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Long-term Thermal Stability of Two-phased Lithium Orthosilicate/Metatitanate Ceramics

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Abstract

The long-term thermal stability of advanced ceramic breeder pebbles consisting of lithium orthosilicate (Li_4SiO_4) and additions of lithium metatitanate (Li_2TiO_3) was tested in an annealing experiment at 900 °C for up to 128 days. Different gas atmospheres were used to test the influence of moisture in the purge gas. Li_4SiO_4 pebbles including nominally 25, 30, and 35 mol% Li_2TiO_3 were investigated with regard to their chemical composition, microstructure, porosity, and mechanical properties after predetermined time intervals and at the end of the experiment. No lithium loss and no secondary phases were detected. The microstructures, porosities and mechanical stabilities did not show significant changes over time. Moreover, moisture in the purge gas atmosphere has no negative influence on the material properties.

Keywords: fusion technology, ceramic breeder, long-term stability, Li_4SiO_4, Li_2TiO_3

1 Introduction

Ceramic breeder (CB) materials are an essential component of the solid breeder concept in fusion technology. Different ceramic materials applied as pebbles in pebble beds are investigated to develop the European Helium Cooled Pebble Bed (HCPB) blanket concept. For the use in a future fusion reactor these ceramics have to provide enough Li-6 for breeding tritium and exhibit good tritium release properties. Beside the bombardment with neutrons to breed the required tritium for the fusion reaction, the ceramic pebbles have to sustain high temperatures and be resistant against thermomechanical stresses during their use. A stable and therefore reliable material is necessary to provide a sufficient tritium supply during the operation of a fusion reactor.

Lithium orthosilicate (Li_4SiO_4, LOS) and lithium metatitanate (Li_2TiO_3, LMT) are promising tritium breeding materials for the HCPB blanket concept as they show positive material properties such as an adequately high lithium density and decent mechanical stability, respectively. Moreover, especially Li_4SiO_4 is a low activating compound [1,2], which is important to prevent the generation of radioactive waste and to allow for the recycling of the material. Advanced breeder ceramics consisting of both phases have been produced and investigated to combine their favourable material properties such as high lithium density (LOS) and high mechanical stability (LMT). For the production of these biphasic ceramic pebbles a melt-based process named KALOS was designed and developed at KIT [3,4]. Beside a high yield of pebbles, this process offers the possibility of facile recycling of used material which saves resources [5,6].

Within this study the long-term stability of advanced CB pebbles with different compositions was investigated at high temperatures of 900 °C for the maximum annealing duration of 128 days. The