Characterization of Microturbine Materials

Mechanical Property Characterization of EBCs

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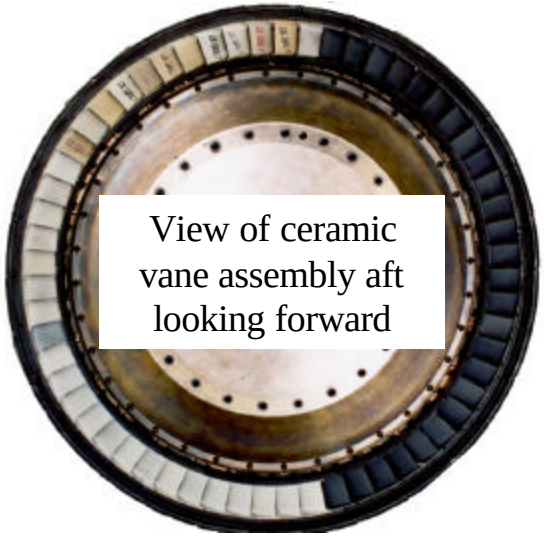
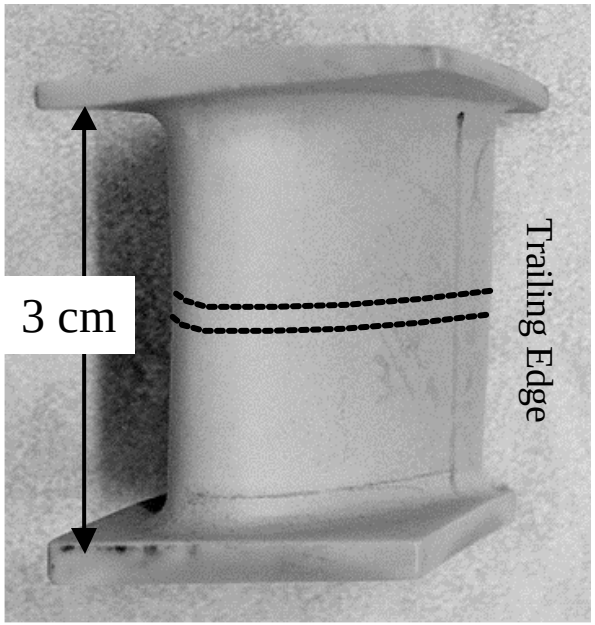
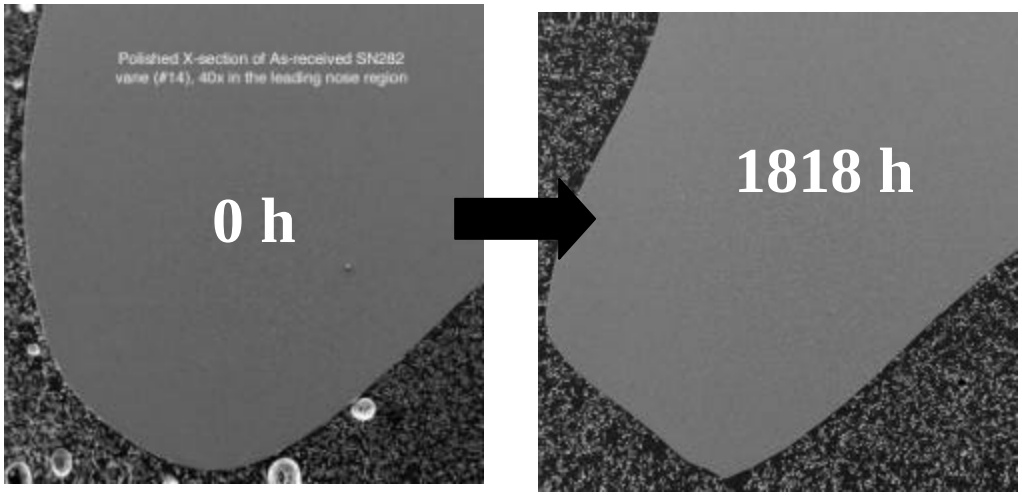
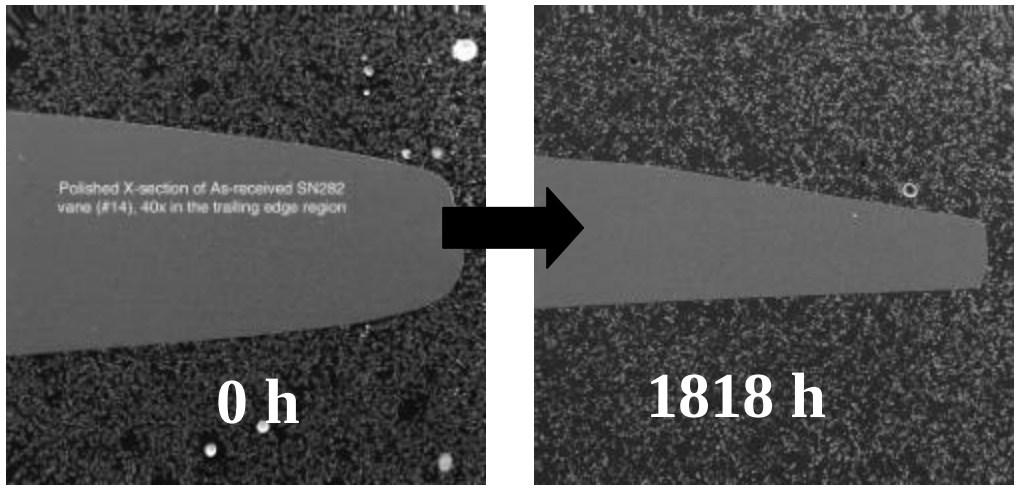
Background

The Recession Challenge



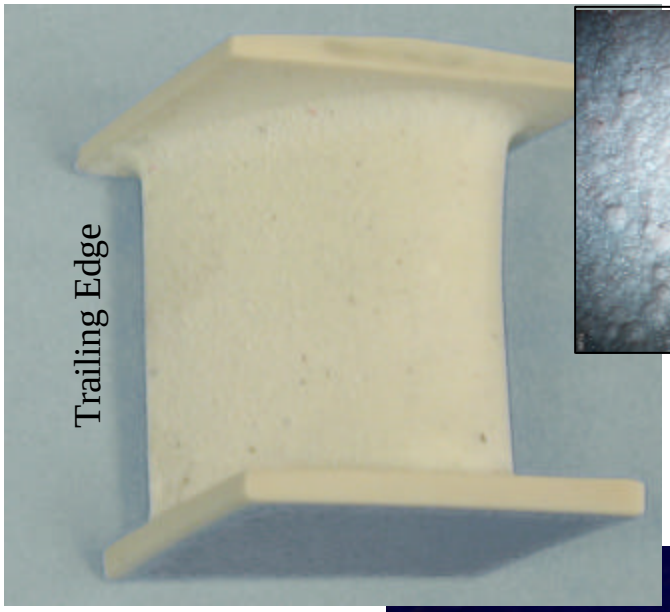


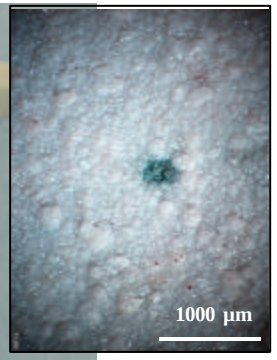


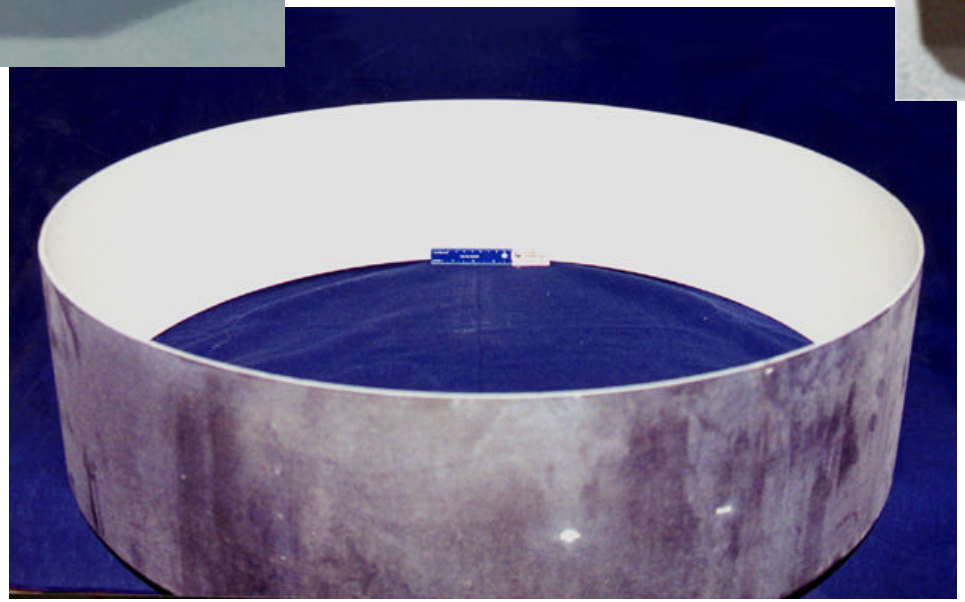


SN282 Vanes

There is Currently Much Emphasis on the Development of Environmental Barrier Coatings (EBCs) for Monolithics







This Project has Two Main Objectives

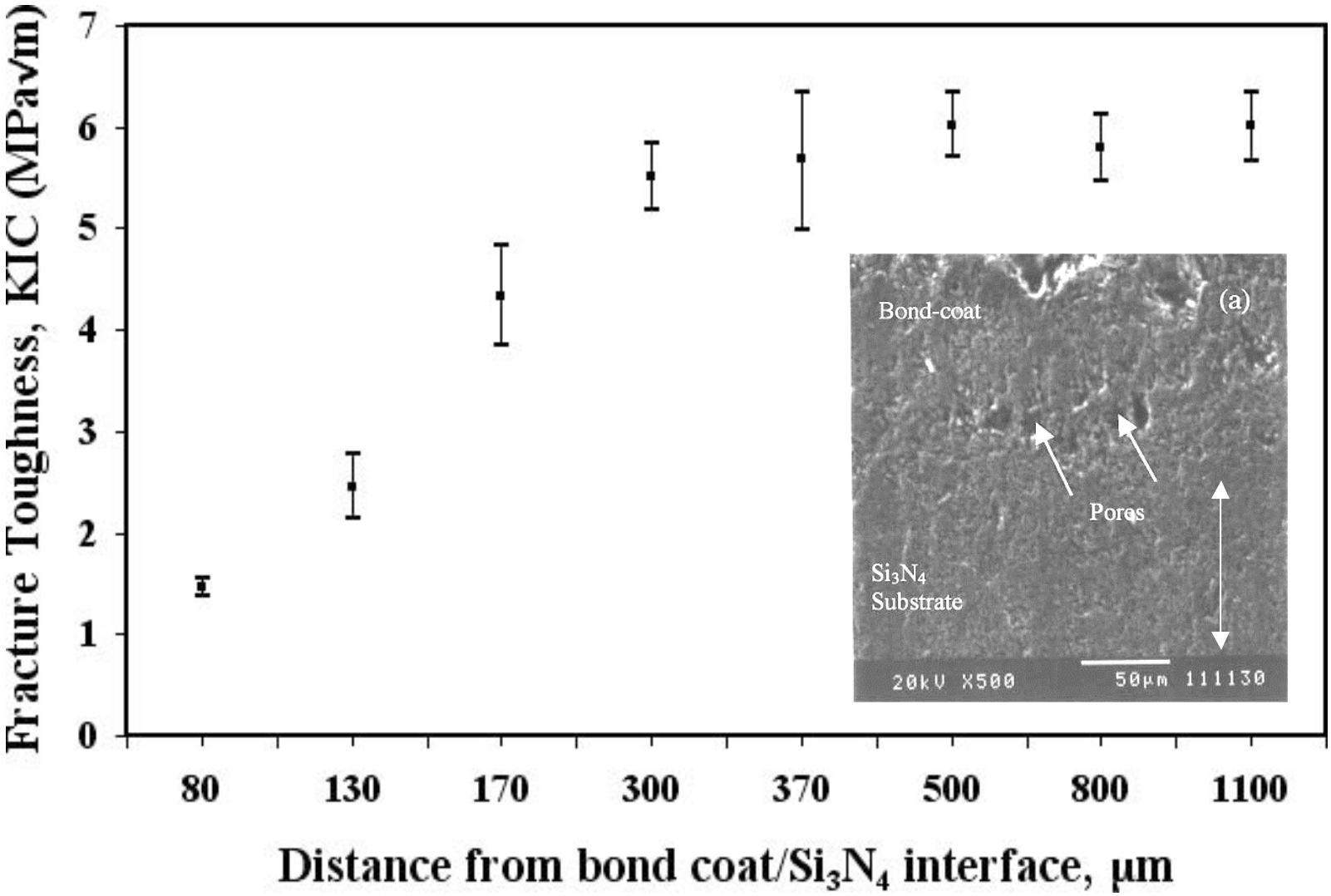
- **Evaluate Environmental Barrier Coatings (EBCs)**
  - Effectiveness of EBC as a Diffusion Barrier
  - Influence of Environment on the Stability of the EBC
  - Influence of EBC on Mechanical Behavior of Silicon Nitride Substrate
  - Influence of Substrate Deformation of Reliability of EBC

- **Explore Several Methods for Evaluating Long-Term Mechanical Reliability of Structural Ceramics in the Presence of High-Pressure Water Vapor**

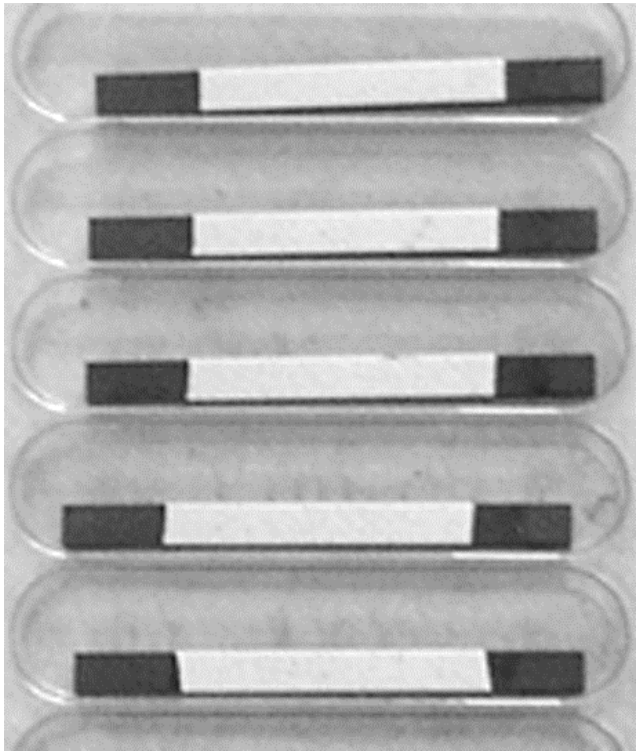
Characterization of Microturbine Materials

Mechanical Property Characterization of EBCs

Micro-Mechanical Characterization Has Been Used to Evaluate Effect of EBC on Fracture Toughness

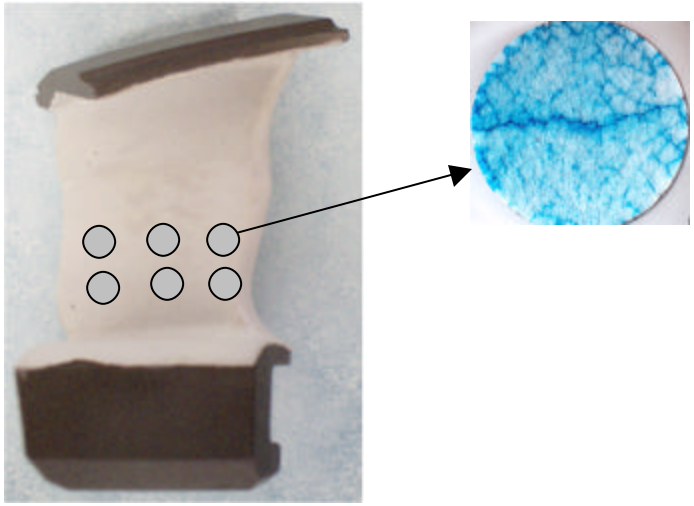


Influence of EBC Upon Strength Has Been Examined Using Room-Temperature Four-Point and Biaxial Flexure



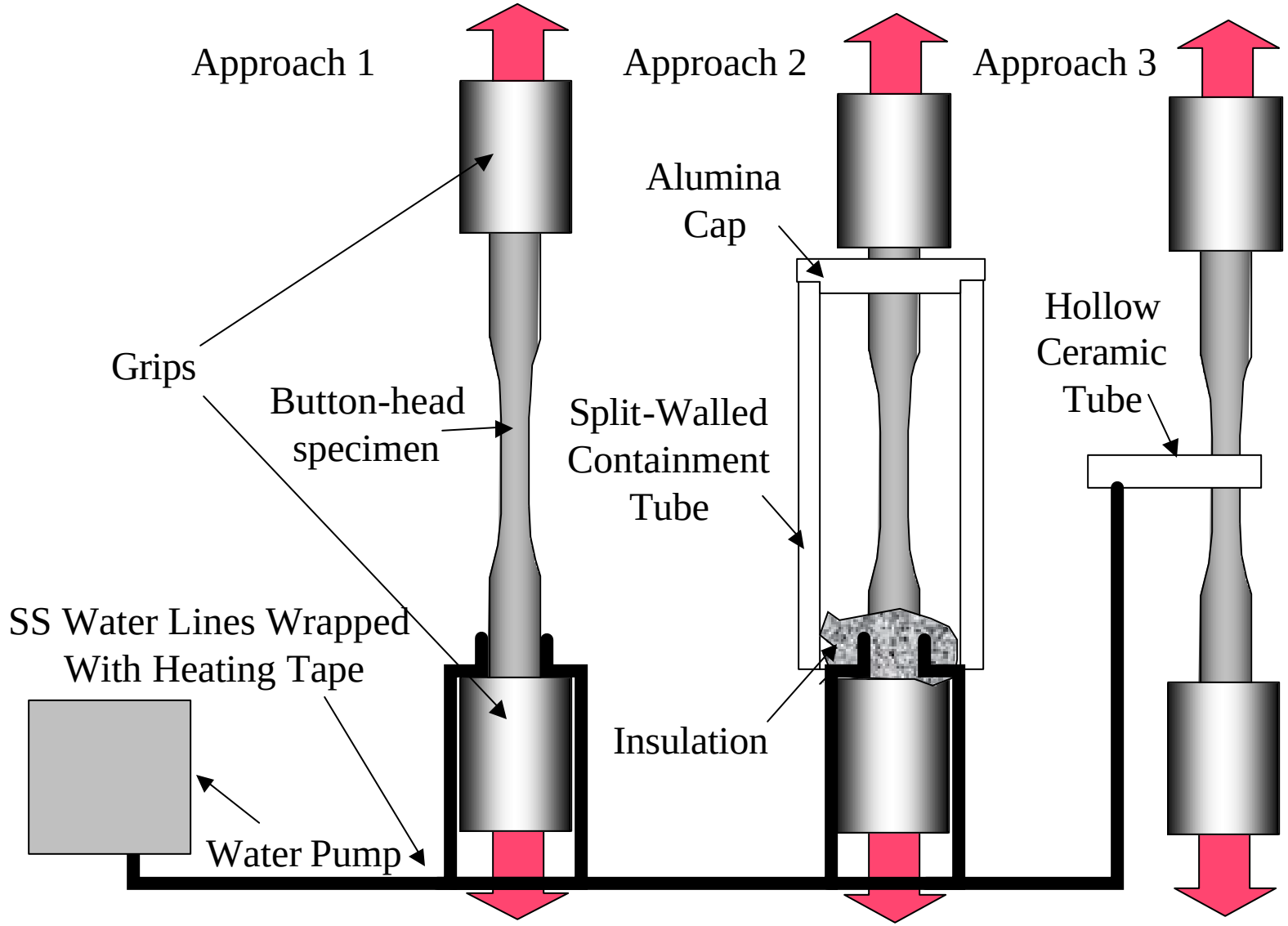
As Coated Flexure Specimens

Keiser Rig Coupon

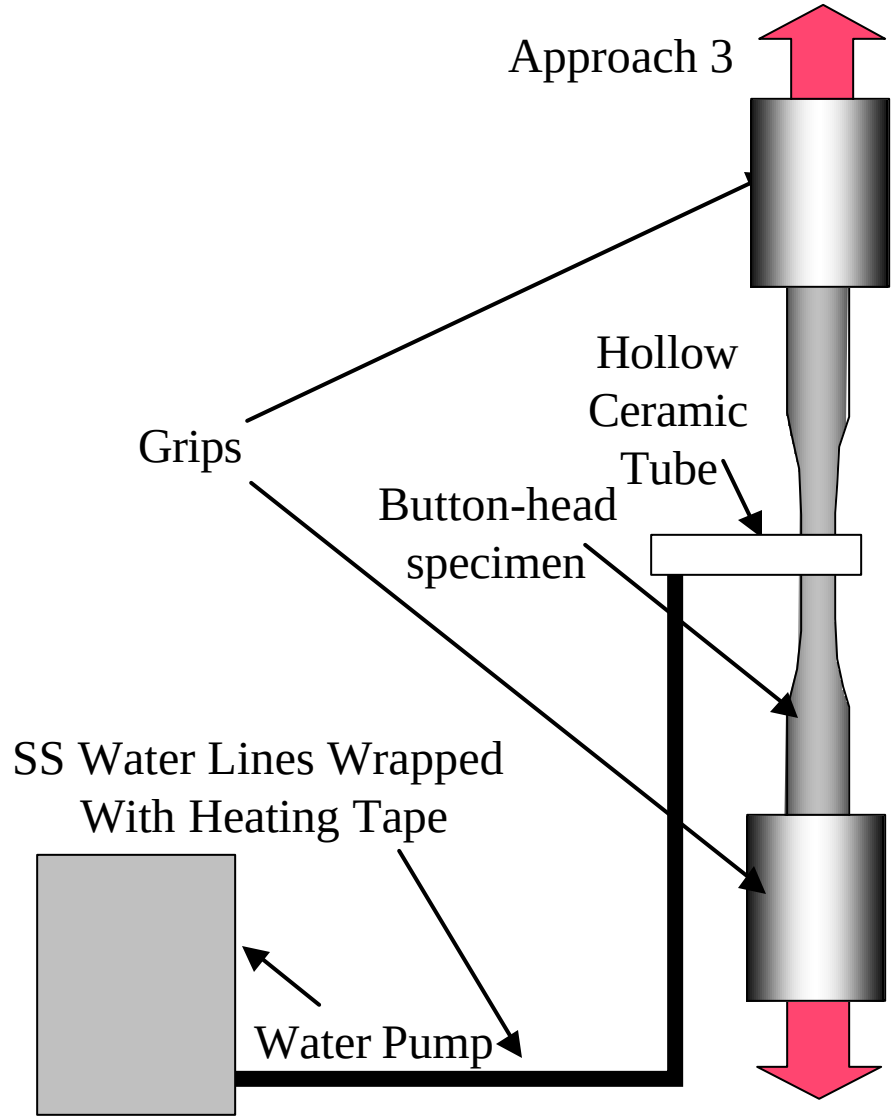


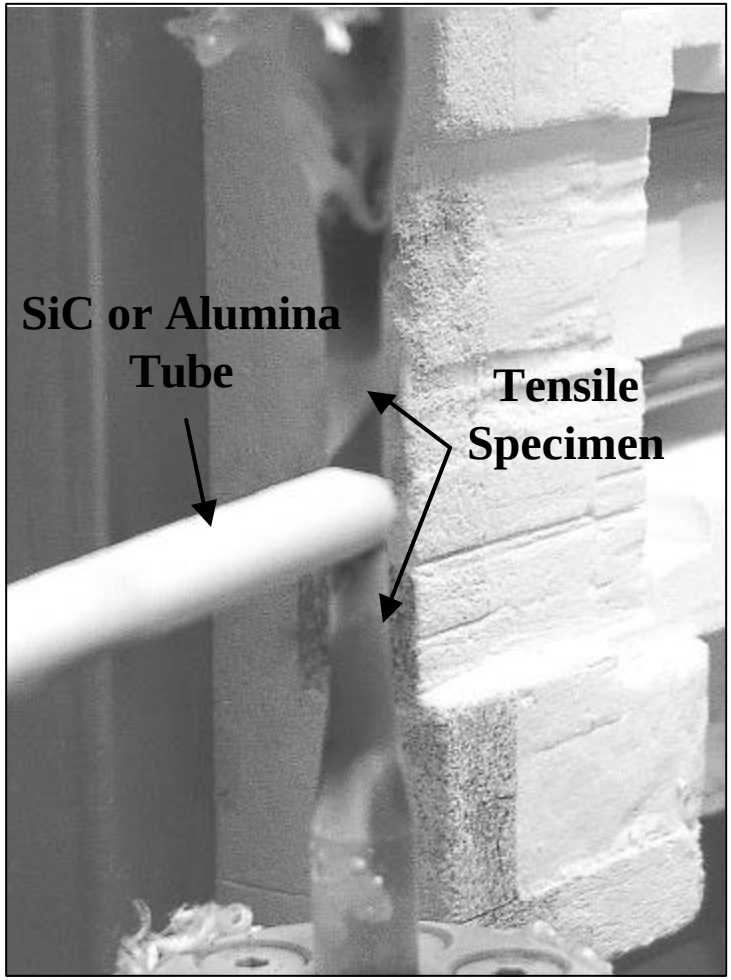
Ceramic Nozzle

Current Efforts Have Focused on Measurement of High-Temperature Behavior is a Steam Environment

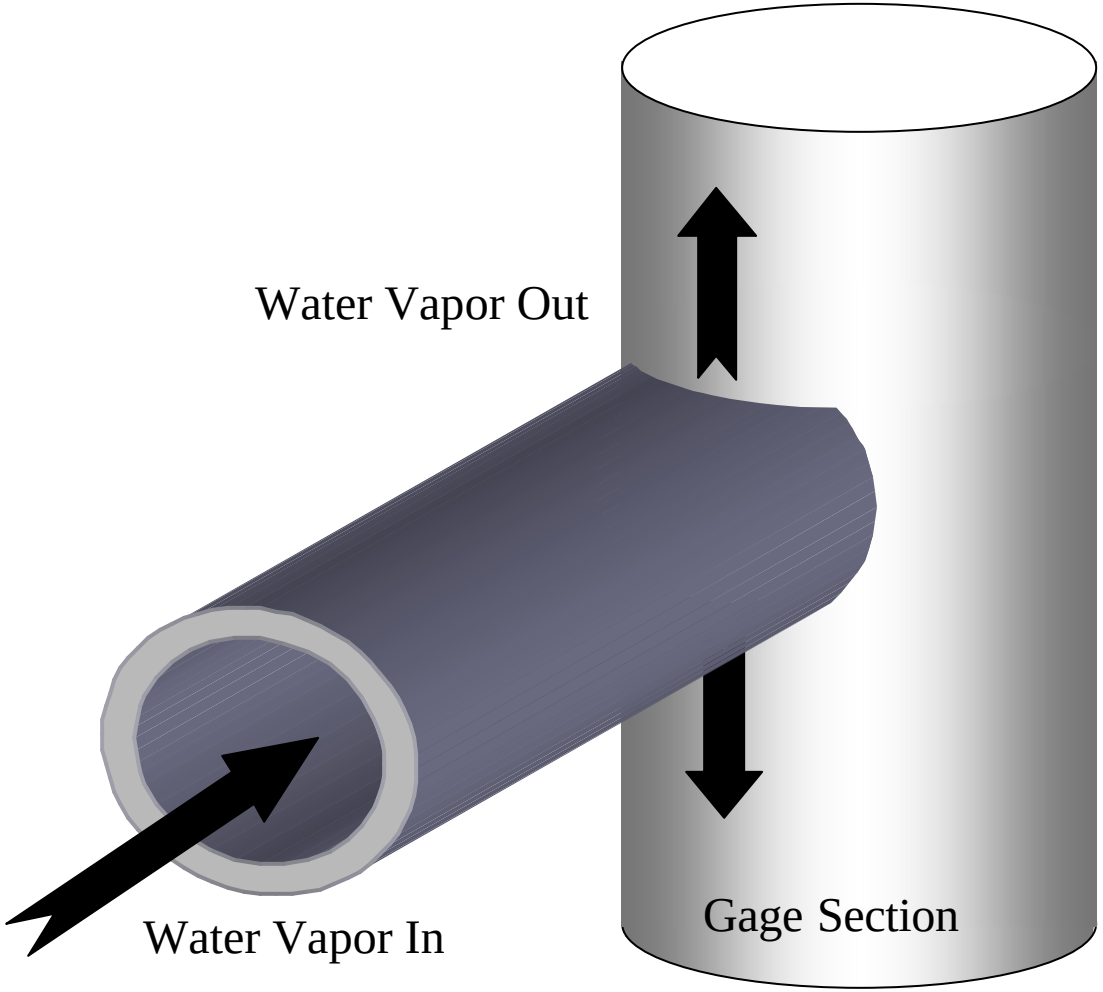


Direct Injection Onto the Gage Section Has Been Quite Effective



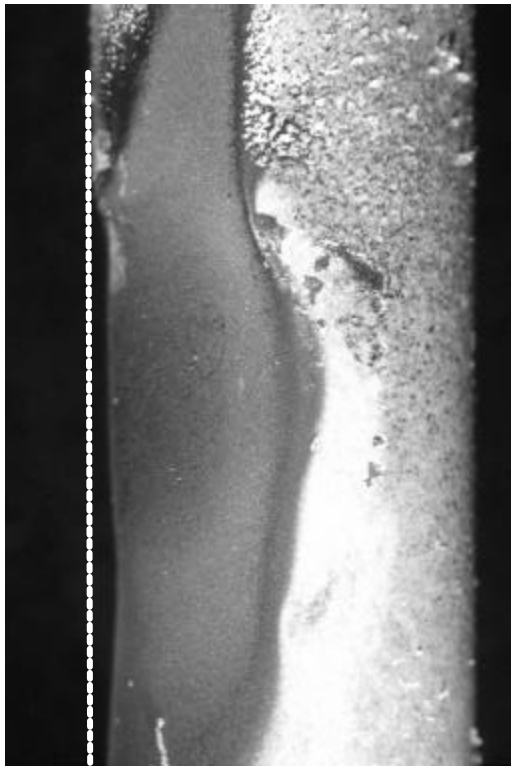


Relatively High Water Vapor Velocities are Possible with Approach 3

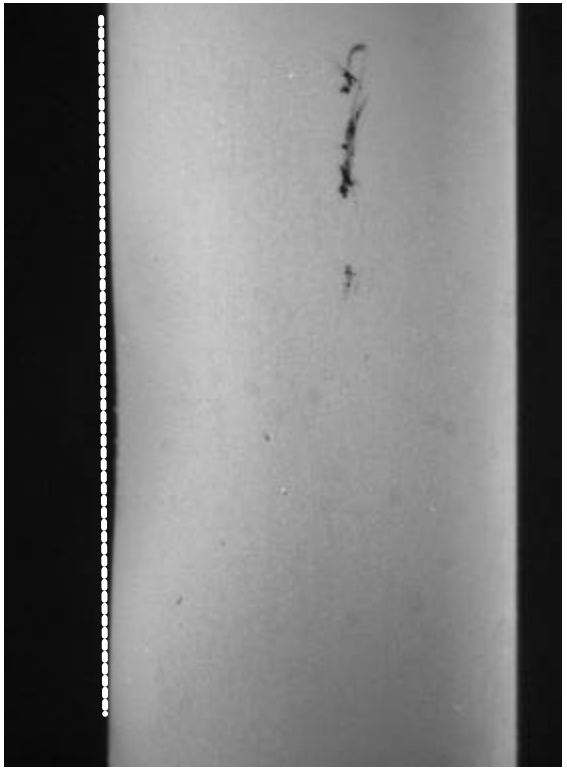


Velocities can be quite high

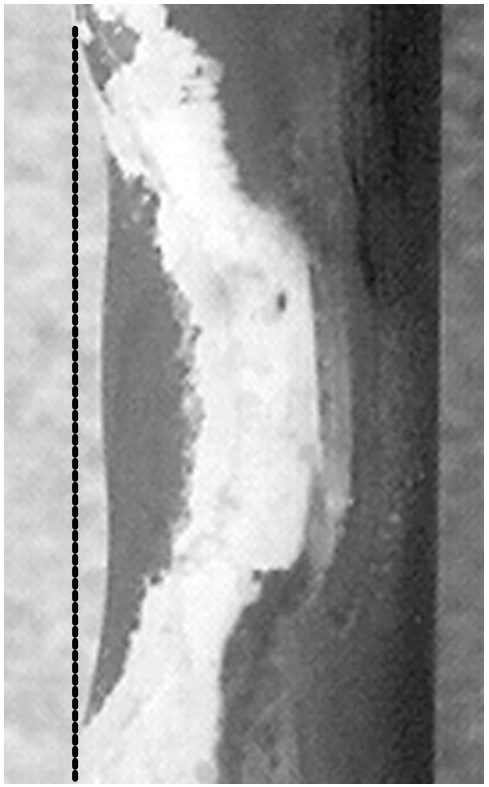
This Approach Yields Extensive Recession in Contact Region



SA SiC- 291 1200°C & 500 h with Water Vapor (250 µm)



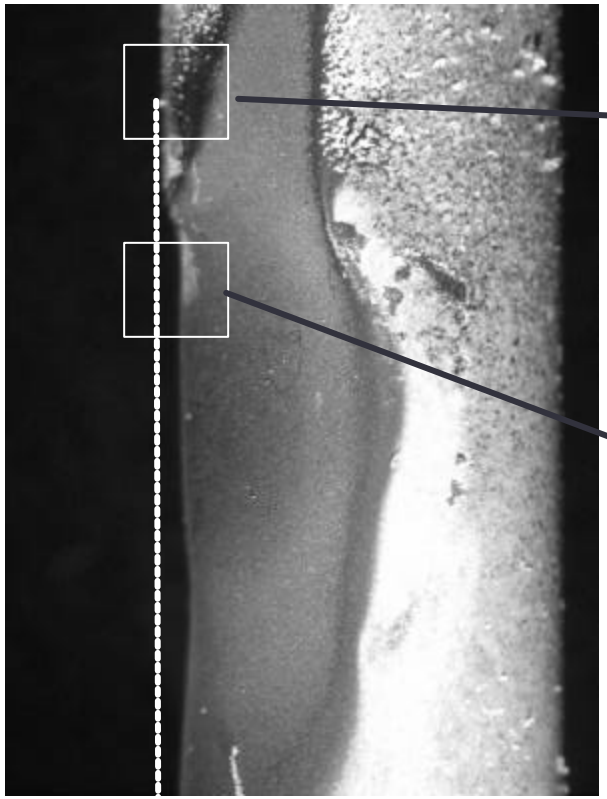
NT154-1 1200°C & 500 h with Water Vapor



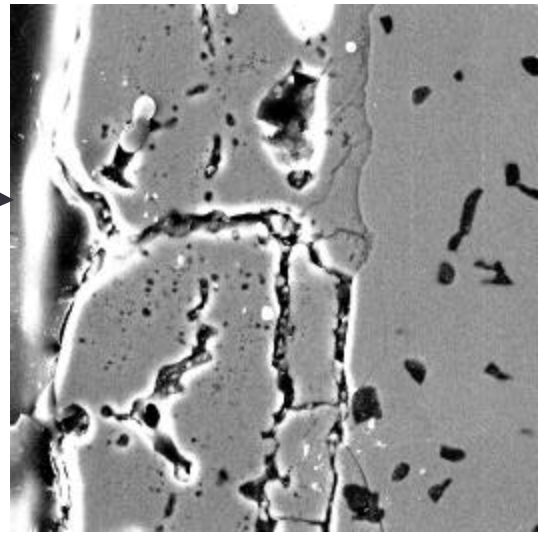
NT164-81 1288°C, 150 MPa, & 2000 h with Water Vapor (500 µm recession)

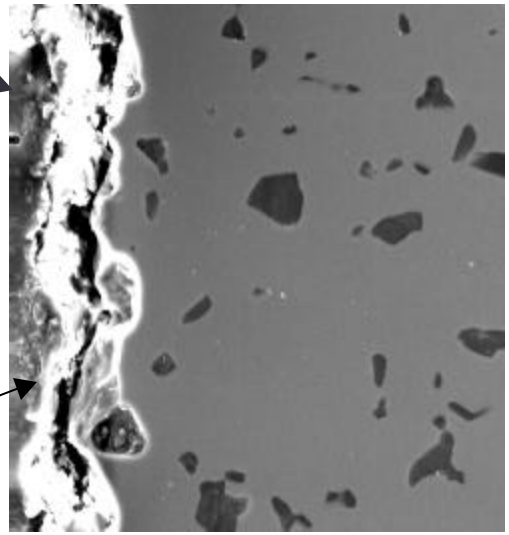
Surface Subjected to Direct Steam Injection Typically Exhibits Little or No Silica Formation

- **SA SiC 1200°C 500 h with Water Vapor Specimen 291**



SA SiC- 291 1200°C & 500 h with Water Vapor

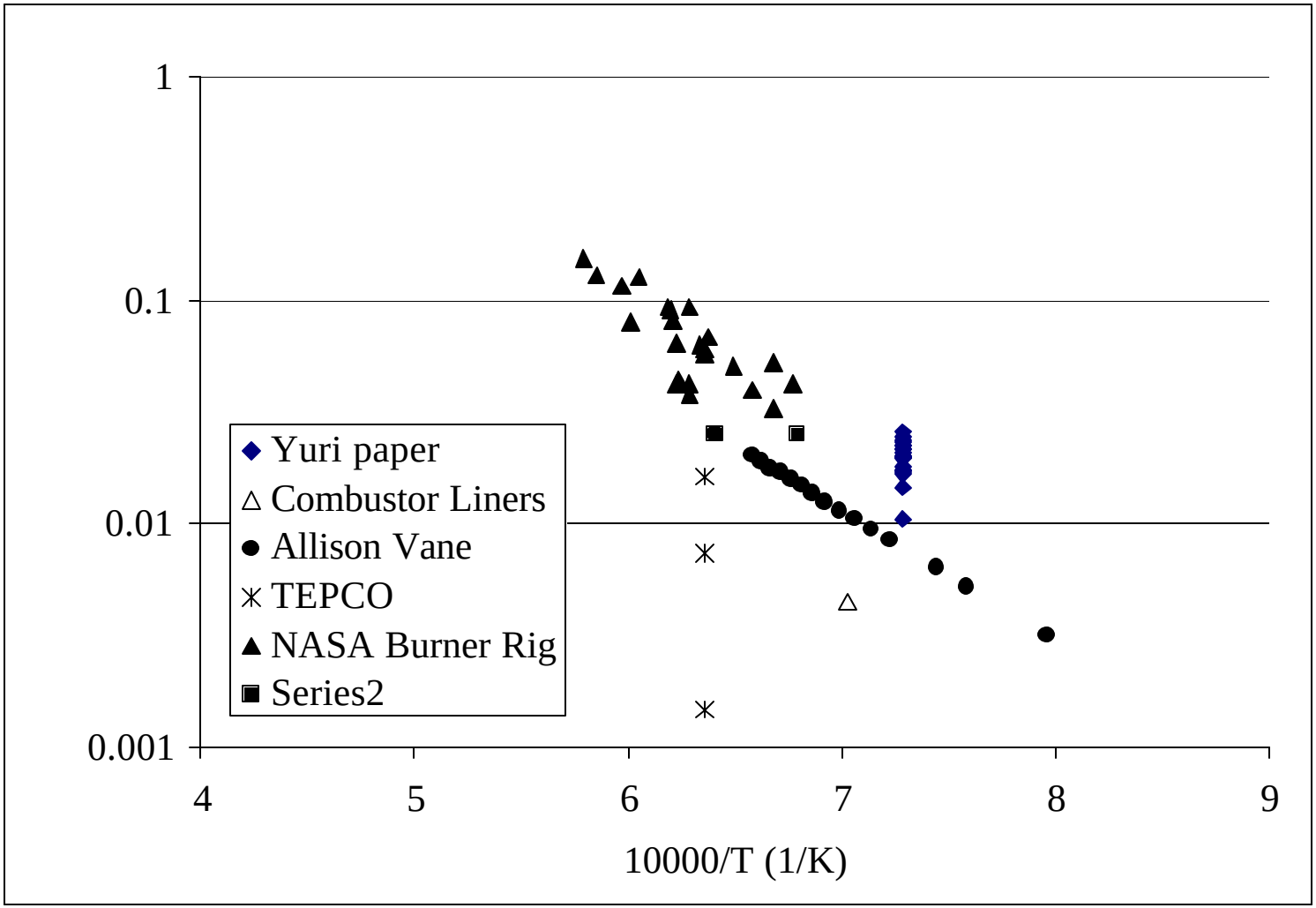




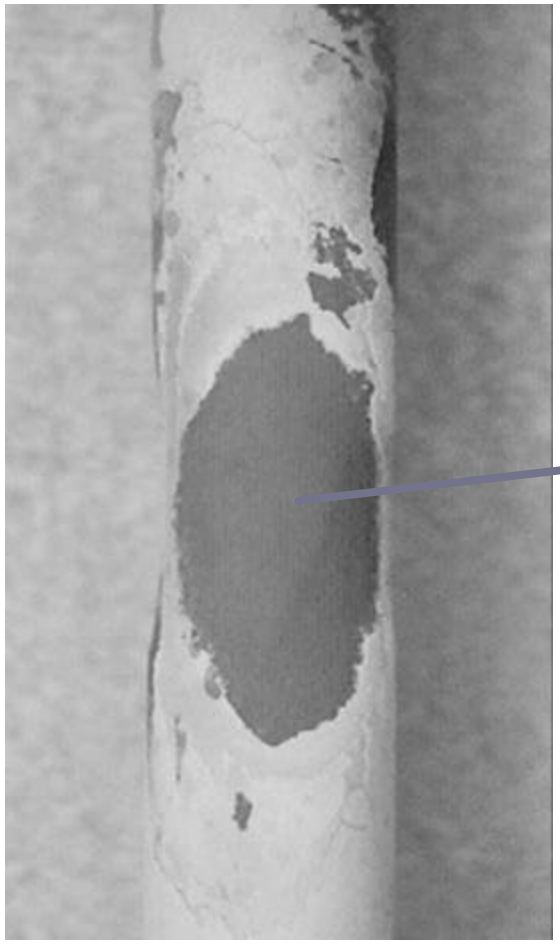
Epoxy (no silica)

5 µm

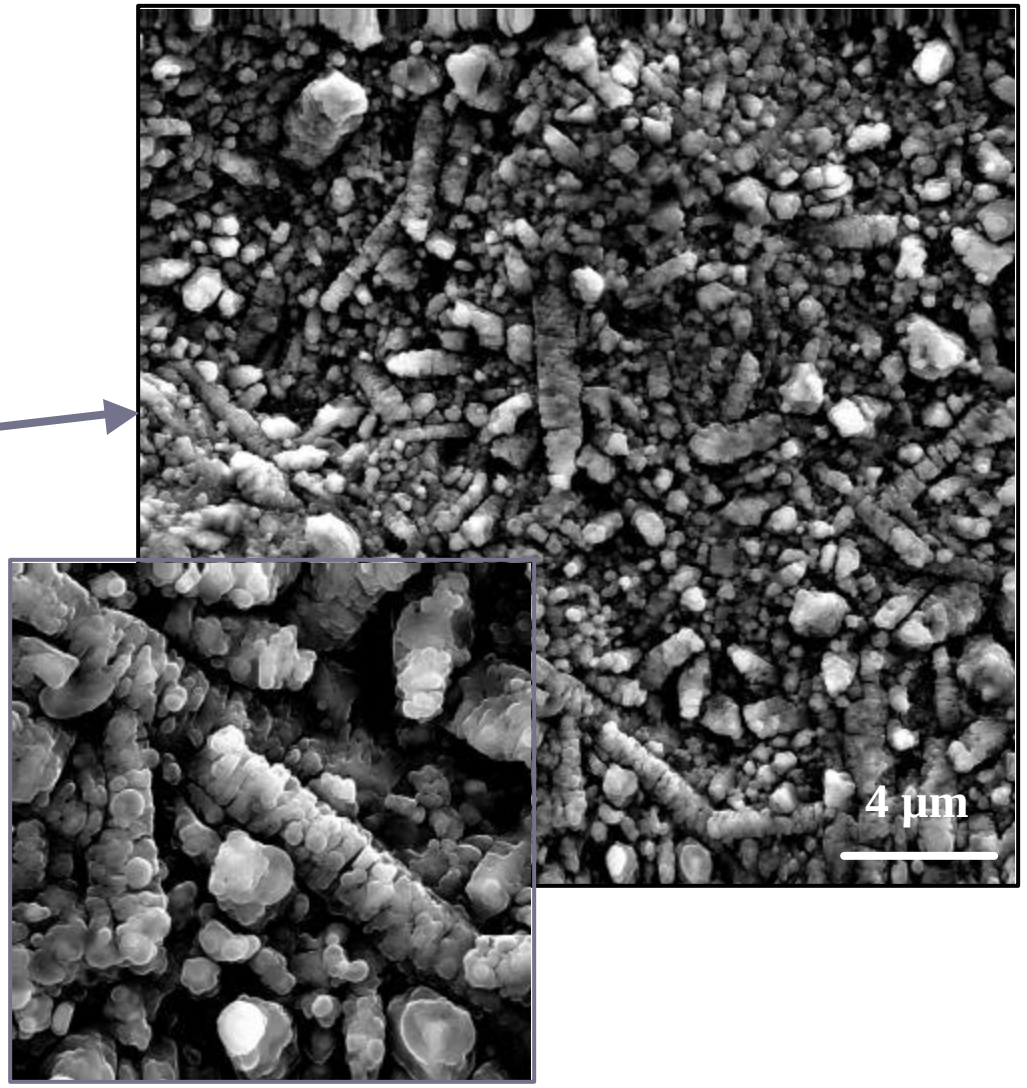
Recession Results are In Agreement with Data Obtained in Other Programs



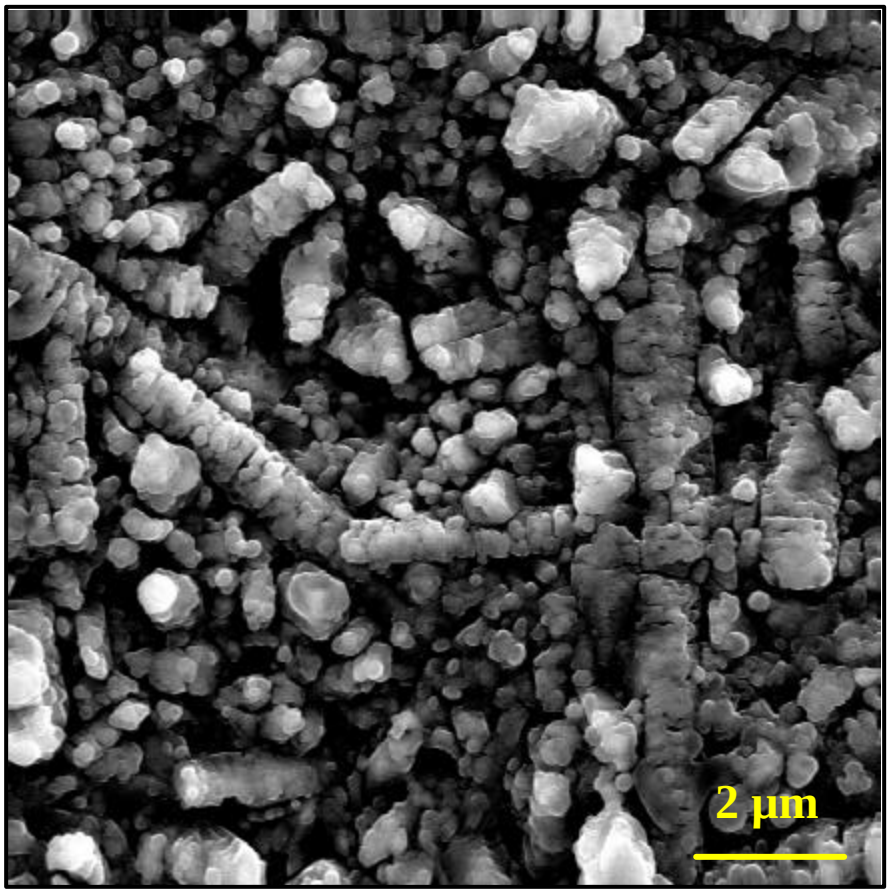
Surface Subjected to Direct Steam Injection Exhibits Extensive Degradation of SN Grains



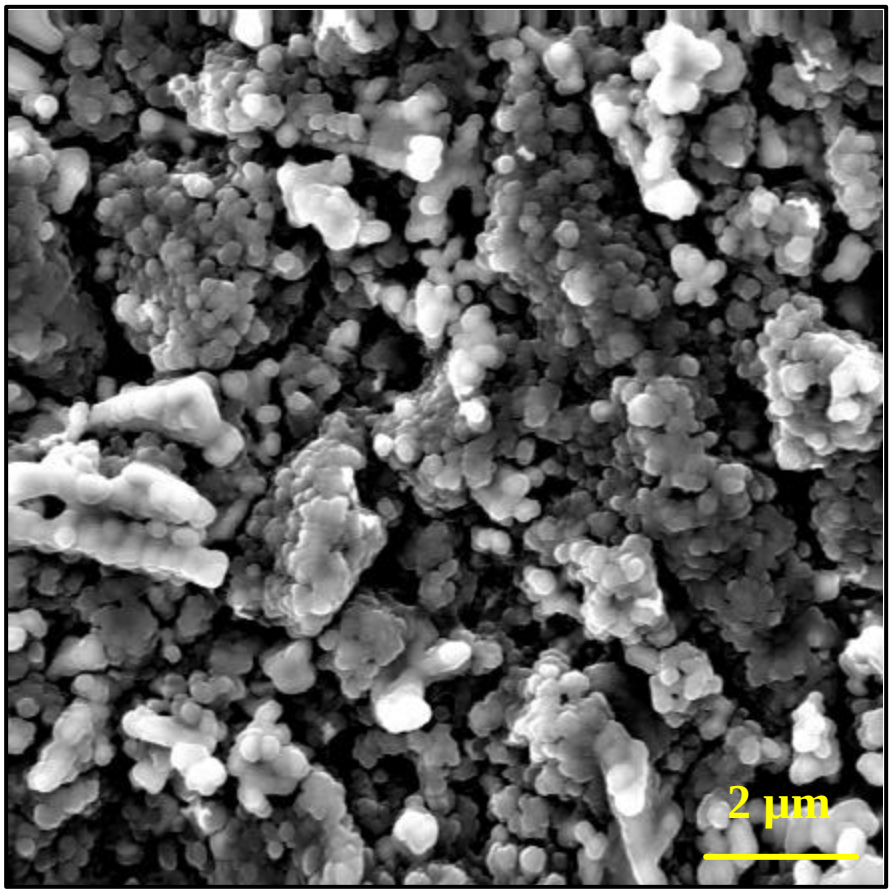
NT164-81 1288°C, 150 MPa,
& 2000 h with Water Vapor



These Surface Characteristics are Similar to Those Exhibited During Field Tests

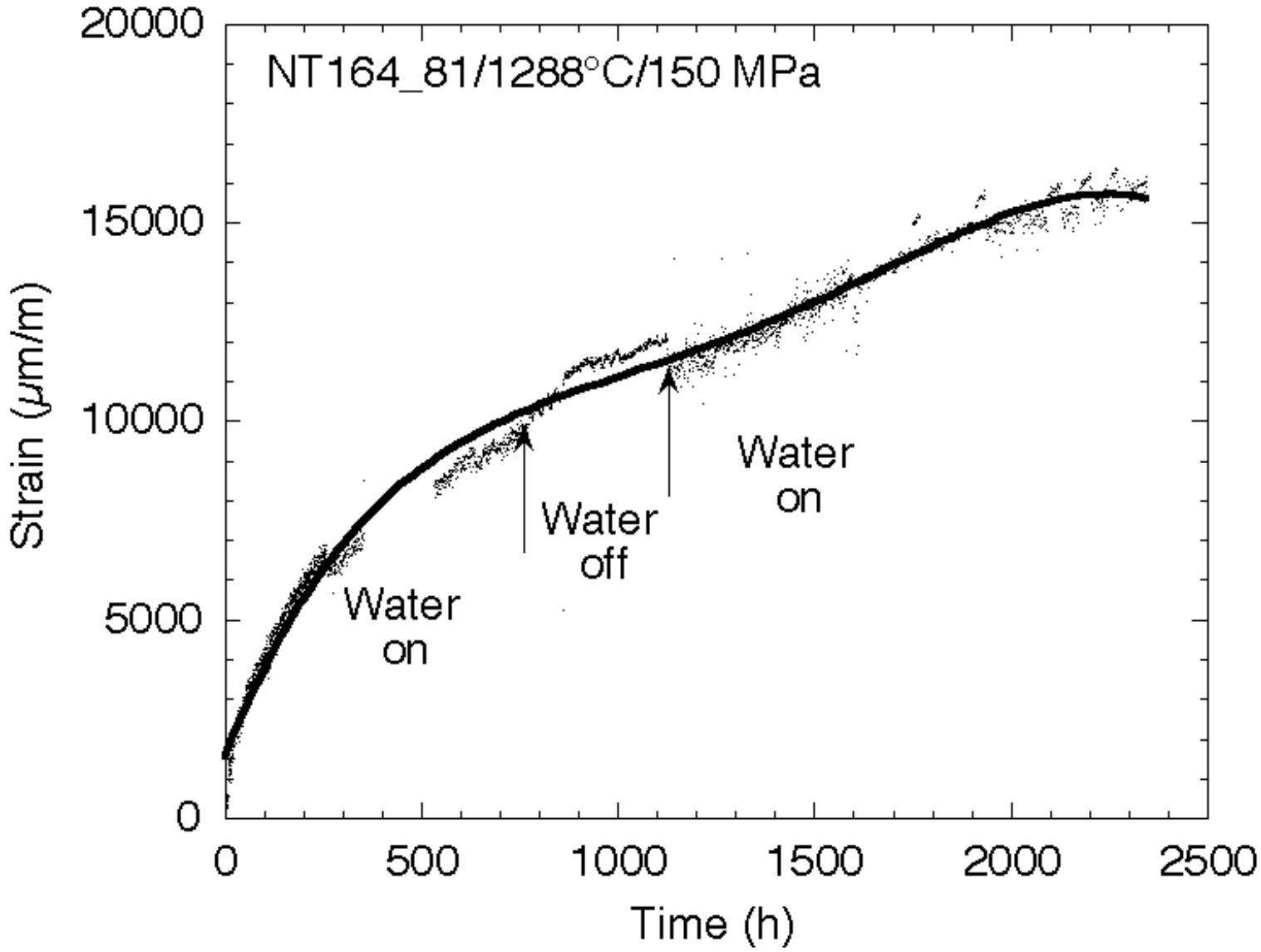


Exposed surface of NT164 BH specimens after ~2000h test @ 1288°C, 150 MPa, H2O

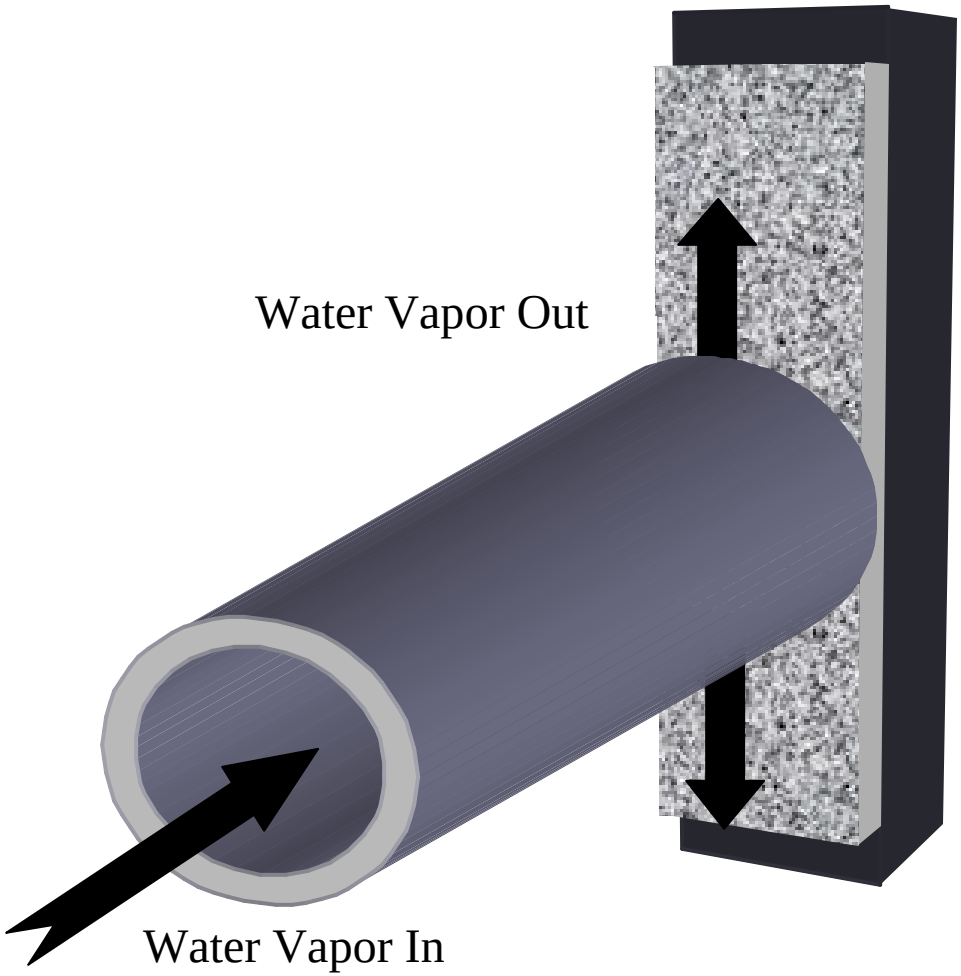


Trailing Edge surface of Allison AS800 vane (#152) after 624h engine test

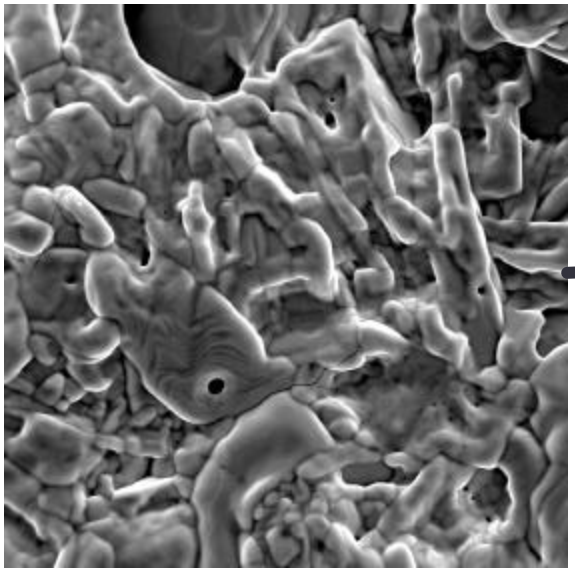
The Affect of Water Vapor on Creep of NT164 Appears to Be Negligible

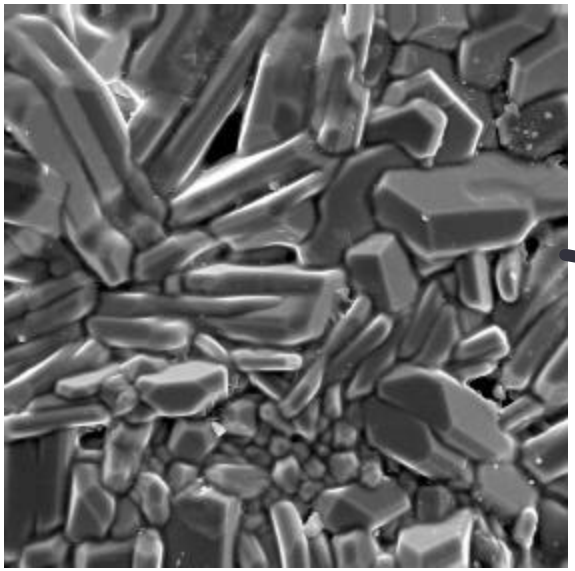


Water Injection System Has Also Been Used to Evaluate EBCs on Flexure Bars



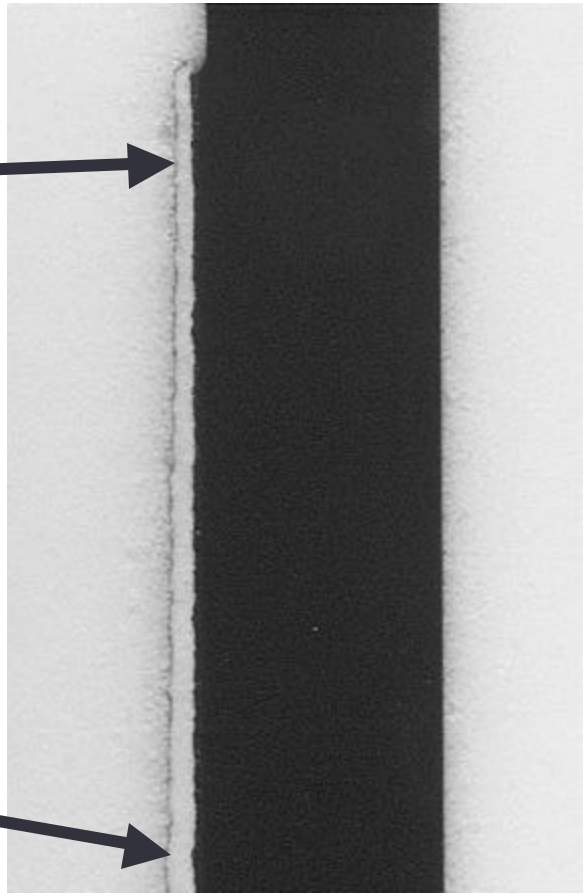
EBC Morphology Is Affected By Steam Injection





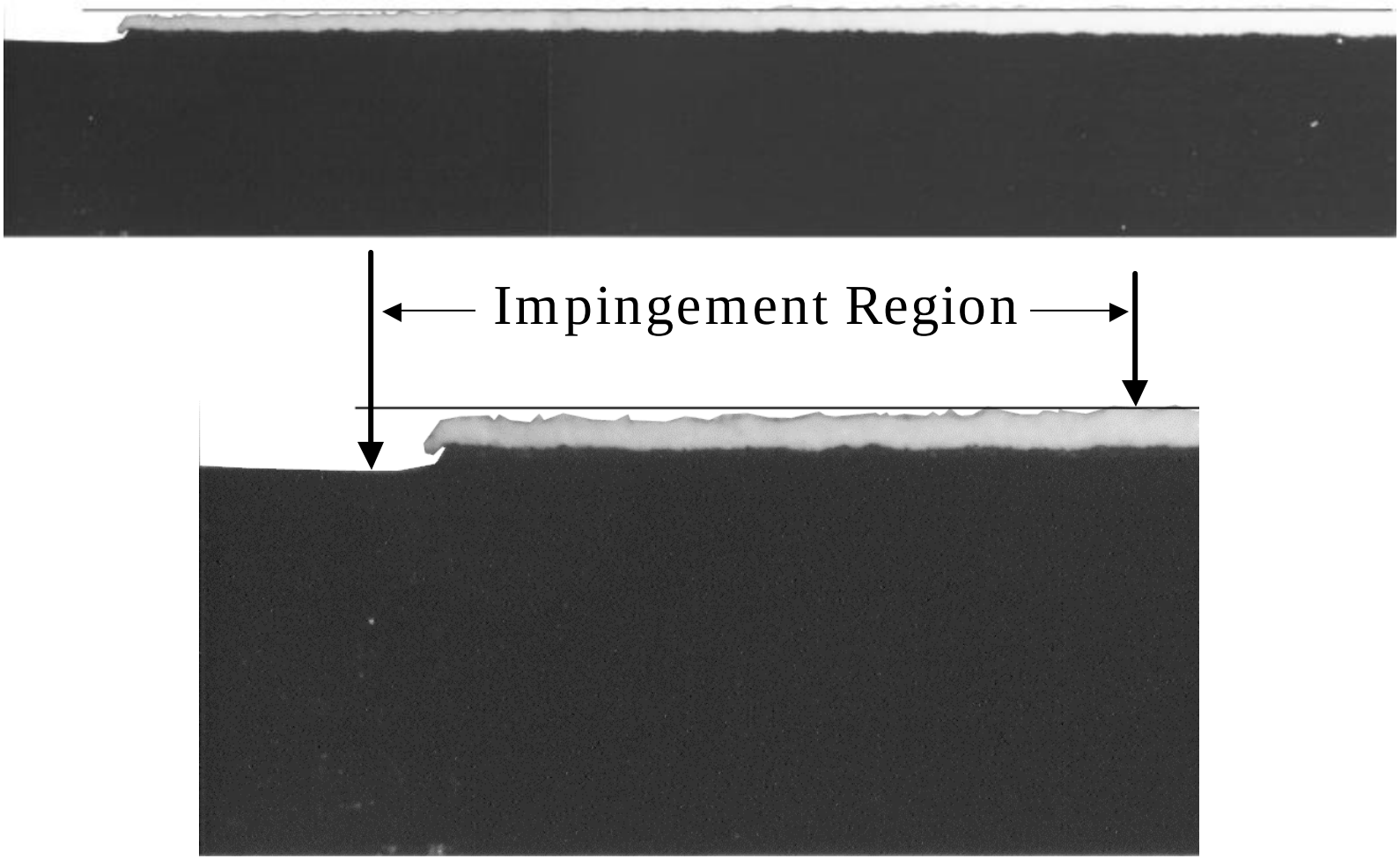
Impingement Region

10 µm

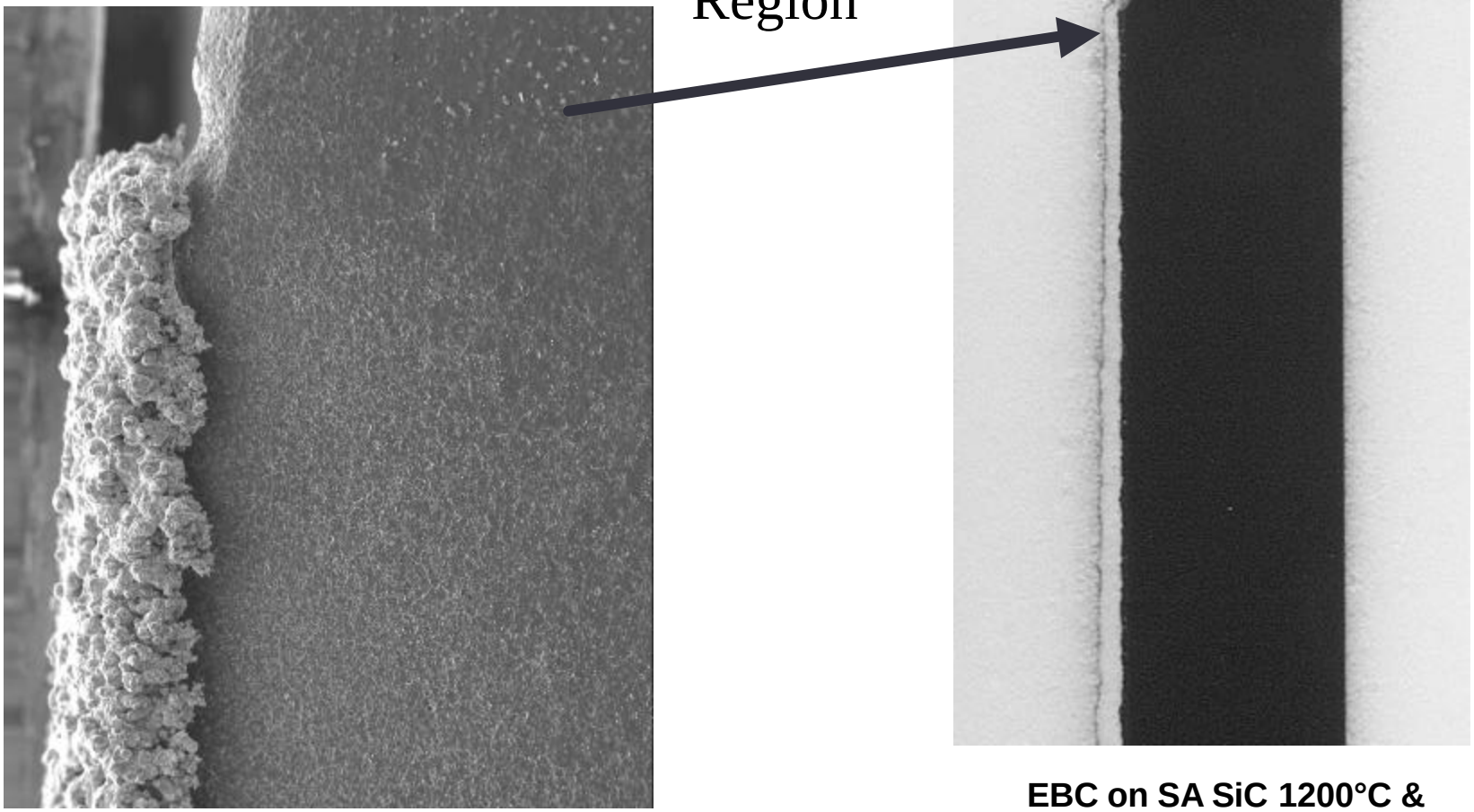


EBC on SA SiC 1200°C & 260 h with Water Vapor

Measurement of EBC Recession is Hindered by Variability in As-Coated Thickness



The Side Surfaces of the SiC Also Experience Recession



**EBC on SA SiC 1200°C &
260 h with Water Vapor**

Summary

- **EBCs may be Required to Insure Reliability for Microtubine Components**
- **The Deposition of the EBC may Adversely Affect the Mechanical Behavior**
  - Micro and Macro-Mechanical Testing Coupled with Microstructural Characterization is being used to Evaluate Changes in Mechanical Performance
- **The Steam Injection System Developed Shows Promise for the Study of Several Key Characteristics of EBC/SN Systems**
  - Recession Behavior of Uncoated Ceramics
  - Effectiveness of the EBC as a Barrier to Water Vapor (Simple Flexure Bars)
  - Impact of EBC on Mechanical Performance of the Silicon Nitride (Focus on Creep and Stress Rupture)