Seminar

Institute for Plasma Research

Title : Development of Li_4SiO_4-based Ceramics for Solid breeder and CO_2 Absorption Applications

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Venue : Committee Room 4, (New Building), IPR

Abstract :

Lithium orthosilicate (Li4SiO4) have been studied as an attractive ceramic solid breeder material due to its high lithium atom density, low neutron activation characteristics and prominent tritium release rate at low temperatures. In addition, Li4SiO4 also considered as a promising solid sorbent for CO2 capture owing to its sorption capacity at high temperatures (450-700oC), excellent cyclability, faster sorption rate, cost-effective and lower regeneration temperatures (≤800oC). However, there are certain critical issues relating to the practical use of Li4SiO4. Calcination of Li4SiO4 above 900oC leads to the formation of larger particle sizes owing to the particle sintering and evaporation of Li2O that promote impurity phases. Densification of the powder above 80% of its theoretical density and maintaining phase purity in the sintered product are challenging. Fabrication of Li4SiO4 pebbles in large scale using complex processes like melt spraying, wet, sol-gel, hydrothermal and freeze-drying is difficult. Moreover, in most of the processes LiOH or lithium acetate has been used as the source of lithium for which maintaining stoichiometry is tough. Extrusion – spheronization is a simple and feasible technique for the bulk preparation of Li4SiO4 pebbles. However, there is no report in the public domain that addresses the factors affecting the formation of pebbles using this technique. For solid breeder application samples having a higher bulk density (>85% TD), open porosity (around 10-15%), phase purity, uniform grain size (<10µm) with narrow distribution are required. Phase purity and particle size of Li4SiO4 are the two critical factors which can directly influence the CO2 absorption capacity. Use of nanoscale Li4SiO4 powders may improve the sinterability and CO2 capture property of the ceramic. The current thesis aim to develop Li4SiO4 ceramics by addressing the above mentioned problems.

In the present work, Li4SiO4 powder was prepared by solution combustion and solid-state methods using cheaper silica source silicic acid. It was found that solution combustion method was useful to produce nanosize Li4SiO4 powder at 700oC. The average particle size of solution route Li4SiO4 powder (for Φe =0.6) was found to be 72 nm with high surface area (26.7m2 /gm). The combustion derived powder showed higher sinterability (~84% RD at 900oC) and CO2 absorption capacity of 30.7wt% (307mg/g at 700oC after 60min) which is equivalent to 83.9% of its theoretical efficiency. Secondly, Li4SiO4 pebbles were fabricated by extrusion-spherodization technique using three different binders: PVA, PVP and guar gum. Sintered Li4SiO4 pebbles were characterized for sphericity, pore size distribution, grain size, crushing load. Further, Li4SiO4-Li2TiO3 and Li4SiO4-Li2ZrO3 composite powders were synthesized using solidstate method with an aim to improve the sintered density. A substantial improvement in the mechanical strength of composite sample was achieved. Thermal expansion, thermal and electrical conductivity of the composite pellets were studied. The composite pebbles showed good stability to moisture when compared to pure Li4SiO4.