

Thick Thermal Barrier Coatings (TTBC)

- Introduction of TTBC
- Microstructure of TTBC
- Test apparatus
- Monotonic test
- Strain hold
- Future research

Ceramic
80% Ceramic- 20% Bond Coat
50% Ceramic-50% Bond Coat
20% Ceramic- 80% Bond Coat
Bond Coat
Substrate

Figure 1. Functionally graded material (FGM).

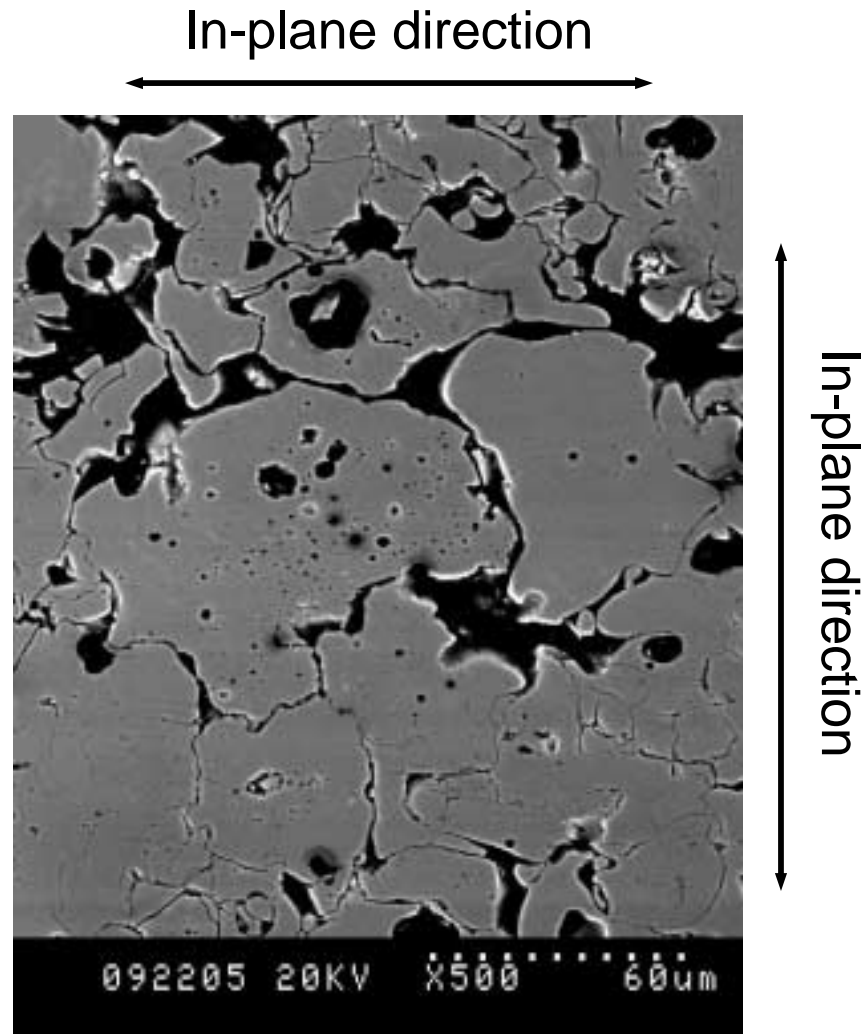


Figure 2. Micrograph of TTBC coating (100% ceramic) parallel to substrate

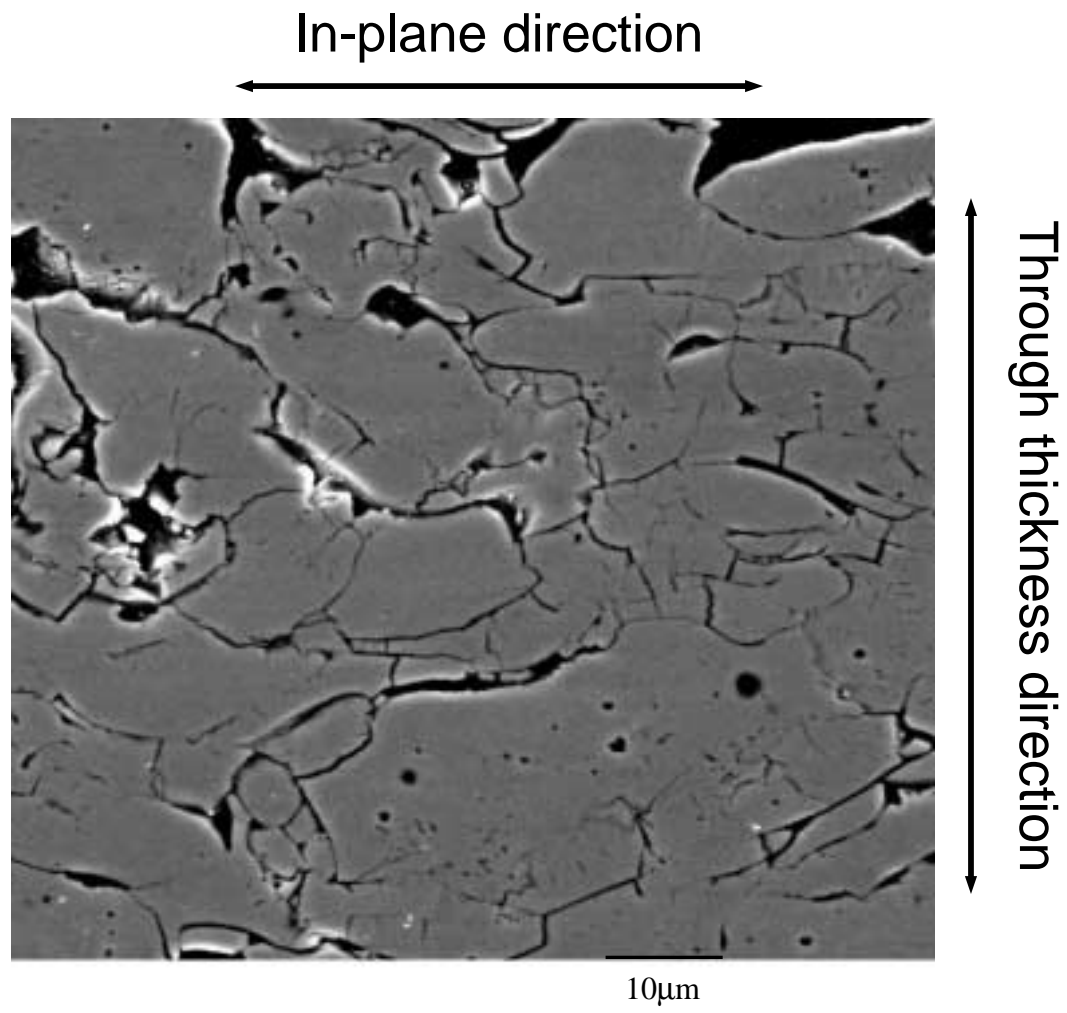


Figure 3. Micrograph of TTBC coating (100% ceramic) normal to substrate

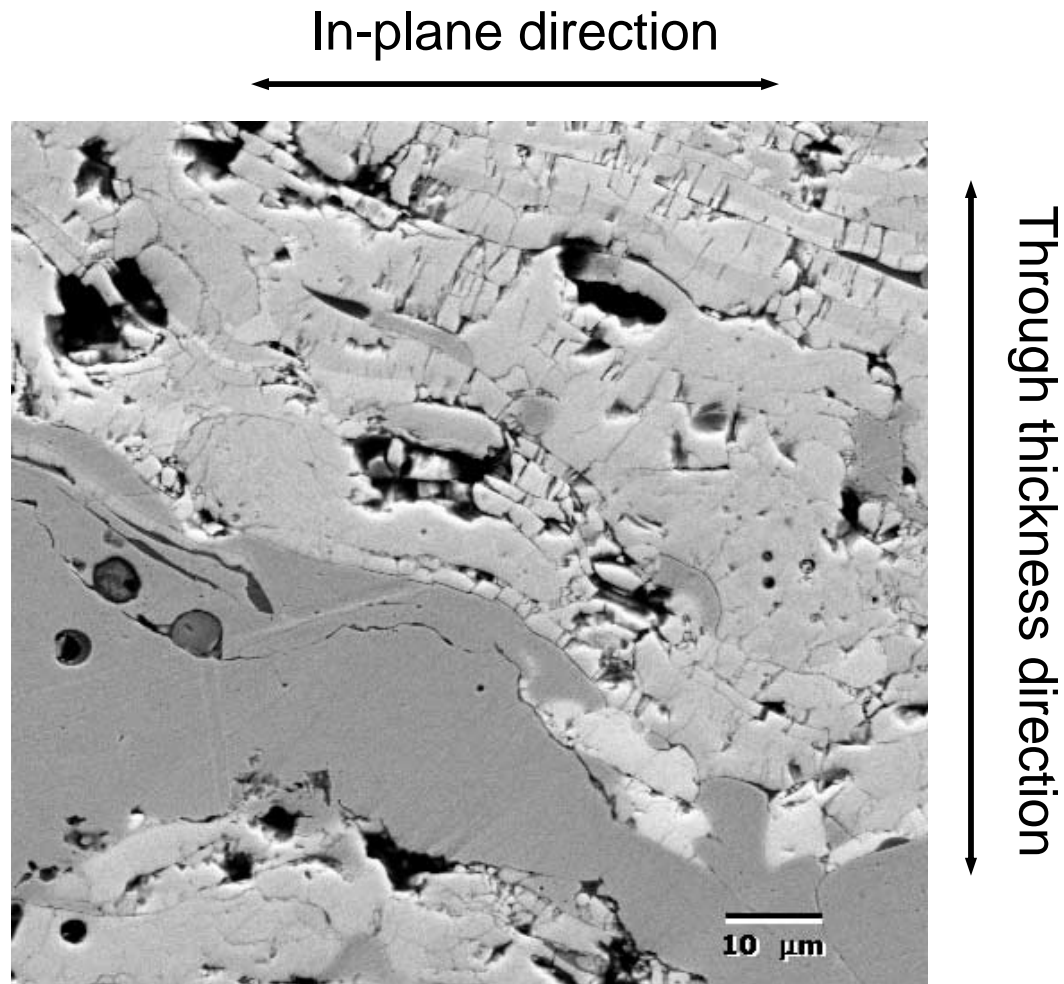


Figure 4. Micrograph of TTBC coating (50% ceramic and 50% bond coat) normal to substrate

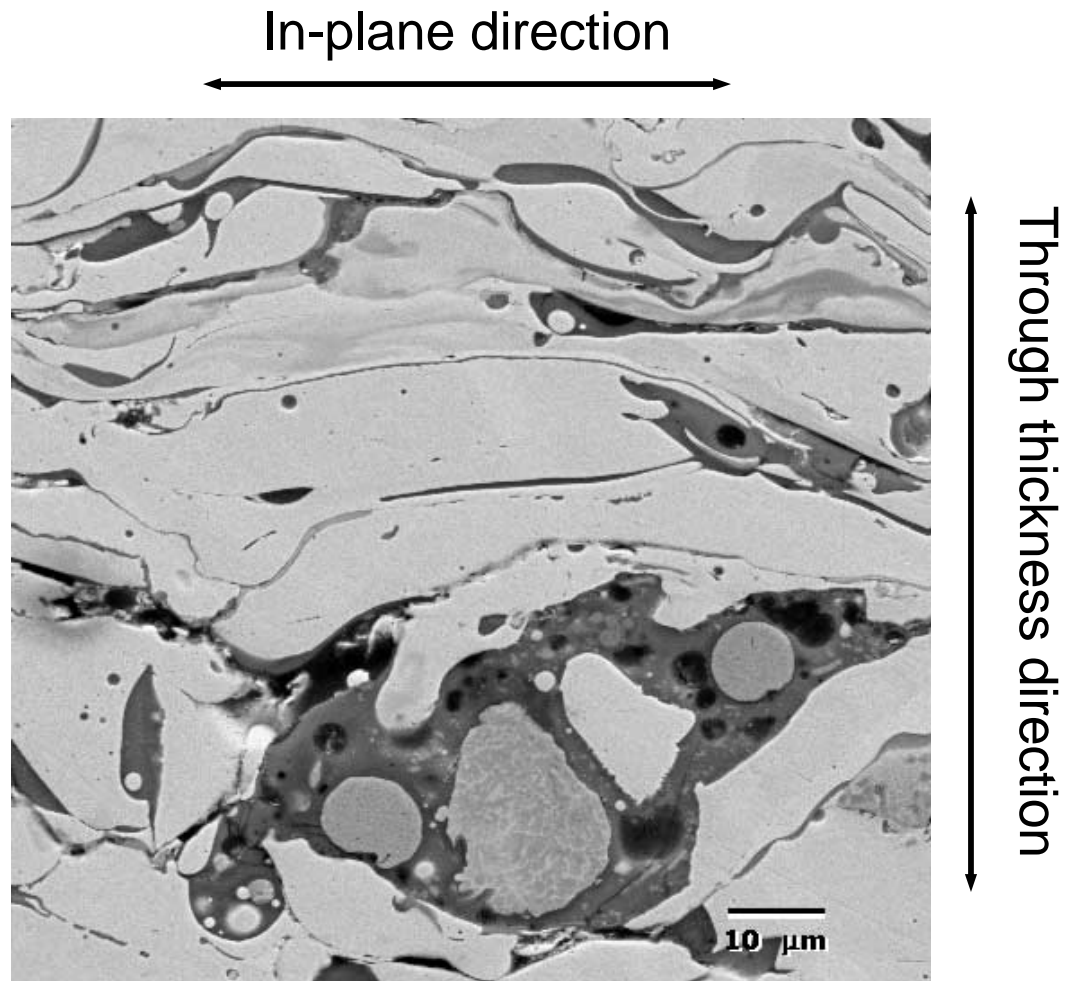
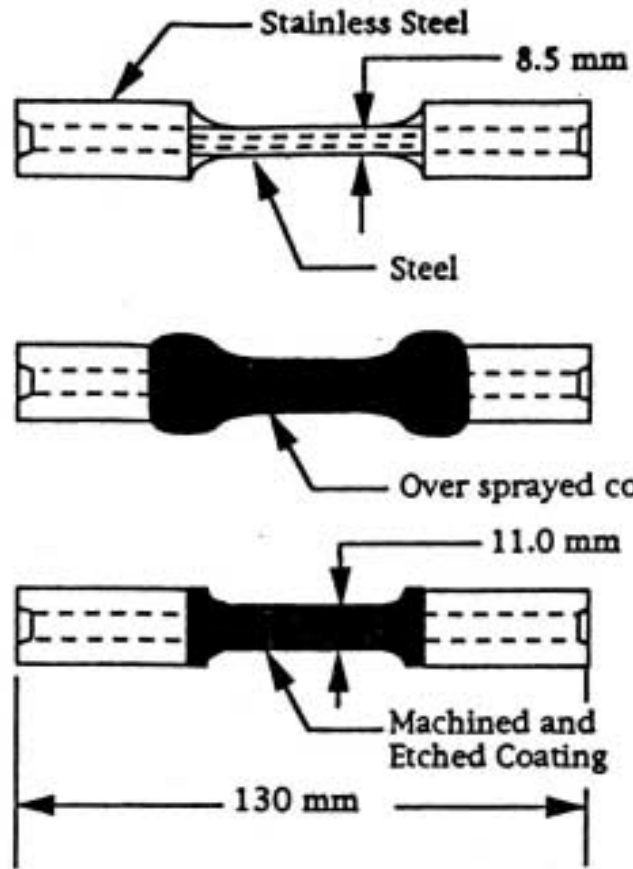


Figure 5. Micrograph of 100% bond coating normal to substrate.



Step 1: Press-fit and machine steel substrate

Step 2: Plasma spray mid-section

Step 3: Perform final machining and etch away inner steel press-fit tube

Figure 6. Specimen fabrication processes.



Figure 7. Test system.

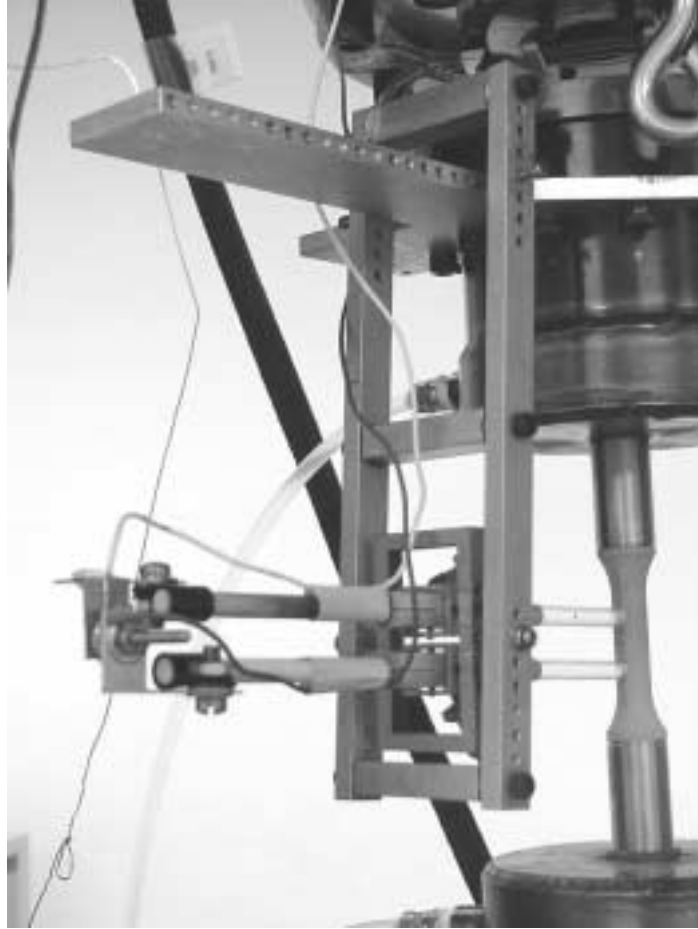


Figure 8. Extensometer.

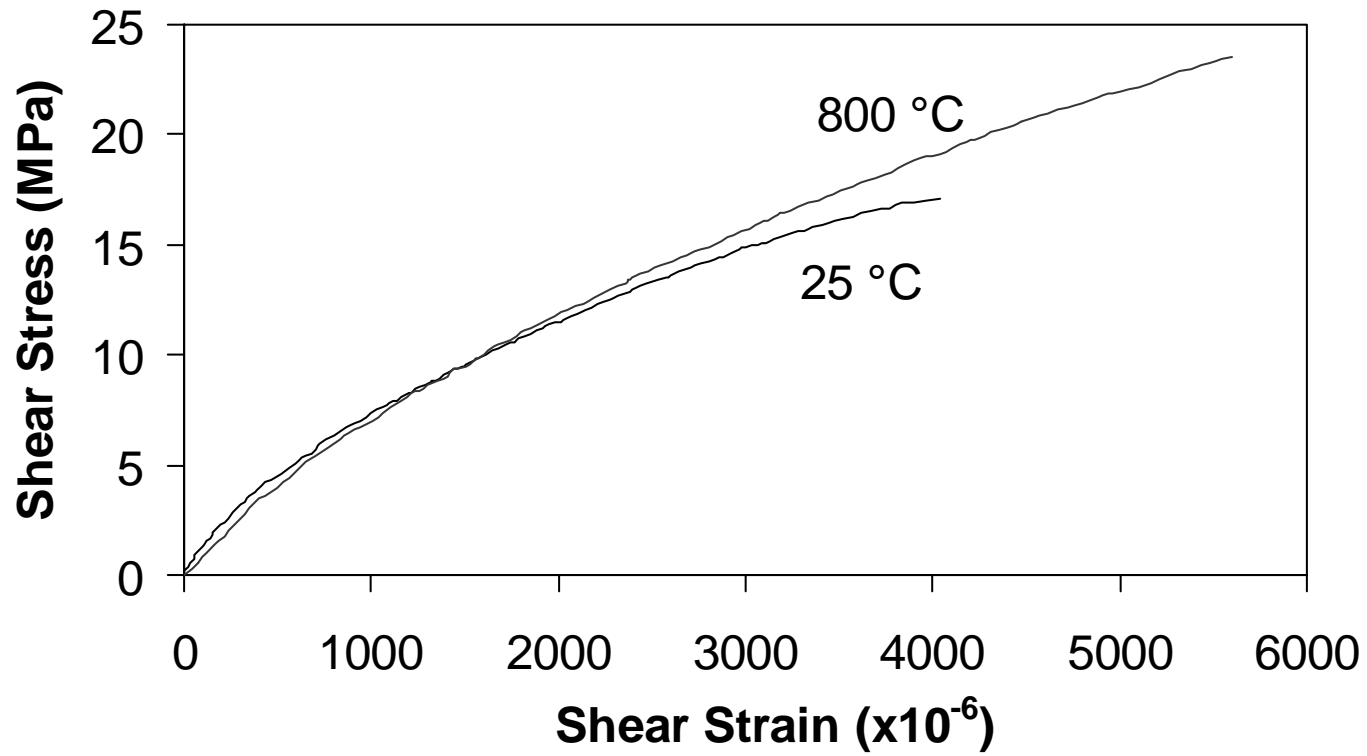


Figure 9. Ceria-stabilized TBC in-plane monotonic shear deformation to failure.

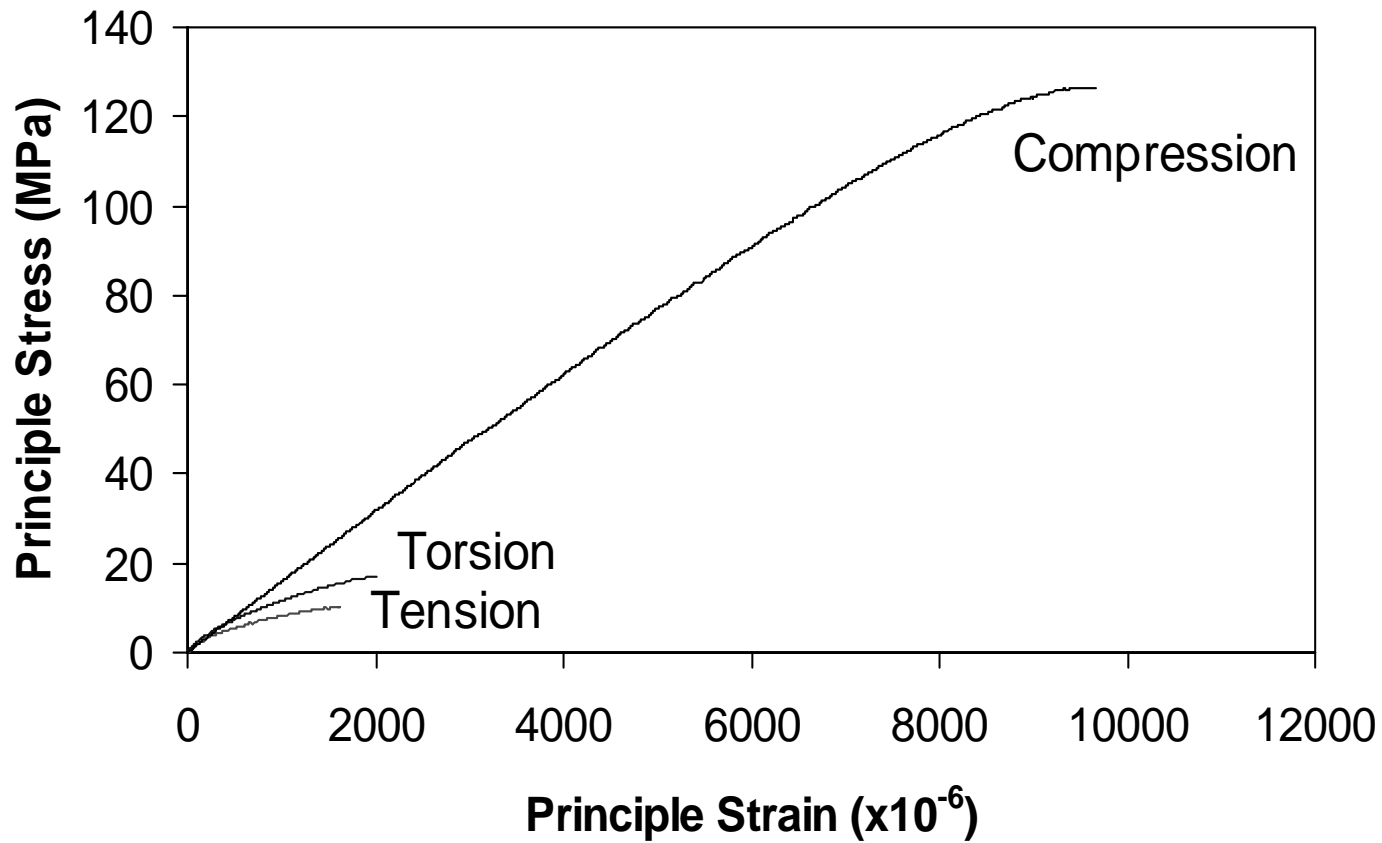


Figure 10. CSZ: comparison of principle stress-strain curves for monotonic test at room temperature.

Table 1. Material properties of CSZ

Loading type	Strength (MPa)	Elastic modulus (GPa) E (G)
Shear	11.9-17.9	(6-10)
Tension	10.2	8
Compression	126	14.6

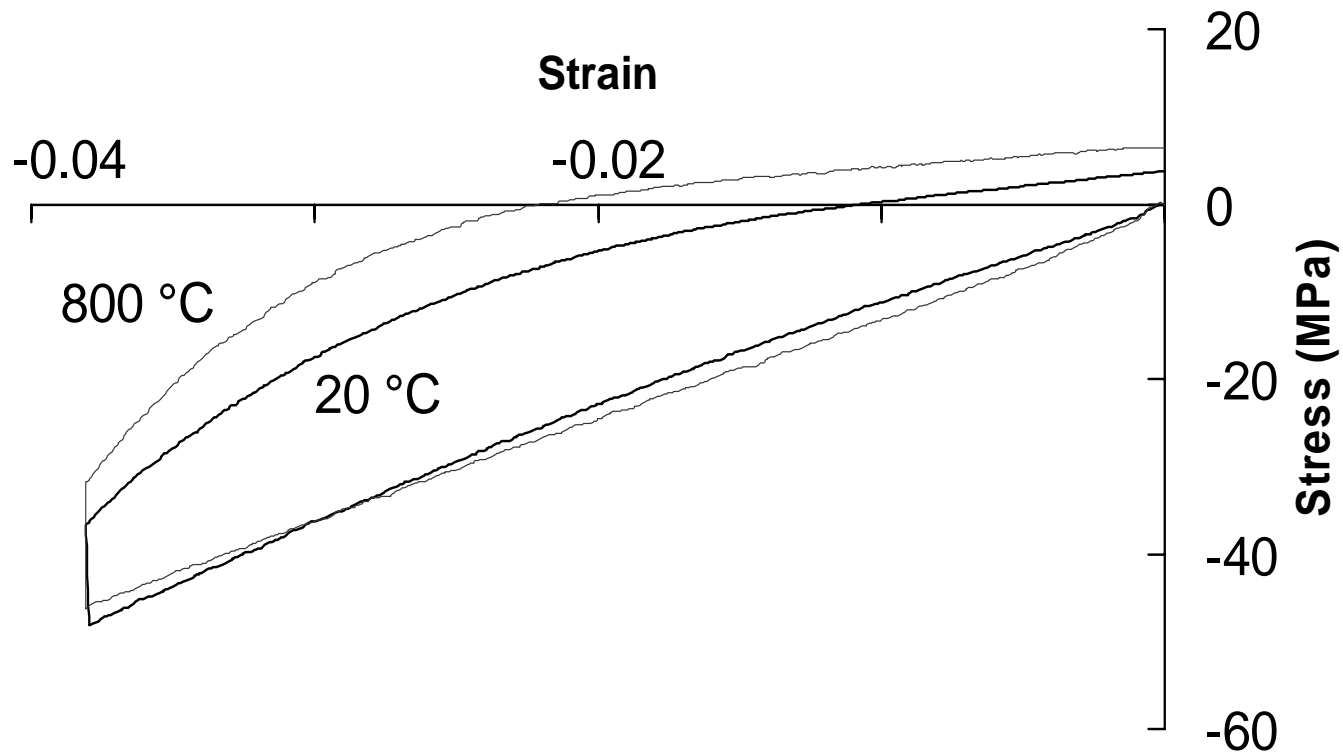


Figure 11. 10-hour compression strain hold of CSZ at $3800 \mu\epsilon$.

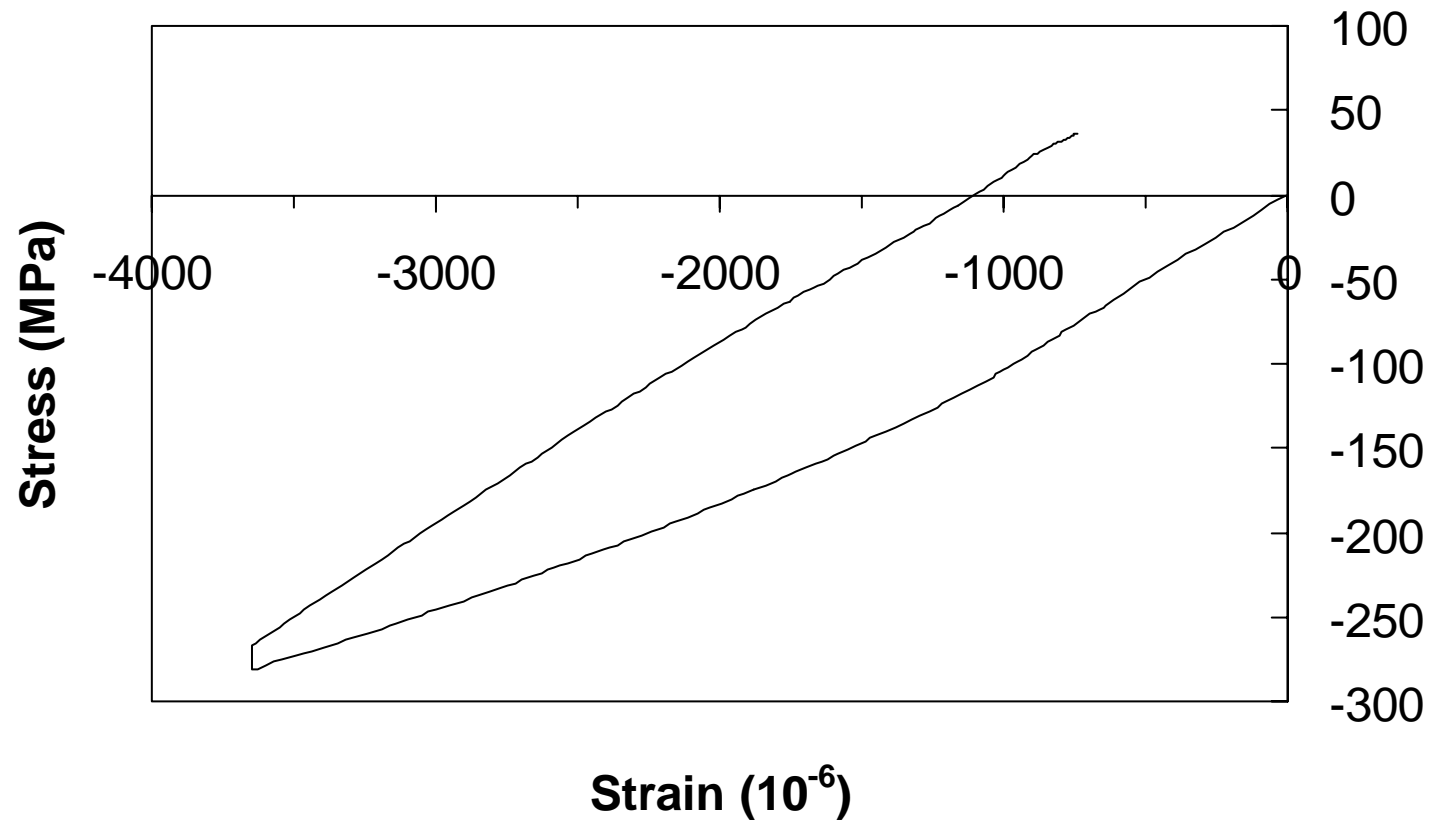


Figure 12. 10-hour compression strain hold of bond coating at $3650\mu\epsilon$.

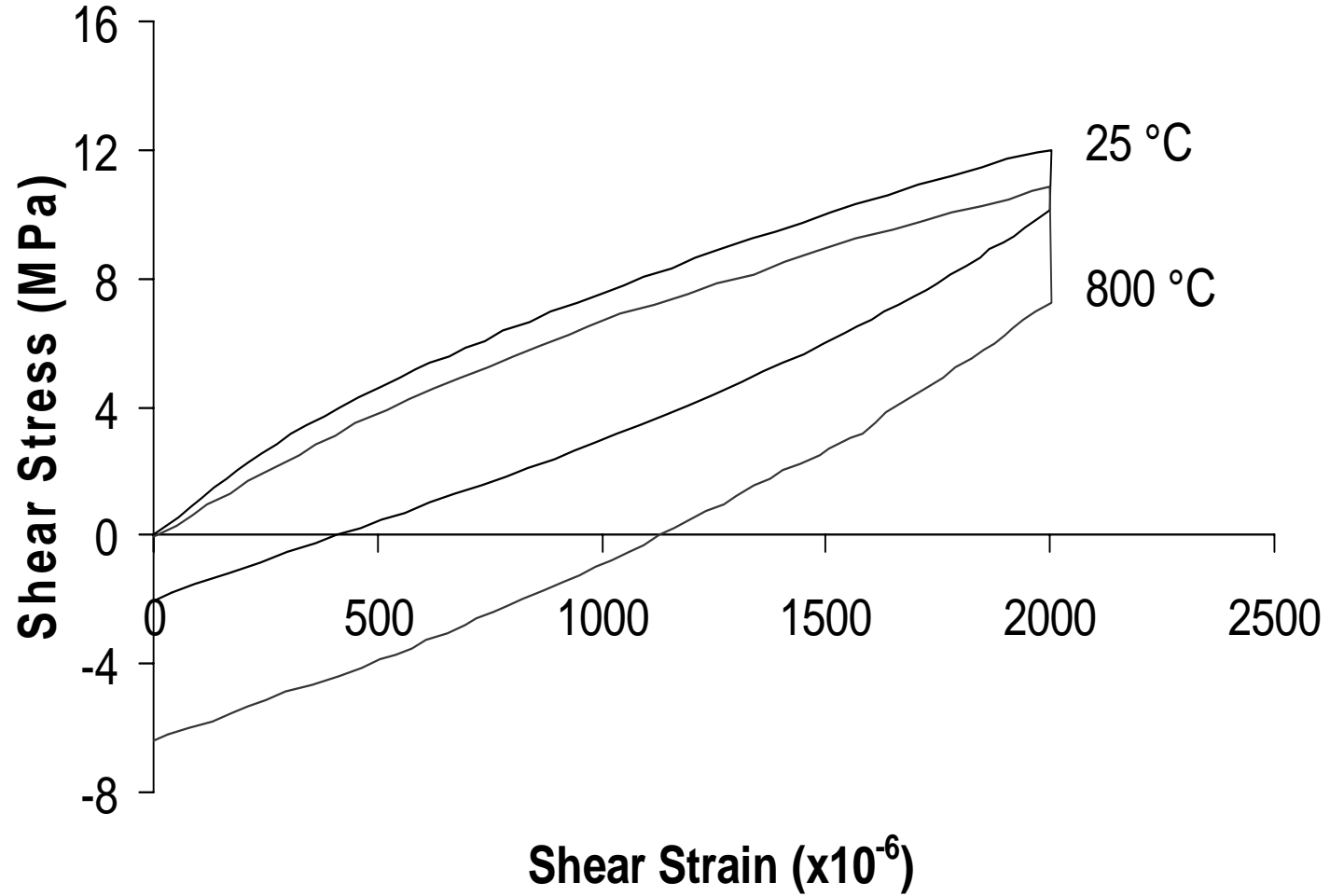


Figure 13. 10-hours shear strain hold test of 100% CSZ at $2000\mu\epsilon$.

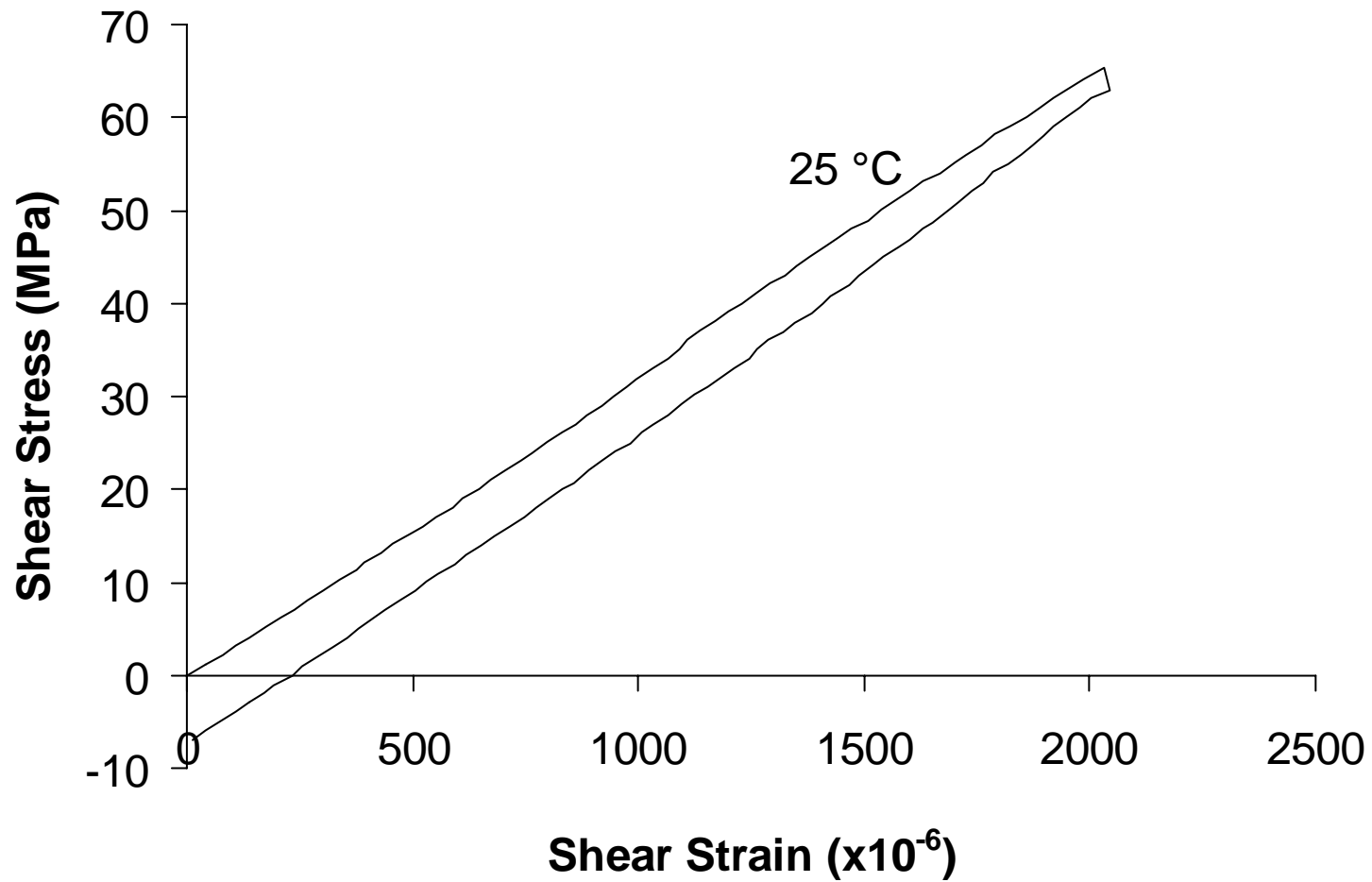


Figure 14. 10 hours shear strain hold test of bond coating at 2000 $\mu\epsilon$.

Table 2. Stress relaxation during 10 hours holding

Loading type	Materials	Stress relaxation
Compression	100% CSZ	48.1MPa to 36.8MPa (23.5%)
	Bond coating	281MPa to 267MPa (5.0%)
Shear	100% CSZ	12.0MPa to 10.1MPa (15.8%)
	Bond coating	65.3MPa to 62.9MPa (3.7%)

Future research:

- To study and explain the phenomena of non-linear deformation in the monotonic test and stress relaxation and creep at room temperature.
- To model the deformation process of TTBC.

Future research:

- Loading: Combined loading.
- Materials: with controlled crack density.

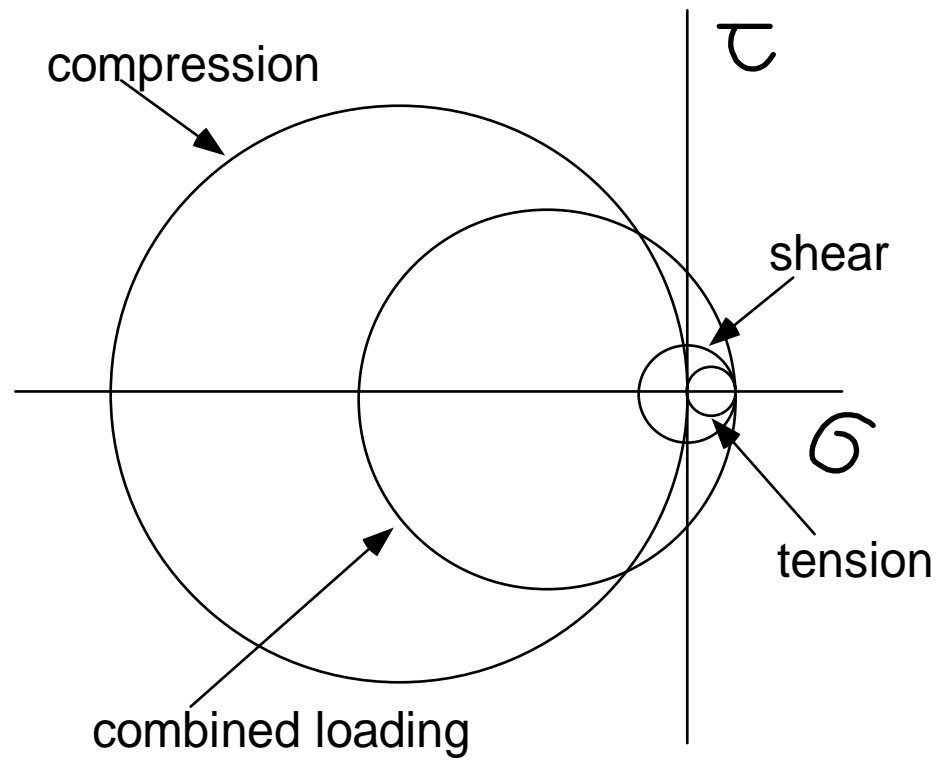


Figure 15. The Mohr circle.