Metal Silicide Reaction-Bonded SiC for Fusion

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Fusion applications

Silicon carbide is intended for use in the breeding blanket of future fusion reactors due to its corrosion resistance, high temperature strength, low thermal expansion, good thermal conductivity, and low nuclear activation.

RB-SiC is simple to make in the required shapes, but radiation resistance needs to be improved due to differential radiation-induced swelling between silicon and SiC. Replacing silicon with a metal silicide is hoped to improve toughness and radiation resistance.

Processing with Si-alloys

Silicon alloys were made by arc melting silicon with chromium, or tungsten, at near-eutectic compositions. These were melt infiltrated into SiC/carbon black porous preforms in vacuum. Si + C → SiC + residual disilicide. Samples were sectioned, polished, nanoindented, and imaged.

Conclusions and future work

- Silicon can be replaced in RB-SiC with a metal silicide via eutectic alloy reactive melt infiltration
- Nanoindentation shows reduced cracking
- Raman stress mapping of residual phases and indents
- High energy ion implantation to simulate radiation damage
  - EBSD strain mapping
  - Corrosion in molten Li-Pb alloy for breeder blanket compatibility

References & Acknowledgements


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Recent work: nanoindentation plasticity, and observation of reaction-formed SiC

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SiC/WSi2/Si nanoindent

1000 nm Berkovich indent and FIB cross-section
Purple circle shows a crack stopping when it reaches WSi2
Orange arrows show plasticity (or cracking)
Red circle shows WSi2 pulling out or crack bridging the SiC matrix
No visible sub-surface cracking

Ion irradiated SiC/WSi2/Si indents

2000 nm cube-corner indent into SiC/Si region and a 500 nm cube-corner indent into SiC/WSi2 region (red circle expanded below)
Some signs of plasticity in the WSi2 phase along the indenter edges

Formation of RB-SiC

The mechanism of reaction formed SiC is disputed: nucleation and growth from carbon-saturated solution, or by diffusion controlled transformation of a carbon layer.

These images of grains in partially reacted RB-SiC which was starved of silicon suggest that SiC grows epitaxially on the existing SiC grains rather than by diffusion of carbon or silicon through a SiC layer. Further investigation required.