Potential Ternary Compounds for First Wall Fusion Applications

D.J. O'Connor, E. Kisi, D. Riley, M. Healy
University of Newcastle, NSW 2308 Australia

The demands placed on a first wall in a fusion facility are both numerous and demanding. In most cases up till now, the materials considered have largely been elemental or two component alloys but so far none have met the demanding benchmarks for a practical solution for long term applications.

A family of compounds, call MAX Phases, cover a broad range of elements and have very promising synthesis properties as well as physical properties which indicate that they are well placed to be considered as potential candidates. There are over 600 compounds in this family though only 50 known have been synthesised so far, so it is not yet possible to claim a thorough study has been undertaken of this class of material. An examination of the properties of just one compound, Ti_3SiC_2, shows the potential for this class of materials.

Consideration of Ti_3SiC_2 is based on the earlier work on TiC and SiC as potential first wall materials. As a three element material Ti_3SiC_2 is essentially a machineable ceramic with exceptional properties and is suited to both mechanical and electrical applications. Ti_3SiC, has the high temperature and chemical resistance of a ceramic combined with a degree of ductility and a higher electrical conductivity than pure Ti. Furthermore, the material has far higher thermal conductivity than commercial stainless steel or Ti alloys, and although it has a high fracture toughness at high temperatures, it can be machined using conventional hardened steel tools. It exhibits excellent damage tolerance and good thermal shock resistance.

Ti_3SiC_2 has the advantage that there are a number of synthesis processes established which provide the opportunity to tailor the synthesis to meet specialist needs. One form of manufacture, called Self-Propagation High-Temperature Synthesis (SHS) promises to both form large quantities relatively inexpensively but also, through the high temperatures generated, will facilitate bonding to a variety of surfaces.

Preliminary experiments have been conducted on the native surface composition and response to low energy (2keV) He bombardment to characterise the materials equilibrium composition and effects associated with preferential sputtering and annealing.

Future pathways for this research will be outlined.