Karlsruhe Institute of Technology

The Production of Tritium Breeding Pebbles at KIT

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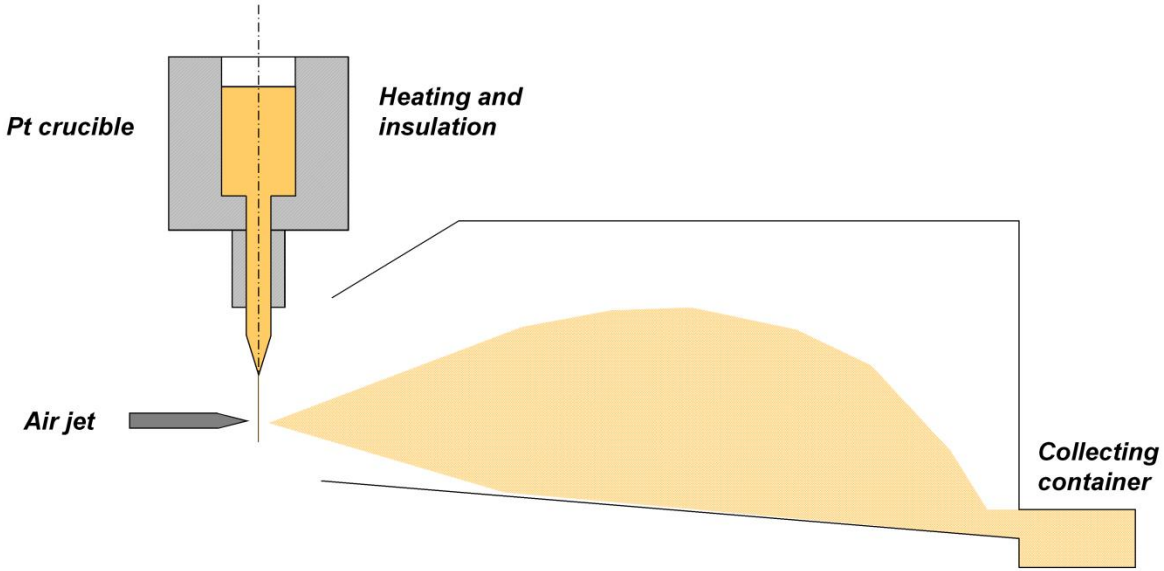
Overview

- Processing
  - Schott AG Process
  - KALOS Process
- Improving the Quality of the Pebbles
  - Strengthening Phase
  - Long-Term Stability
- Jet Control
  - Optimisation of the Operating Pressure
- Further Qualification Studies

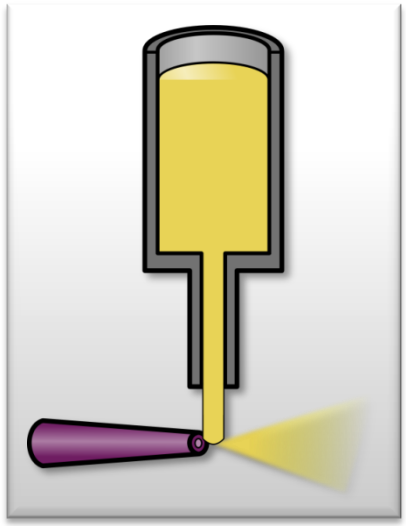
Processing The Schott Process

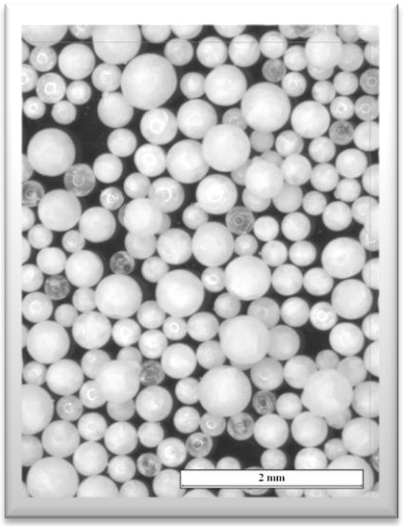
- Originally, a process was developed at Schott AG (Mainz, DE) to produce lithium rich ceramic pebbles
- LiOH and SiO_2 were melted in a platinum crucible at high temperatures
- The melt was then ejected through a nozzle and sprayed with a high pressure cross-flow air jet



Processing The Schott Process

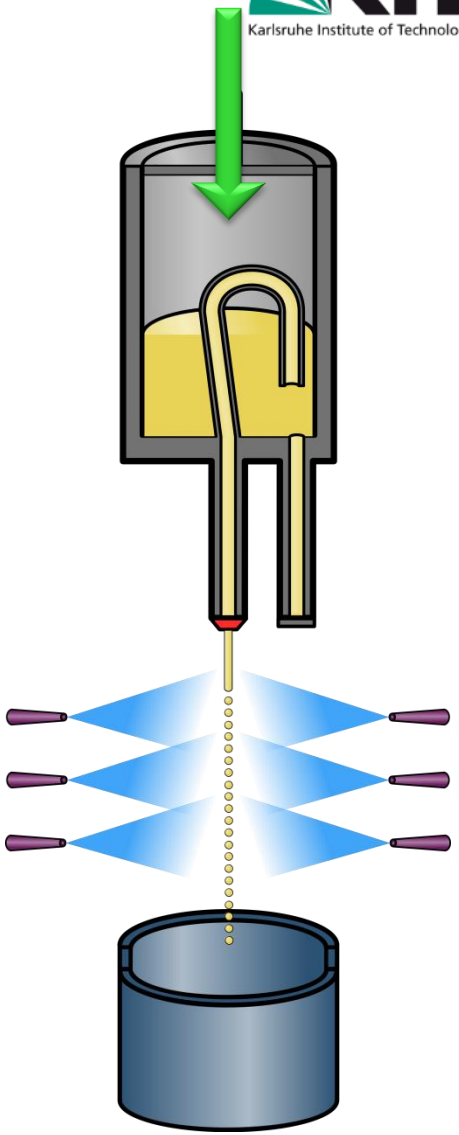
- Due to the excess of silica added, a 2-phase ceramic is formed:
  - Lithium Orthosilicate (Li_4SiO_4) with 10 mol% metasilicate (Li_2SiO_3)
  - This remains the reference breeder material for the EU
- Capacity:
  - 1.5 kg per Batch
  - Approx. 300 kg/year





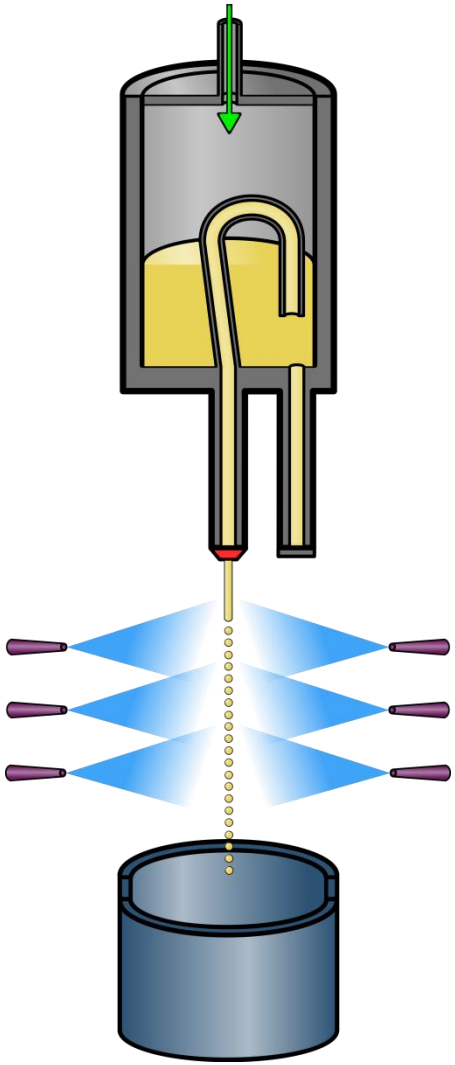
Processing The KALOS Process

- The KALOS Process (KArlsruhe Lithium OrthoSilicate) was developed in order to offer greater process control
  - A melt is formed in a platinum crucible at 1350 °C
  - A controlled pressure is then applied to the crucible to form a laminar jet from a nozzle
  - The jet decays into small droplets as described by the Plateau-Rayleigh instability theory
  - The droplets are solidified using a liquid nitrogen spray system
- Centralised process computer for monitoring, controlling and recording the process
- Separate autonomous safety control system



Processing The KALOS Process

Max. Batch Size	**Approx. 1 kg**
Production Capacity	**150 kg/year**
Max. Operating Temperature	**1450 °C**
LMT Content	**0 – 35 mol%**
Operating Pressure	**200 – 1000 mbar**
Cooling Capacity	**3 Cooling Zones**

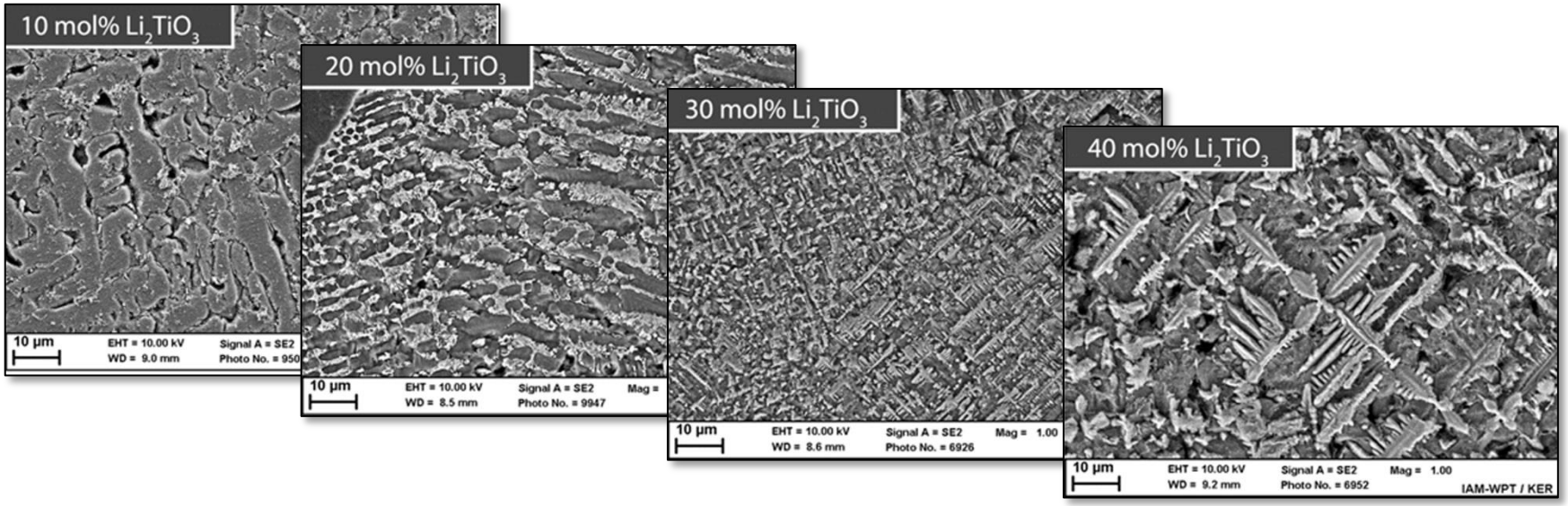


Processing The KALOS Process

Processing The KALOS Process

Composition Effects Lithium Metatitanate

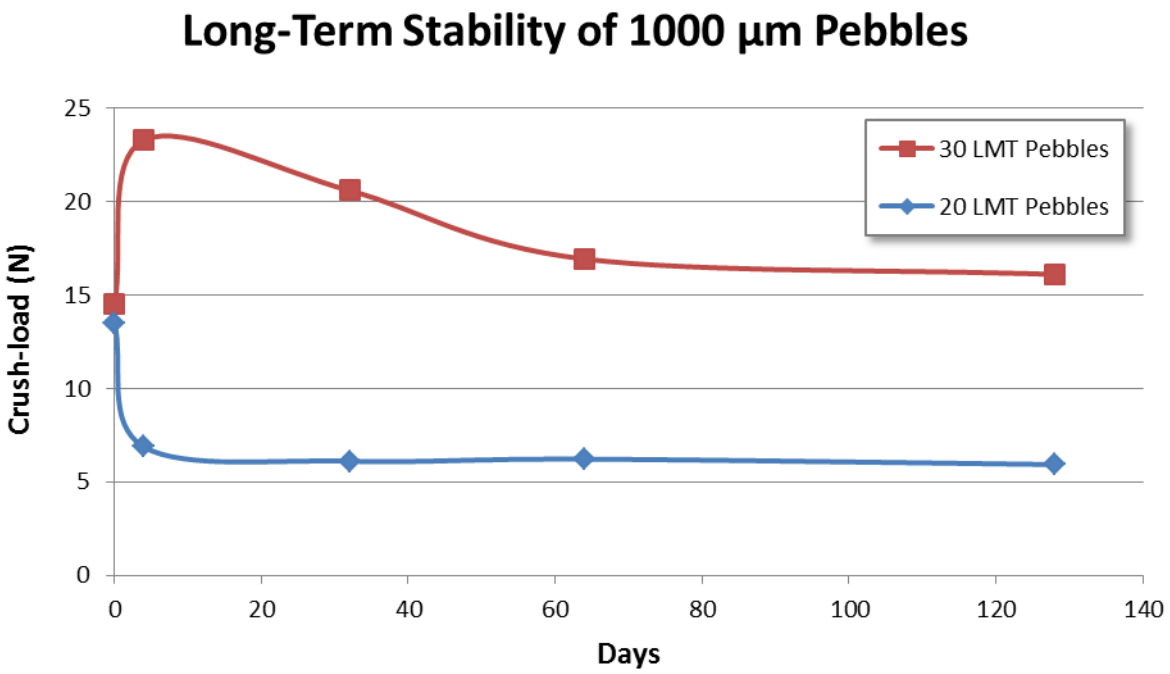
- In order to increase the mechanical strength of the ceramic pebbles, the MSi was replaced with lithium metatitanate (Li_2TiO_3) by adding TiO_2 to the melt
- Between 20 and 30 mol% there is a distinct change in the microstructure which indicates a change in the crystallisation order and hence the presence of a eutectic point



Composition Effects Lithium Metatitanate

- Above 25 mol% LMT, a change in the crystallisation behaviour is observed and leads to:
  - Enhanced mechanical strength…
  - …and longer stability in reactor relevant conditions

(He + 0.1 % H_2 Atmosphere at 900 °C)



Jet Control Operating Pressure Optimisation

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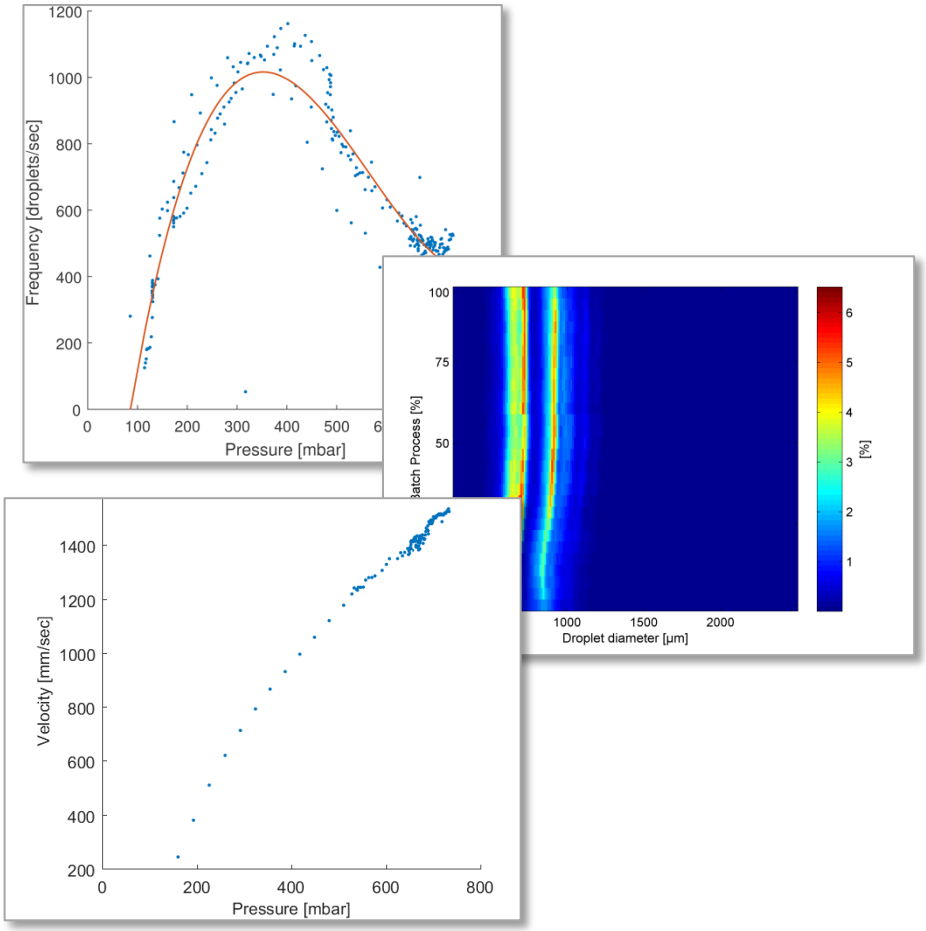
- An image processing algorithm can extract a series of information from the high-speed camera footage:
  - Droplet generation frequency
  - Droplet-size
  - Number of merged droplets in image
  - Jet-velocity
  - Jet-length
  - Jet-angle
  - Plateau-Rayleigh instability wavelength



Further Material Qualification Studies

- Eurofer Compatibility
- Pebble Bed Heat Transfer
- Li Re-enrichment and Reprocessability
- Activation Simulations
- Post Irradiation Examinations
- Radiolysis Testing (University of Latvia)
- Deuterium loading/unloading (CIEMAT, Spain)

Summary

- The KALOS process was developed in order to offer greater process control and the ability to produce a wider range of compositions
- Additions of lithium metatitanate greatly increase the mechanical strength and long-term stability
- Control of the operating pressure affects the overall jet stability and droplet generation rate
- A series of further material qualification tests are currently taking place

Acknowledgments

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