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## Introduction

Thermal barrier coatings (TBCs) are multi-layered systems used on high temperature engines to increase durability and extend the operational capabilities of turbine blades [9]. During high temperature cycling, thermal expansion mismatch between each of the layers leads to the development of residual stresses within the coating layers.



The importance of *in-situ*, in-cycle, mechanical responses of TBCs investigated under conditions using thermal gradients and mechanical fatigue loading is that it can provide an understanding of how these coatings behave under realistic engine conditions.

## Objective

- To show in-situ stress and strain measurements of a pre-aged tubular and internally cooled TBC system using X-ray diffraction
- To show the thermal mechanical integration in-between the TBC material layers during high temperature



# Inelastic Response and Impact of Internal Cooling on Thermal **Barrier Coatings via Synchrotron Study**

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#### **Experimental Setup A)** 3-NiAl (111) Cool Air t'YSZ (20 3-NiAl (110) t'YSZ (111) Yttria Stabilized Zirconia (YSZ) Top Coa 240 µm EB-PVD Coating ι-Al<sub>2</sub>0<sub>3</sub> Oxide Layer (TGO) -Coated estimated 1.5 μm Thickness NiCoCrAlY Bond Coat 80 μm EB-PVD Coating scanned Substrate IN 100 Dutside Diameter = 8 mm nside Diameter = 4 mm ε<sub>22</sub> X-ray Beam ε<sub>11</sub> Hot Air The experiment was conducted at the Advanced Photon Source at Argonne National Laboratory **Representative Flight Cycle Coating Temperature Inner Substrate Temperature**





• The YSZ and TGO gradually bear less of the applied load as temperature increases

• This highlights the existence of inelastic behavior (plasticity and/or

### **Future Work**

In the future, we will continue to conduct analysis to study the inelastic behavior seen in the materials and start the the mechanical loading analysis on During experiment. the summer, will conducted on experiments be damaged samples at the Advanced Photon Source at Argonne National Laboratory. Use of a larger heater and rotational stage will allow for higher temperatures and the capability to capture 3-D measurements.

**Loading Conditions** 





**Example of a Damaged Sample** 

Schematic of Mechanical Load Isolation Experiment

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