MANUFACTURING AND CHARACTERIZATION OF POROUS SiC FOR FLOW CHANNEL INSERTS IN DUAL-COOLANT BLANKET DESIGNS

A. Bereciartu[1], N. Ordás[1], C. García-Rosales[1], A. Moroño[2], M. Malo[2], E.R. Hodgson[2],

I. Peñalva[3], G. Alberro[3], J. Abellà[4], L. Sedano[2]

[1] CEIT and Tecnun (University of Navarra), Manuel de Lardizábal 15, 20018, San Sebastián, Spain
[2] CIEMAT, Avenida Complutense 22, 28040 Madrid, Spain
[3]Department of Nuclear Engineering and Fluid Mechanics, University of the Basque Country, Spain
[4] Institut Químic de Sarrià, University Ramon Llull, Via Augusta 390, 08017 Barcelona, Spain

Corresponding author: cgrosales@ceit.es

The materials envisaged for the insulating flow channel inserts (FCI) in dual-coolant type blanket designs play a decisive role for the blanket efficiency since they have to provide enough thermal insulation to allow the temperature of the Pb-15.7Li coolant inside the channels being significantly higher than the maximum allowable temperature of the structural steel (Eurofer) [1]. Thus, FCI materials should exhibit low thermal and electrical conductivity, low tritium permeability, low corrosion in contact with Pb-15.7Li at the temperature of operation, and sufficient mechanical strength to withstand the thermo-mechanical and thermo-electrical stresses.

SiC is presently the primary candidate material for FCI due to its excellent thermal, mechanical and chemical stability at high temperature, low thermal expansion, high thermal shock resistance, low corrosion by Pb-15.7Li at the temperatures of operation, low activation and good resistance to neutron irradiation. Among the different types of SiC under consideration, porous SiC is one of the most attractive one, since it is a low cost manufacturing route by which it is expected to achieve the required properties.

A major programme objective is the development of production routes for ceramic materials based on porous SiC for their application as FCI. Within this project, first batches of porous SiC have been produced by the powder metallurgy route using a mixture of SiC and C powders. The starting powders were compacted, sintered and oxidised in air to eliminate the free C and achieve the desired porosity and thus, the required thermal and electrical conductivity by maintaining a sufficiently high mechanical strength [2]. Different powders with nm- and μm size have been used, and sintering was performed at different temperatures ranging from 1800 to 2200°C. Samples were produced with and without sintering additives. Furthermore, a dense SiC coating on the porous SiC have been developed to avoid tritium permeation. In this work, results of porosity, microstructure, mechanical properties and thermal conductivity under different manufacturing conditions are presented. In addition, first results on the electrical conductivity of selected samples under ion irradiation to simulate the expected neutron damage are presented. Finally, measurements of hydrogen permeation and transport in these materials are shown.

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[2] Yi-Hyun Park, Tatsuya Hinoki, Akira Kohyama, "Development of multi-functional NITE-porous SiC for ceramic insulators", J. Nucl. Mater. 386–388 (2009) 1014–1017.

This work is founded by the Spanish National Project on Breeding Blanket Technologies TECNO_FUS through CONSOLIDER-INGENIO 2010 Programme.