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Stability of Porous SiC Based Materials under Relevant Conditions of Radiation and Temperature

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Abstract : SiC based composites are candidates for possible use as structural and functional materials in the future fusion reactors, the main role is intended for the blanket modules. In the blanket, the neutrons produced in the fusion reaction slow down and their energy is transformed into heat in order to finally generate electrical power. In the blanket design named Dual Coolant Lead Lithium (DCLL), a PbLi alloy for power conversion and tritium breeding circulates inside hollow channels called Flow Channel Inserts (FCIs). These FCI must protect the steel structures against the highly corrosive PbLi liquid and the high temperatures, but also provide electrical insulation in order to minimize magnetohydrodynamic interactions of the flowing liquid metal with the high magnetic field present in a magnetically confined fusion environment. Due to their nominally high temperature and radiation stability as well as corrosion resistance, SiC is the main choice for the flow channel inserts. The significantly lower manufacturing cost presents porous SiC (dense coating is required in order to assure protection against corrosion and as a tritium barrier) as a firm alternative to SiC/SiC composites for this purpose. This application requires the materials to be exposed to high radiation levels and extreme temperatures, conditions for which previous studies have shown noticeable changes in both the microstructure and the electrical properties of different types of silicon carbide. Both initial properties and radiation/temperature induced damage strongly depend on the crystal structure, polytype, impurities/additives that are determined by the fabrication process, so the development of a suitable material requires full control of these variables. For this work, several SiC samples with different percentage of porosity and sintering additives have been manufactured by the so-called sacrificial template method at the Ceit-IK4 Technology Center (San Sebastián, Spain), and characterized at Ciemat (Madrid, Spain). Electrical conductivity was measured as a function of temperature before and after irradiation with 1.8 MeV electrons in the Ciemat HVEC Van de Graaff accelerator up to 140 MGy (~ 2·10 -5 dpa). Radiation-induced conductivity (RIC) was also examined during irradiation at 550 ºC for different dose rates (from 0.5 to 5 kGy/s). Although no significant RIC was found in general for any of the samples, electrical conductivity increase with irradiation dose was observed to occur for some compositions with a linear tendency. However, first results indicate enhanced radiation resistance for coated samples. Preliminary thermogravimetric tests of selected samples, together with posterior XRD analysis allowed interpret radiation-induced modification of the electrical conductivity in terms of changes in the SiC crystalline structure. Further analysis is needed in order to confirm this.

Keywords : DCLL blanket, electrical conductivity, flow channel insert, porous SiC, radiation damage, thermal stability
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