

Coating Evaluation & Performance: New Annex?



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07 May 2006
IEA Executive Committee Meeting
Calgary, Alberta
Canada



Research sponsored by the U.S. Department of Energy, Office of Transportation Technologies, as part of the Heavy Vehicle Propulsion System Materials Program, under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

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Outline

- **First proposed - October 2005 in Porto, Portugal**
- **Examples of coating evaluation and performance of interest at ORNL**
- **Should we proceed? How? Who to lead?**

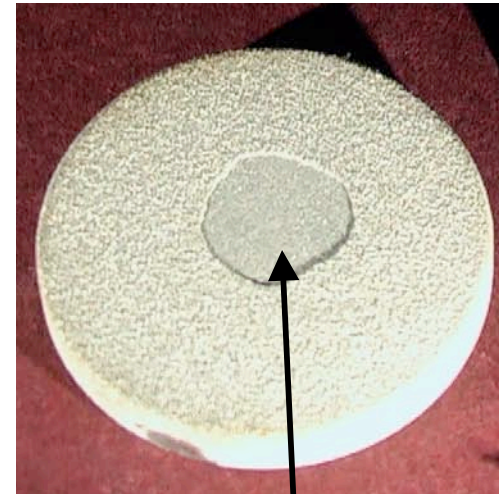
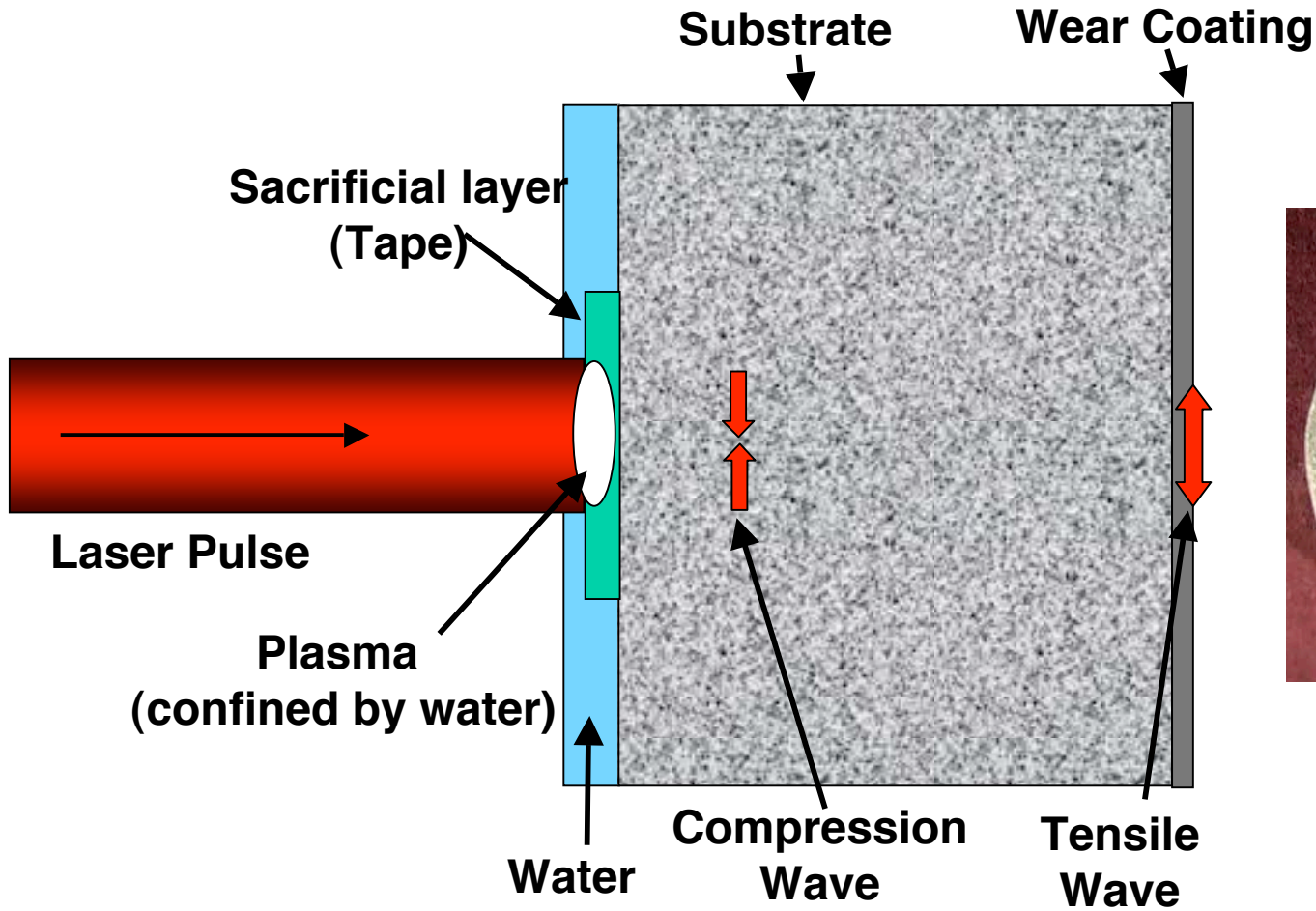
From October 2006 IA-AMT ExCo Meeting in Porto, Portugal

- **Concept for coating project discussed at ExCo meeting**
- **Several attendees voiced support**
- **“Coating Evaluation and Performance” was of interest**
 - **Cross-cuts many applications**
 - **Basic properties - e.g., elastic properties, adhesion, etc.**
- **Discussion at today’s ExCo meeting to be used to help guide possible path forward**

Examples of Characterization Methods at ORNL of Interest for Use for Coating Evaluation & Performance

- **Adhesion strength measurement using laser shock spallation**
 - Effective way to produce tensile-stress-induced spall
 - Shock physics modeling needed to interpret results
- **Adhesion strength from scratch testing**
 - Equipment is relatively simple
 - Analysis needed to interpret results
- **Large ball-on-ring deflection**
 - Good for strain-to-failures or adhesion strains greater than $\sim 0.5\%$
 - Combine with piezoRaman and optical fluorescence

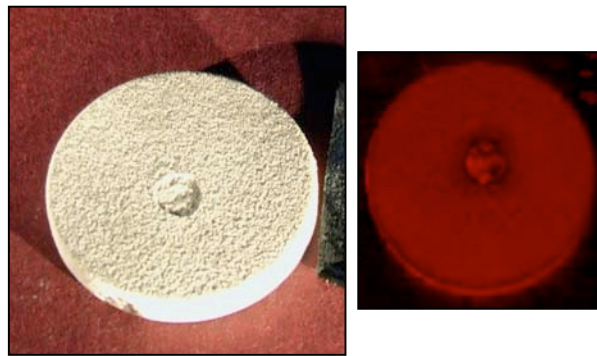
Laser Shock Principle



Spalled Coating

Laser Shock can Generate Controlled Failures in Both Ceramic and Metallic Coatings

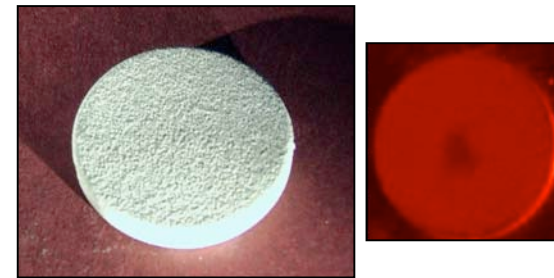
Complete spall



Optical

Infrared

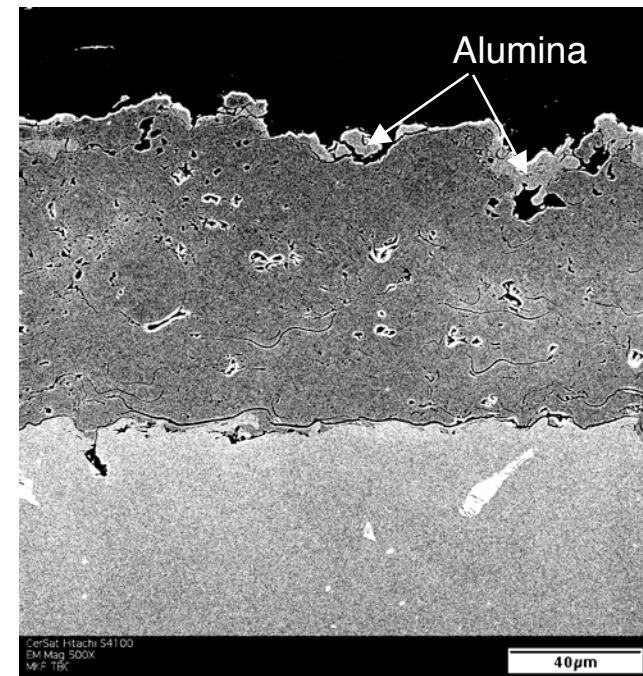
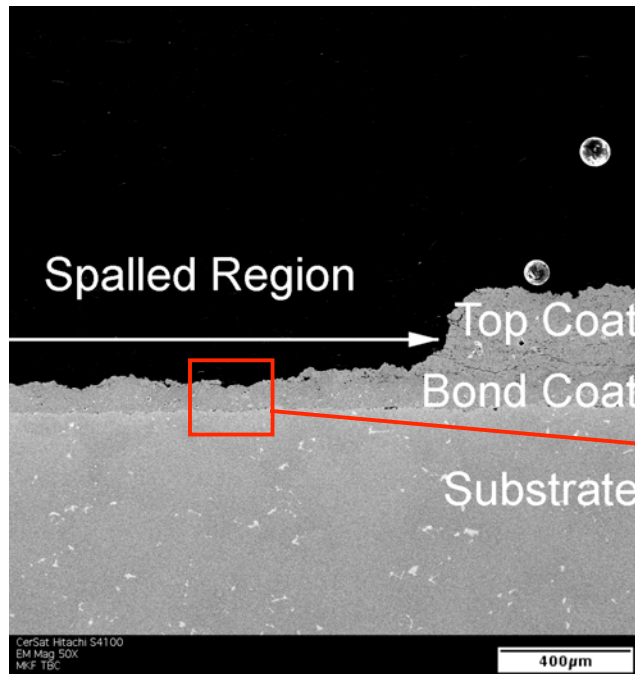
Partial spall



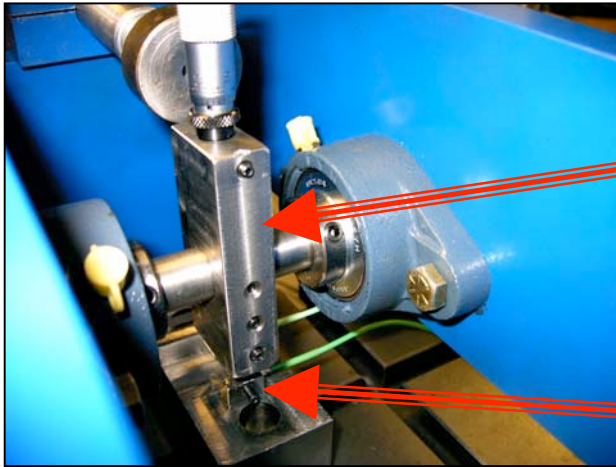
Optical

Infrared

The Primary Crack at the Highest Power Density Formed at the Top Coat / Bond Coat Interface

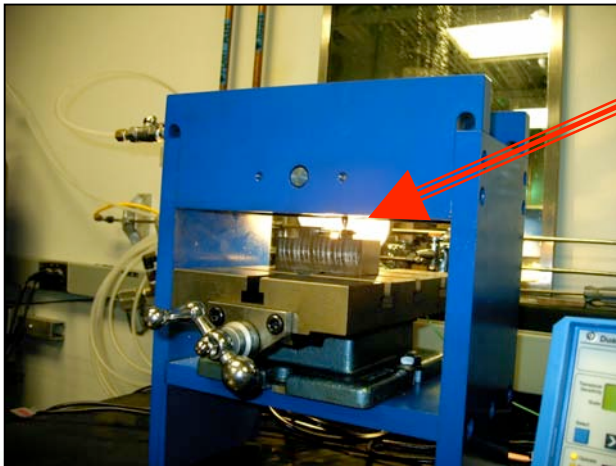


Instrumented (Pendulum) Scratch Testing Has Promise for Coating Adhesion Testing

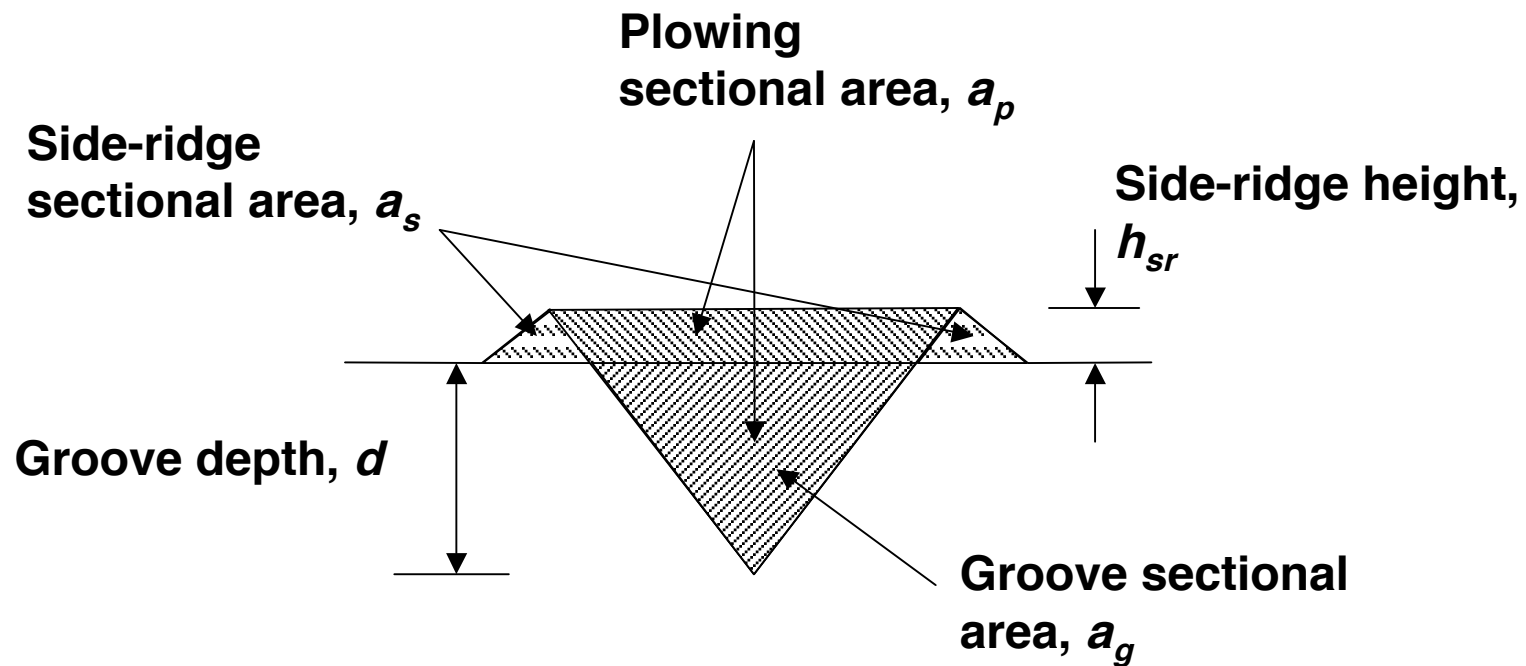


The pendulum is driven by a piston to generate the rotation of tool in the vertical plane.

A conical tool, attached to the end of the pendulum, scratches the specimen when the pendulum rotates.



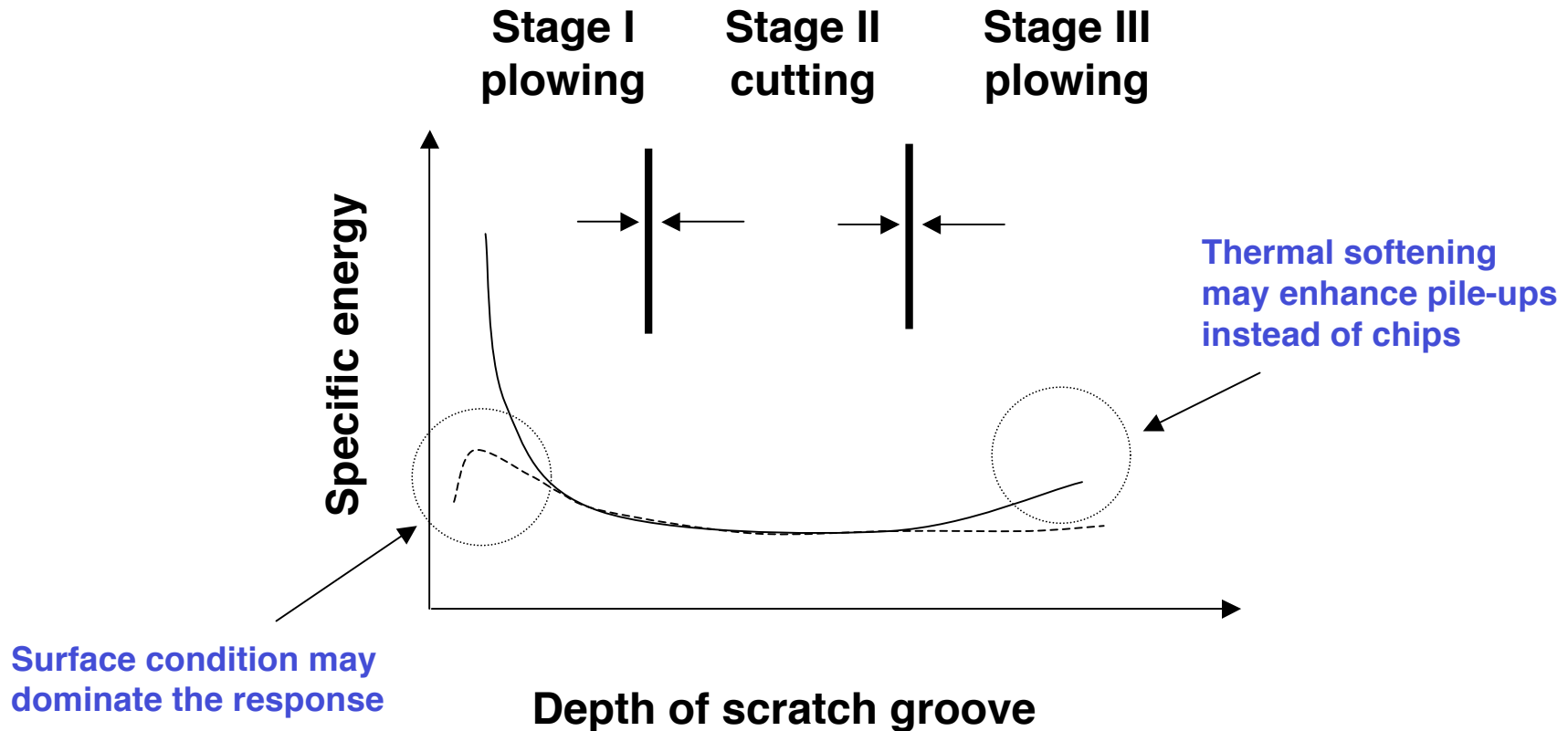
Characterization of the Sectioned Scratch Provides a Lot of Information



Removed sectional area, $a_r = a_g - a_s$

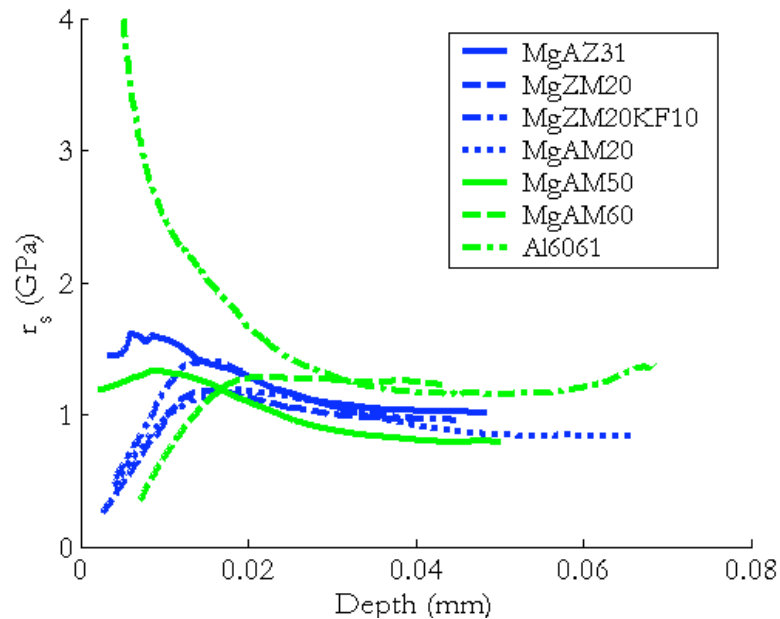
Wear rate = a_r / a_g

Three-Stage Response of Scratch Deformation Could Be Used to Assess Adhesion Strength

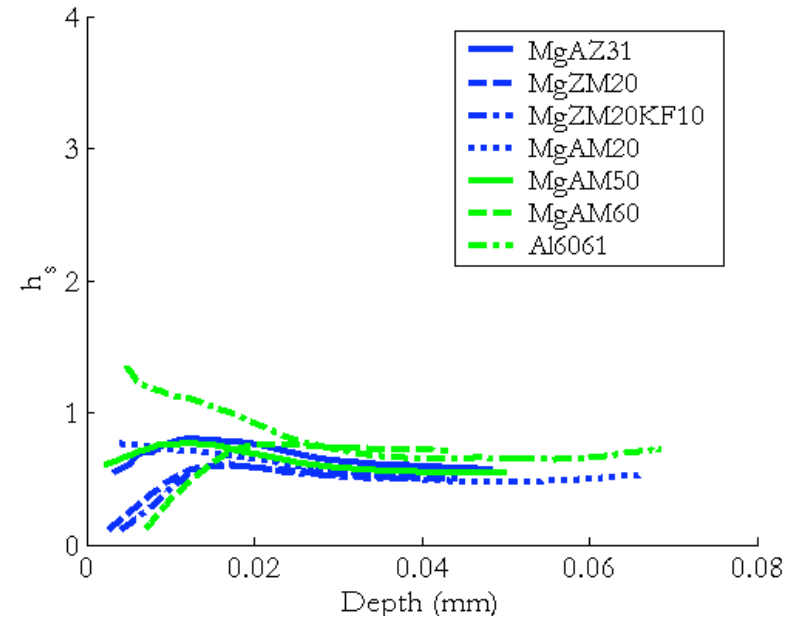


Scratch Analyses That Could Be Used with Coatings Adhesion Strength Testing

Scratch Resistance



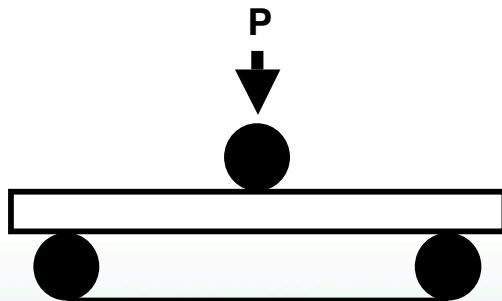
Scratch Hardness



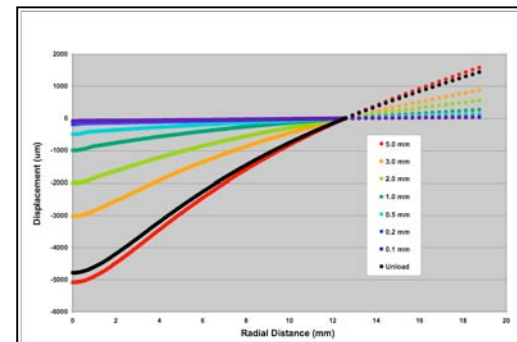
Test results of Mg alloys

Ball-on-Ring Testing is an Effective Method to Measure Coating Adherence and Lends Itself to High Temperature Testing

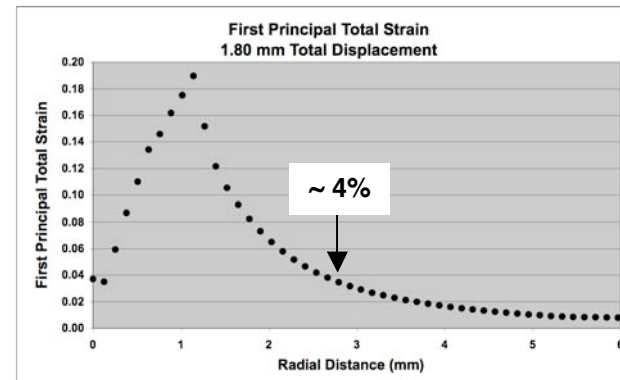
Examples of Tested Coupons



FEA is Used to Estimate Local Curvature and Strain to Failure



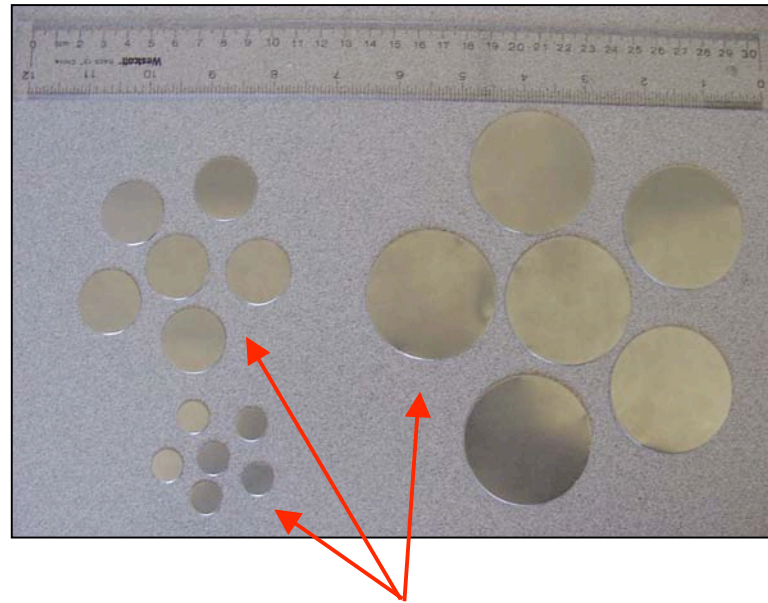
Variables:
Thickness
Ball ϕ
Ring ϕ



Axisymmetric Model: Deflection and 1st-P strain profiles on contact surface shown

Optical Fluorescence Will Measure Surface Strains from Large Deflections of Metal Coupons

Oxidized MCrAlY Will Be Used to Verify Stress State



Disks will be oxidized, then permanently deformed with ball-on-ring testing, and stresses then measured.

Optical Fluorescence Was Successful at Validating Strains From Small Deflections

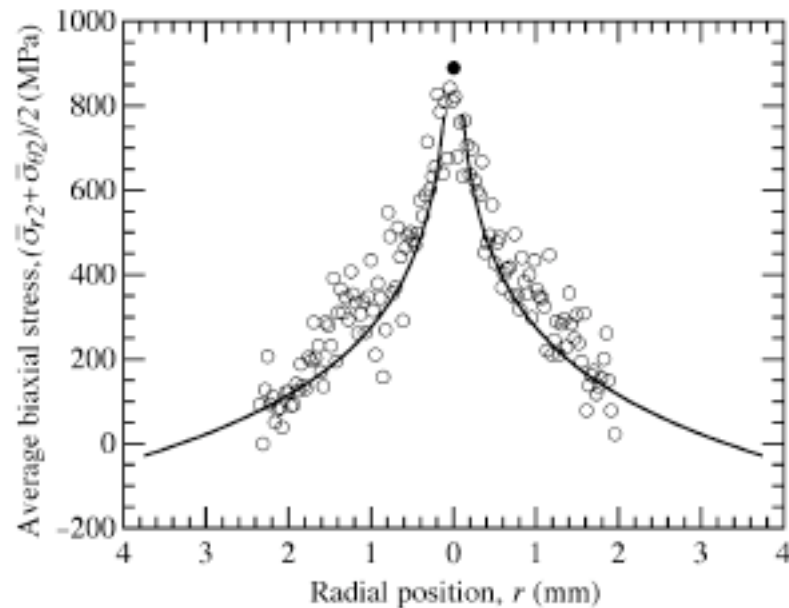


Fig.2. The calculated and measured average biaxial stresses, $(\bar{\sigma}_{r2} + \bar{\sigma}_{\theta2})/2$, through Al_2O_3 layer thickness as functions of r for alloy/ Al_2O_3 bilayer disc subjected to ball-on-ring tests.

C. H. Hsueh, M. J. Lance, and M. K. Ferber, "Stress Distributions in Thin Bilayer Discs Subjected to Ball-on-Ring Tests," J. Am. Cer. Soc., 2005.

Suggested International Studies of a Possible New Annex

- **Adhesion strength**
- **Elastic modulus measurement of coating**

Proceed?

Suggestions?

Ideas?