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CHARACTERIZATION OF ADVANCED TRITIUM BREEDER CERAMICS

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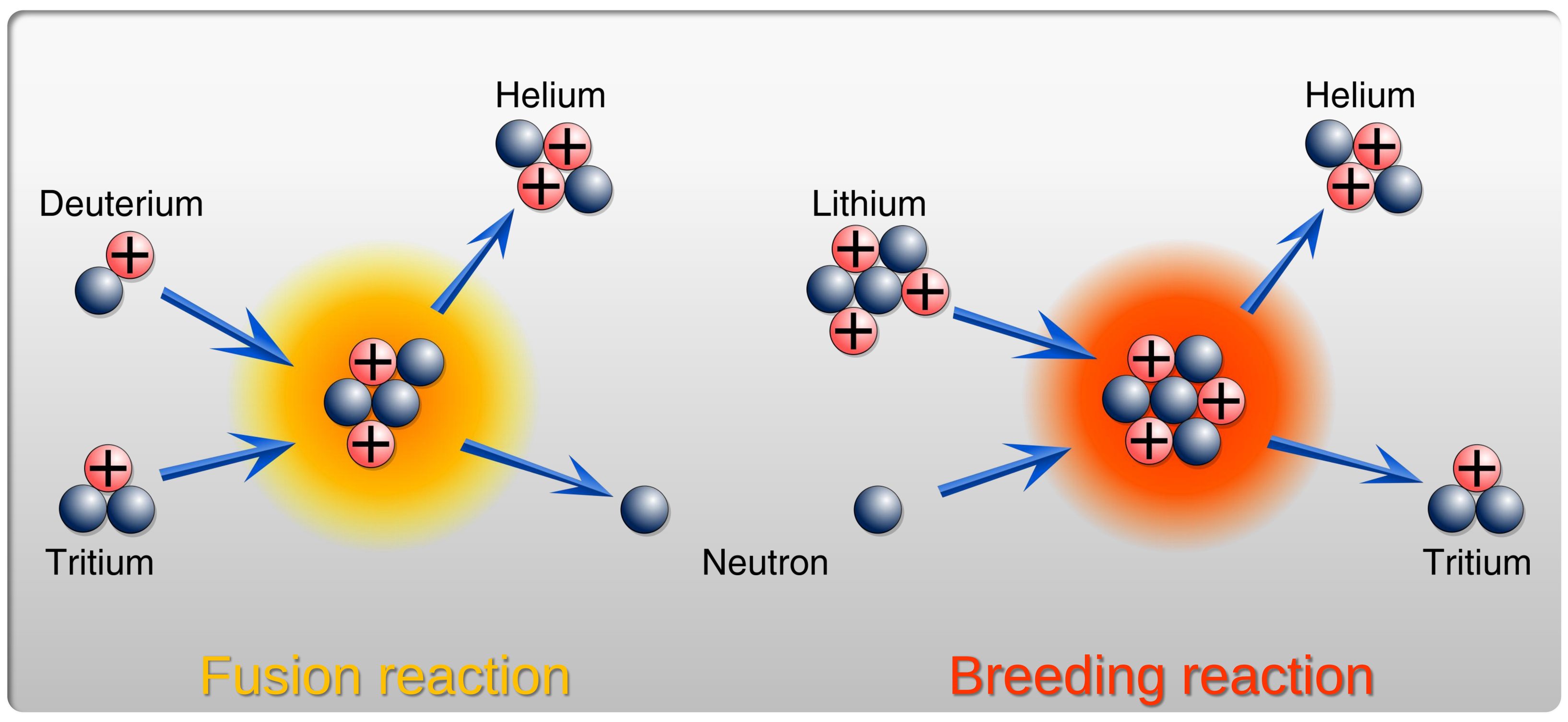
INTRODUCTION

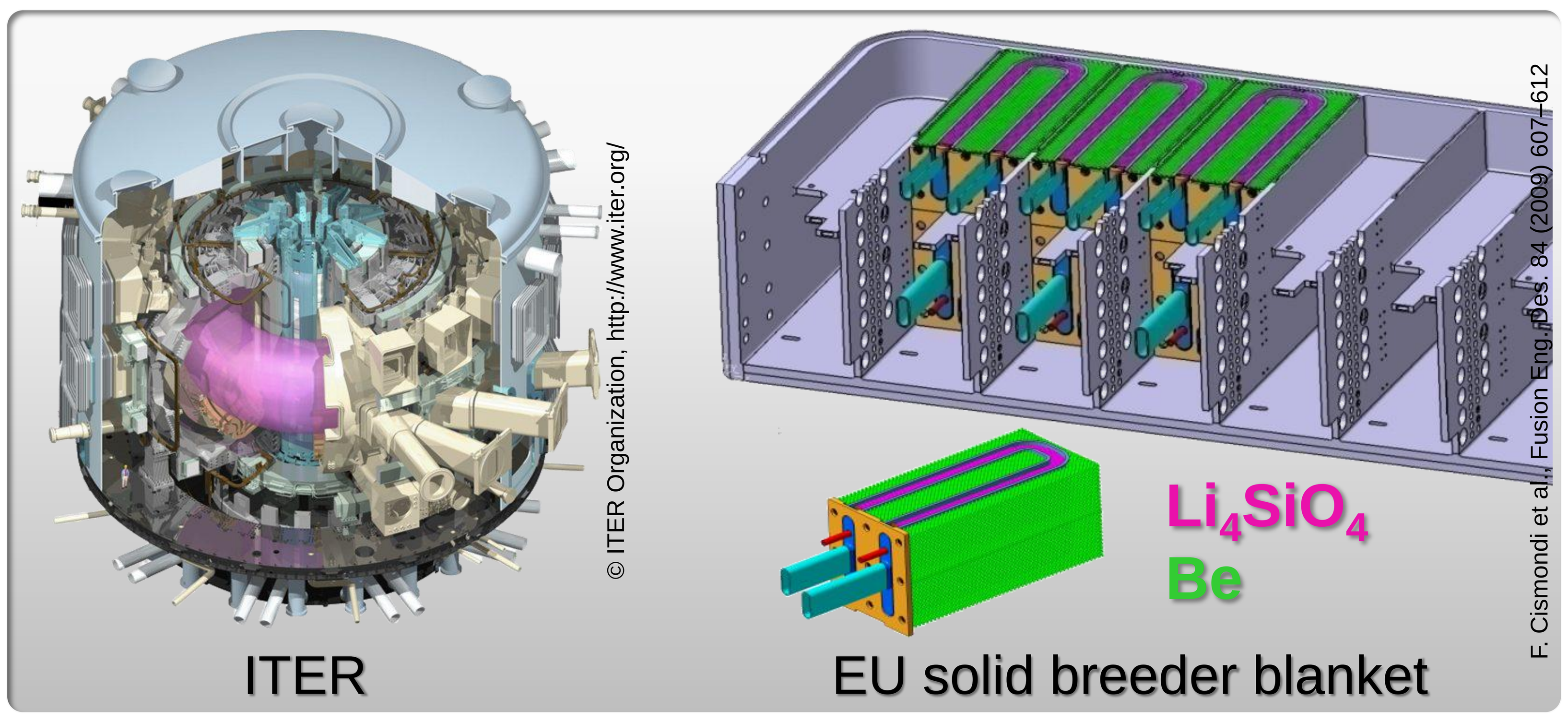
Fusion energy has the potential to play an important role in the future as a clean and sustainable energy source. The deuterium-tritium fusion is currently regarded as the most promising fusion reaction, setting free an enormous amount of energy. During one year of full power operation, gigawatt class fusion reactors will only consume a few hundred grams of deuterium and tritium.

As tritium is hardly available on earth, a fusion power plant has to produce, or “breed”, tritium and achieve tritium self-sufficiency. This can be realized by using the free neutrons that are produced in the fusion reaction for the transmutation of lithium to helium and tritium.

This reaction is going to be carried out in the so-called “blanket” – a steel structure on the inside of the vacuum vessel surrounding the fusion plasma. One blanket concept developed in the European Union and to be tested in ITER features lithium ceramic pebble beds for tritium breeding.

Lithium orthosilicate, Li_4SiO_4, and lithium metatitanate, Li_2TiO_3, are considered as the most suitable breeder materials since they fulfill the requirements without exhibiting major weaknesses. For facile recycling of the breeder material without wet-chemical reprocessing, a melt-based fabrication process of lithium orthosilicate pebbles is being developed at KIT.





MOTIVATION

Since the fusion relevant properties of lithium orthosilicate and lithium metatitanate are complementary, an advanced tritium breeder pebble consisting of both materials is expected to exhibit more balanced properties. Such pebbles are currently fabricated and investigated.

However, little is known about the relevant system. As additions of lithium metasilicate to the material are also looked into and the burn-up of lithium in a fusion reactor will eventually generate Li_2SiO_3, understanding the system Li_4SiO_4-Li_2SiO_3-Li_2TiO_3 is essential for breeder ceramic research.

RESULTS & OUTLOOK

The quasi-binary system Li_4SiO_4-Li_2TiO_3 has not been investigated in the past. Differential scanning calorimetry measurements show a decline of the liquidus temperature with increasing lithium metatitanate concentration. Beyond 20 mol% the liquidus temperature begins to increase.

The microstructure shows an increase of typically eutectically solidified grains up to 20 mol% as well.

The transition to the primary solidification of lithium meta-titanate is clearly visible from 25 mol% upwards. XRD investigations do not show intermediate phases, so the results clearly suggest a purely eutectic system.

Important details of the system are still unknown. Also high-temperature phase transformations have to be investigated in more detail in the future.