Karlsruhe Institute of Technology

Institute for Applied Materials

Fabrication of Advanced Ceramic Tritium Breeders

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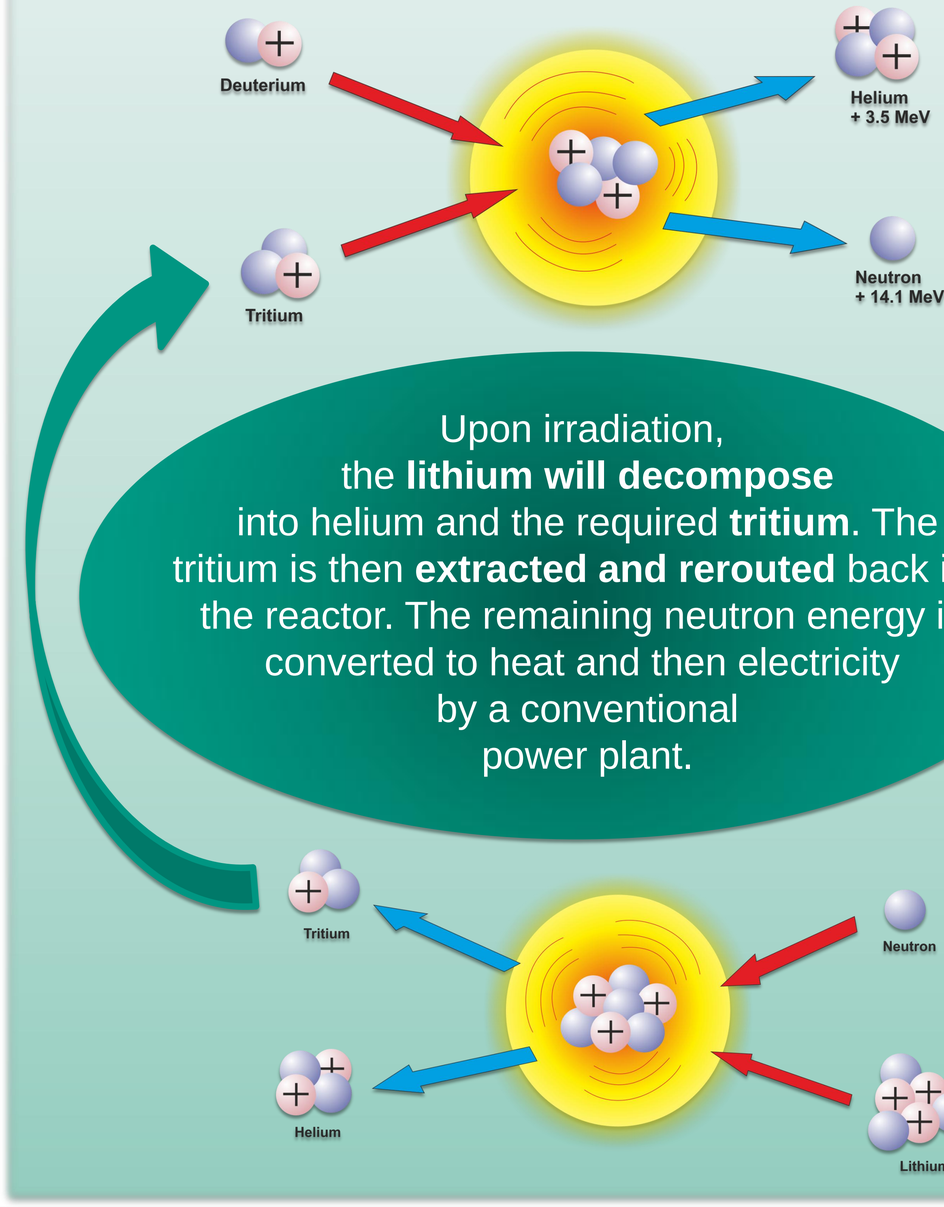
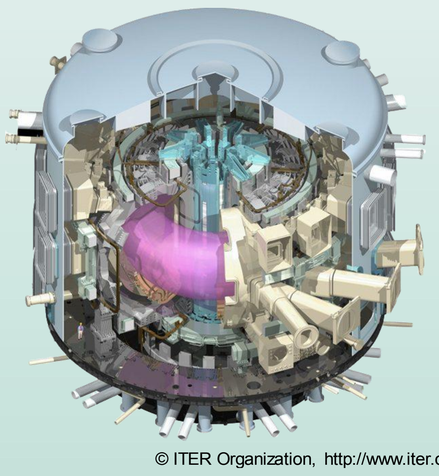
Fusion Energy

Fusion energy has the potential as a clean and renewable energy source. The fusion reaction between **deuterium and tritium** has been chosen as the optimum reaction. This requires a temperature of 150 000 000 °C to overcome the electrostatic repulsion forces and this is achieved by a **plasma** confined in a magnetic field.

While deuterium can be distilled directly from water, tritium will have to be produced on-site. **Lithium-rich ceramics** will be present in the form of pebble beds alongside **beryllium neutron multipliers** inside the so called **'Blanket'** in the reactor wall.

Although the pebbles themselves have no structural function, they still need to have the mechanical strength to withstand **thermal-expansion forces** and **neutron irradiation.**





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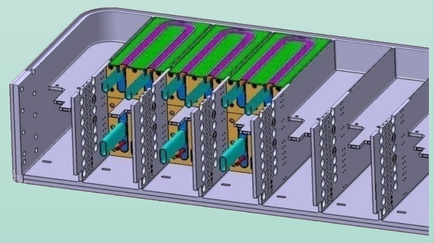
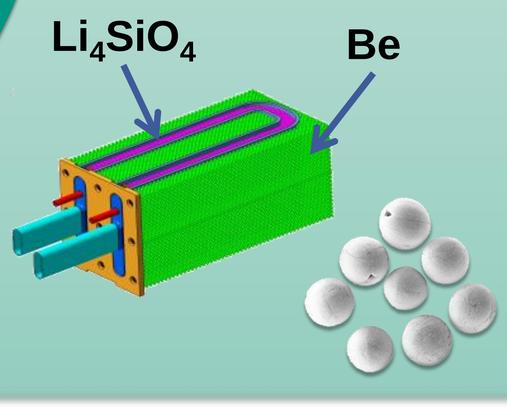
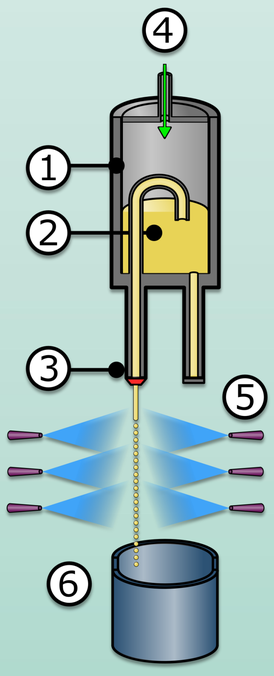


F. Cismondi et al., Fusion Eng. Des. 84 (2009) 607–612



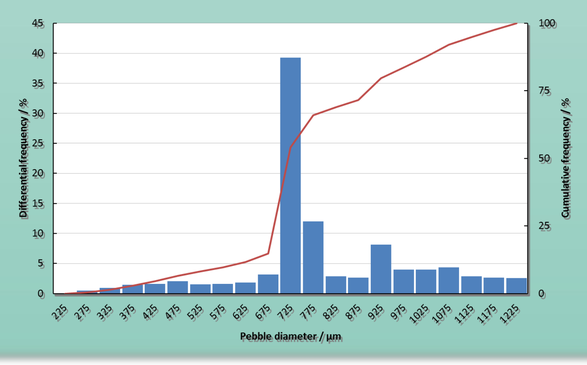
Pebble Fabrication

A novel, melt-based process is used for the production of ceramic pebbles composed of **lithium orthosilicate**, Li_4SiO_4, with additions of **lithium metatitanate**, Li_2TiO_3.

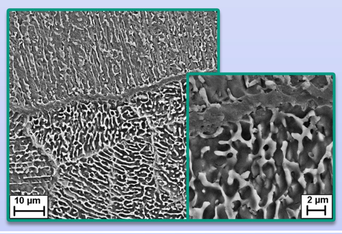
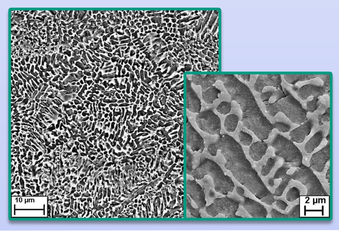
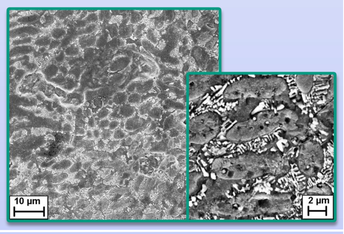
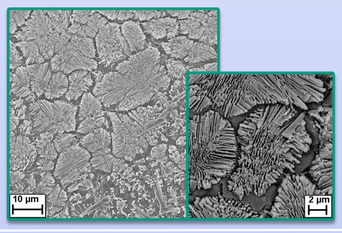
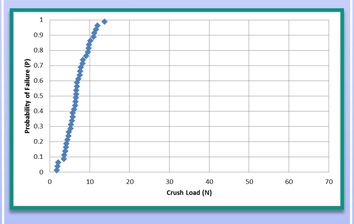
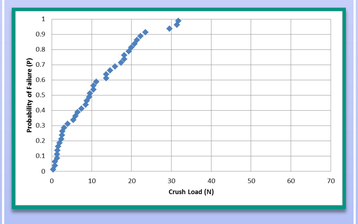
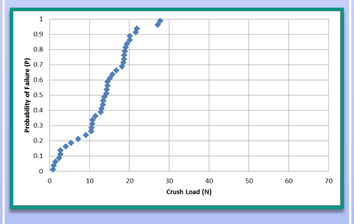
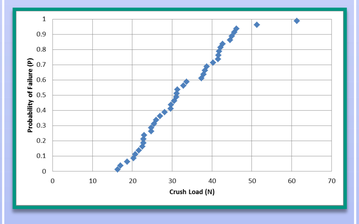


1 Crucible temperature: **1300-1400 °C**
2 Precursors: **LiOH, SiO_2** and **TiO_2**
3 Nozzle diameter: **400 µm**
4 Filling tube and inlet for **400 mbar** synthetic air
5 LN_2 **spray cooling** method
6 LN_2 **quench** method

- Controlled droplet generation
- Close process control
- Narrow pebble size distribution



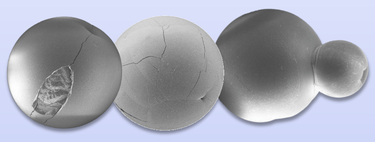
Effect of Different Cooling Methods

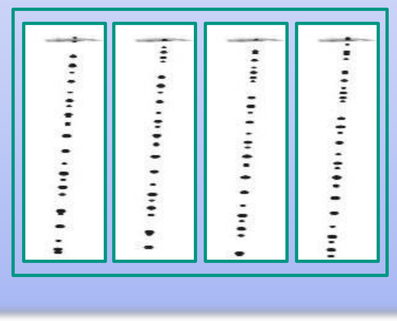
	3 m Drop LN_2 Quench	14 m Drop No Quench	3 m Drop LN_2 Quench	Liquid Nitrogen Spray Cooling
	95 mol% Li_4SiO_4 / 5 mol% Li_2SiO_3		80 mol% Li_4SiO_4 / 20 mol% Li_2TiO_3	
Microstructure				
Crush-load Analysis				
	Mean 6.9, SD 2.9	Mean 11.3, SD 9.1	Mean 13.4, SD 7.0	Mean 32.7, SD 10.4

High-Speed Camera Analysis

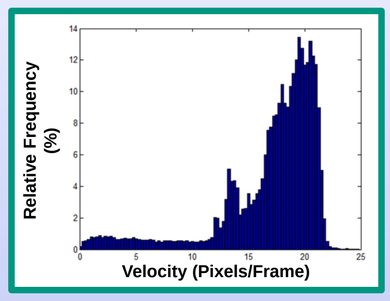
Possible Pebble Defects:

- Fusion of non-solidified pebbles
- Collision damage





- Analysis of pebble dynamics



- Analysis of process stability