Title Slide

- **High Performance Valve Materials (HPVM) (Agreement 16304)**
  - Philip J. Maziasz – (PI and Presenter) ORNL, and Nate Phillips (PI) Caterpillar, and Neal D. Evans, University of Tennessee, Knoxville
  - Oak Ridge National Laboratory, Oak Ridge, TN
  - Thursday, May 21, 2009, evening poster session

"This presentation does not contain any proprietary or confidential information"

Project ID: pmp_12_maziasz

Overview

Timeline

- Project began Oct., 2007
- Project ends in Dec., 2009
- Project is about 70%, but is being extended for 12 mo because of technical success

Budget

- Total Project Funding - $950,000
  - DOE - $475,000
  - Caterpillar - $475,000
- DOE - $225,000 in FY2008 and $102,675 in FY2009

Barriers

- Technical Barriers Addressed:
  - Higher fuel efficiency demands valve/seat wear resistance to maintain combustion efficiency
  - Higher fuel efficiency demands higher temperatures for exhaust valves and seats
  - Higher temperatures dramatically reduce component performance and durability

Partners

- ORNL, Caterpillar, and Caterpillar valve and seat supplier
- Technical lead - Caterpillar

Objectives

- This ongoing ORNL/Caterpillar CRADA project (NFE-07-00995) is defined to research innovative valve designs and advanced alloys, to rapidly and efficiently enable production of prototype valves with upgraded capability for valve rig and engine testing
- This CRADA began in Sept., 2007 and is set to end in December, 2009, but is currently being extended to December, 2010, because more work needed to support the initial technical successes.

Milestones

- **FY2008** – New CRADA Project, no milestones except to initiate characterization to better define effects of temperature on exhaust valve/seat wear
- **FY2009** – Perform the initial microanalysis of modified exhaust valves and/or seats after simulation-rig testing to evaluate wear-reduction (Dec., 2008) – Status: delayed until June, 2009 due to Caterpillar simulation rigs being unavailable during facilities upgrade/expansion (from 1 to 3 new test rigs). In progress. Initial rig testing showed that modified processing to seats dramatically reduced low temperature wear, and longer-term and expanded testing to validate “success” is now in progress.

Barriers – DOE/EERE/OVT

- This CRADA project is focused on developing valve/seat insert designs for operating at the higher diesel engine temperatures necessary to achieve the program goals of higher fuel efficiency and lower emissions.
- Higher engine temperatures are causing exhaust valve and seat wear to become unacceptable. Higher temperatures also reduce component durability.

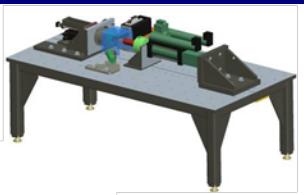
Approach

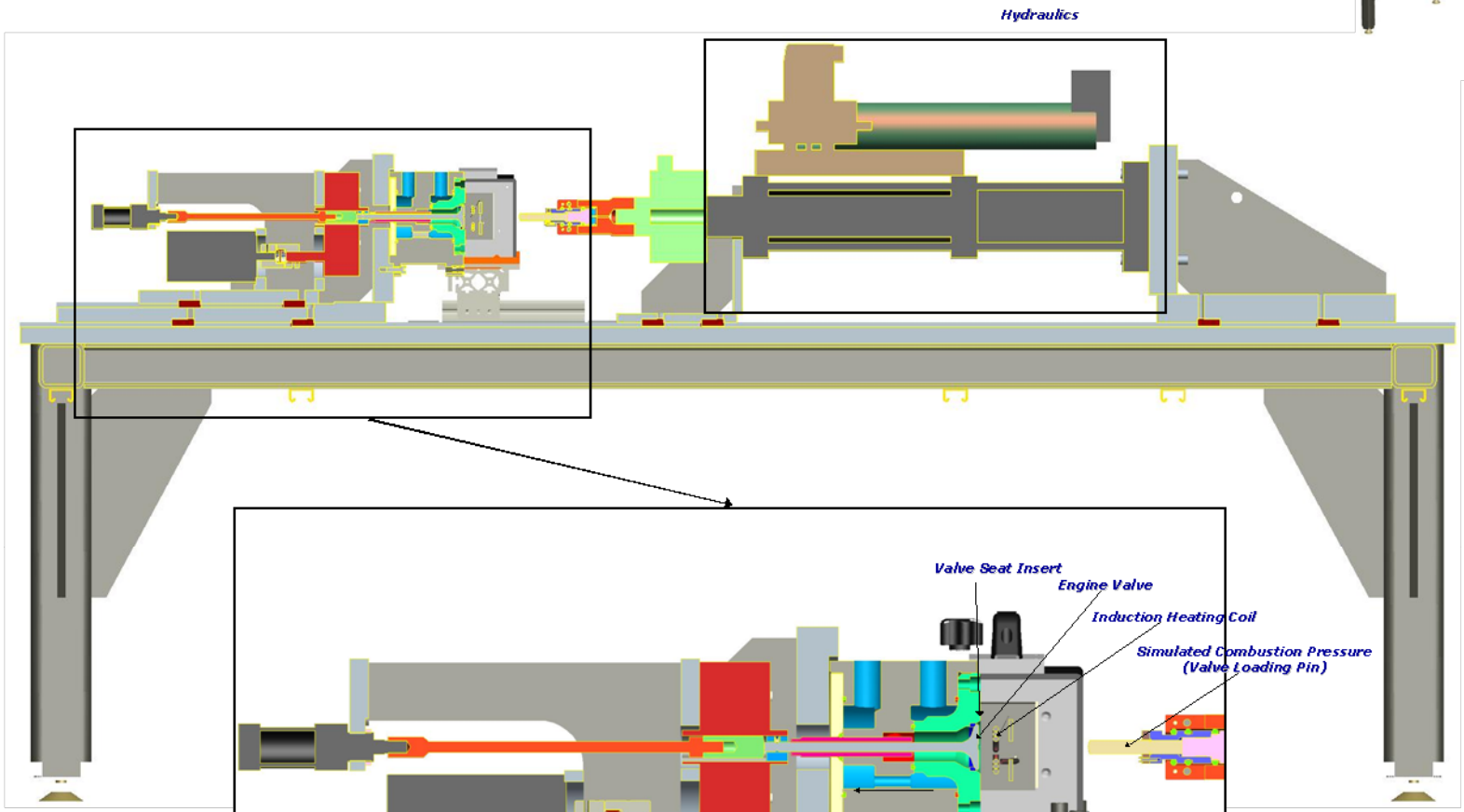
- Caterpillar has assembled a team that includes the engine business units, and the commercial exhaust valve and seat suppliers, and ORNL
- Caterpillar has defined the valve-seat wear issue by analyzing and comparing engine-tested and wear-rig simulation tested components
- ORNL has added more in-depth microanalysis and materials behavior/mechanism analysis, to completely define the problem and to help the team select and test the first several solution options

Approach – Analyze Components on CAT Valve Rig (U.S. Patent 6,647,770)

2009 DOE Merit Review Guidelines

Thermo-Mechanical Valve & Seat Insert Test Rig

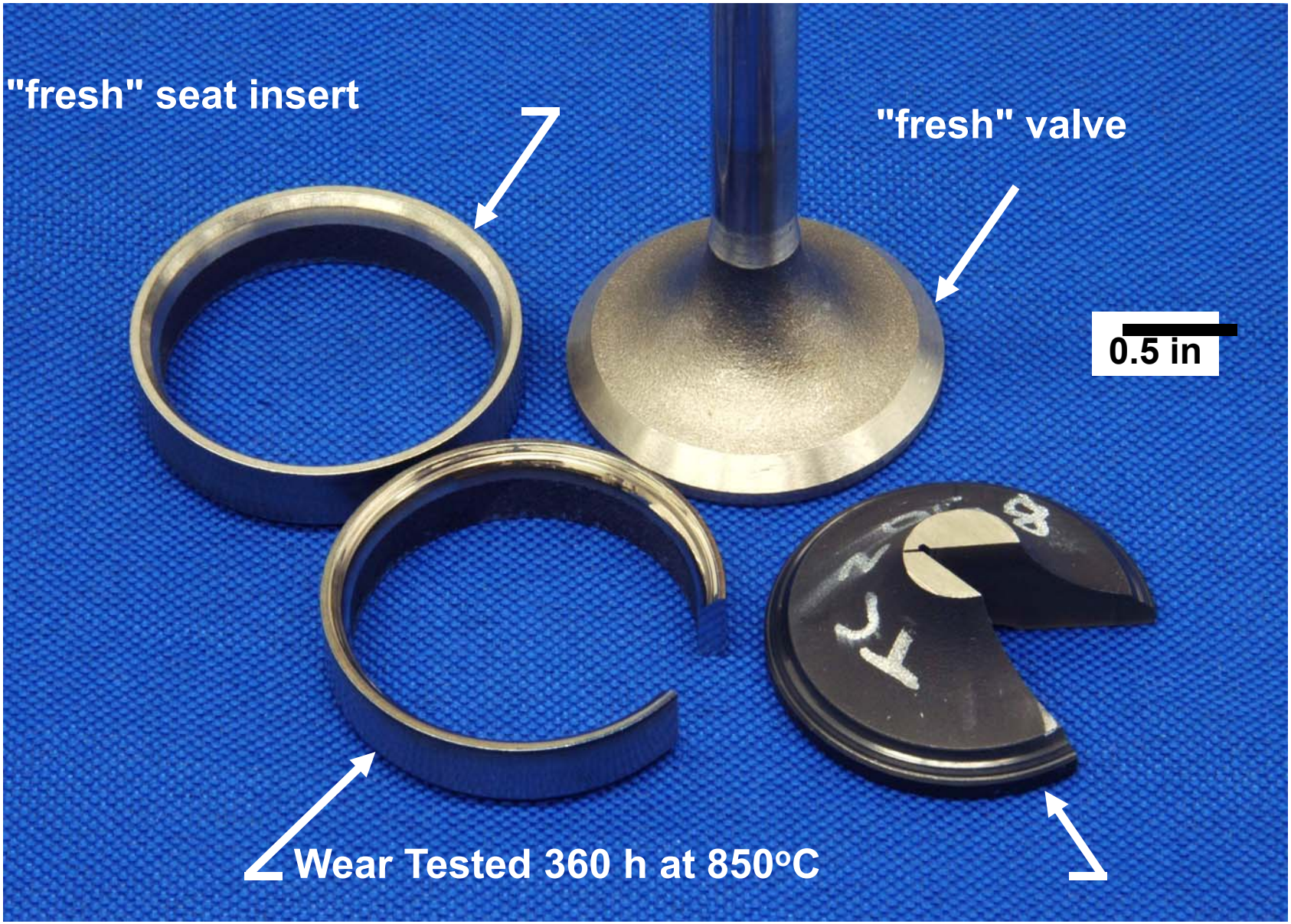




- *Simulated engine operating range – 900 RPM to 1800 RPM*
- *Precise induction heating system and closed loop cooling system*
- *Software capabilities to replicate valve displacement profiles with valve rotation*

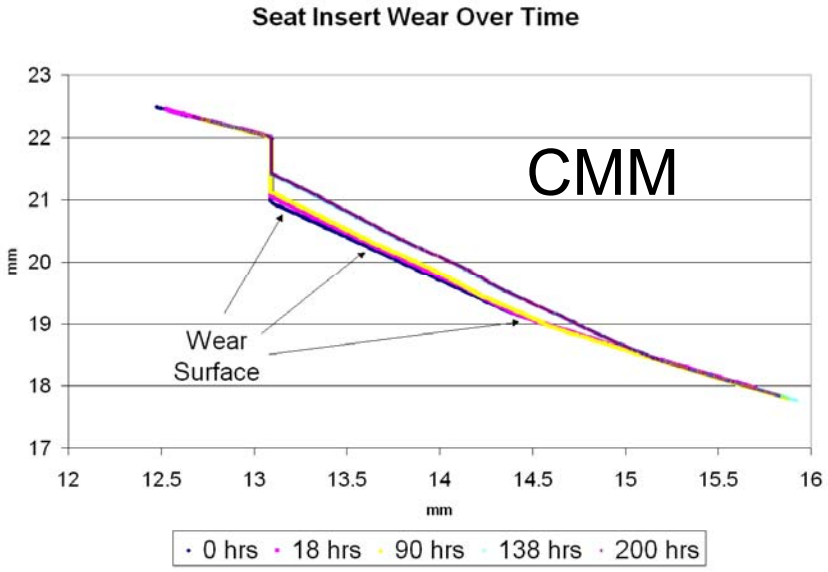
- *Engine oil lubrication*
- *Can measure valve and seat wear on test without disassembly*
- *Both static and dynamic testing capabilities*

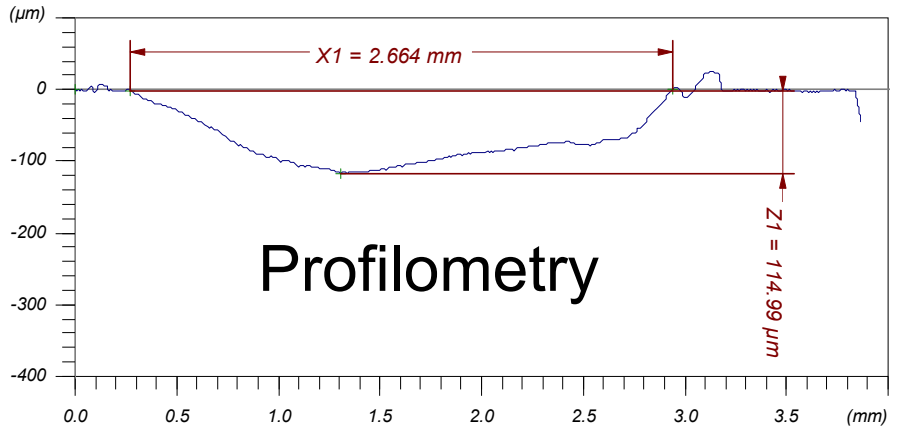
Approach - Valves and Seat Inserts In Both New and Tested Conditions Have Been Examined

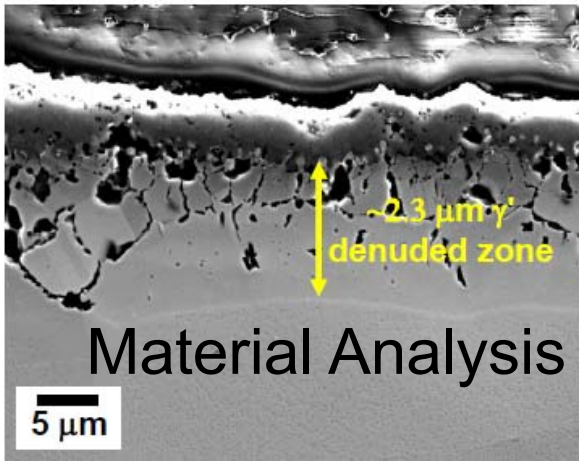


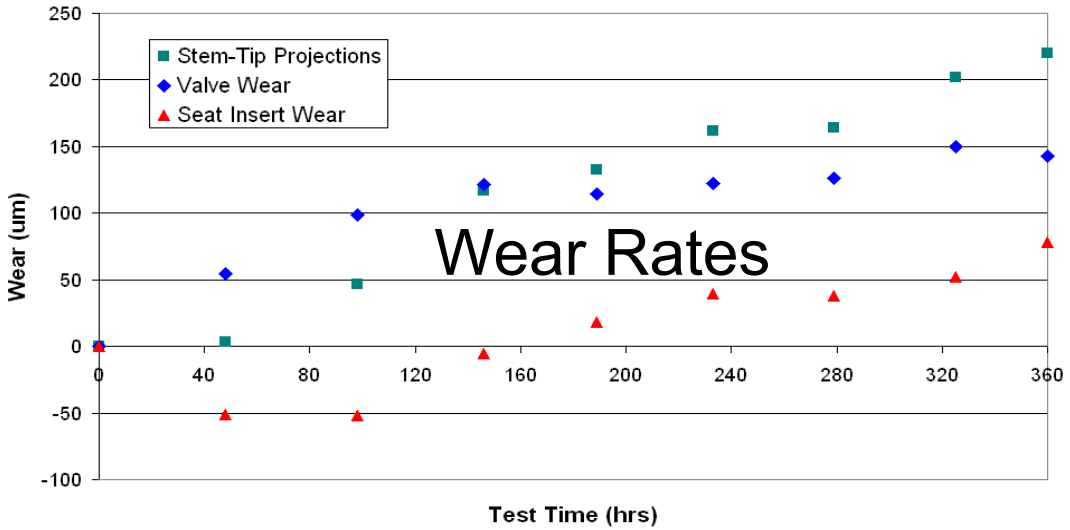
Valve and Seat Insert Wear Study

Example Analysis Capabilities

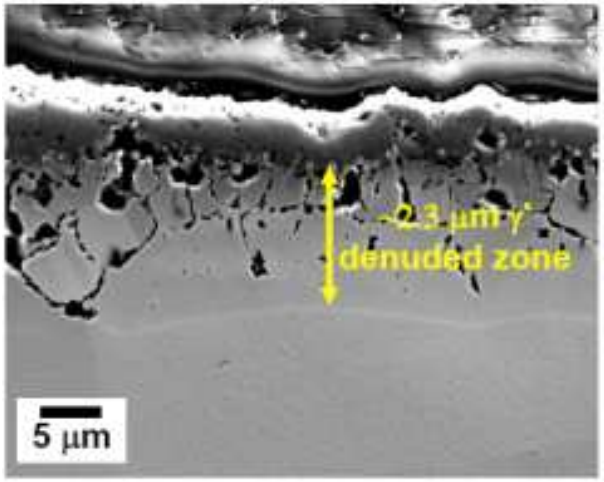




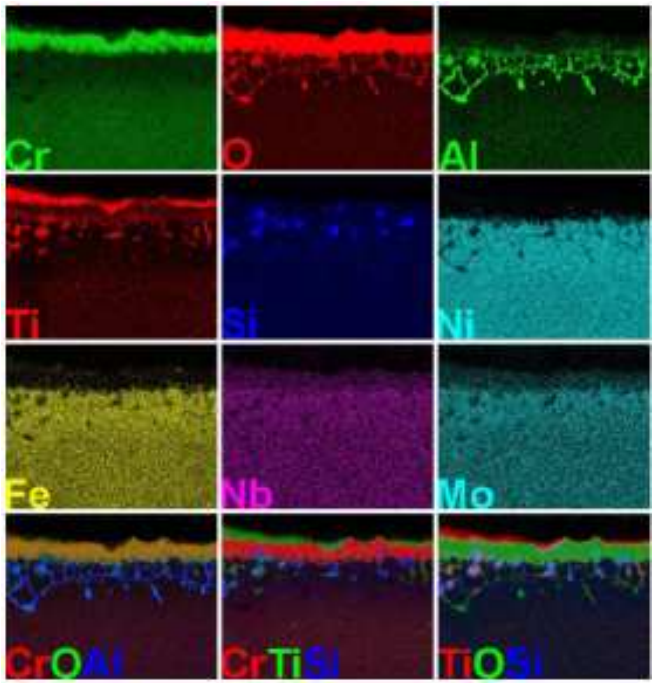


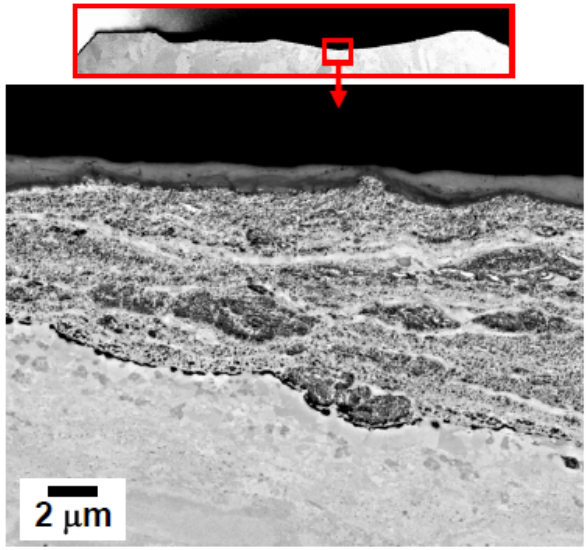


Technical Progress – Valve Wear (ORNL)



Ni-Superalloy, Exhaust Valve, 360hr, 850°C Valve Rig-Tested, Unworn Surface





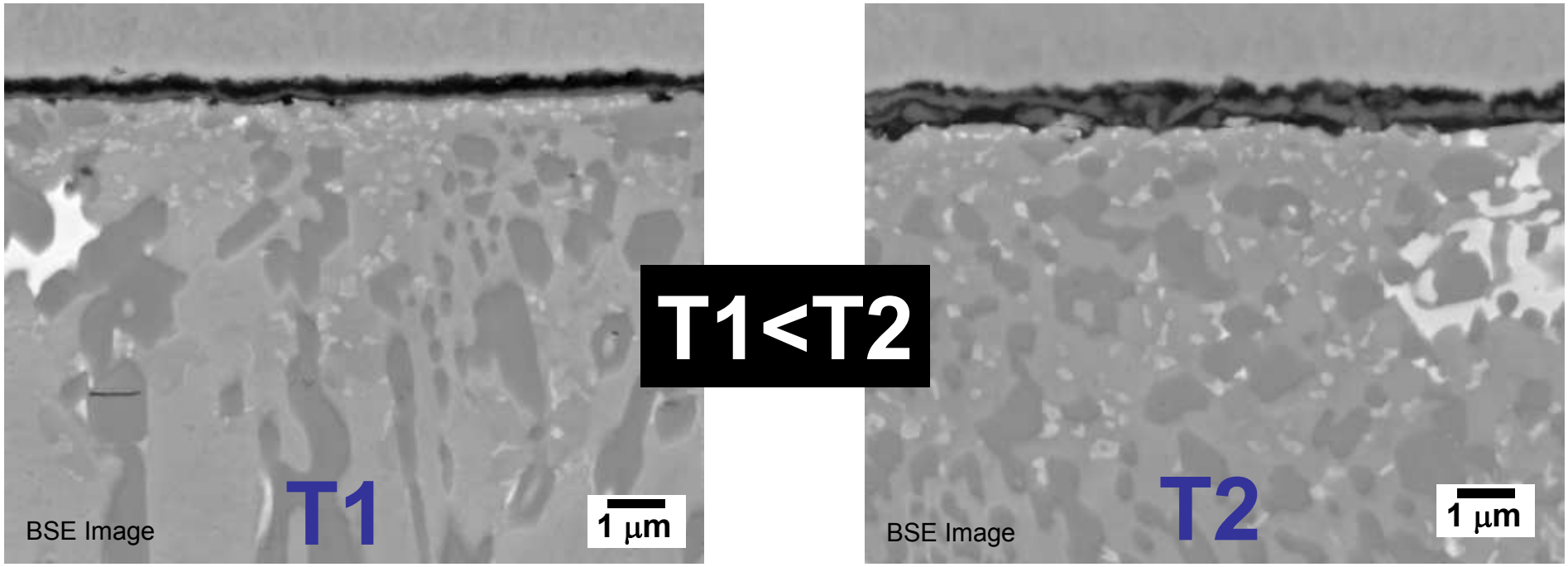
Seating Interface

- Newly discovered high-temp phenomenon that causes the valve to wear @ accelerate rates
- "Soft zone" forms at and beneath the surface
- "Soft zone" gets gradually deeper as temperature increases
- Same phenomenon has been identified on engine-tested valves, validating "root cause" assessment made from rig-tested valves

Technical Progress – Seat Insert Wear (ORNL and CAT)

- Beneficial solid state lubrication forms as a complex oxide along the surface of the seat insert during engine operation

- Studies have been performed, with the help of the supplier, to determine chemical nature and morphology of the oxide layer.



Technology Transfer/Application

- Caterpillar valve seat insert supplier has tested and accepted a new concept to mitigate wear, and is producing seats for more thorough Caterpillar testing. "Instant Success" was achieved by understanding the wear mechanism on real parts, and then making a rapid transition to commercial implementation.
- Caterpillar valve manufacturer has accepted analysis and failure mechanism on "standard" Ni-based superalloys used for valves. Several alternative alloys with potential for overcoming these temperature/wear limitations have been identified are being supplied for ORNL and Caterpillar for further testing.

Activities for FY2009/FY2010

- The next steps are to rig test the redesigned seat inserts for 500 – 1000 hrs (CAT)
- Test thermal and mechanical properties of some candidate seat-valve upgrade alloys (ORNL)
- Rig test seat-valve upgrade alloys (CAT)
- Testing and Characterization of upgraded alloys will quantify improvements and enable further alloy modifications based on mechanistic understanding (CAT, ORNL)