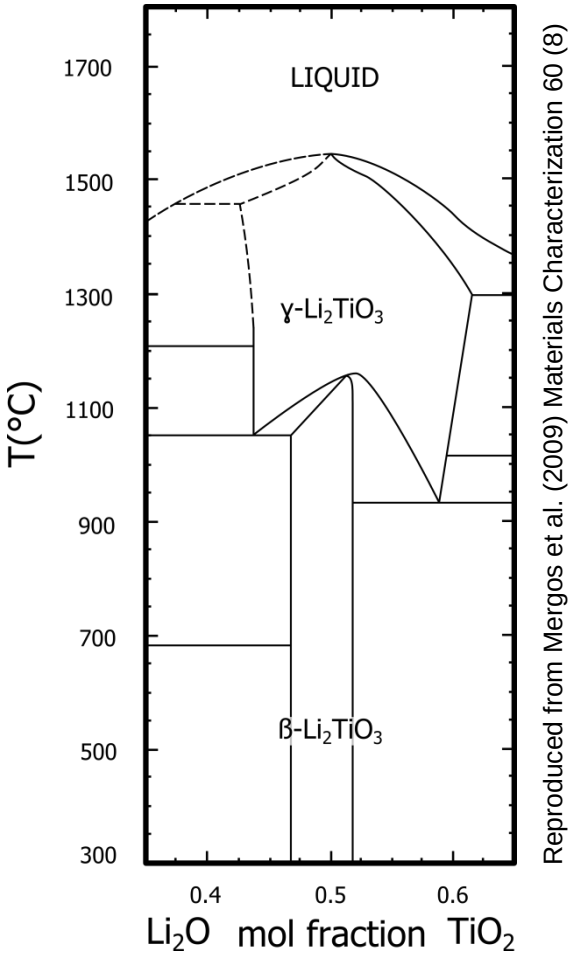




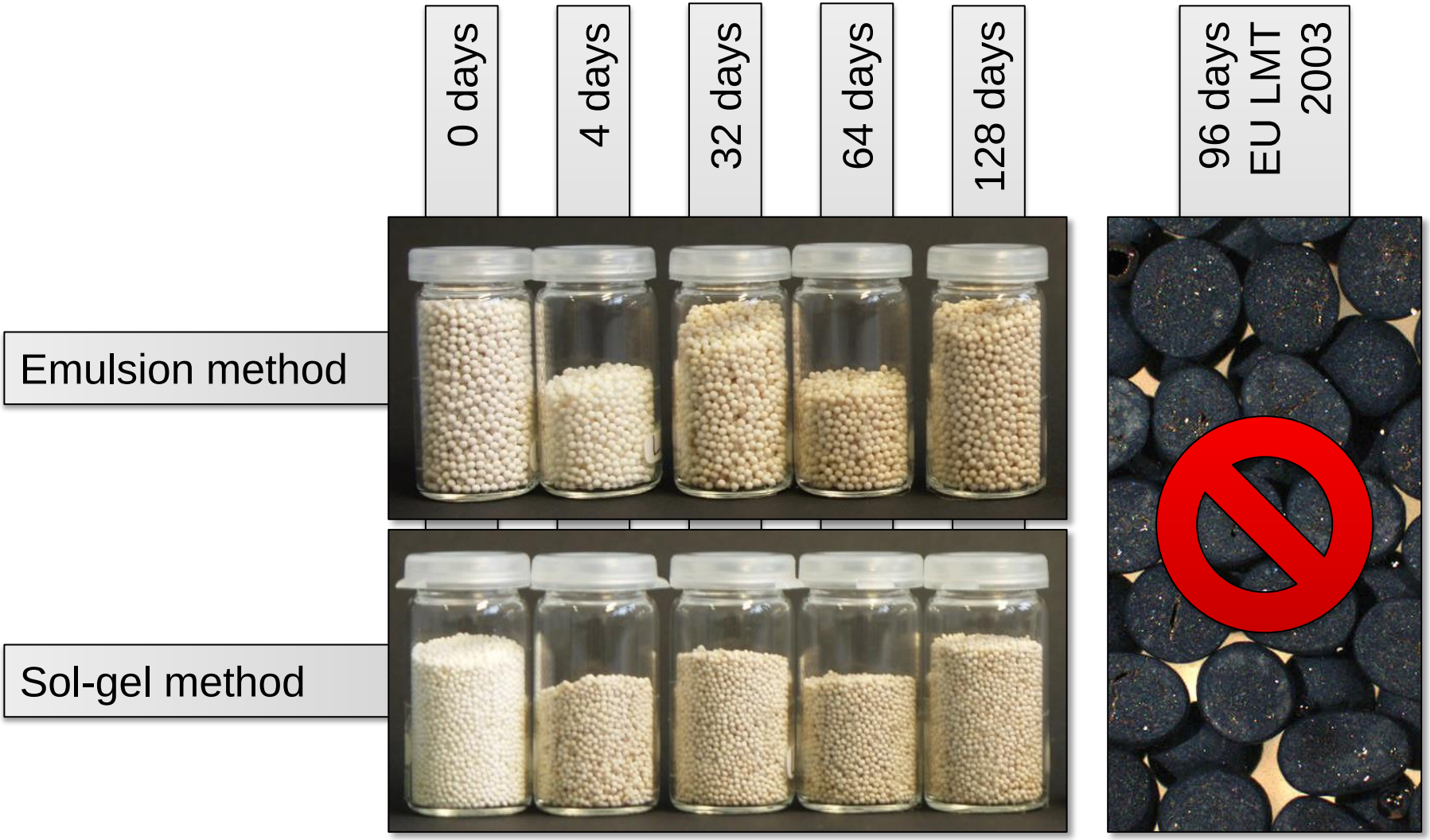
Chemical & phase analysis

- Vaporization of lithium compounds
  - Li/Ti-ratio equally reduced
  - Equilibrium phase after 128 days: ß-Li_2TiO_3
- Low level of impurities in general
  - Rapid decline of sodium levels



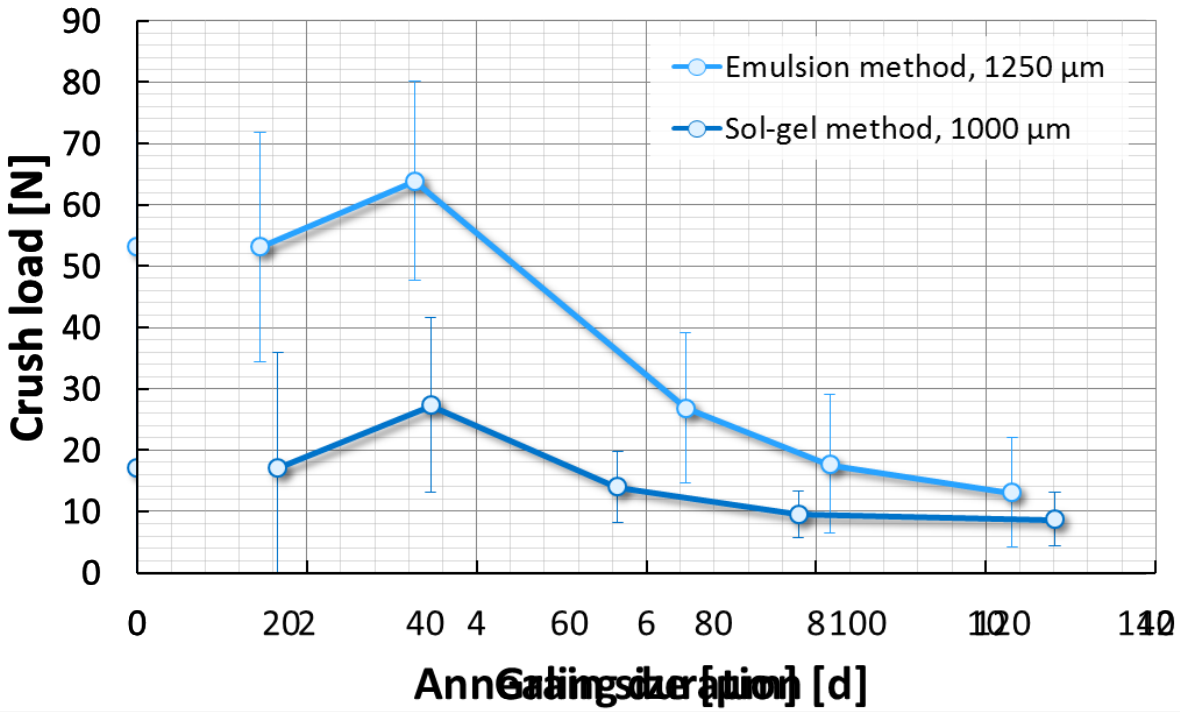


Appearance


0 days
4 days
32 days
64 days
128 days
96 days EU LMT 2003
Emulsion method
Sol-gel method

Mechanical properties

- Very high initial rigidity
- Significant decrease of crush load with continued annealing
  - Commonly observed grain size dependence for non-cubic ceramics
    - Usually explained by thermal expansion anisotropy
    - Comparably small optimum grain size hints at high anisotropy



Conclusions

- Long-term annealing for a maximum of 128 days
  - Continuous monitoring of process values
  - Reasonable mimicking of the blanket conditions
  - Continuous release of gaseous species

- Advanced lithium metatitanate breeder pebbles withstand these conditions well over 128 days of annealing
  - Grain size of the pebbles increases significantly
  - Single phase ß-Li_2TiO_3 pebbles are maintained
    - Almost linear loss of lithium might be an issue in the very long-term
  - Reasonable crush load values after 128 days of annealing
    - Strong dependence of the crush load on the grain size
    - Optimum grain size for maximum rigidity: about 4 µm
    - Limiting grain growth as a potential future target
  - Fabrication method does not impact the long-term behavior of the pebbles

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Thank you for your attention

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