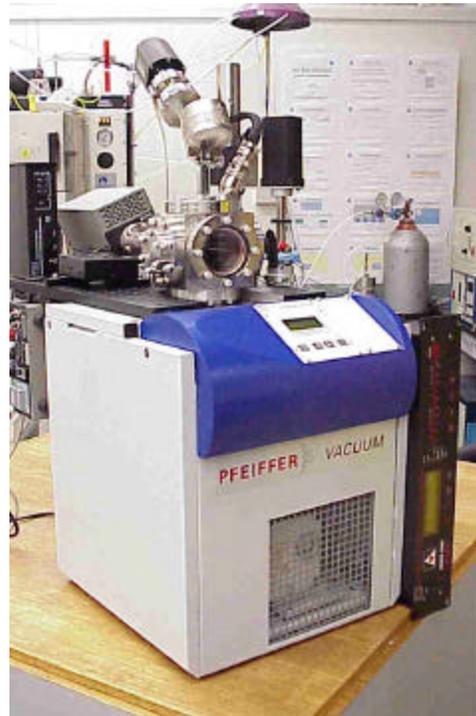
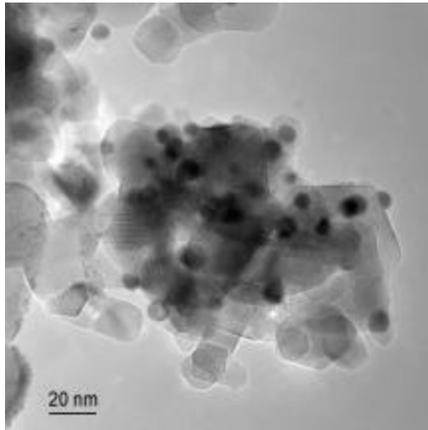


Diesel Engine Research Tools



Roger England

Materials Engineering



April 26th 2002

High Temperature Materials Laboratory

- Technical Expertise
- Collegial Atmosphere.
- World class equipment.

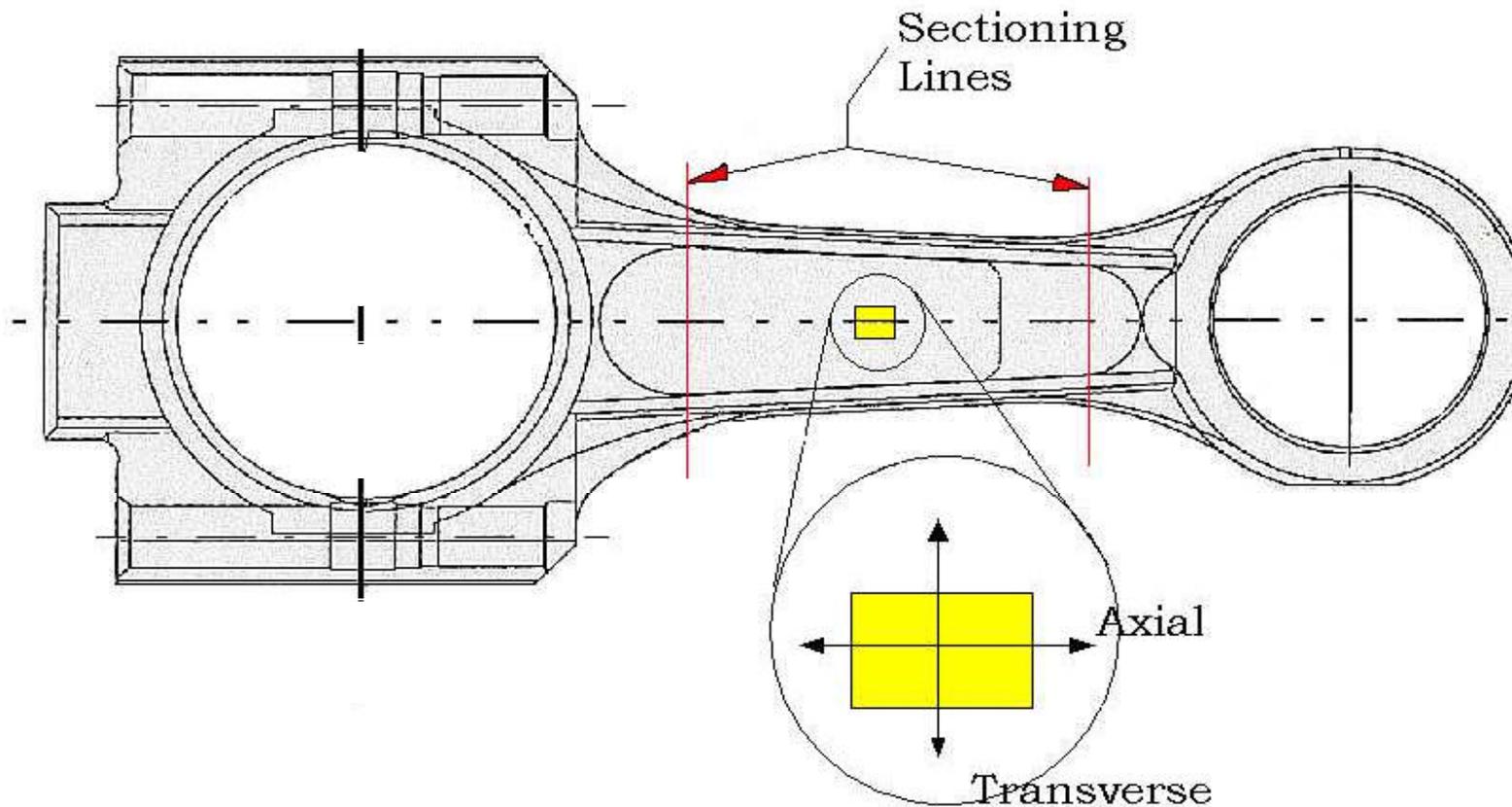


HTML / Cummins projects.

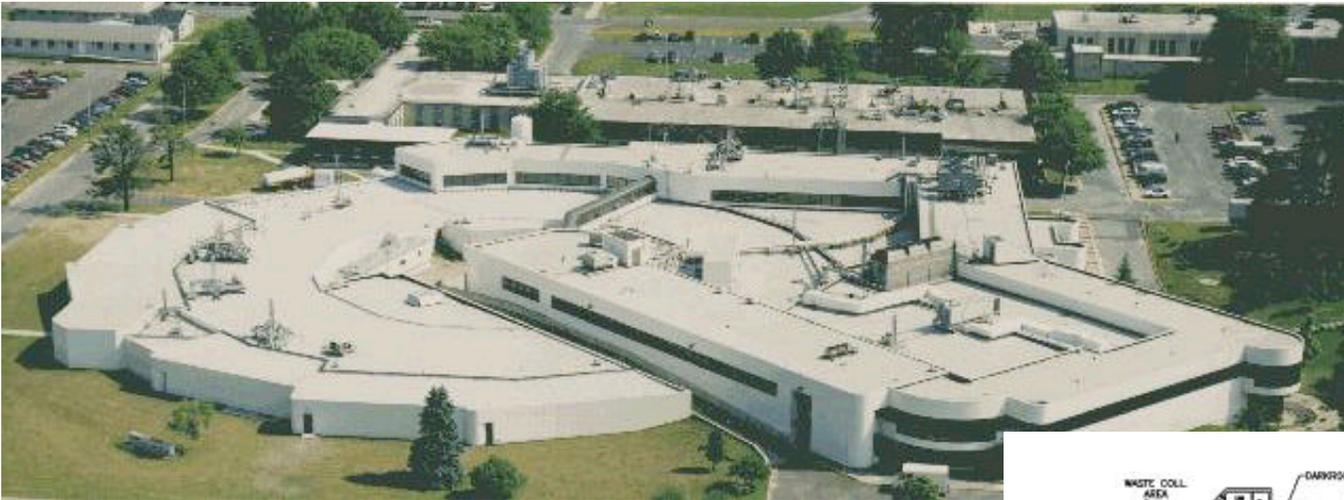
- Connecting Rod Residual Stresses.
 - Neutron.
 - Synchrotron.
- Nitrided Fuel System Component Fatigue Life Predictions.
 - Modeling.
 - Nanoindenter.
 - GIXD.
- Catalysts.



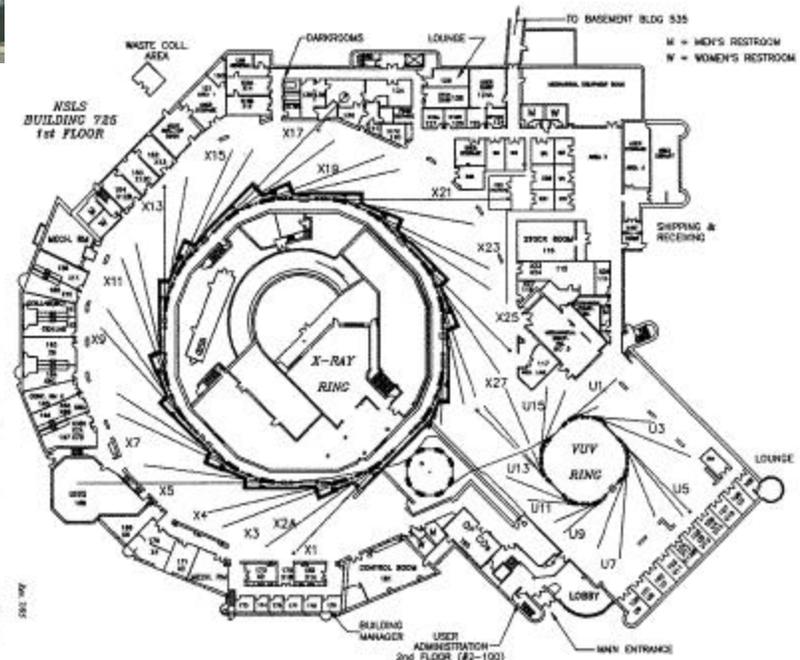
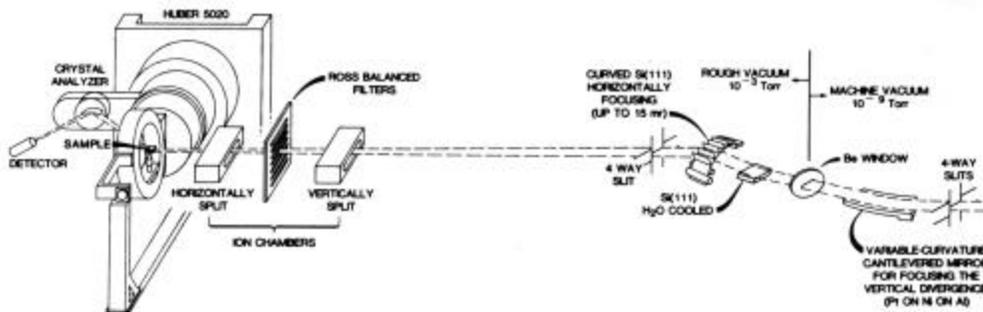
Residual stress measurement versus depth was indirect relying on an etch layer removal to gain access to the interior.

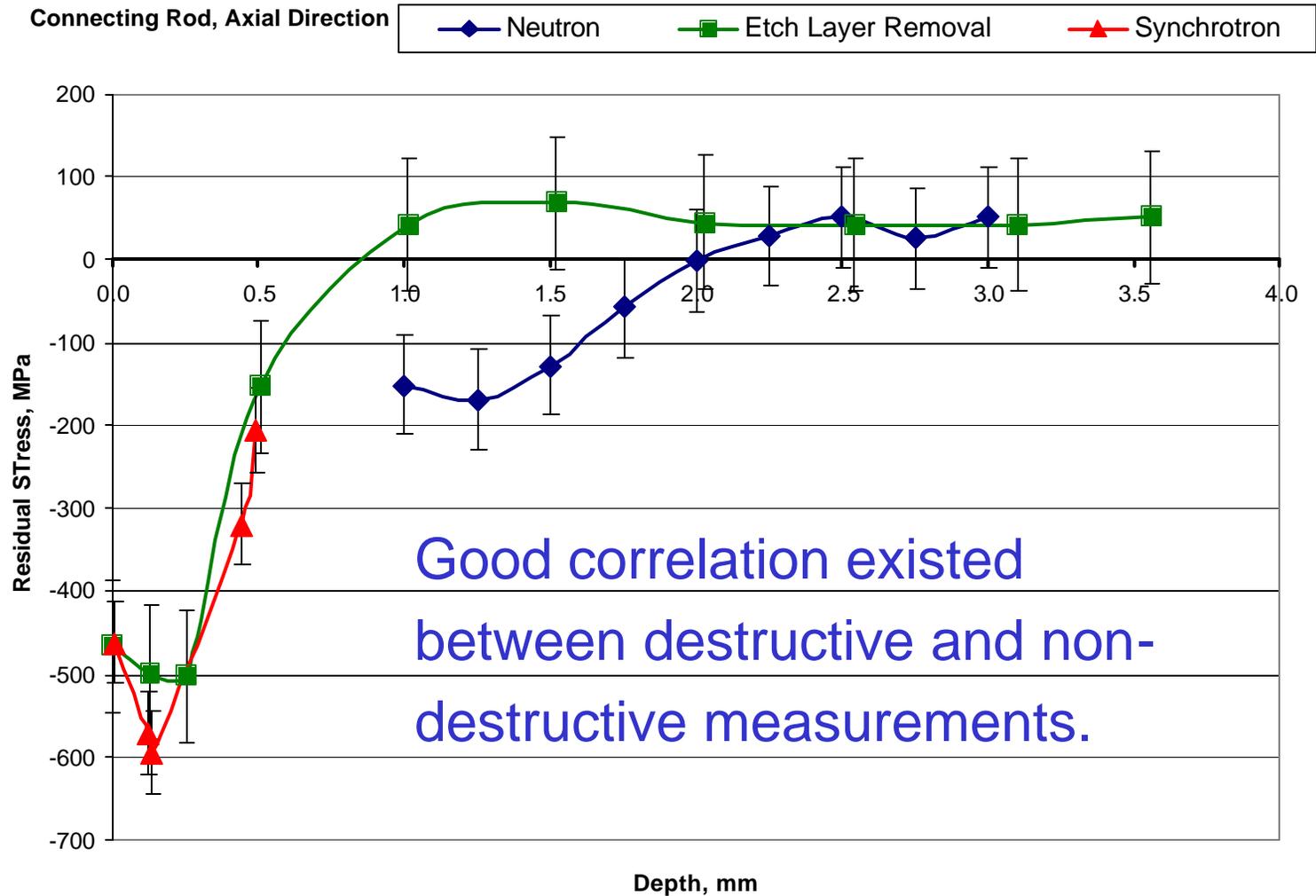


Diesel Engine Research Tools



X14A Synchrotron beamline utilized for near surface stress measurements.





What did we learn?

- HTML provided synchrotron and neutron facilities and expertise to allow improved understanding of residual stresses.
- The indirect etch layer removal method of measuring residual stresses was verified and the errors calculated.



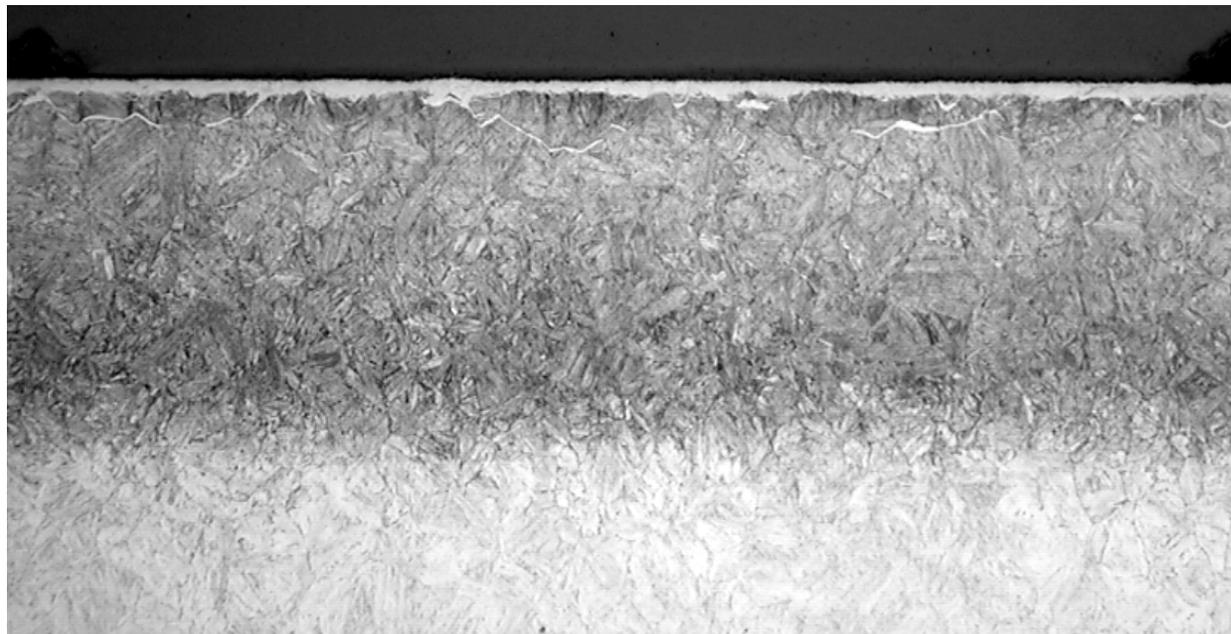
The effect of the nitride white layer on fatigue life and residual stress profile was controversial.

- Approach
 - Measure bulk elastic properties with the nanoindenter.
 - X-ray elastic constants derived by X-ray diffraction.
 - Nitrogen content via microprobe.
- Results
 - Residual stress determined.



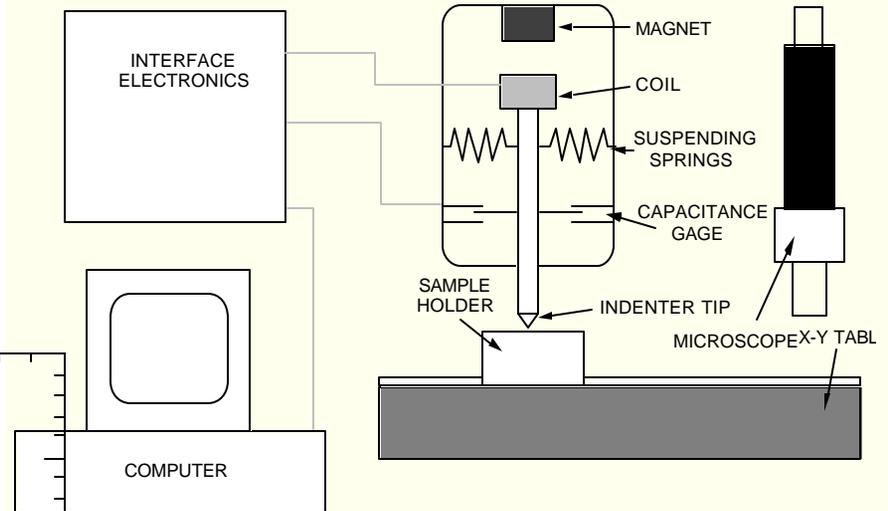
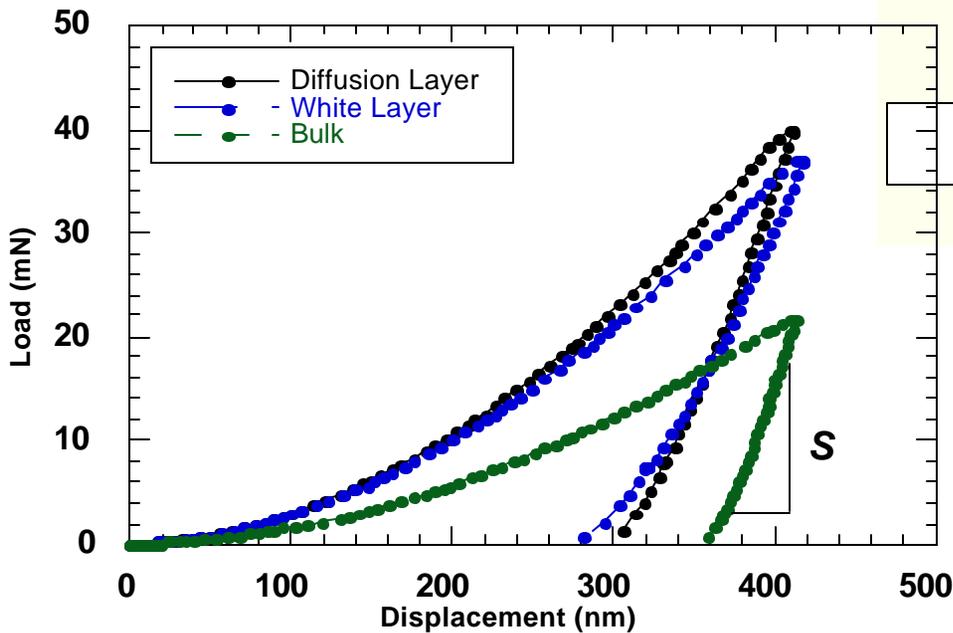
Nitrided Martensitic Microstructure

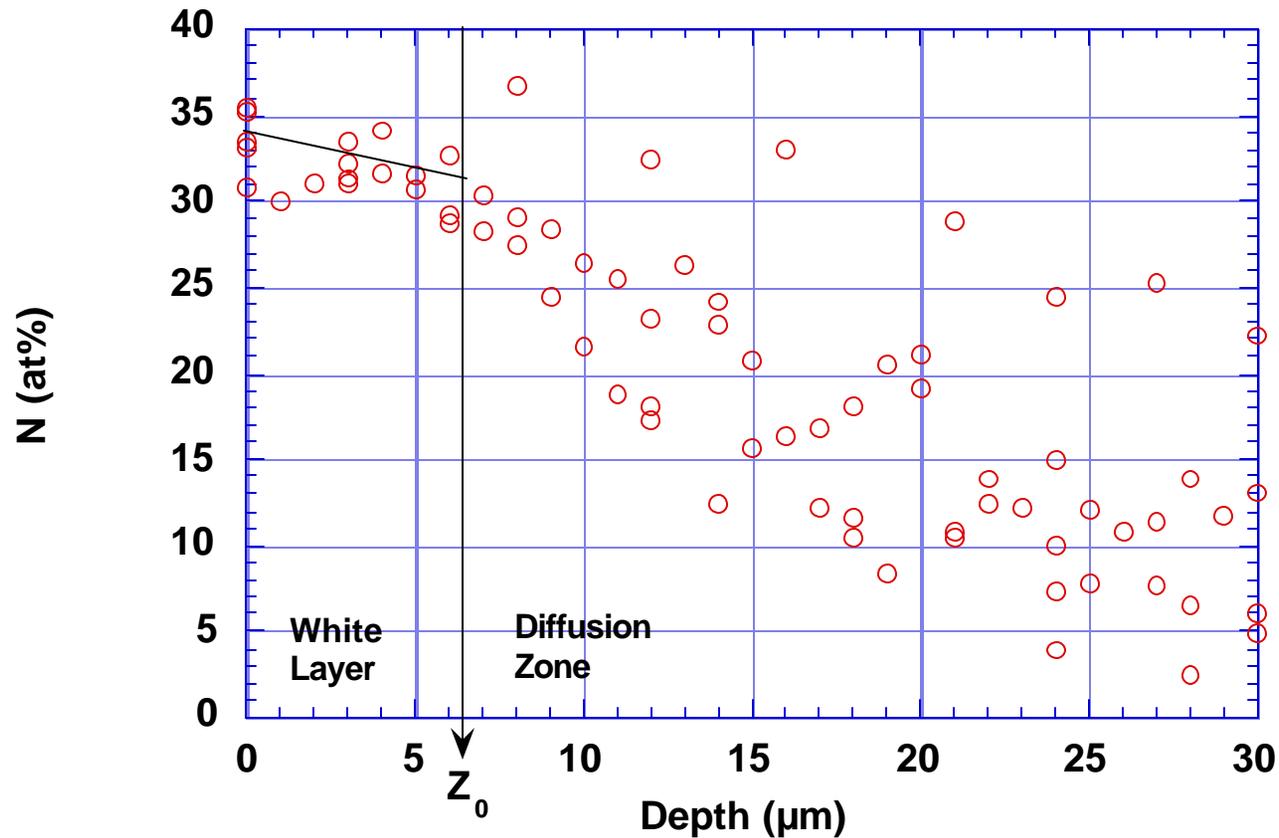
0.2%C martensitic steel



- ← white layer
~10 mm
- ← diffusion zone
~280 mm
- ← substrate

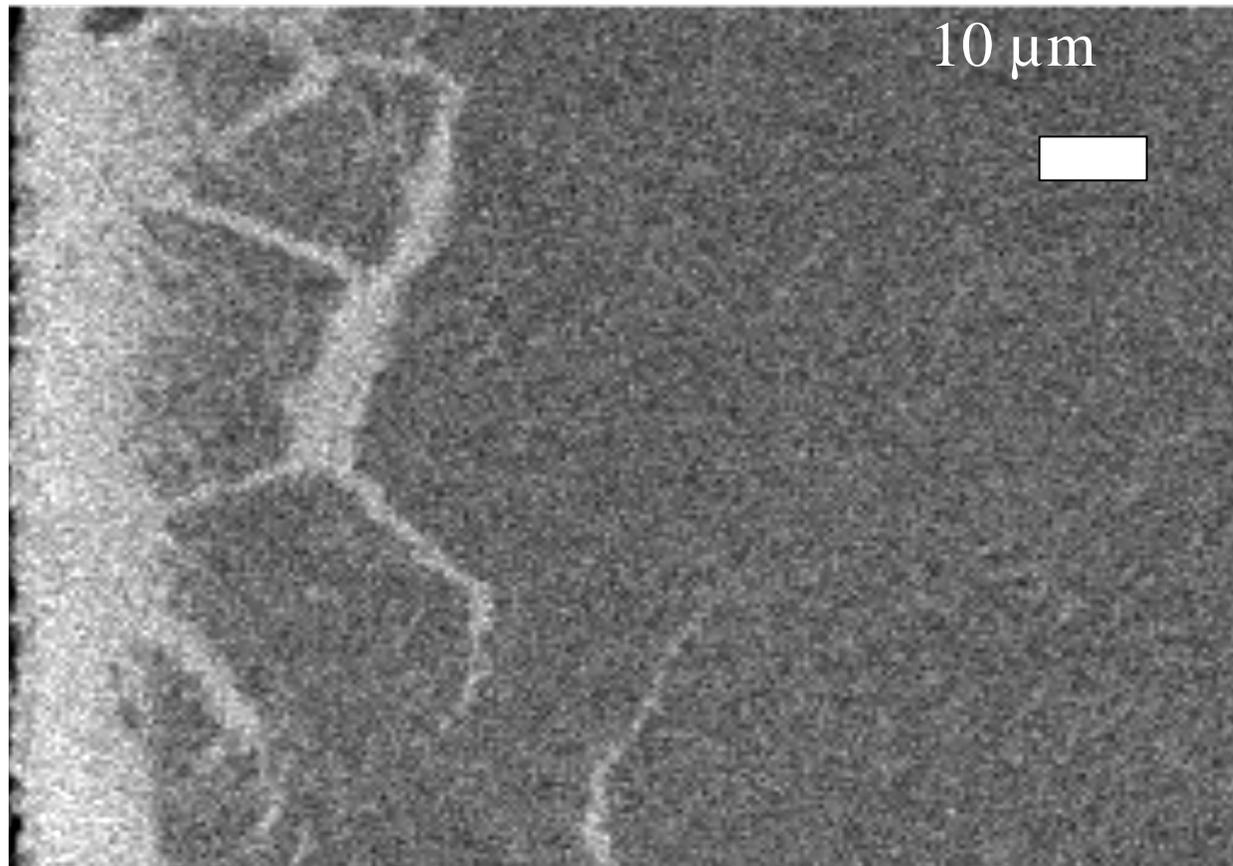
Nanoindenter used to determine bulk elastic constants.





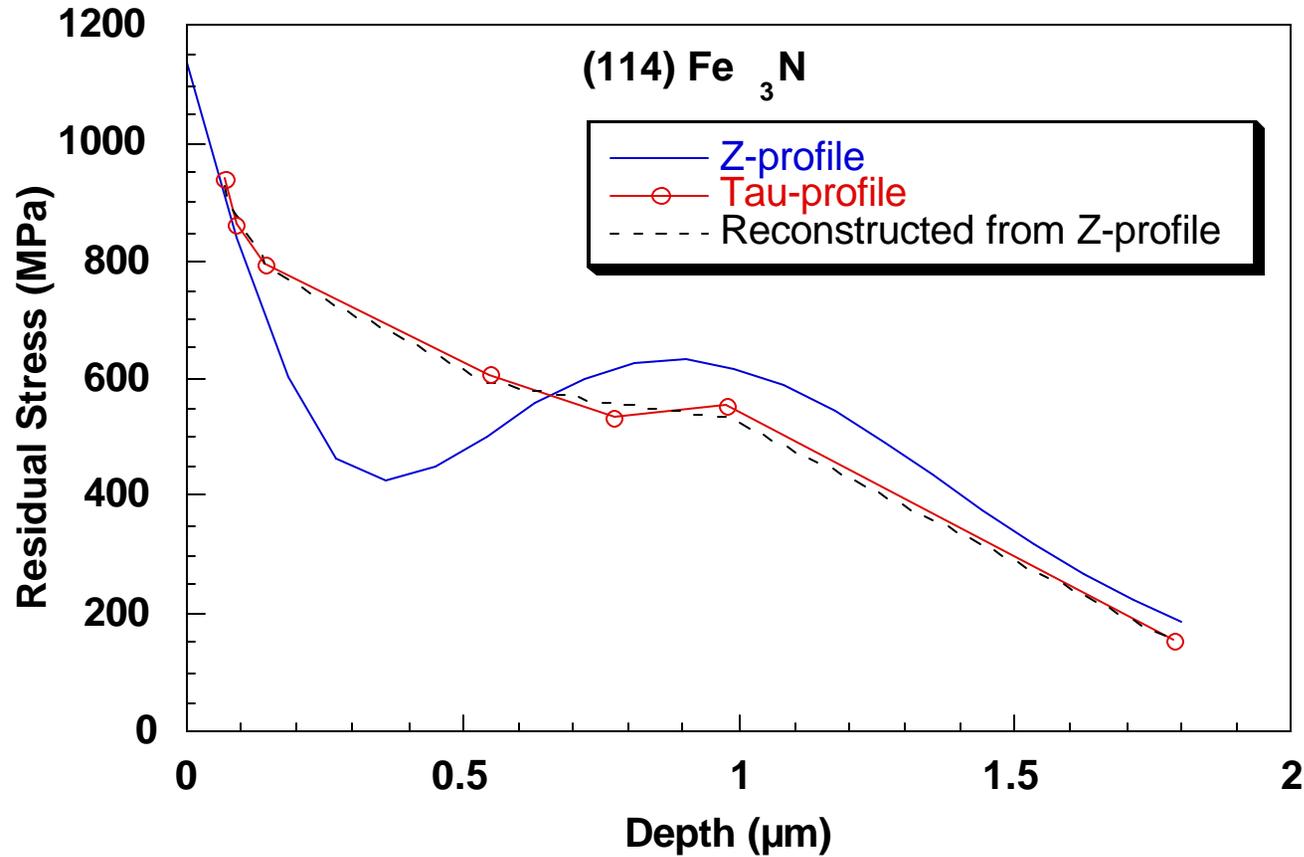
The nitrogen gradient was measured with the electron microprobe, which allowed correction of the unstressed lattice spacing.

Nitrogen diffusion along grain boundaries can be seen via elemental mapping.



JOEL 733 Electron microprobe

The Fe₃N layer did increase fatigue life by increasing compressive stress.



What happened?

- Nitride white layer had tensile - not compressive stresses at surface
- Standard Sin^2Psi method indicated +300 MPa.
- SEM of this layer showed a porous and microcracked layer.
- Fatigue life improvement due to nitriding because of nitrogen interstitials in martensite with compressive stresses underneath the white layer.

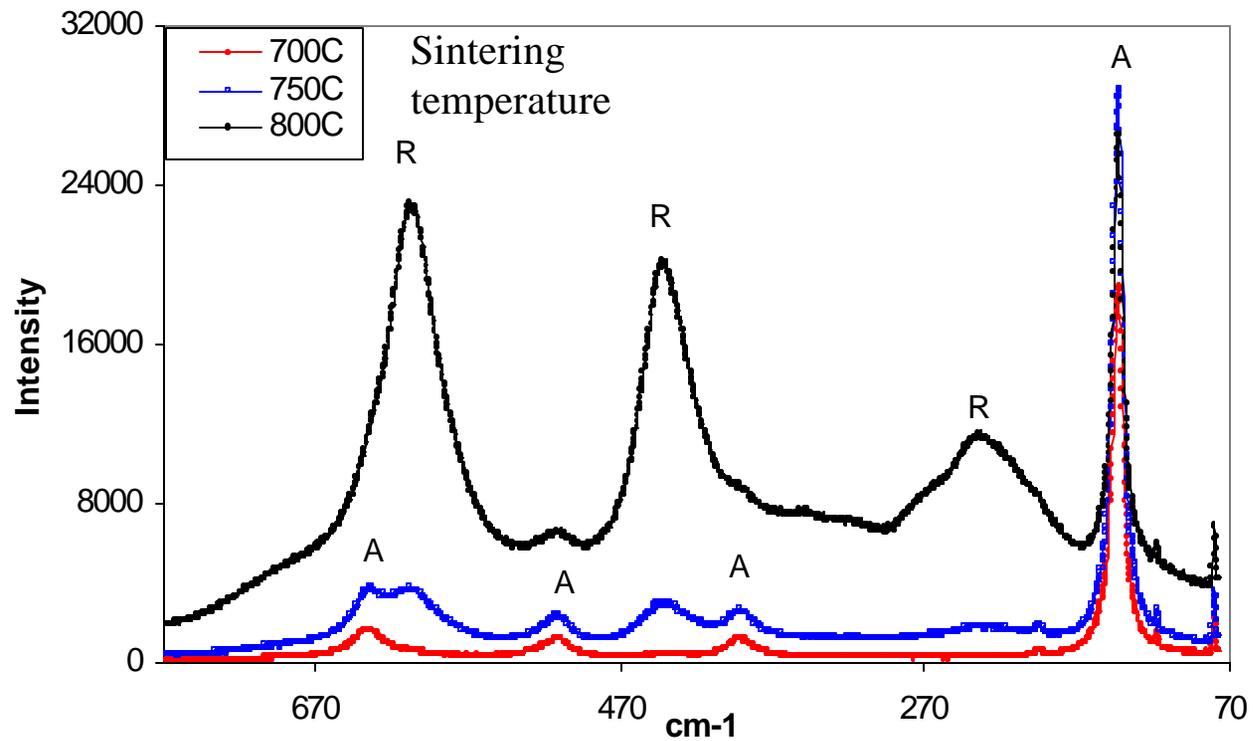


Catalysts

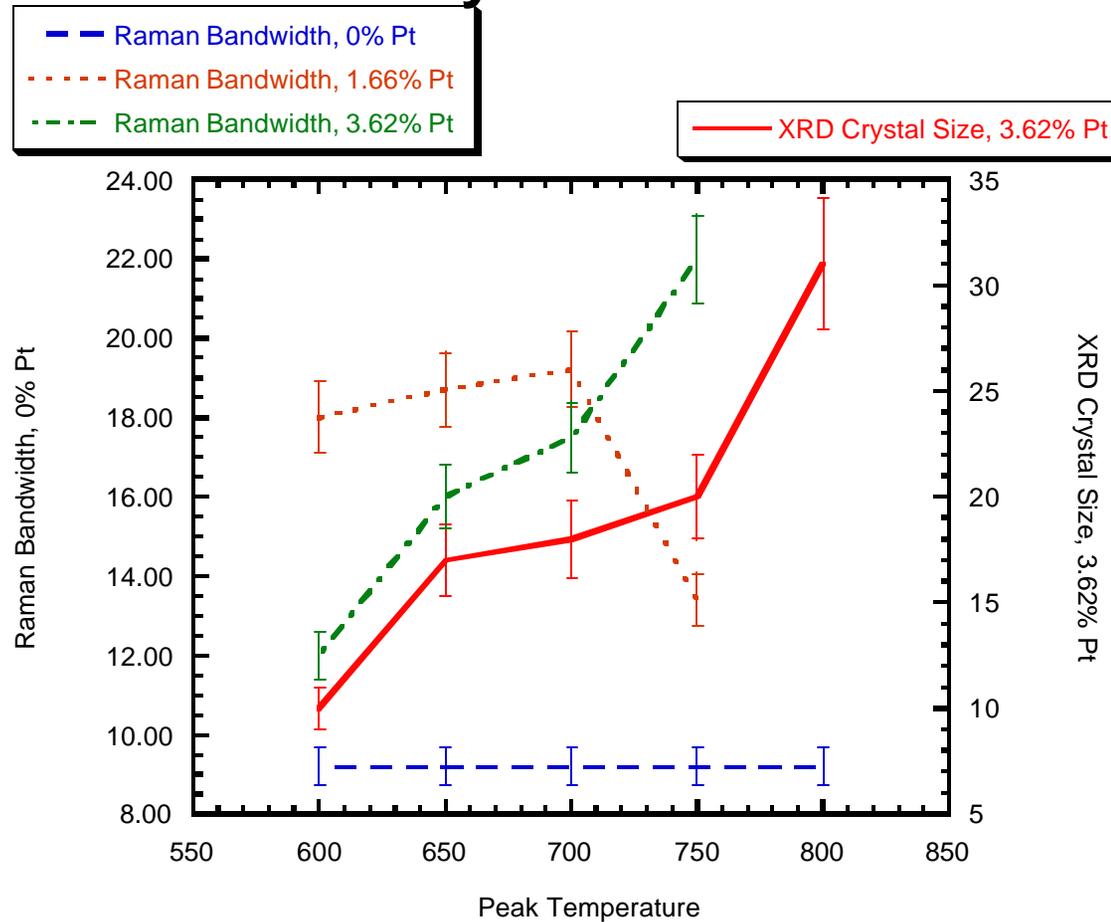
- Diesel engine companies must understand the degradation mechanisms in catalyst systems.
- Controls development requires an in-depth understanding of catalyst functions.



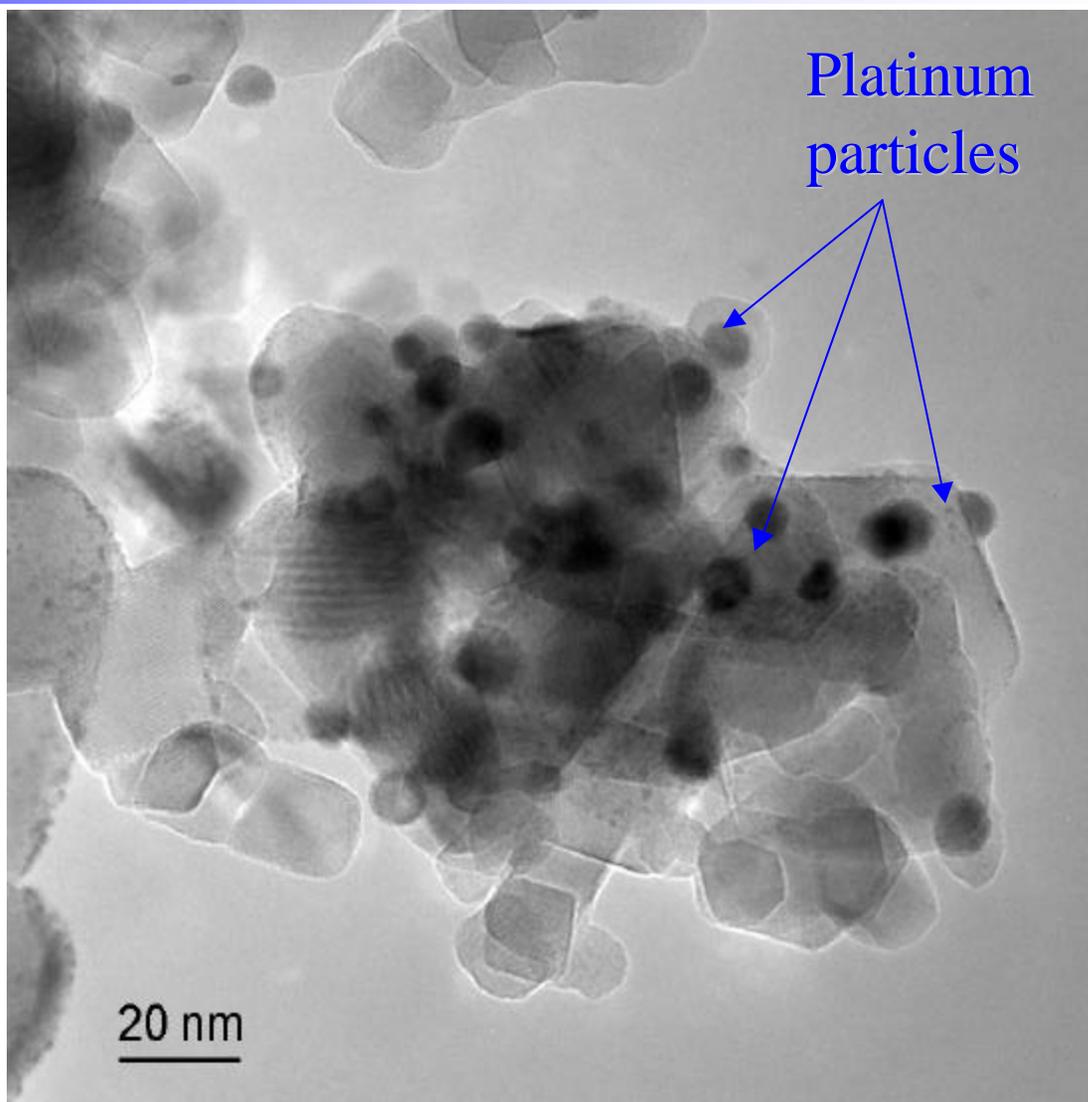
Raman Probe of Anatase to Rutile Phase Changes as Function of Temperature.



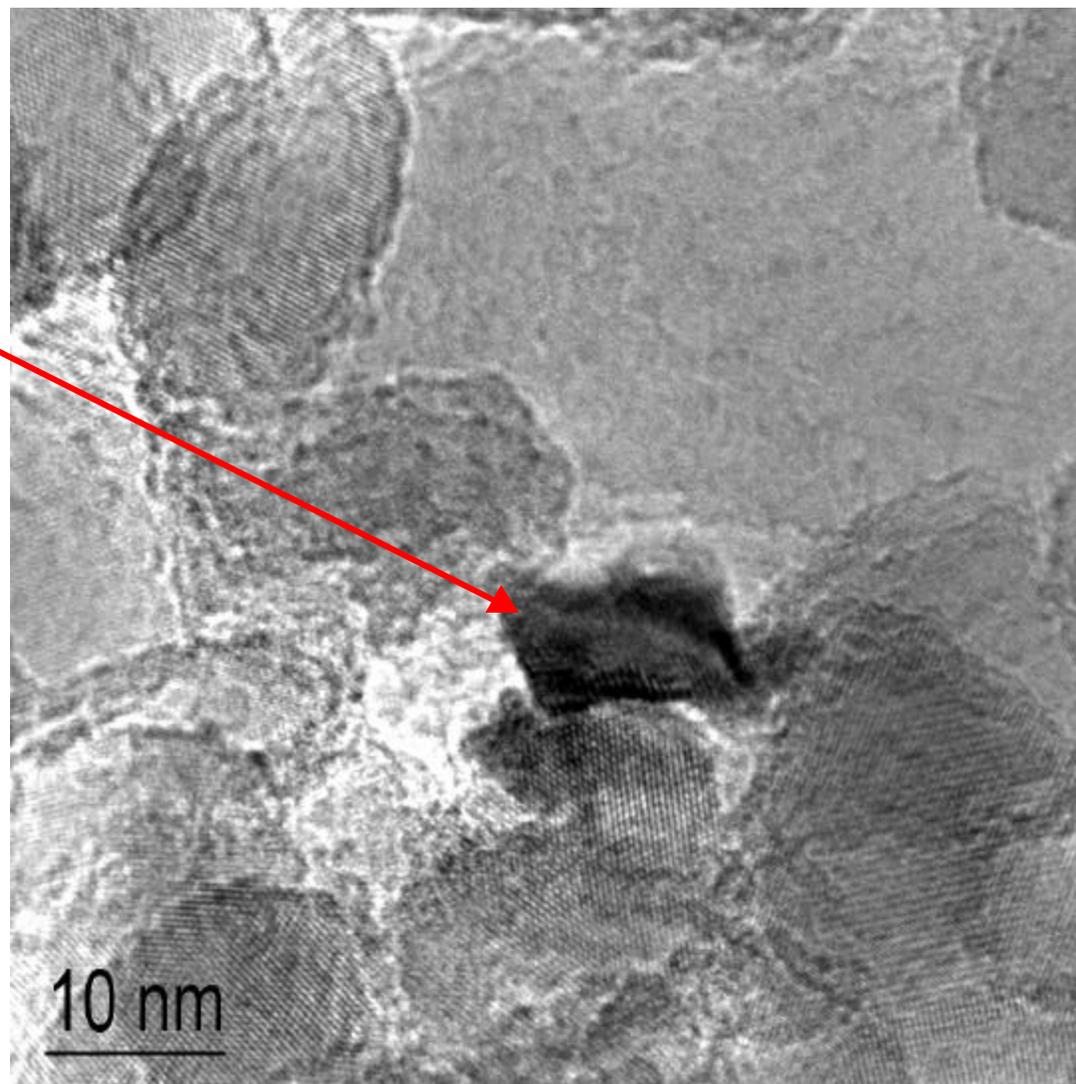
Correlation of the Raman bandwidth response to the XRD measured crystallite size



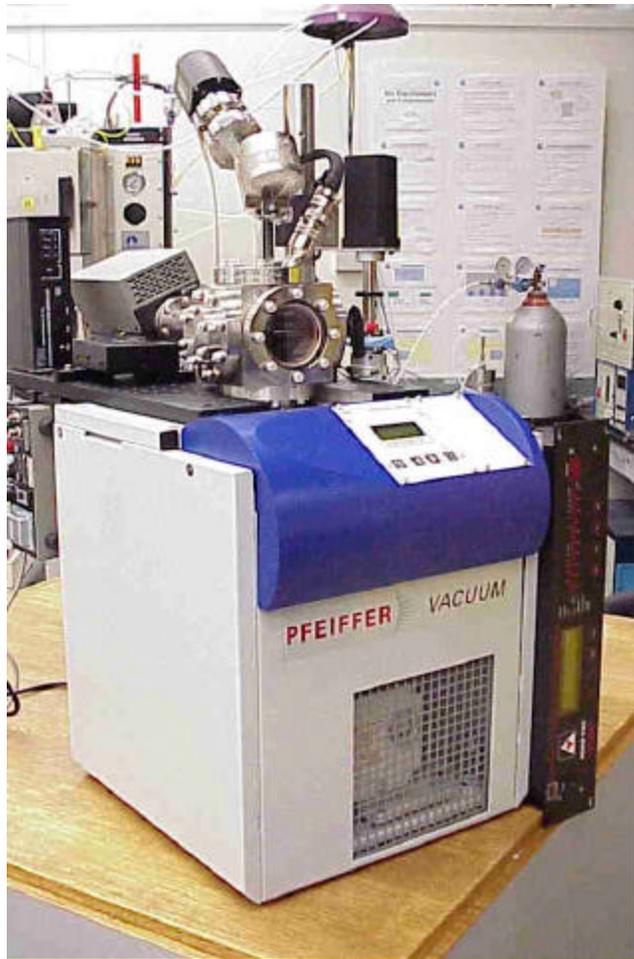
TEM image showing dispersion of ~10 nm Pt particles on washcoat surface.



**TEM
image of
~10 nm
Pt
particle
on
washcoat
surface.**



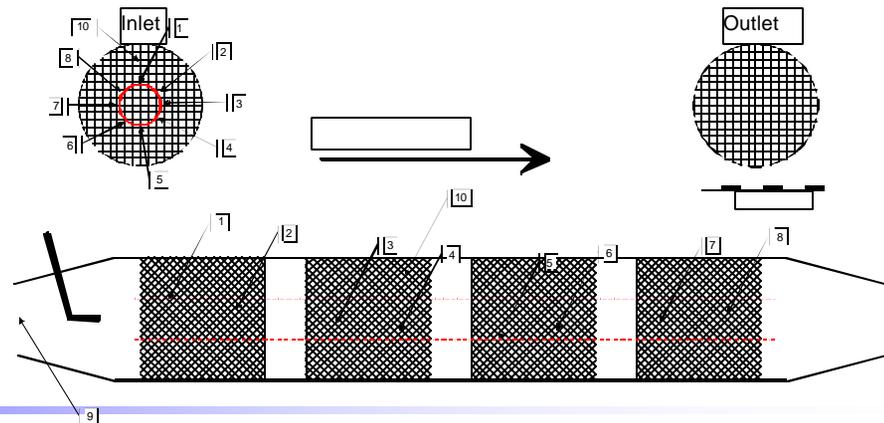
SpaciMS



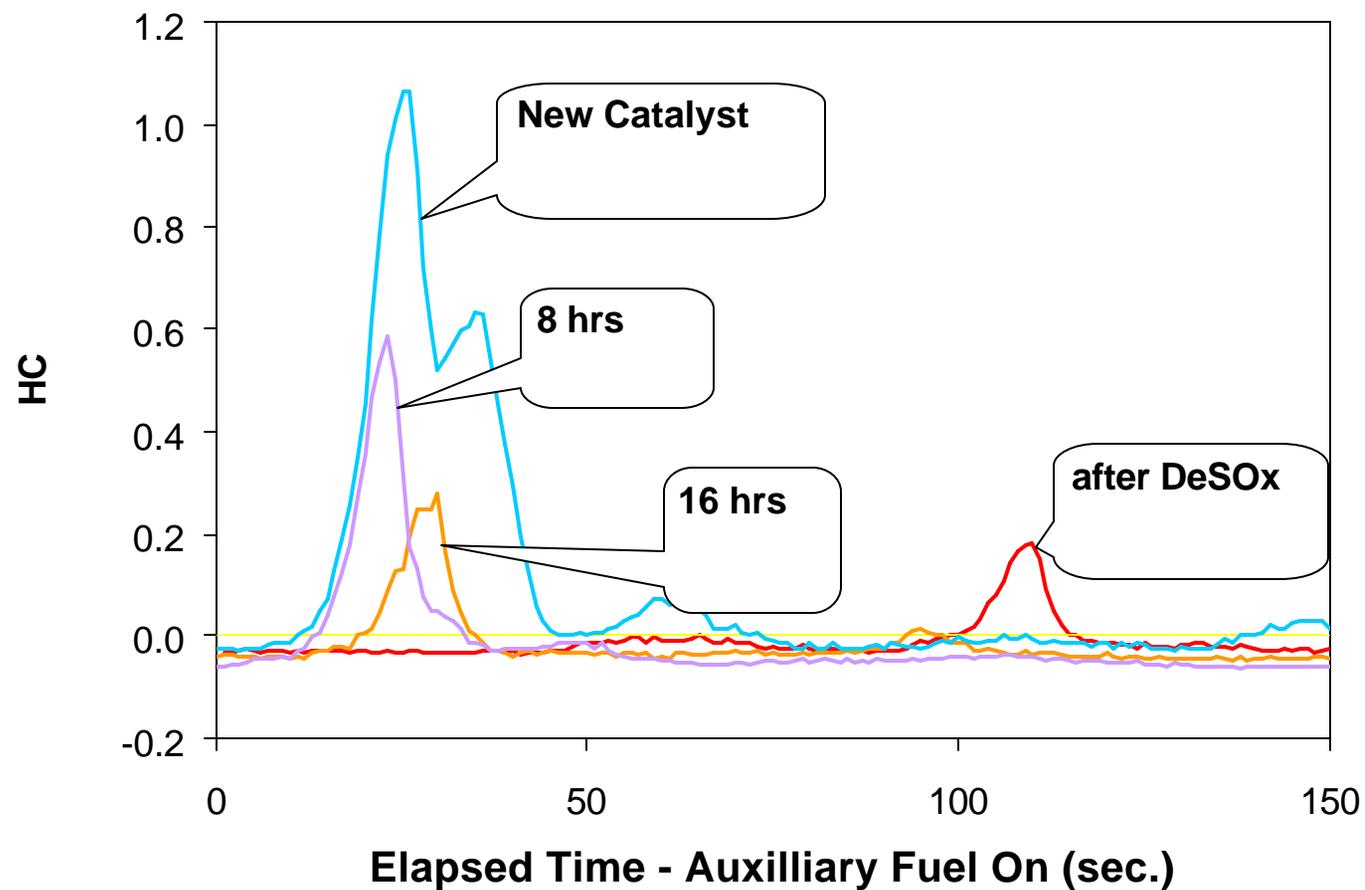
Developed and built by ORNL and Cummins under a CRADA

Features:

- **Spatially resolve reactions within the catalyst in real time**
- **Capabilities:**
 - speed 33 msec./point
 - NO/NO₂, O₂, CO₂, HC
 - Hydrogen Detection
 - Improved sampling port



SpaciMS - Desulfation alters catalytic activity.



Understanding of catalyst systems

- Delineate S-poisoning mechanism in NO_x absorbers by monitoring either adsorbed species or functionality of the support materials.
- XRD and TEM measurements correlated with Raman bandwidths measurements to particle size and sintering effects.



A National Resource

- Technical Expertise
 - Companies can access depth of knowledge not readily available outside of National Laboratories.
- Collegial Atmosphere
 - Excellent working relationships
 - Helpful discussions.
 - Collaborative efforts.
 - Problem Solving



A National Resource

- Excellent equipment
 - No single company can afford the capabilities available through the HTML.
 - Synchrotrons
 - Neutron
 - High resolutions TEM
 - Spatially resolved Mass Spectrometers



