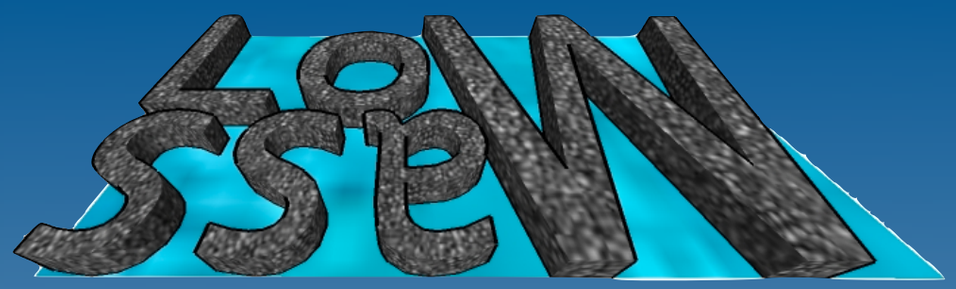


Low-Mass Vertex Detector Structures Using Silicon Carbide Foam

Ryan Page

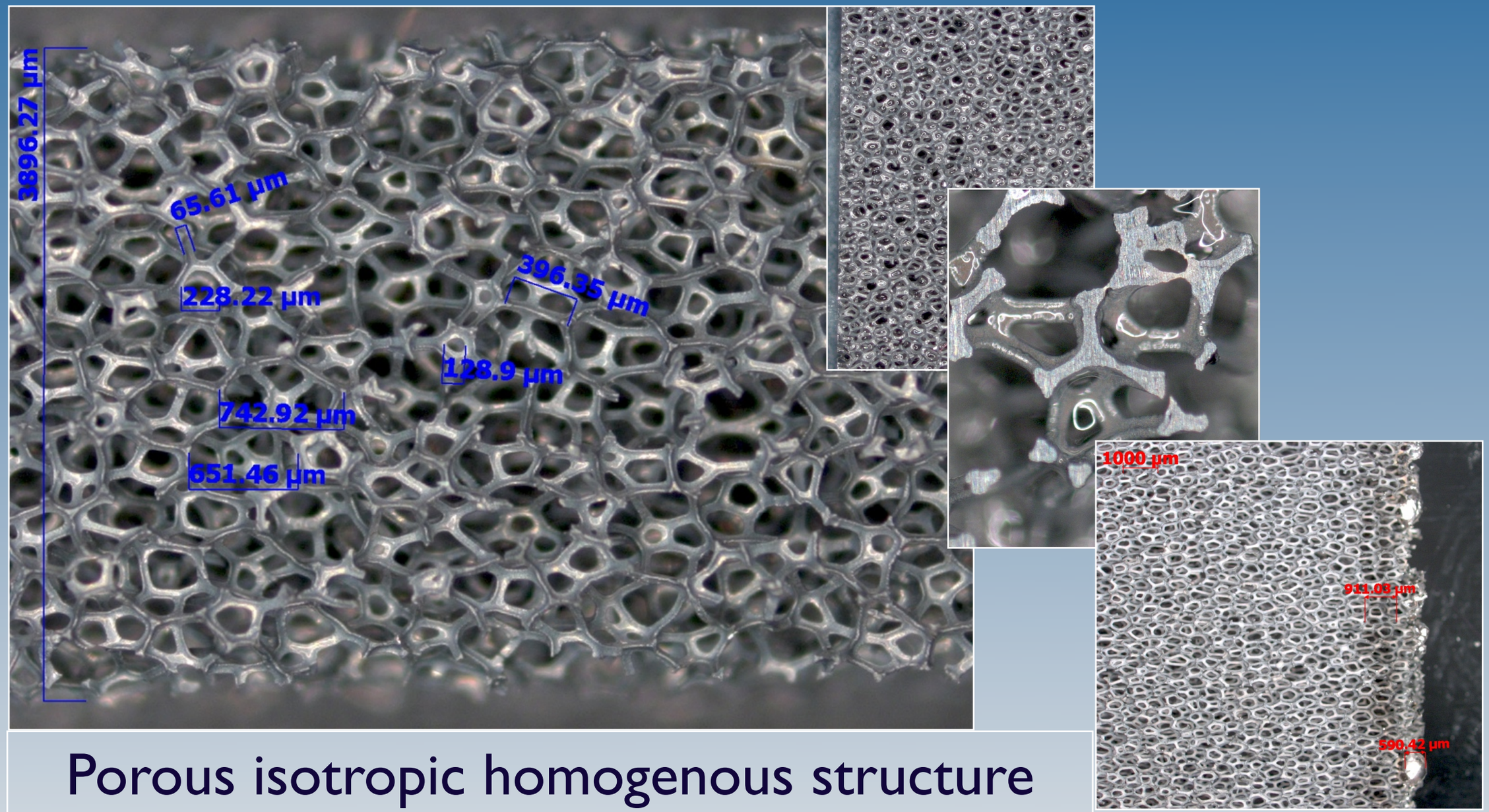
Low-Mass

- Collaboration of Universities of Bristol, Glasgow, Liverpool and STFC RAL
- Study of Silicon carbide foam thermal and mechanical properties for use in future detectors

Introduction

- Aim: To show that SiC is a credible choice for the support of sensors in a vertex detector
- Low-Mass has made in roads into turning this technical ceramic foam into a engineering material by analysing:
    - Machining Methods
    - Mechanical Properties
    - Charactering of features
    - Module construction
    - Thermo-mechanical analysis
    - Vertex detector geometry

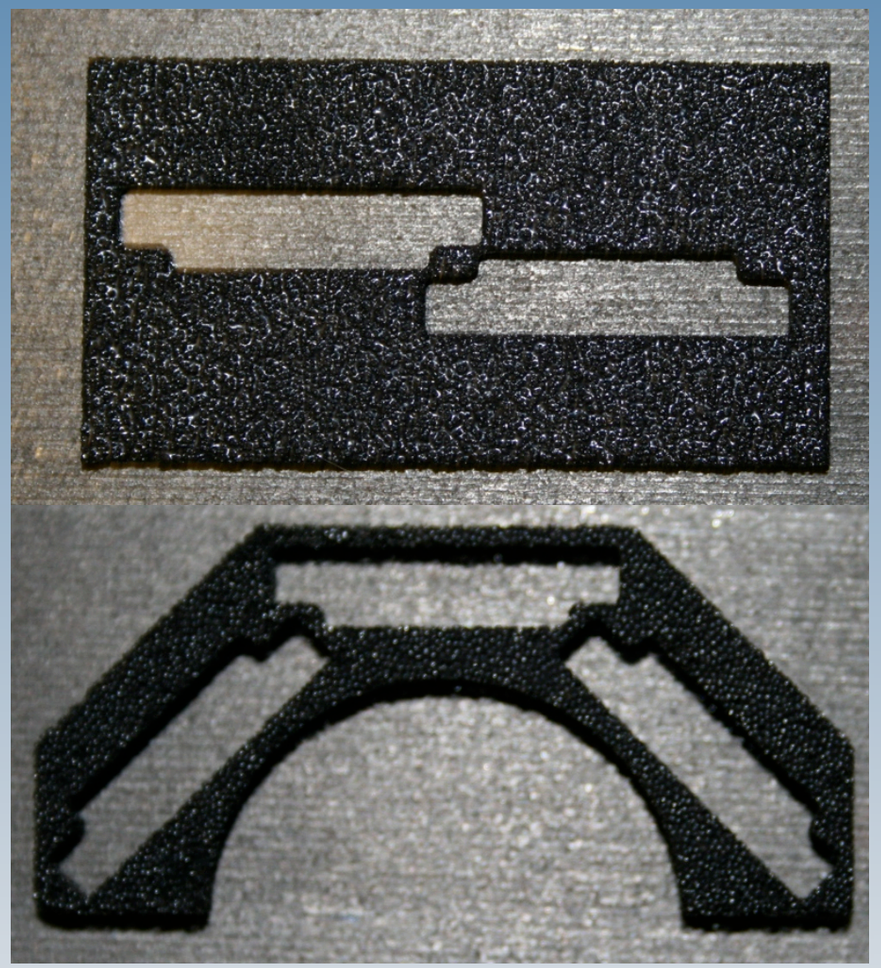
Silicon Carbide Foam



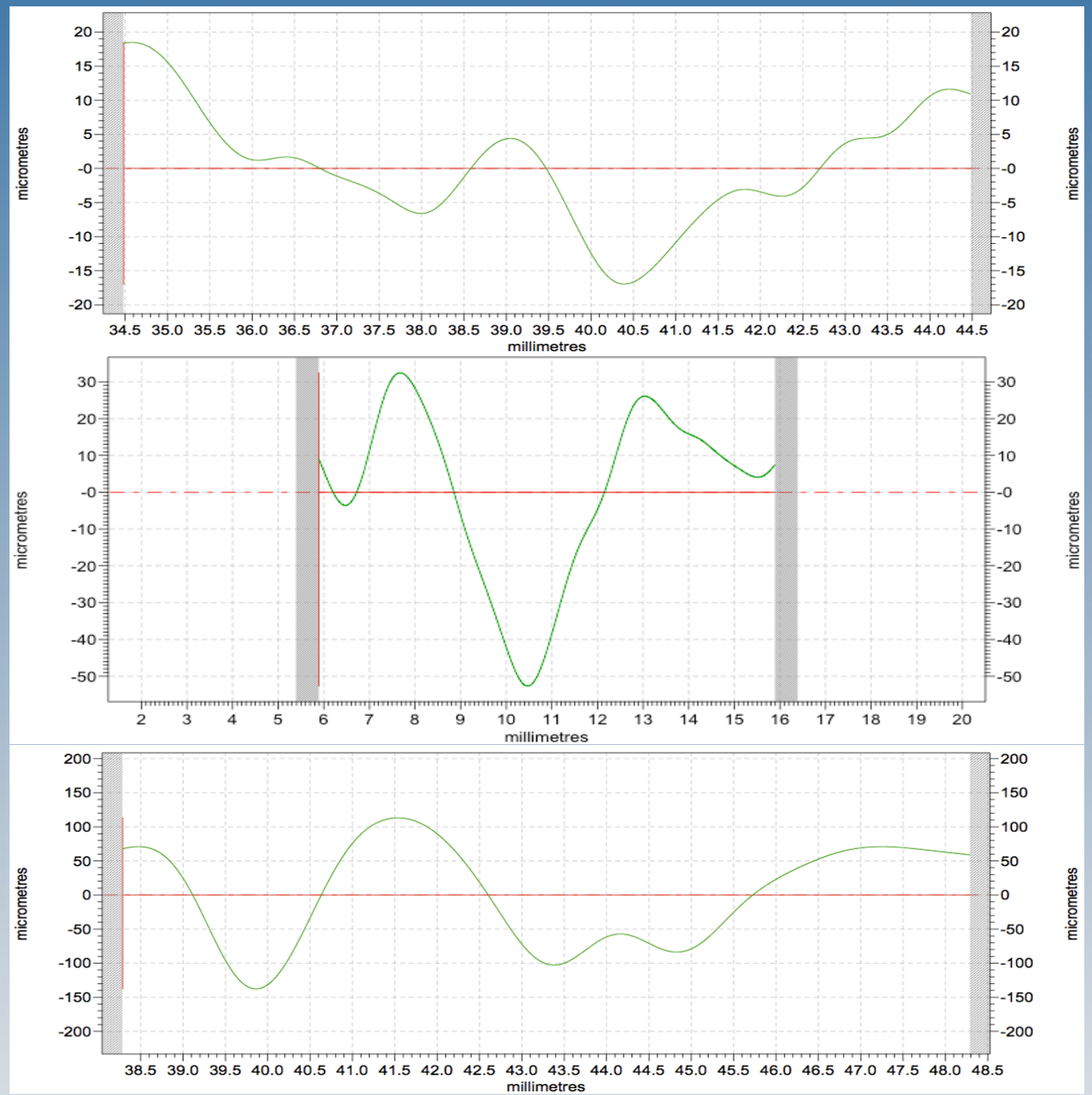
Porous isotropic homogenous structure made up of inter connected struts forming polyhedra cells with hexagonal faces

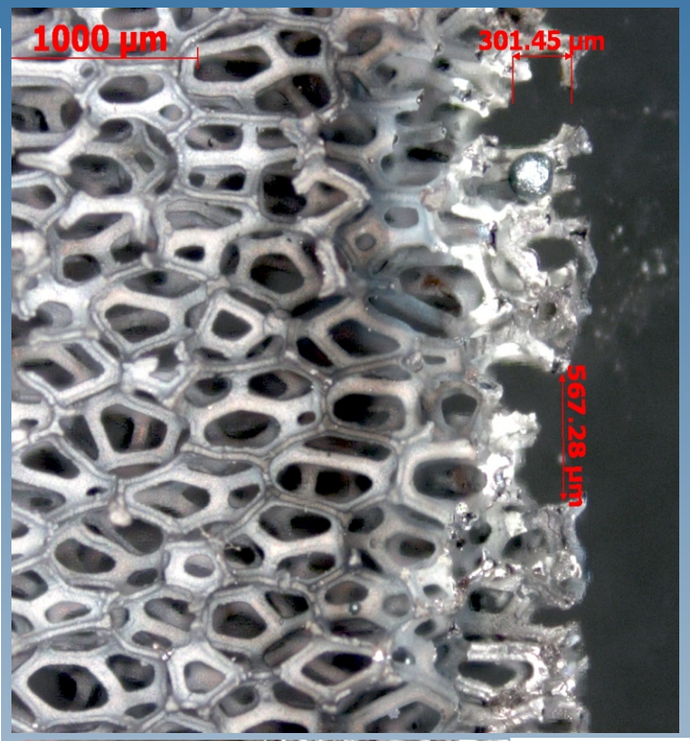
Machining SiC foam

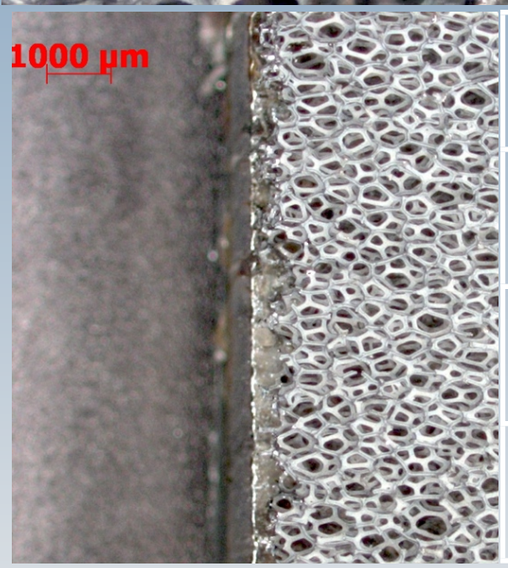
- Methods of machining analysed so far include: milling, laser cutting, dicing
- To look at the cut precision the measurement of waviness (wc) from a surface trace can be used
- The benefit being that there is a cutoff for high frequencies that allows the effects of the pores to be filtered out leaving only the effect on the SiC caused by the machining



Machining Analysis





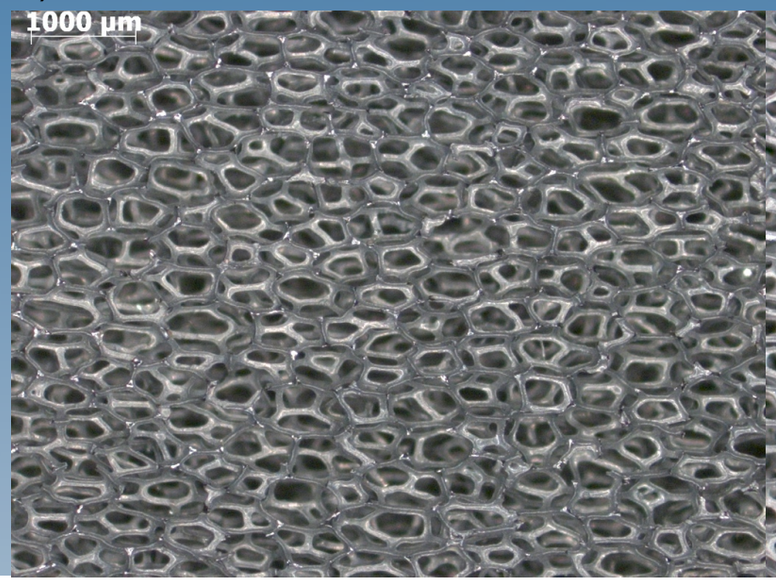


Machining Method	wc (µm)
Dicing	35
Milling	83
Laser Cutting	251

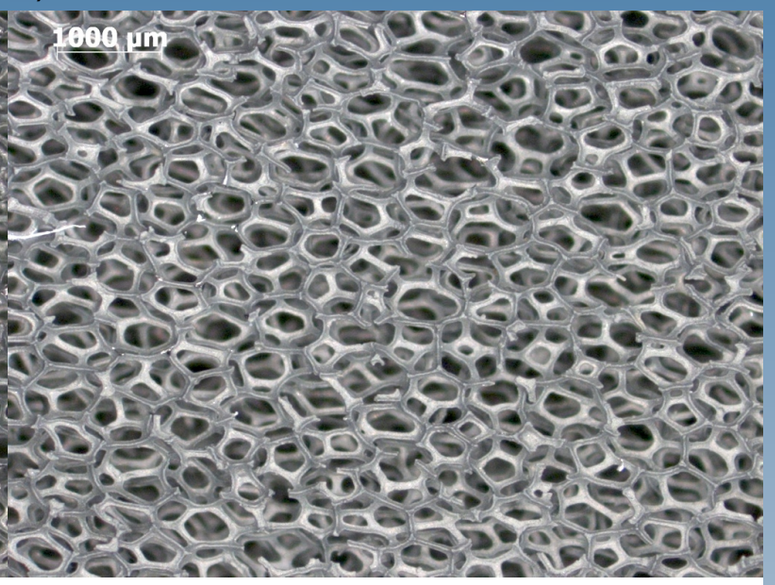
Characterising SiC Foam

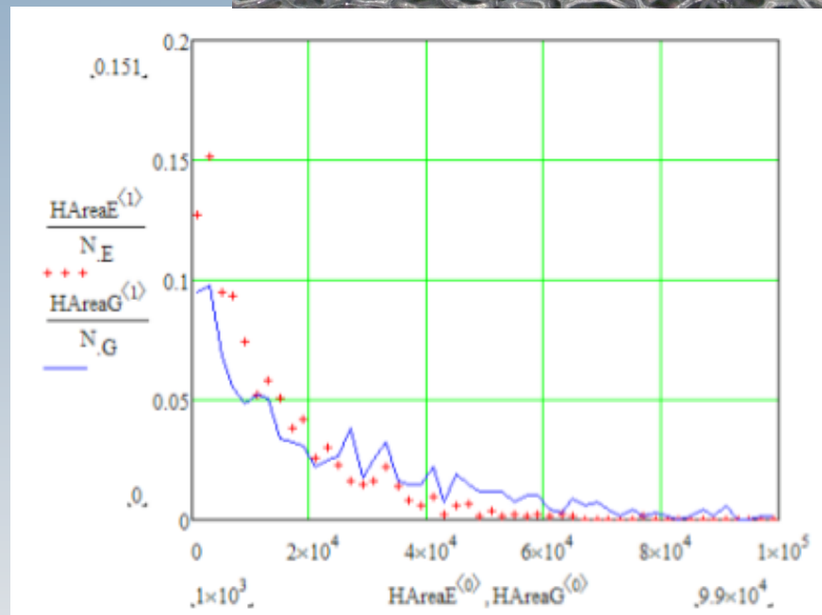
- Need to understand and be able to quantise microscopic structure and how they behave under different stress conditions
- The analysis on ground samples has shown a possibility that the pores dimensions and orientation are changed

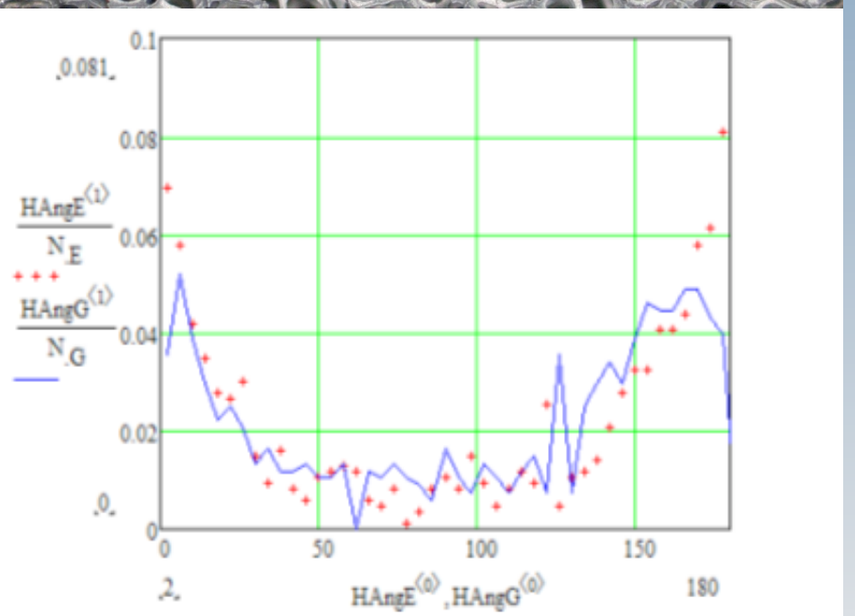
E) Ground 3mm



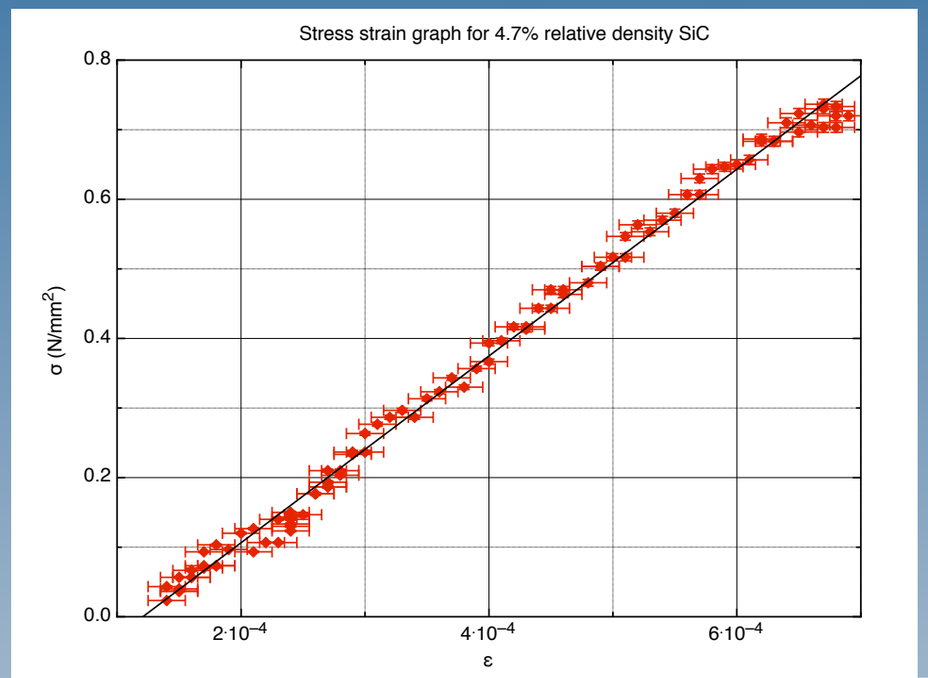
G) 4mm stock



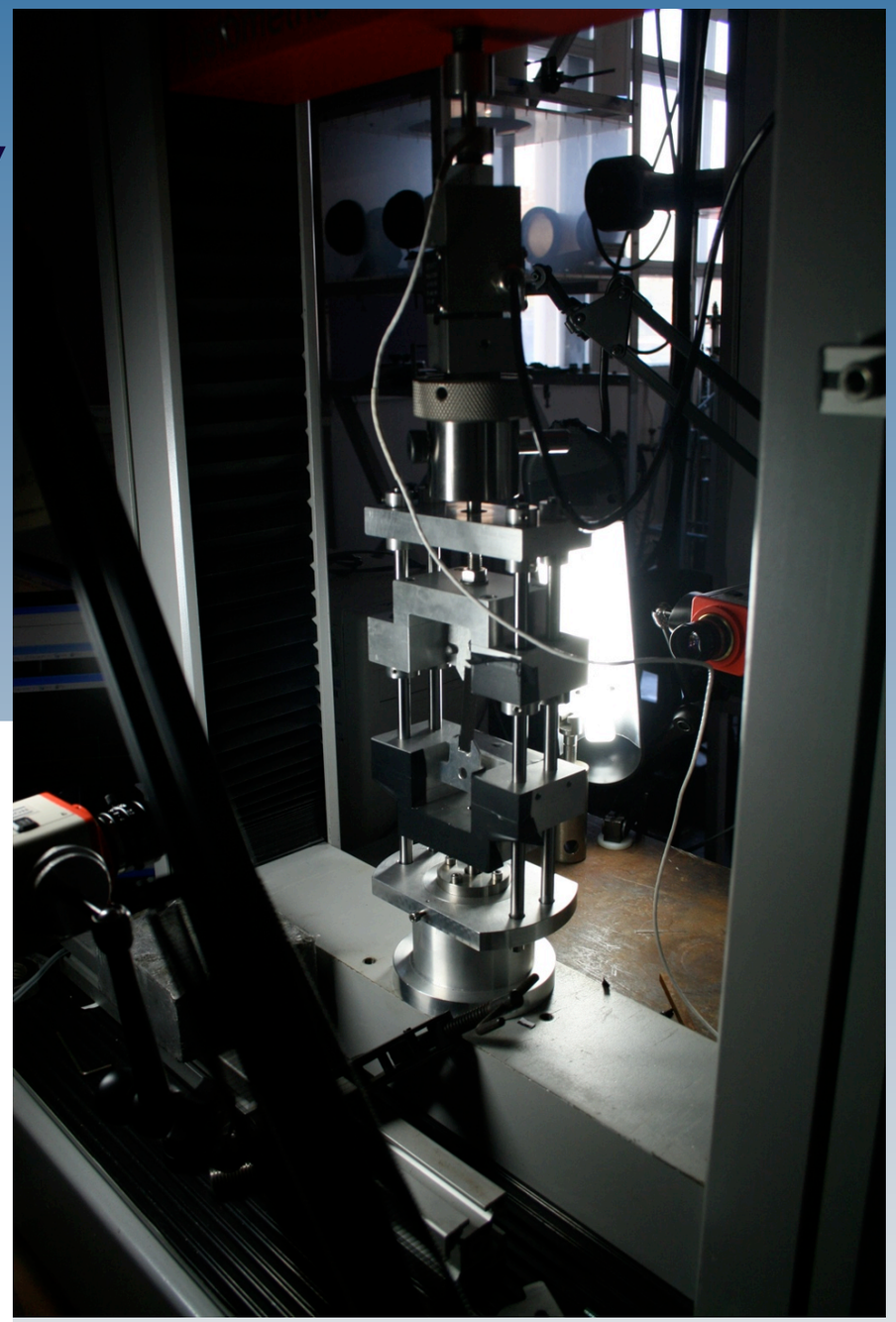




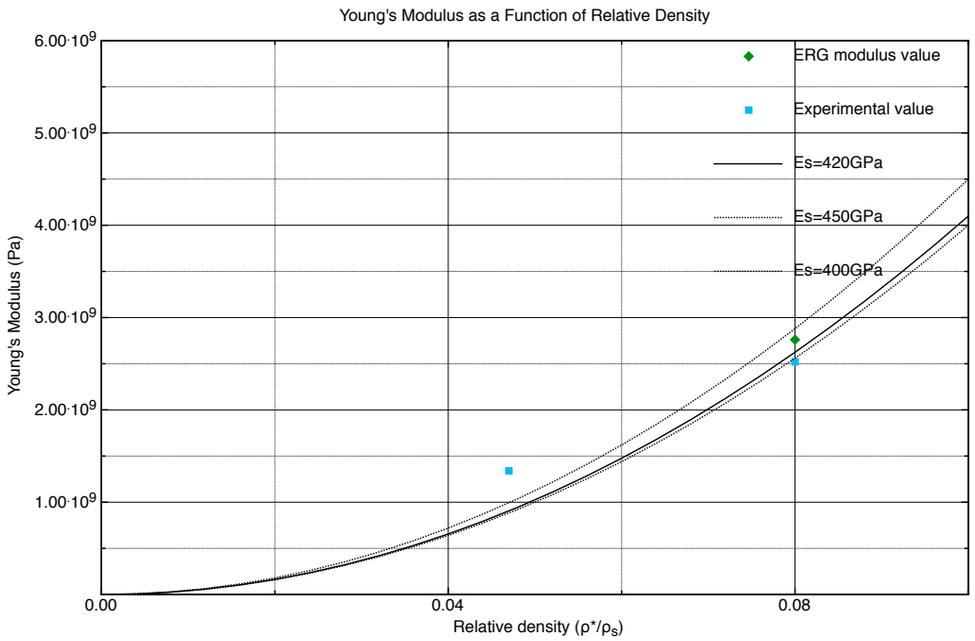
Tensile Tests



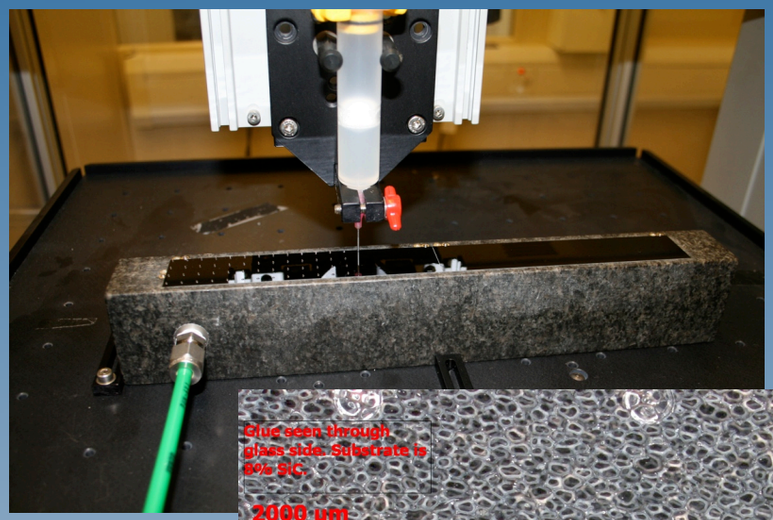
- Jig designed especially for low load axial tests
- Strain measured directly with video extensometers resolution of 15

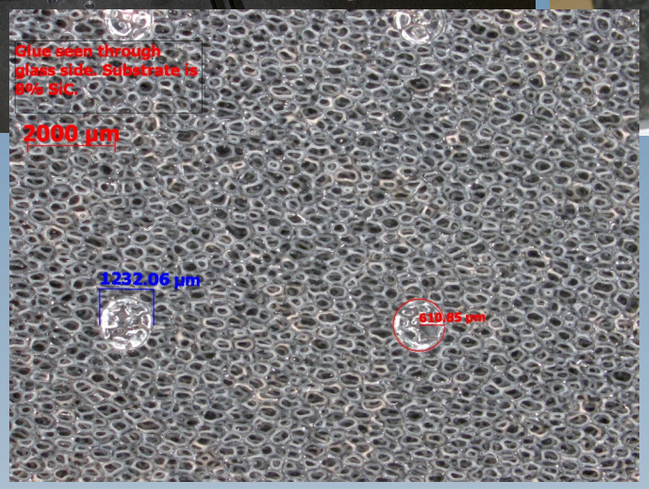


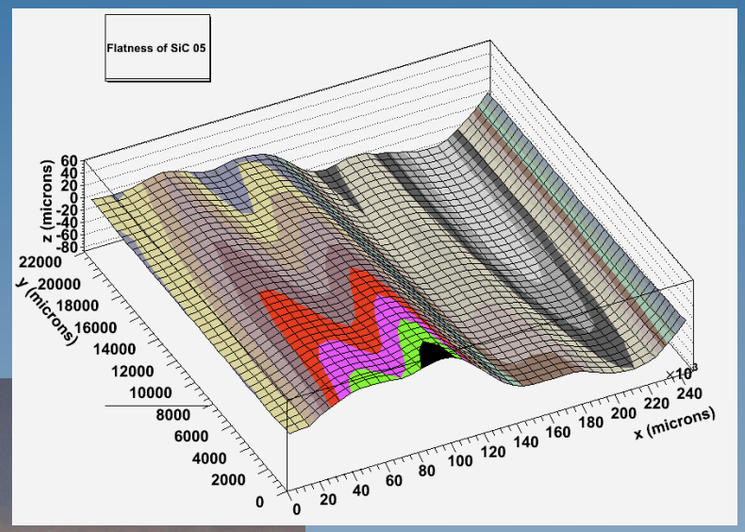
- Experimental value within 10% of ERG value
- Theoretical value dependent on Young's modulus of solid SiC

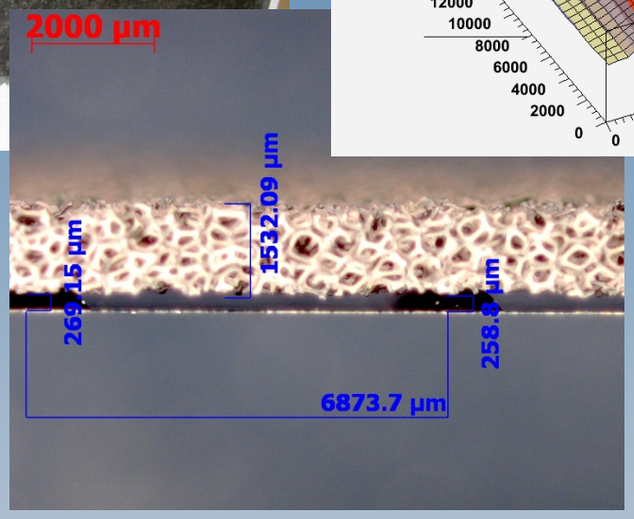


Building and Measuring Si-SiC Ladders



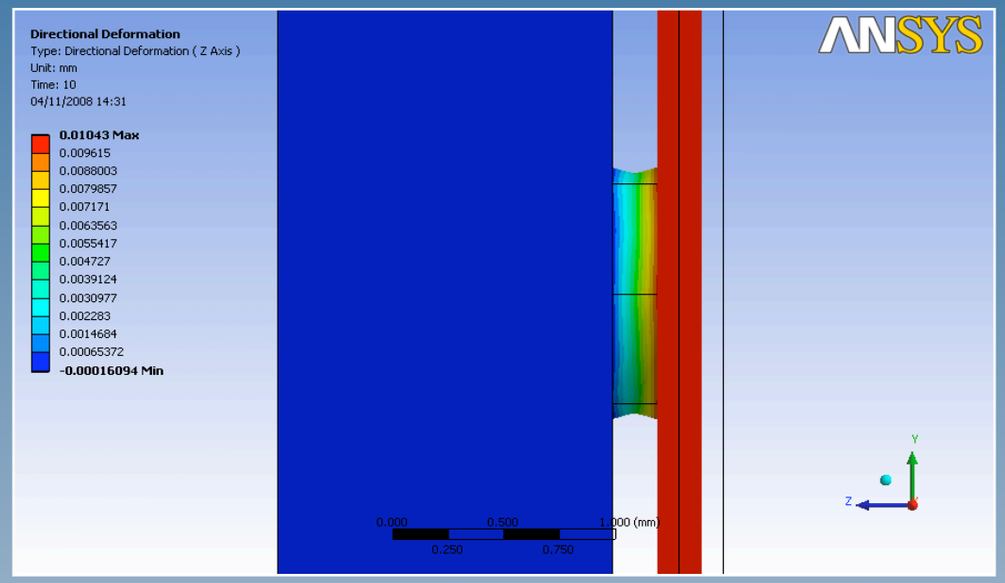


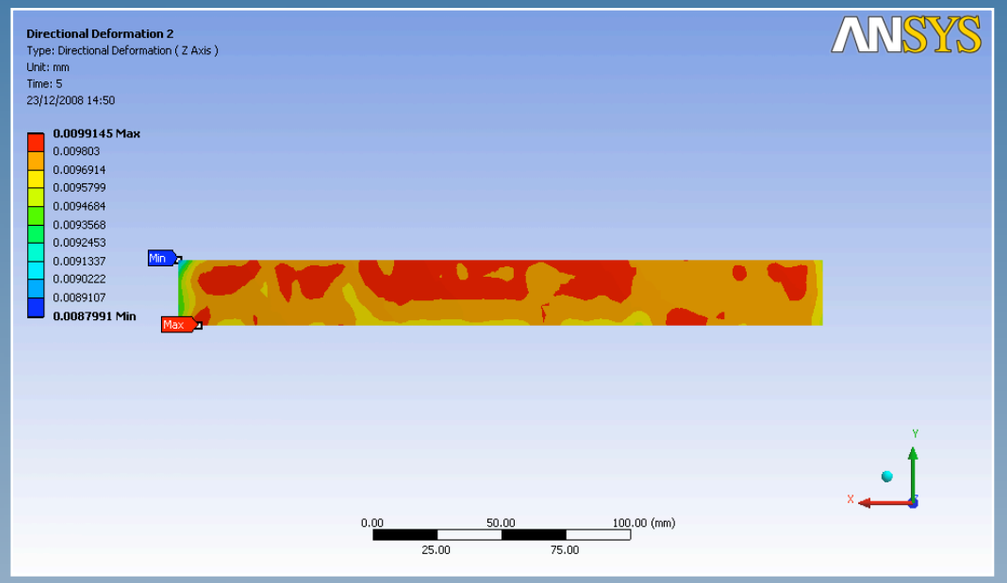




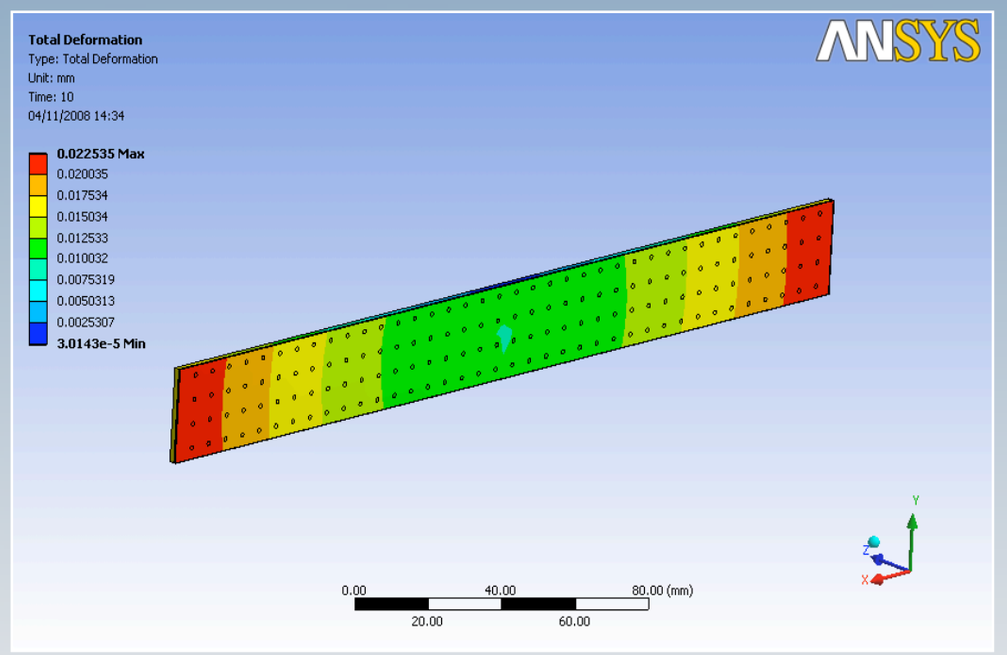
- High precision vacuum jigs hold Si Nusil is applied using a pre-programmed glue pattern then brought together using linear stage
- Survey Si surface with a laser micrometer flatness over whole modules of 100-200µm
- Flatness and straightness measured to within ±5µm
- The material budget for a single ladder of relative density of 6% at 1.2mm thick is 0.11%X_0 for a ladder of 3.2% and 1.3mm thick and using the same glue quantity and silicon is 0.079%X_0

Thermal Stress Analysis



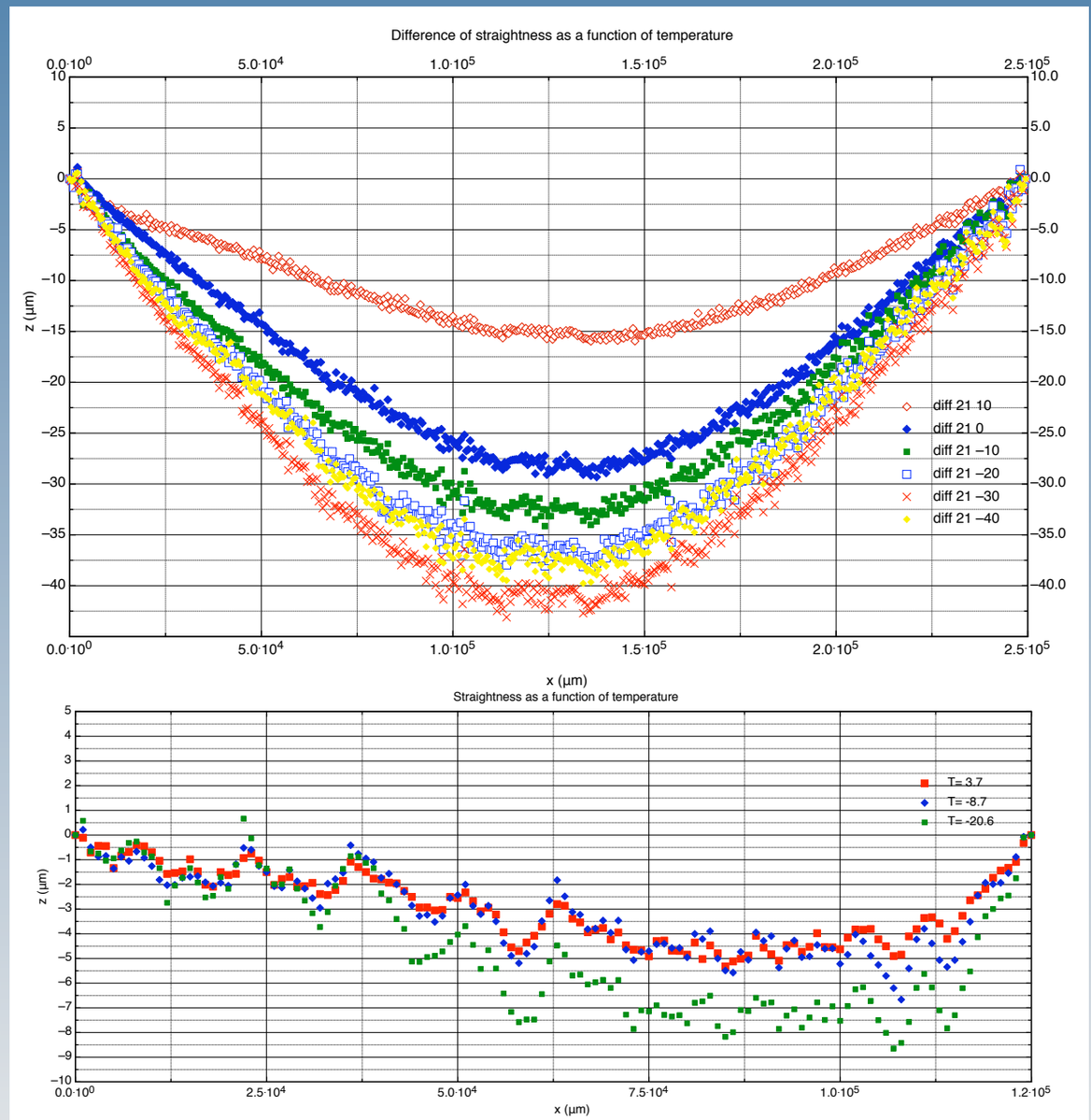


- How the structures behave when subjected to thermal loads
- In plane deformation <1µm
- This is expected as SiC has a CTE of 2.6ppm/K compared to silicon of 3.2ppm/K

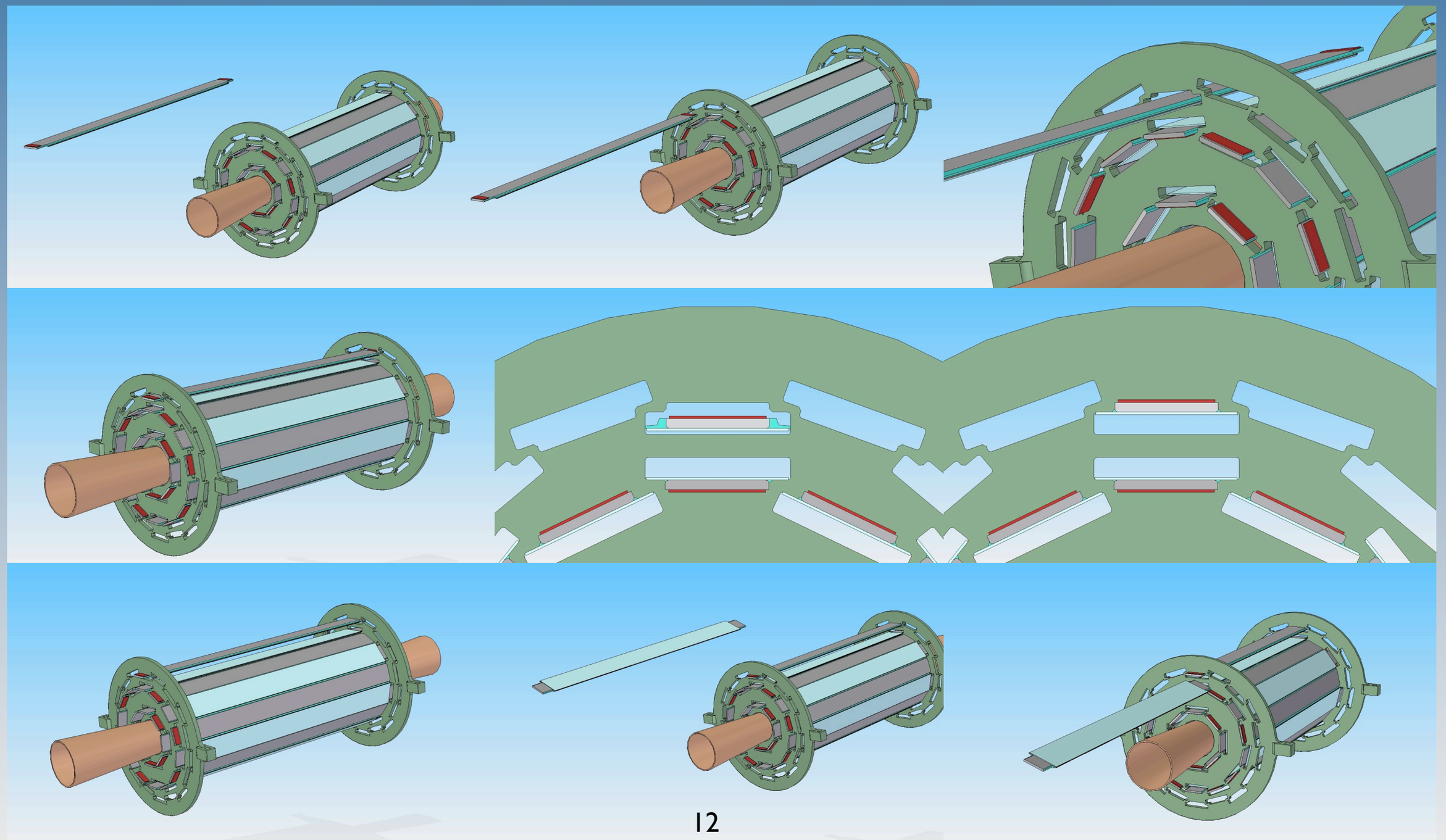


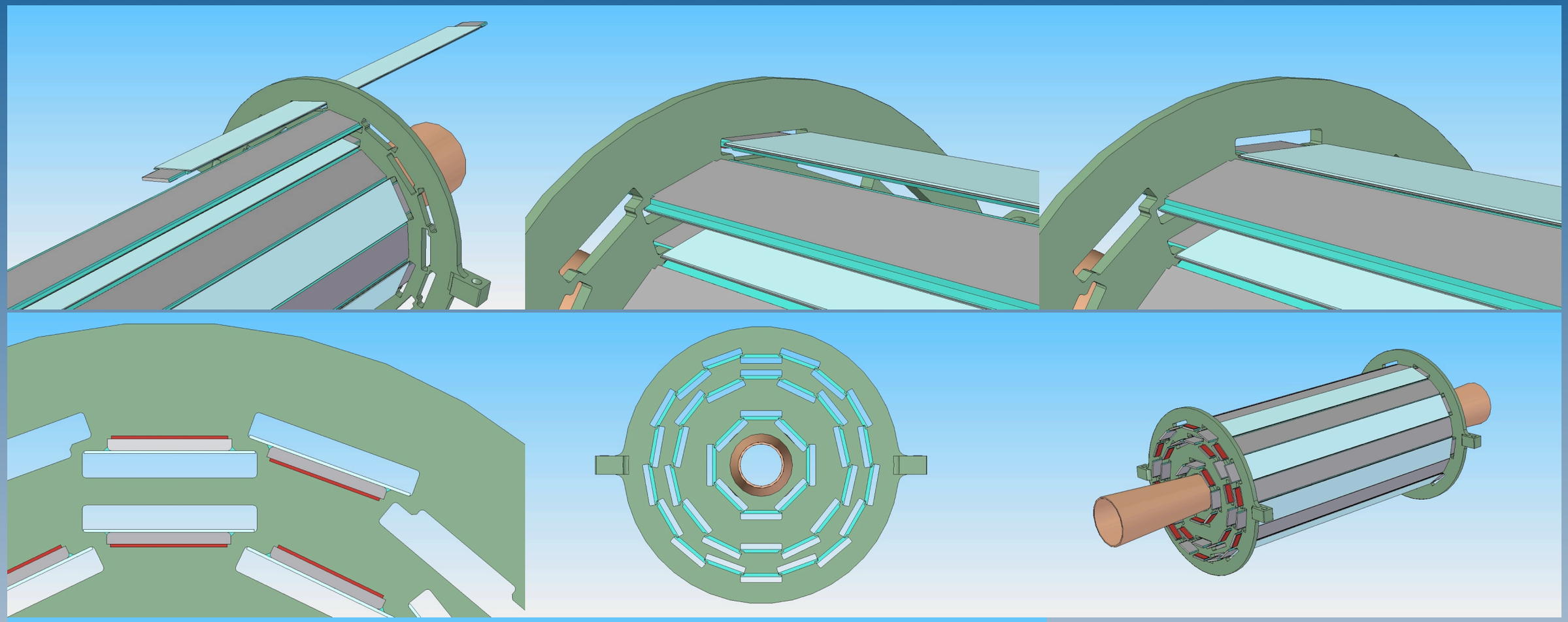
Single module analysis

- Ladders are minimally constrained to allow the displacement of the silicon surface caused by the interplay of SiC and Nusil silicone adhesive to be measured
- Surveying when cold shows effects from support structure causing deflection of Si surface
- Support method effects the form of deflection leading to straightness <50µm for ΔT=60°C and removing this effect is not trivial
- Analysing over half module straightness is <10µm for ΔT=40°C



Vertex Detector Geometry





Conclusion

- Substantial knowledge of machining and the material is known and effects on the mechanical properties caused by machining are being quantised by our collaboration
- The overall geometry allows material to be removed from the end region as complete support structure is SiC and work has begun into looking at sensor coverage
- SiC foam has the mechanical properties combined with the low cost to the material budget making it an ideal choice for a support structure