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Development, characterization and testing of a SiC-based material for Flow Channel Inserts in high temperature DCLL blankets

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Flow Channel Inserts (FCIs) are one of the key elements in the high temperature DCLL blanket concept, one of those being considered for DEMO. FCIs must provide the required thermal insulation between the blanket steel structure and the hot liquid PbLi that is flowing inside them; the high PbLi temperatures (up to 700 ºC) allow a high reactor efficiency, but impose a considerable thermal gradient across the FCI's walls, generating mechanical stresses that must be supported without damage during the operation time. Besides, they should provide enough electrical insulation to minimize MHD pressure drop, they must be inert in contact with PbLi preventing corrosion damage, and should present low tritium permeation. To develop a suitable FCIs material with these requirements is one of the main challenges in the development of a high temperature DCLL.

In this research, a SiC-based sandwich material is proposed for FCIs, consisting of a porous SiC core covered by a dense CVD-SiC layer. SiC fulfils the operational requirements for FCIs including low activation and degradation by neutrons, and porous SiC is an attractive candidate to obtain a thermally and electrically low conducting structure; to prevent corrosion by PbLi and tritium permeation, a dense SiC coating is applied on the porous material. To produce the porous SiC core of the sandwich, a method consisting of combining the particle size of the starting SiC powder mixture with a carbonaceous sacrificial phase is proposed, being the sacrificial phase removed after sintering by oxidation. In this work, a description of the production method is presented as well as the properties of the resulting porous material after sintering and oxidation, like porosity, microstructure, thermal and electrical conductivity, and flexural strength. By using this technique, a wide range of porous SiC materials with different porosities and thus, conductivities and strength values, can be produced. According to thermomechanical calculations and FEM models, and assuming a SiC dense coating of 200 µm and a porous SiC core of 5 mm, the core material should present a thermal conductivity ≤ 7 W/m·K at 700 ºC and mechanical strength > 50 MPa to ensure the required insulation and mechanical integrity. In this work, a material with porosity near 45% and thickness ≈ 5 mm, thermal conductivity of 7 W/mK and flexural strength about 100 MPa is proposed as porous core. Porous SiC samples covered by a dense CVD SiC layer of ≈ 200 µm were tested under hot PbLi to study their response against corrosion. A first batch of samples was tested under static PbLi at 700 ºC during 1000 h, after which they did not show any sign of corrosion damage. Then, a second batch of samples was tested under dynamic PbLi flowing at velocity near 10 cm/s at 550 ºC during 1000 h. A magnetic field of 1.8T was applied during the test to some of the samples to study its possible effects on the corrosion behaviour. Results of all corrosion tests are presented and discussed.

Eligible for student paper award?

Yes

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