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Bristol Composites Institute (ACCIS)

Full-field characterisation of oxide-oxide ceramic-matrix composites using X-ray computed micro-tomography and digital volume correlation under load at high temperatures

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Outline

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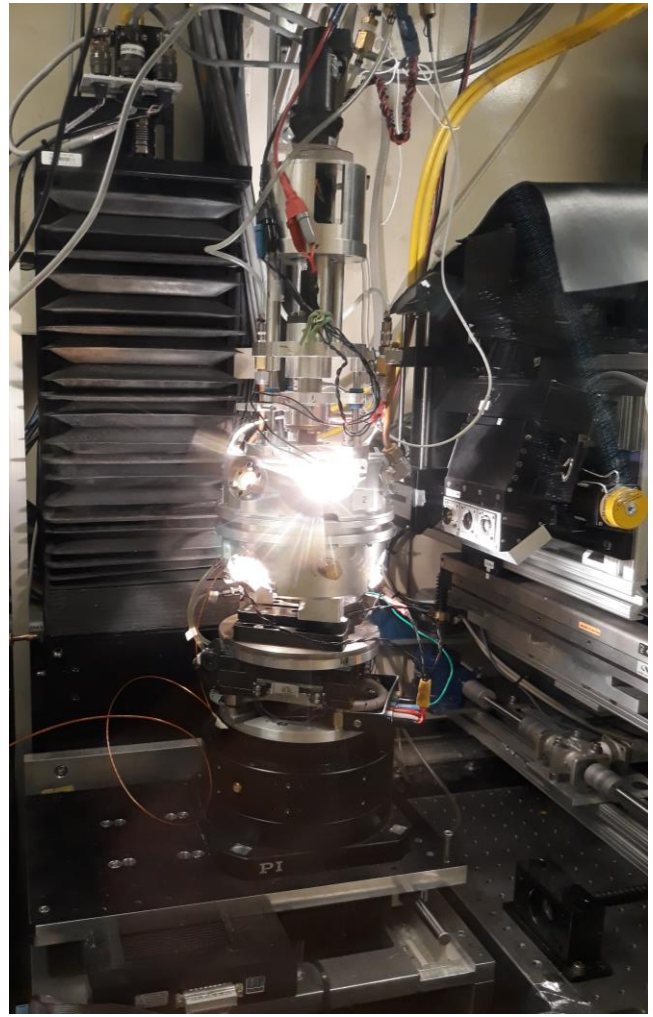
Introduction

- Oxide (Al_2O_3-based) CMCs:
  - \+ Improved oxidation stability over SiC CMCs → better lifetimes;
  - \- Reduced mechanical performance: strength and creep.

- Aim:
  - Test the suitability of in situ X-ray computed microtomography (XCT) coupled with digital volume correlation (DVC) for the full-field characterization of oxide/oxide CMCs
  - Investigate the relationship between microstructure, local 3D strain and damage mechanisms a novel technique: DVC

Experimental Procedure

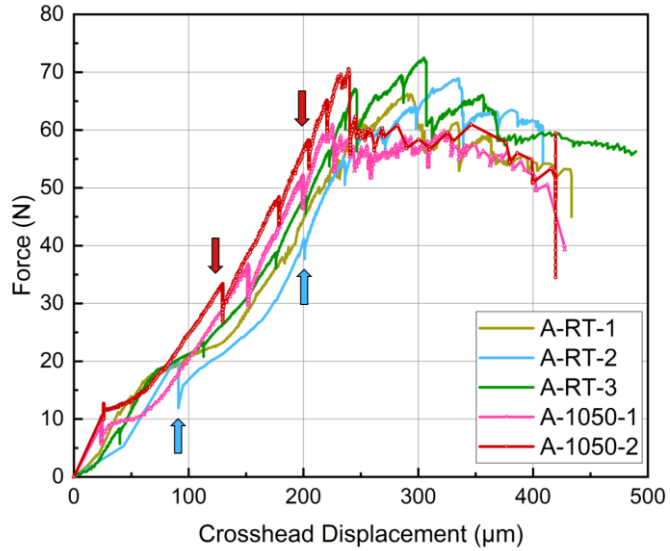
- Materials:
  - Woven Nextel™ 720/Alumina (720/A) – porous matrix
    - **Material A**: sintered at 1200ºC
    - **Material B**: sintered above 1250ºC
- Methods:
  - 3-point bending (3-PB) with *in situ* XCT, ALS, USA (Prof. Robert Ritchie)
    - Fixed dimensions: 3x4x25mm (21mm support span)
    - Room temperature (RT) and 1050°C (HT) in Air
    - Avizo X**D**igital**V**olume**C**orrelation – Global DVC



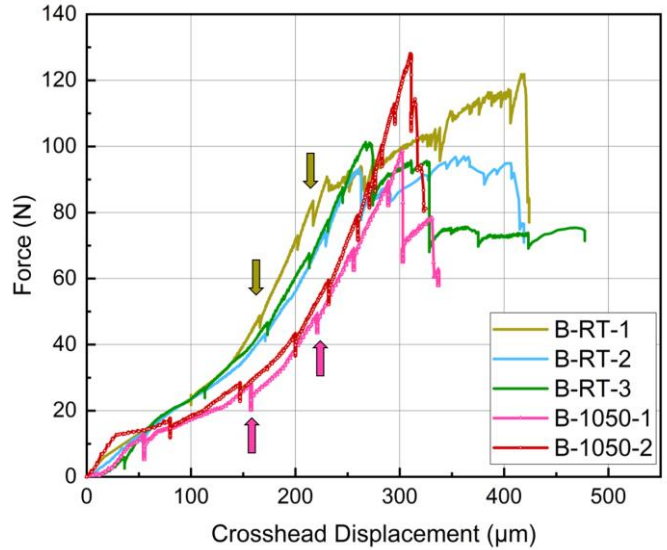
3-PB µXCT cell during high temperature test

Results: 3-point bending

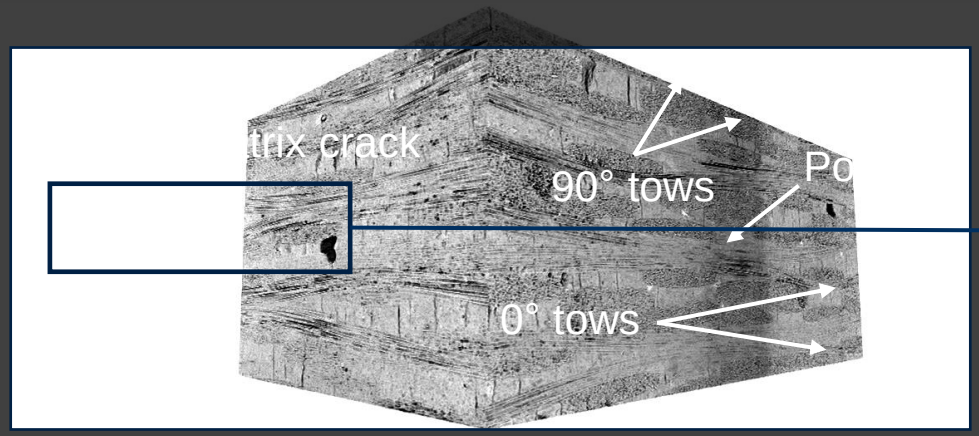
Material	Test Temperature	Flexural Strength[1] (MPa)
A	RT	58.8 ± 1.2
A	1050°C	55.3 ± 4.5
B	RT	93.7 ± 7.7
B	1050°C	103.8 ± 11.1

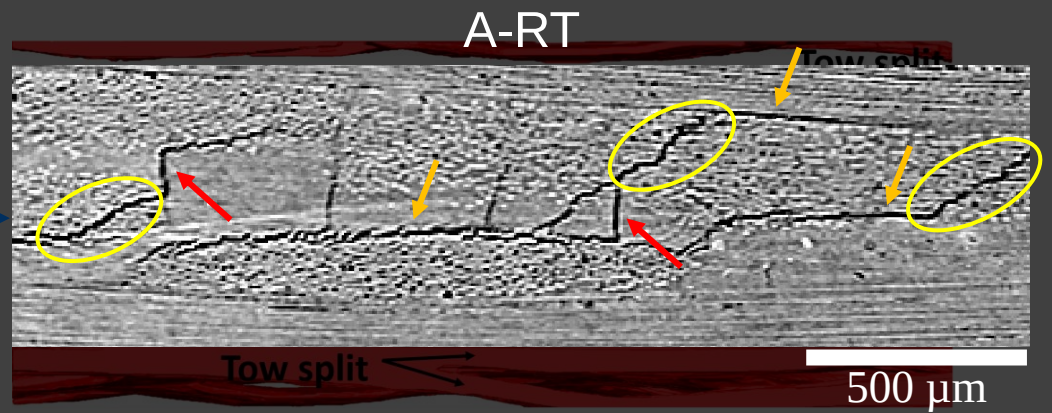


- Higher overall strength for material **B**
- More pronounced load drops at 1050ºC for material **B**
- A more consistent behavior going from RT to 1050ºC for material **A**

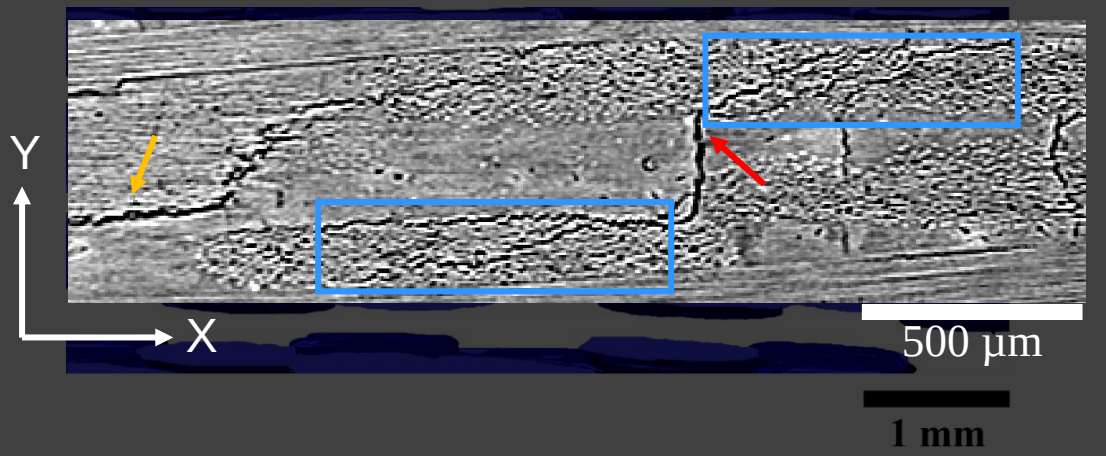


Results: Microstructure



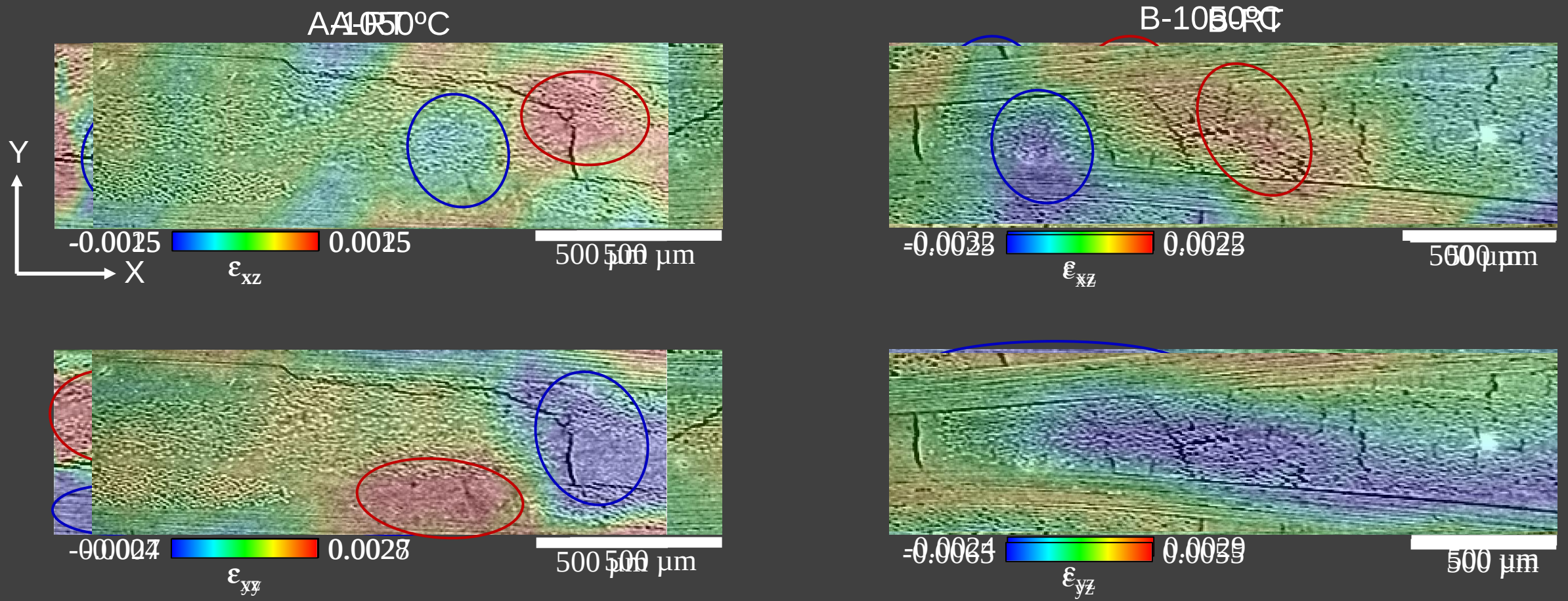


- Type I – Interfacial cracks
- Type II – Inclined intra-tow cracks
- Type III – Opening of matrix shrinkage cracks
- Secondary – Microcracking and ligament bridging



Results: In situ DVC observations

Banding of the shear components



Conclusions

1. The sintering temperature appears to have a significant effect on the mechanical properties of the tested material systems
2. Three primary types of cracks were identified
   - Type I: interfacial cracks
   - Type II: inclined cracking inside the 90º fibre tows
   - Type III: the opening of existing matrix shrinkage cracks
3. The applicability of DVC to oxide-oxide CMCs was demonstrated
4. Areas of maximum principal strain were good predictors for eventual fracture locations
5. High local shear strains with abrupt positive to negative transitions were observed – attributed to the different bonding strength between the 0/90º fibres and the matrix

Future Work: Continued XCT/DVC testing of more advanced CMC systems;

Residual stress analyses using fluorescence microspectroscopy; nano-indentation.

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