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Determination of Interfacial Properties in Glass to Metal seals using Pin Push-out Test

PRESENTED BY

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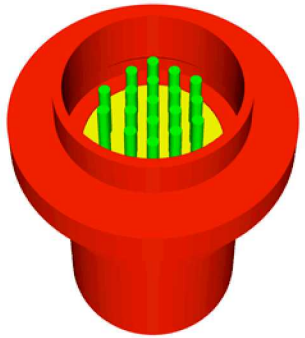
Outline

- Background
- Experimental Procedure
- Results
- Discussion
- Summary

Background

- Hermetic connectors are interconnect devices which provide for the transfer of electrical power, or signal from outside a hermetic chamber to the inside. They provide both a hermetic seal between inside and outside and electrical isolation from the chamber wall



- Common applications of hermetic connectors: semiconductor processing equipment, particle accelerators, satellites, under water electrical connections

Courtesy: Complete Hermetics (http://www.completehermetics.com/hermetic-connectors)

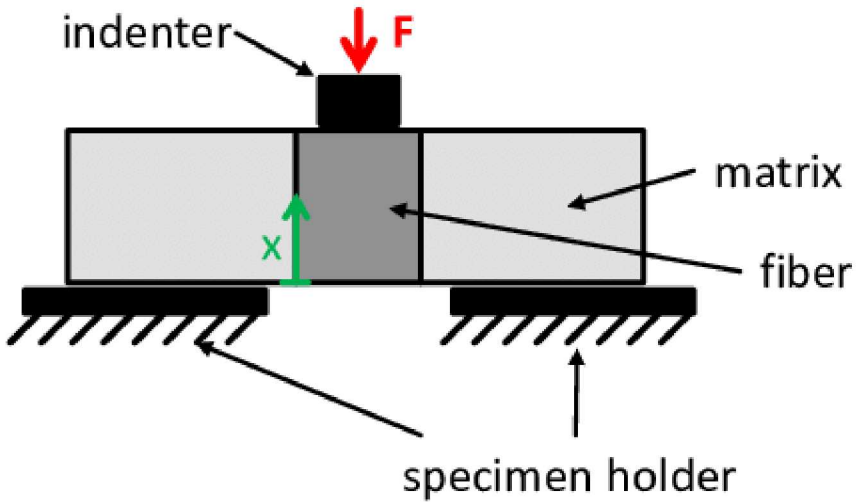
Background

- Glass and glass-ceramics are extensively used as sealant materials for hermetic connectors
  - High degree of leak tightness
  - High temperature stability
  - Capability to withstand high pressure

- Glass/glass-ceramic sealant and metal interactions are very difficult to quantify
  - Bond strength between glass/glass-ceramic sealant and metal pins
  - Interfacial toughness
  - Compressive stresses on pin

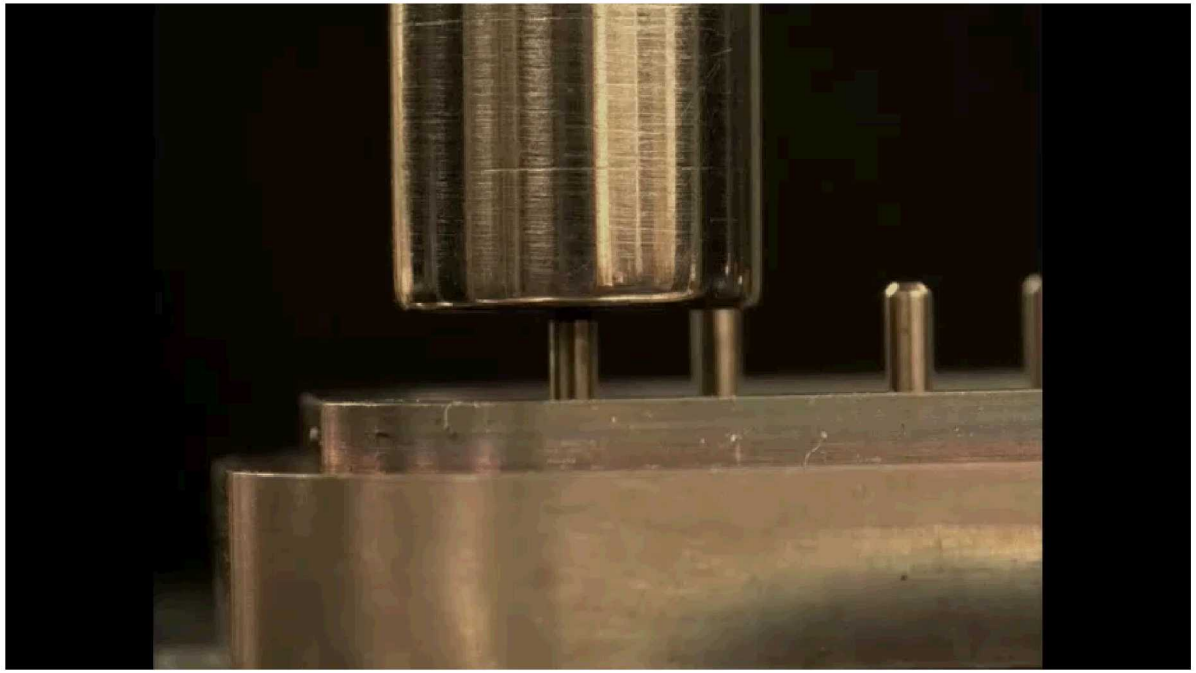
There is a need to develop methods to directly measure the glass-metal bond strength, interface toughness, and compressive stresses

Pin Pushout test

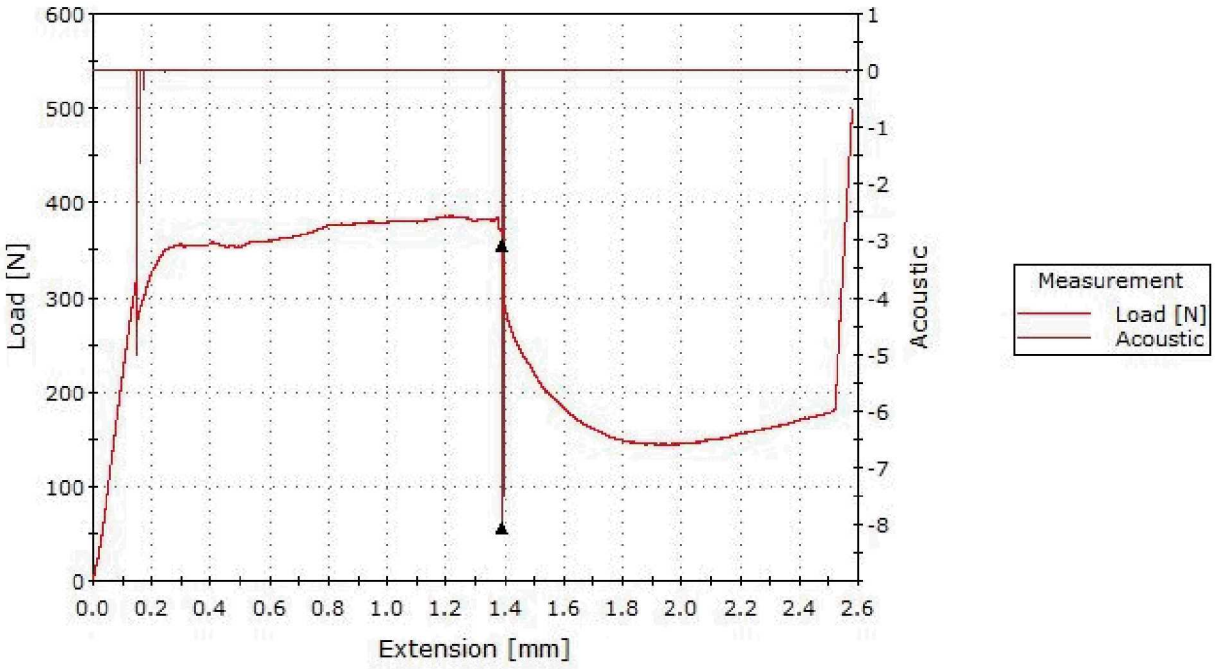


- Any header or connector can be tested in as is condition
- Quantitative and reproducible data
- Load-displacement curve, video of pin displacement, acoustic signature

Test setup and data acquisition

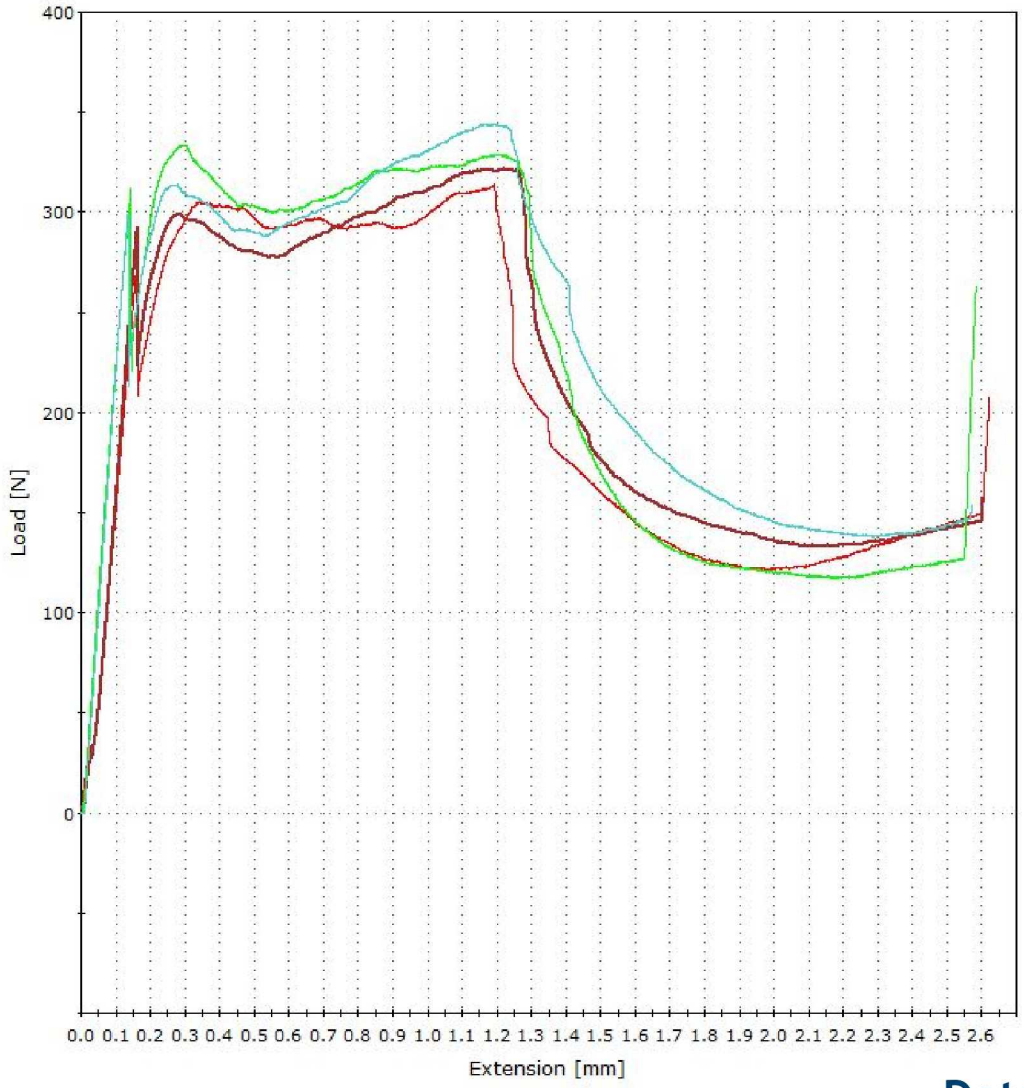


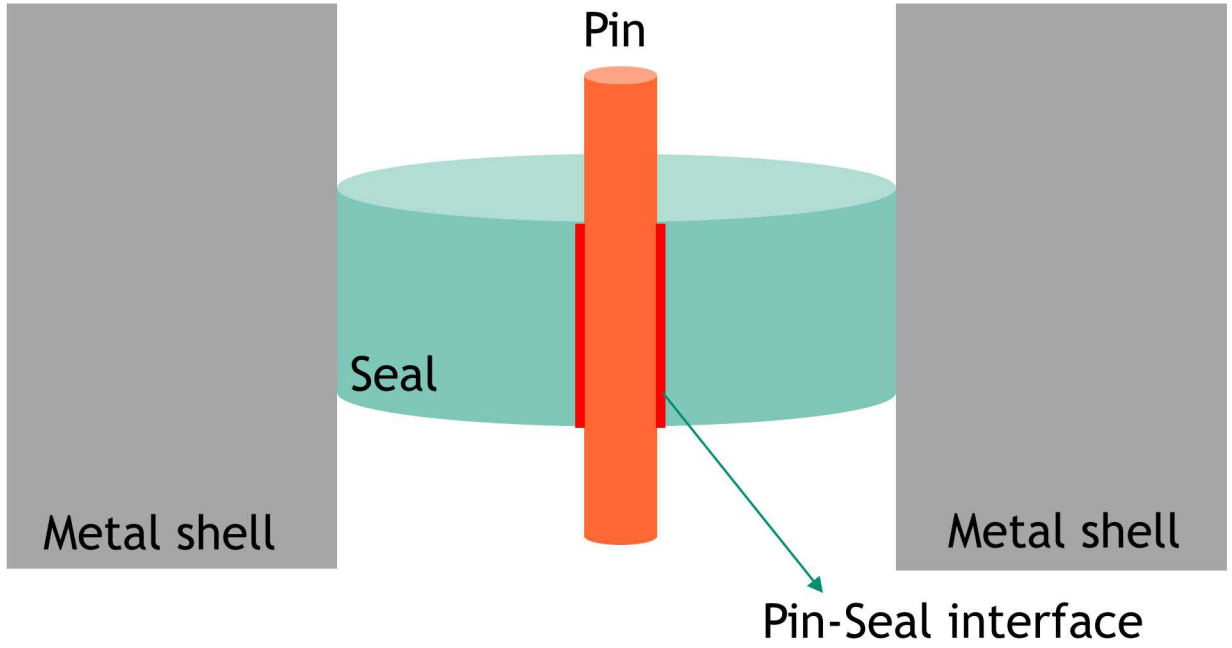
Video



Load-Displacement Curve and Acoustic Signal

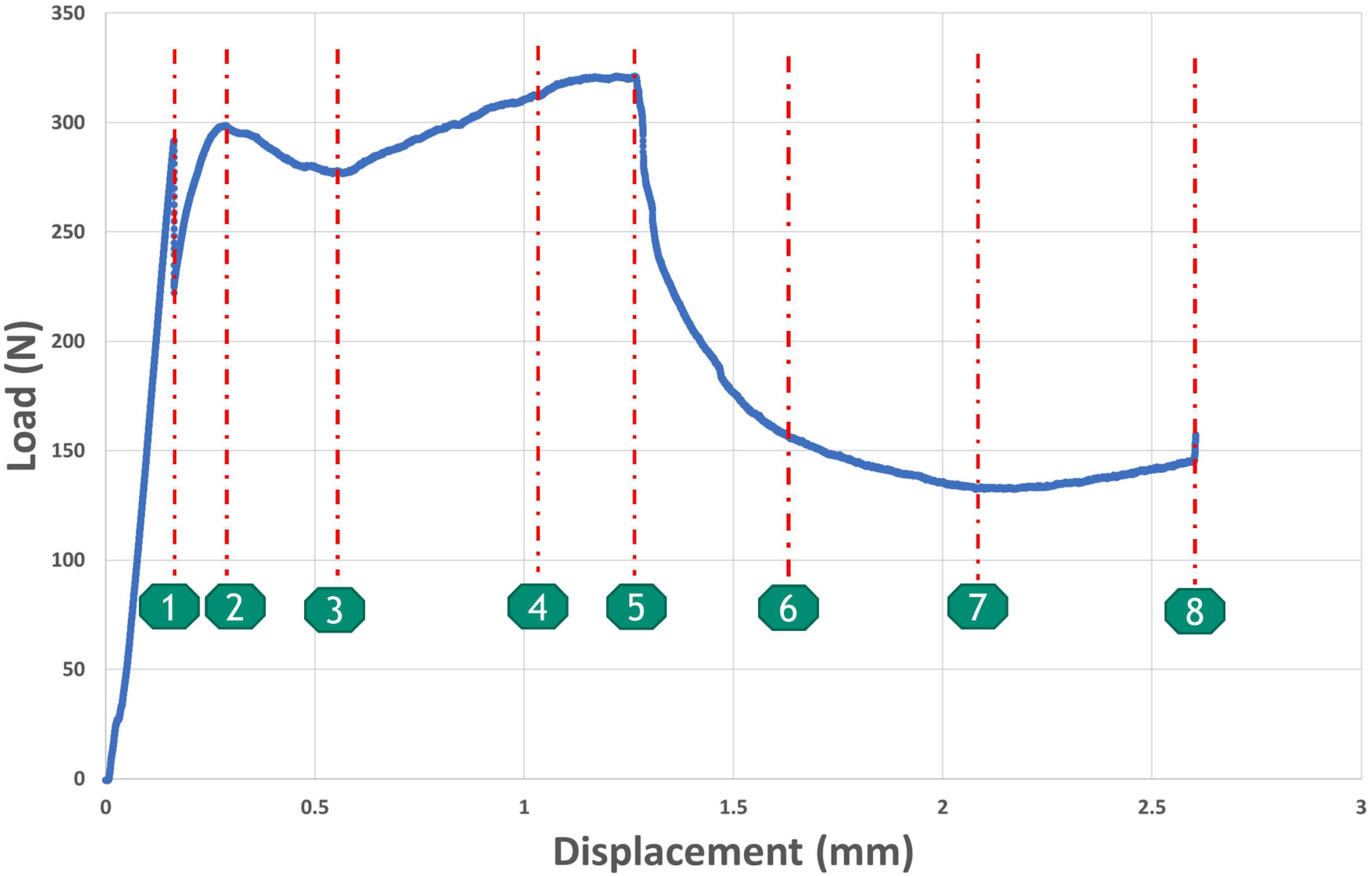
Typical load-displacement curve



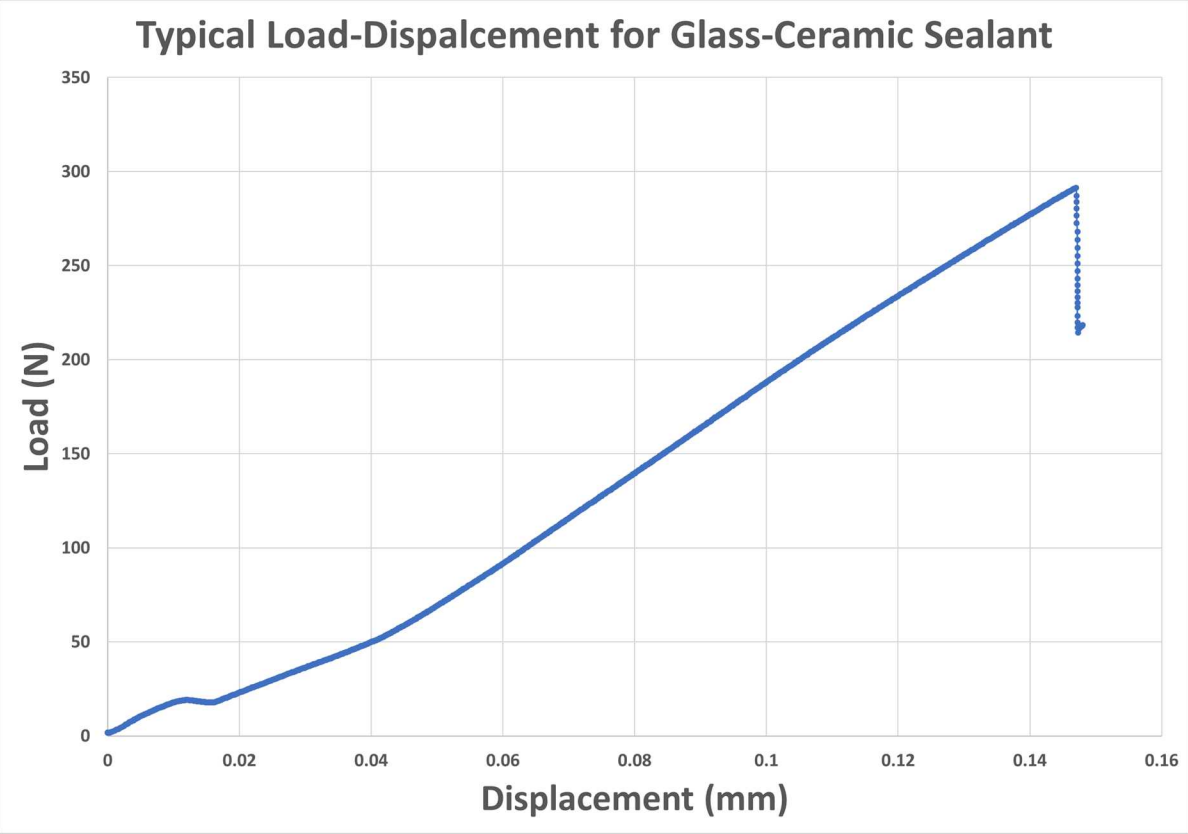


Data is consistent from run to run

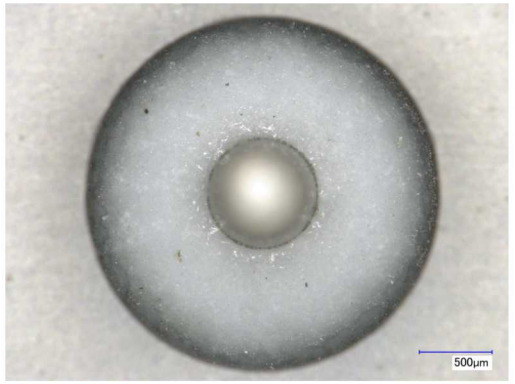
Features of load-displacement curves



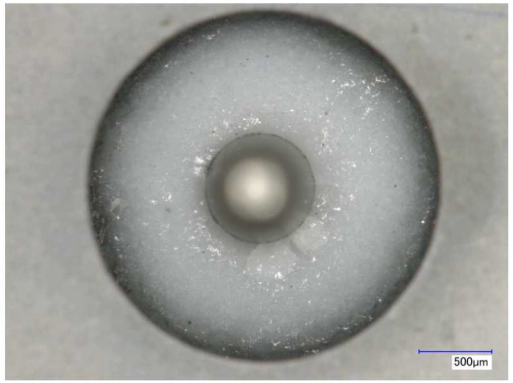
First debonding and crack initiation



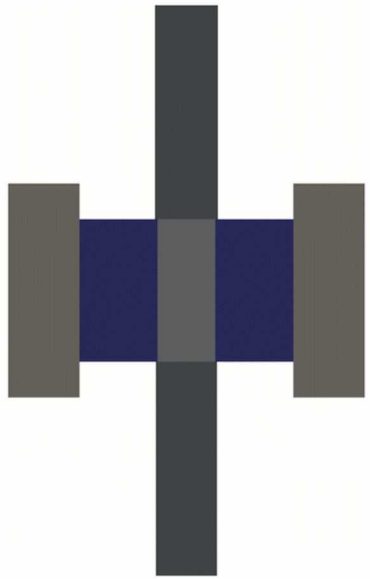
Before test



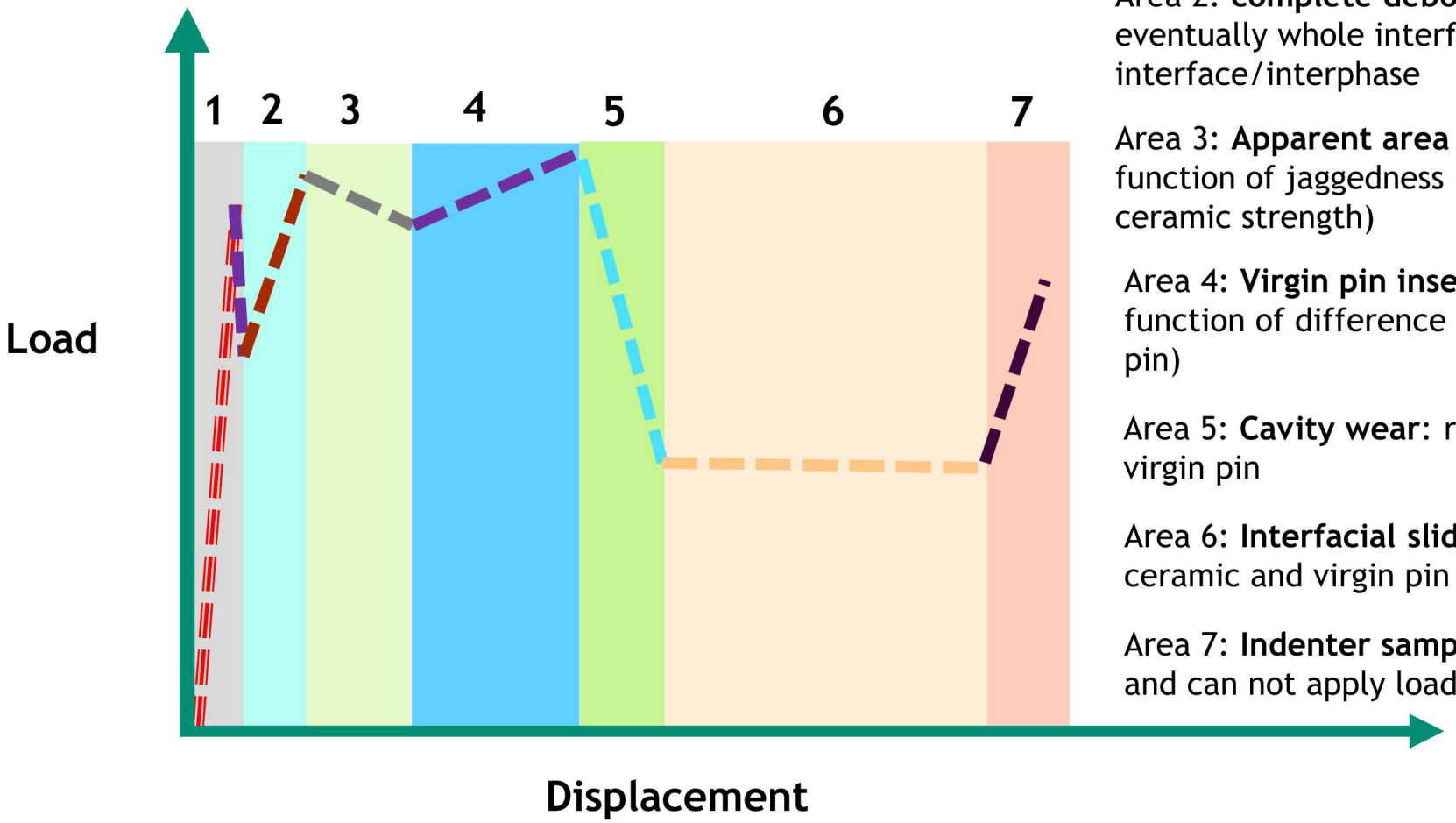
After test



Animation of debonding and sliding of pin



Different stages and dominant processes



Area 1: **Elastic loading and first debonding**: bond strength between glass-ceramic/metal pin

Area 2: **complete debonding**: The pin slowly debonds from glass and eventually whole interface is debonded: toughness of interface/interphase

Area 3: **Apparent area reduction dominated Fiber push-through**: a function of jaggedness of broken interface, (bond strength vs glass-ceramic strength)

Area 4: **Virgin pin insertion dominated Fiber push-through**: a function of difference in diameter of the pin (embedded vs virgin pin)

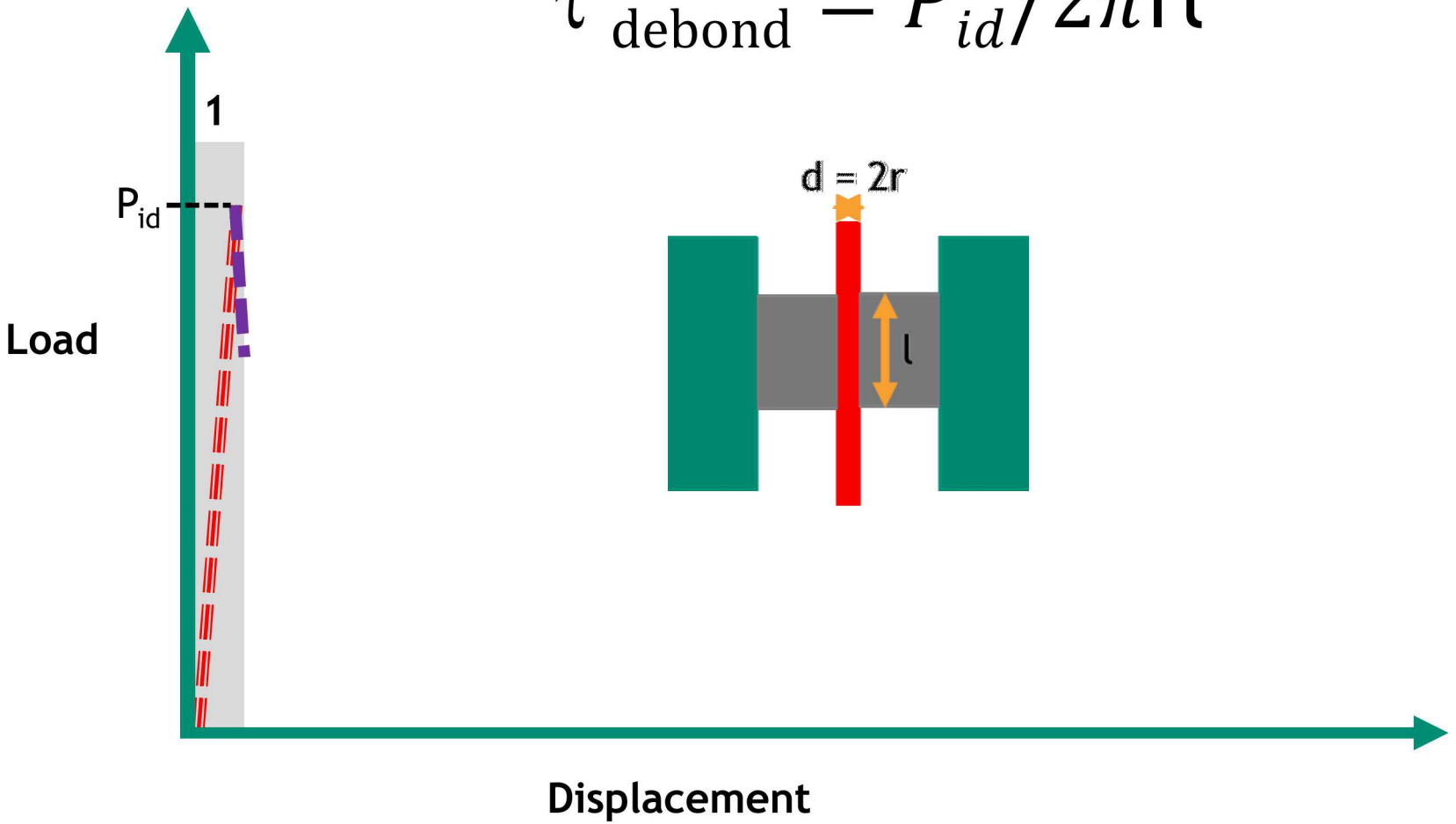
Area 5: **Cavity wear**: removal of material due to wear of cavity by virgin pin

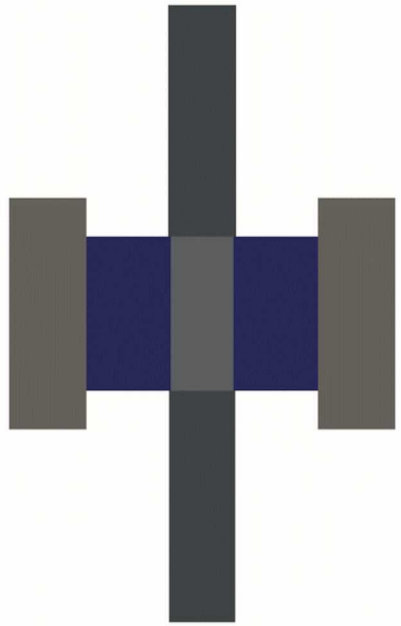
Area 6: **Interfacial sliding**: Frictional resistance between glass-ceramic and virgin pin material

Area 7: **Indenter sample collision**: Indenter touches the seal area and can not apply load on pin any further

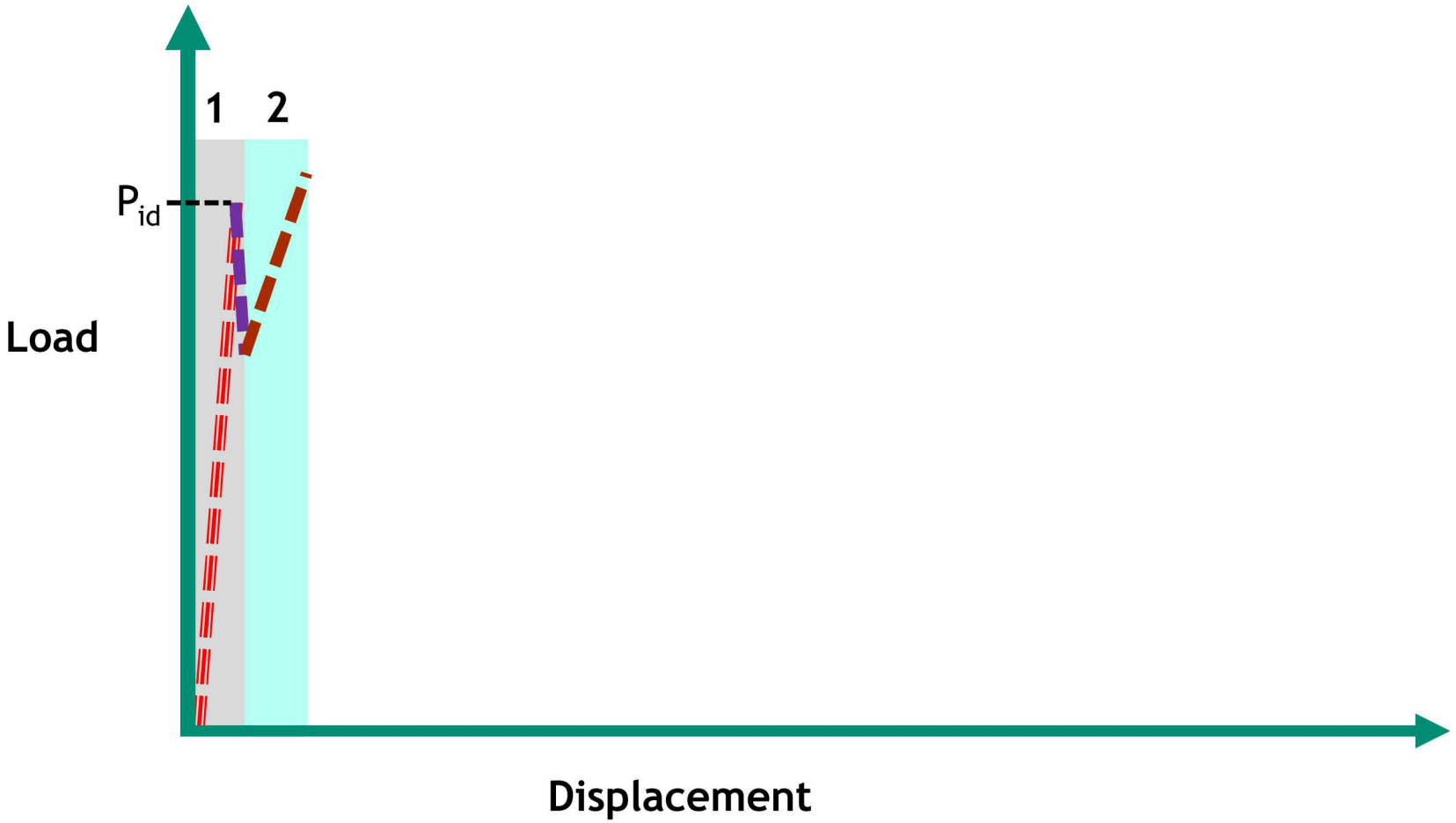
Stage 1: Bond Strength

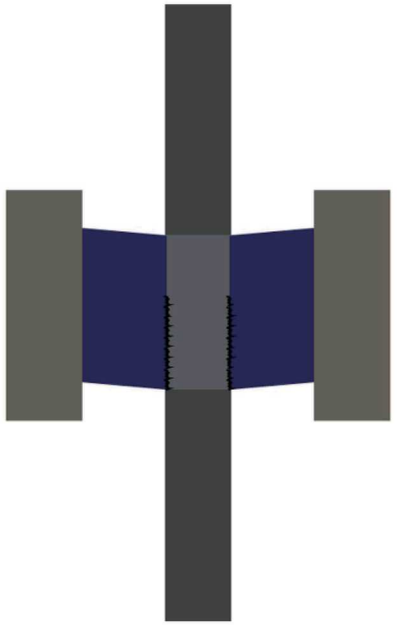
$$\tau_{\text{debond}} = P_{id}/2\pi rl$$



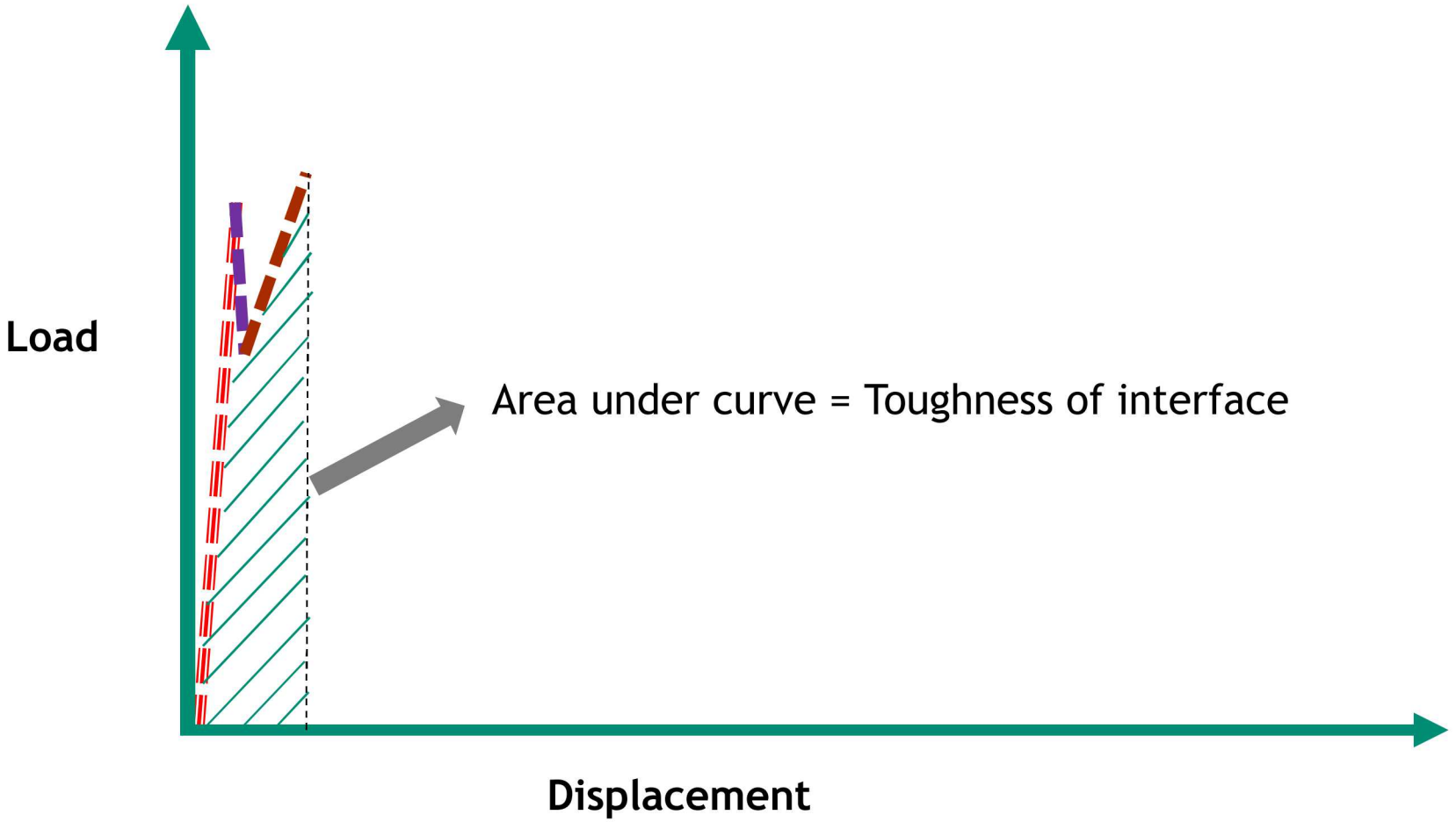


Stage 2: Interface toughness



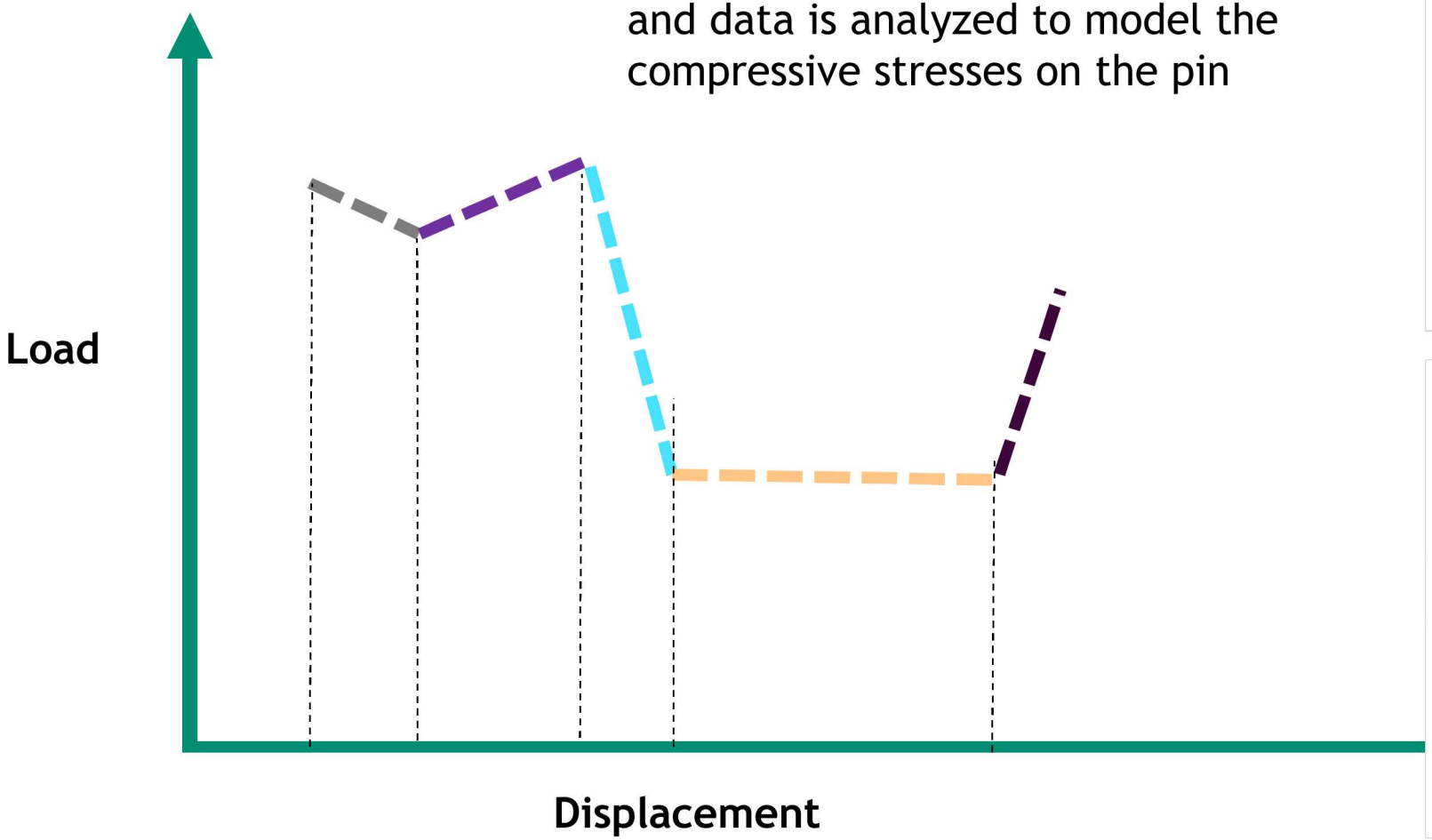


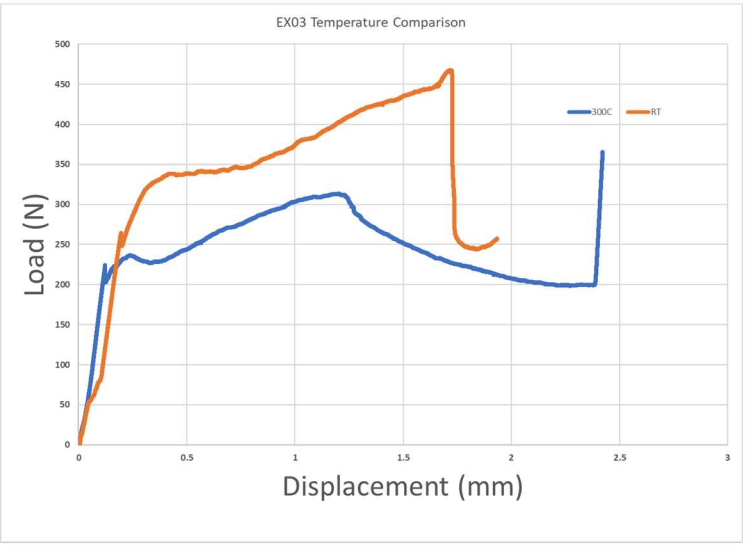
Stage 2: Interface toughness

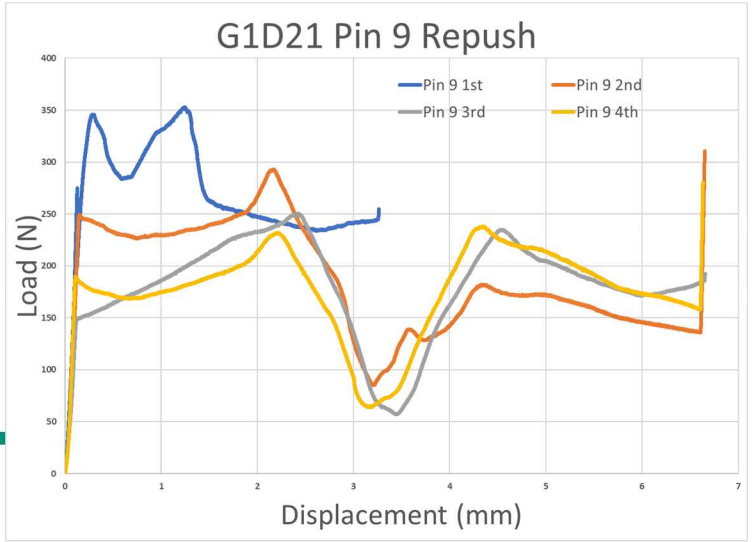


Later Stages

Controlled experiments are being run and data is analyzed to model the compressive stresses on the pin







Conclusions

- We have developed a new method to characterize pin-glass bonding/compression states in glass based hermetic connectors. This could easily be extended to shell-glass interface

- Further analysis and testing is underway to further develop the test method and understand the mechanisms seen during testing

Future work

- Fabricate controlled samples and test them to develop the model for stage 3 and beyond to be able to calculate compressive stresses
- In-situ observation and measurement of crack propagation during push out test
- Further development of high temperature measurement set ups
- Use the method to measure glass/glass-ceramic to metal shell interaction

Acknowledgements

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Questions