



Micro-scale modelling of thermo-mechanical and environmental degradation of non-oxide Ceramic Matrix Composites (CMCs)

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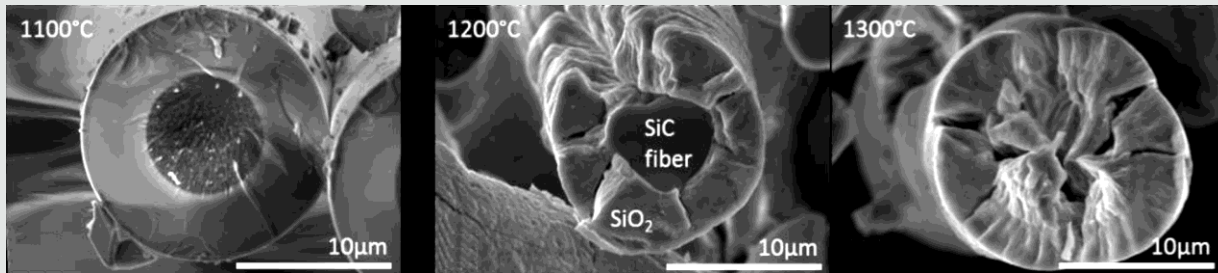
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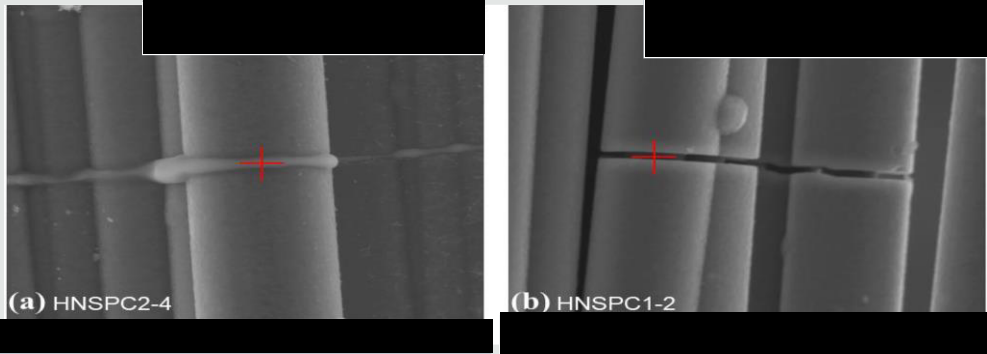
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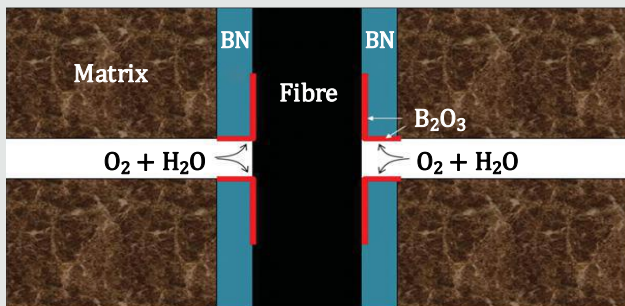
Modelling Framework for Oxidation and Creep in Non-oxide Ceramic Matrix Composites (CMC)



SEM images of Hi-Nicalon fibres showing SiO₂ oxide after exposure to O₂ for 6h [1]

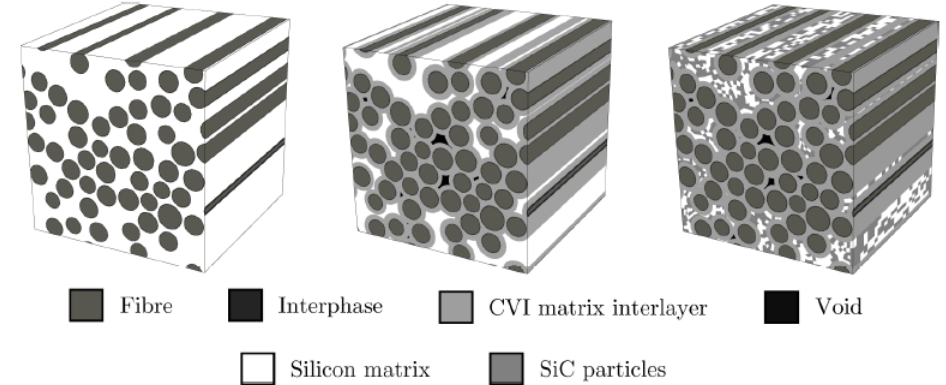


SEM images with EDS elemental composition (wt%) of oxidation products within a crack in Hi-Nicalon™ S mini-composites tested in creep @ 1200°C in air [3]



Semi-analytical model of oxidation reactions around a single fibre bridging a single matrix micro-crack [4]

BCI Microtool for RVE model generation



Microscale representative volume element (RVE) of a CMC [2]

Oxidation reactions

- $\text{Si} + \text{O}_2 (\text{g}) \rightarrow \text{SiO}_2$
- $\text{SiC} + \frac{3}{2}\text{O}_2 (\text{g}) \rightarrow \text{SiO}_2 + \text{CO} (\text{g})$
- $2\text{BN} + \frac{3}{2}\text{O}_2 (\text{g}) \rightarrow \text{B}_2\text{O}_3 (\text{l}) + \text{N}_2 (\text{g})$
- $\text{B}_2\text{O}_3 (\text{l}) + \text{H}_2\text{O} (\text{g}) \rightarrow \frac{2}{3}(\text{HBO}_2)_3 (\text{g})$
- $y\text{B}_2\text{O}_3 (\text{l}) + z\text{SiO}_2 (\text{s}) \rightarrow y\text{B}_2\text{O}_3 \cdot z\text{SiO}_2 (\text{l, s})$

Aims of this research

Develop **micro-scale models** of CMCs accounting for **oxidation**, **creep** and **micro-cracking** to inform meso- and macro-scale models, replacing empirical assumptions:

- Exposed surface area as a function of local stress state
- Exponential reaction decay function due to the build-up of oxidation by-products
- Matrix micro-crack density as a function of local stress state, *etc.*