Li_4SiO_4 based breeder ceramics with Li_2TiO_3, $LiAlO_2$ and $Li_xLa_yTiO_3$ additions

M. H. H. Kolb[1], K. Mukai[1], R. Knitter[1], T. Hoshino[2]

[1]Institute for Applied Materials, Karlsruhe Institute of Technology
[2]Fusion Research and Development Directorate, JAEA, Rokkasho

Introduction – Modifying pebbles by adding a second phase

Currently Li_4SiO_4 (LOS) and Li_2TiO_3 (LMT) are considered as reference class breeder compounds. Lately the melt-based routine fabrication of two-phase pebbles consisting of LOS and LMT (up to 30 mol%) was established [1]. The rigidity of such pebbles is significantly improved compared to EU reference pebbles.

Yet, further improvement of biphasic pebbles might be possible.

These means were used to improve key properties of the pebbles.

- +Li_2TiO_3 (LMT): Increasing the LMT content (>30 mol%)
- +$LiAlO_2$ (LAO): Exceptional mechanical strength
- +$Li_{3x}La_{⅔-x}TiO_3$ (LLTO): Excellent Li-conductor, may improve the T-diffusion and release

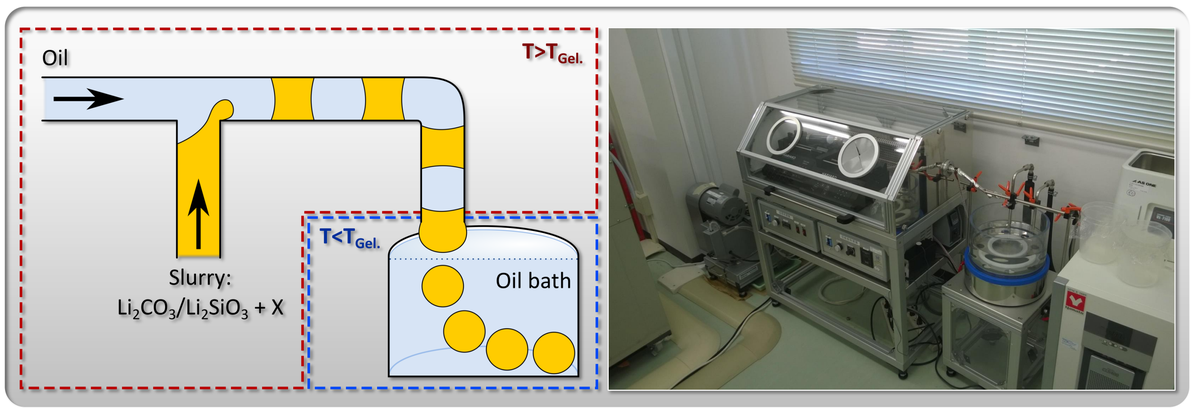
[1] R. Knitter et al., JNM 442 (2013) 433–436

Fabrication setup and parameters – The Emulsion method

The emulsion method [2] is the most suitable for the pebble fabrication in this study since…

- … it is a well established pebble fabrication technique.
- … it is easily adaptable to different starting materials.
- … solid-state reactive sintering is possible.

To produce comparable pebble microstructures, the sintering was performed identically for all samples (↗100 K/h, 1000 °C, 5h).



Solid state phase composition of the slurries

- $Li_2SiO_3 + Li_2CO_3$ + Li_2TiO_3
- $Li_2SiO_3 + Li_2CO_3$ + $Al_2O_3 + Li_2CO_3$
- $Li_2SiO_3 + Li_2CO_3$ + $Li_{3x}La_{⅔-x}TiO_3$ (0.067 ≤ x ≤ 0.1)

⇨ *Li_4SiO_4* ⇨ *Second phase*

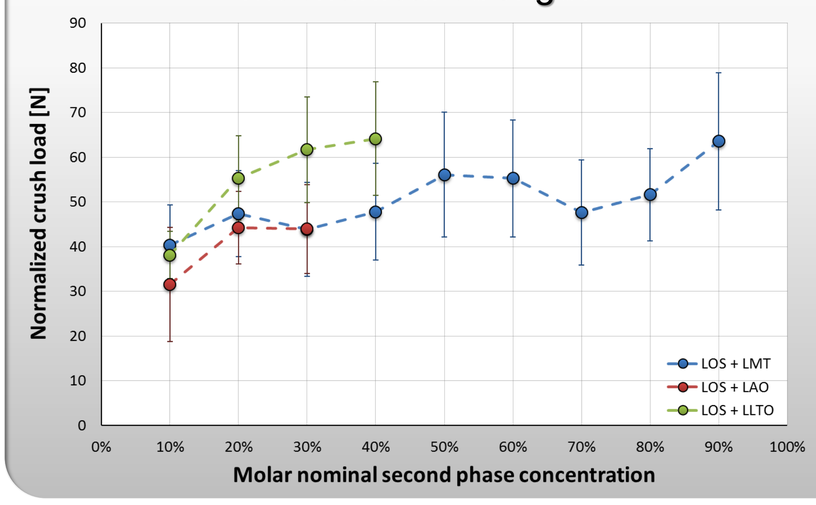
Nominal composition of the fabricated pebbles

- Li_4SiO_4 10% 20% 30% 40% 50% 60% 70% 80% 90% Li_2TiO_3
- Li_4SiO_4 10% 20% 30% $LiAlO_2$
- Li_4SiO_4 10% 20% 30% 40% $Li_{3x}La_{⅔-x}TiO_3$

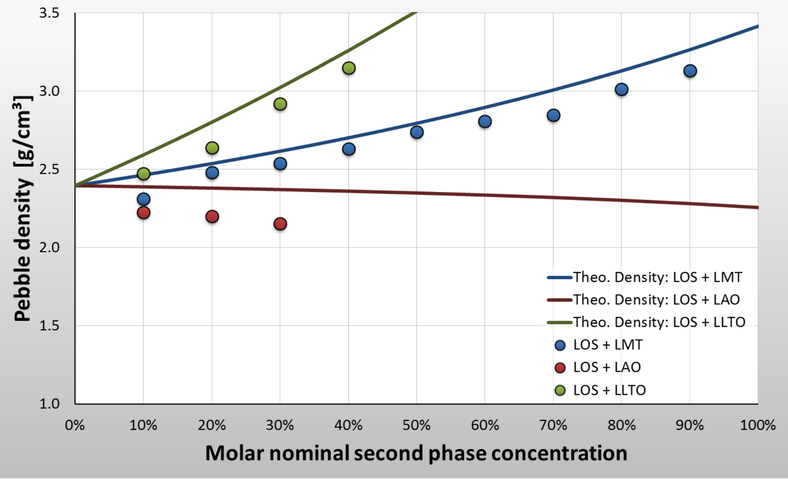
[2] T. Hoshino, FED 89 (2014) 1431–1435

Characterization results & conclusions

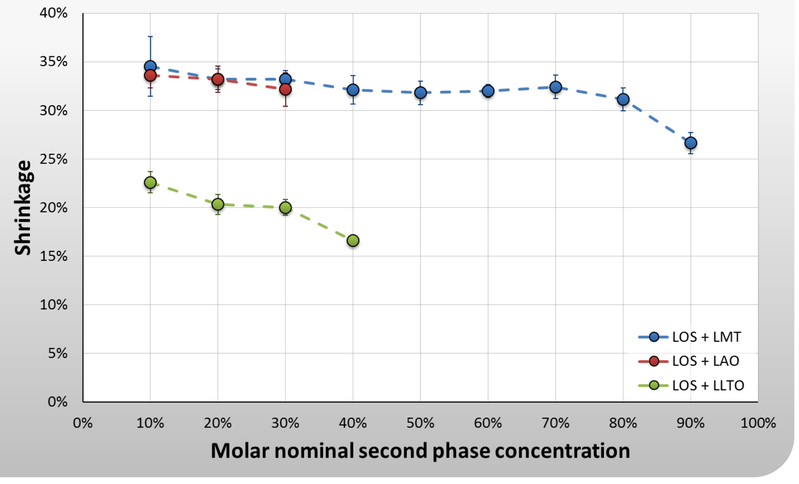
Mechanical strength



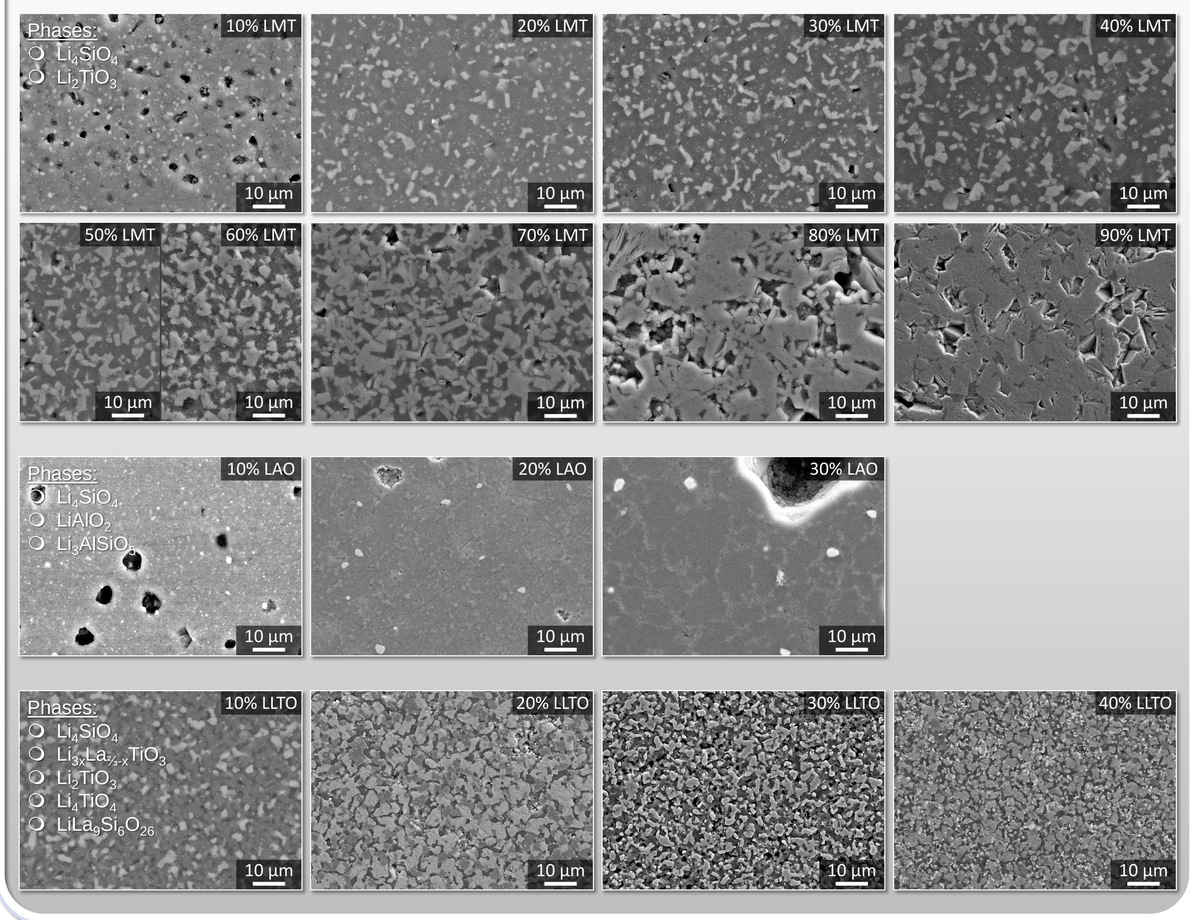
Pebble density



Shrinkage

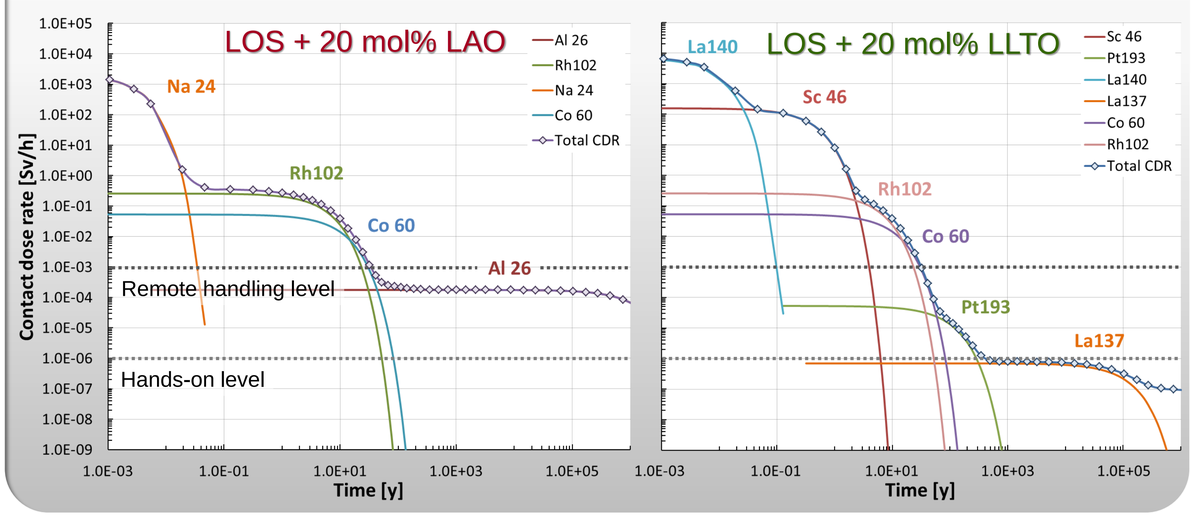


Cross-sections – microstructure



The microstructure is in general very homogenous with reasonably small grains. The addition of one of the tested second phases to the LOS pebbles increases the pebble rigidity. LLTO reacts with LOS, yet, the product excels in mechanical strength. According to the observed phases, LOS+LAO samples show a mild loss of lithium.

Activation behavior – FISPACT calculations



Both material compositions, even with typical melt-based fabrication impurities, qualify as low-activation materials. However, remote handling recycling is necessary to reprocess the materials.

This work was funded by the Federal Ministry of Education and Research under "DEMO R&D within the framework of the German contribution to the Broader Approach" (03FUS0012).

KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

www.kit.edu