

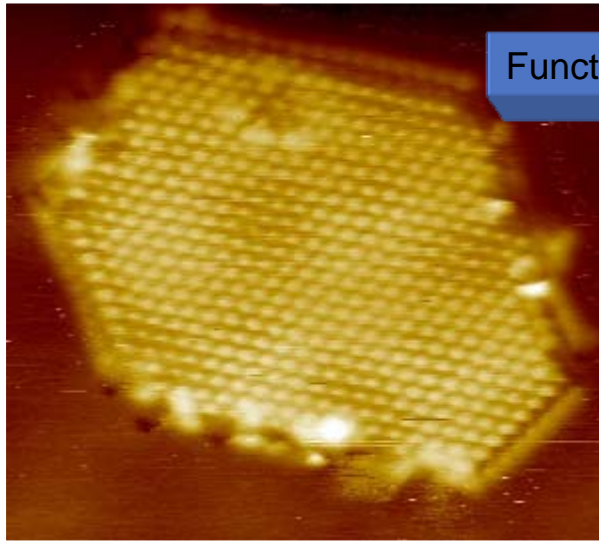
Materials Science & Engineering

Cynthia A. Powell

Office of Research & Development



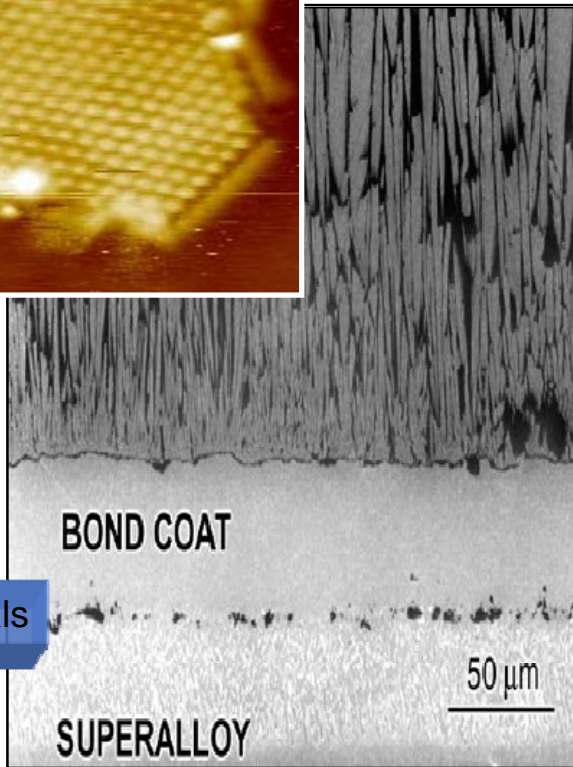
Materials to Enable Tomorrow's Energy Technologies



Functional Materials



Processing Strategies

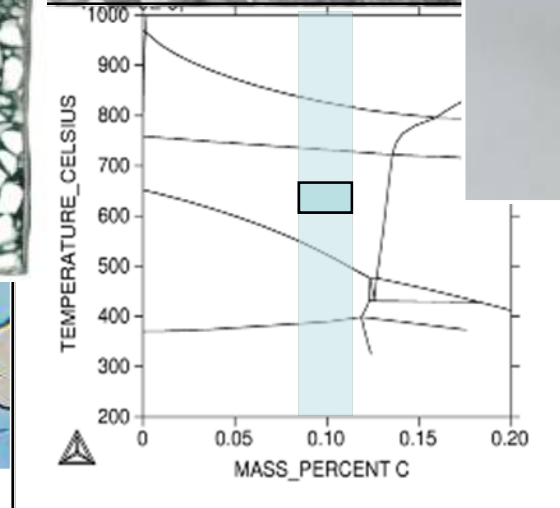
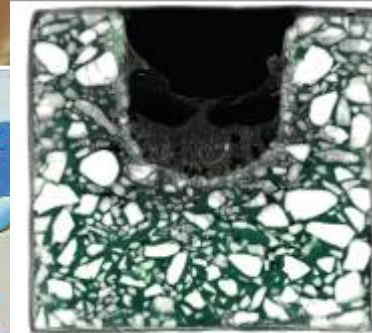
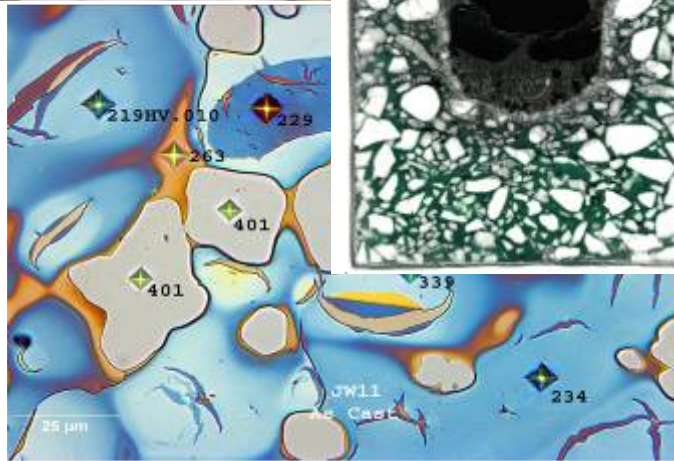
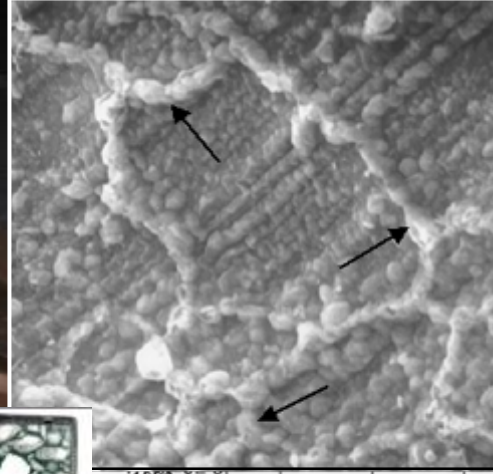


Structural Materials



Proof of Concept

Materials Development

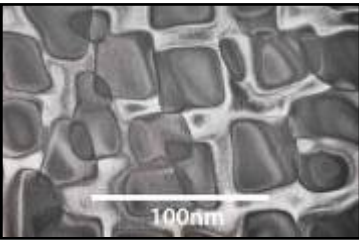
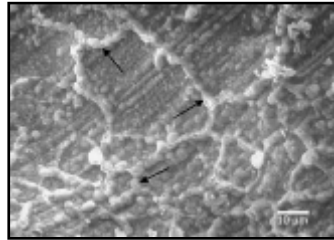
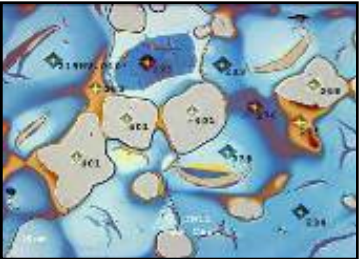


- Metal Alloys
- Ceramics
- Intermetallics
- Composites

Materials Processing

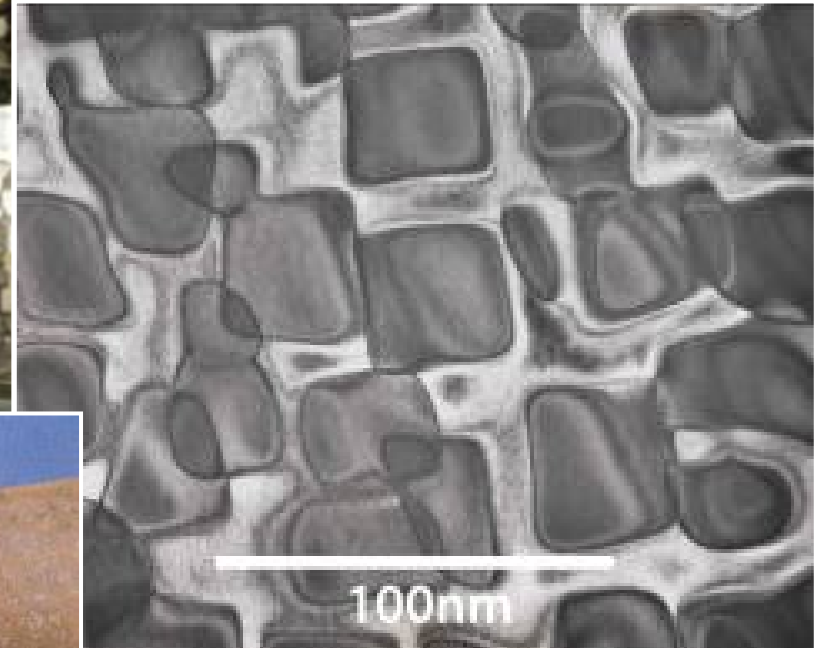
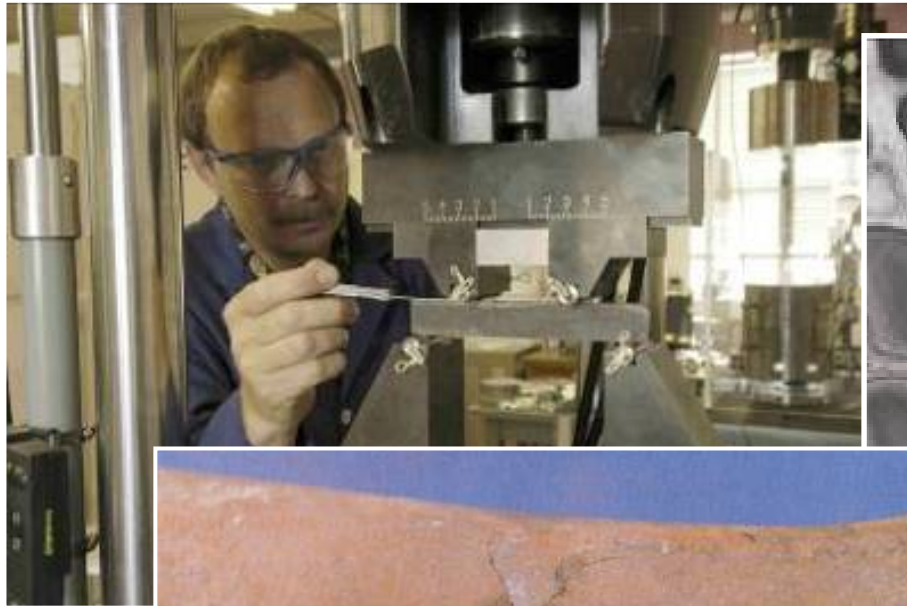


A Complete Metals Development Facility





Materials Performance Assessment

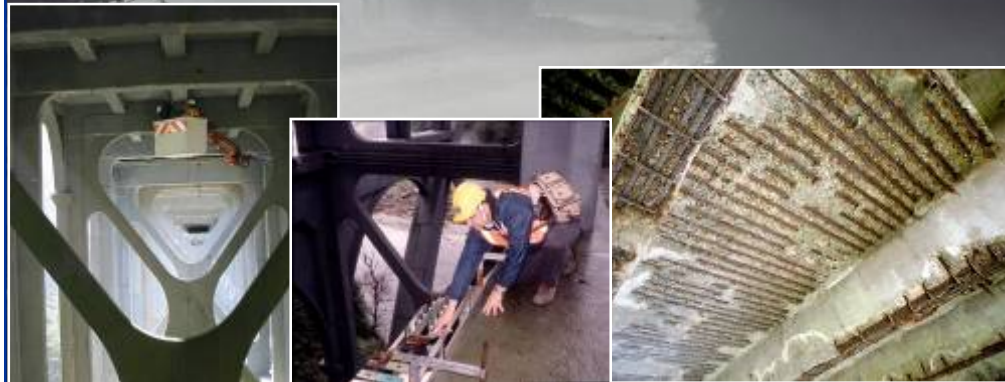


Corrosion, Wear, Microstructural & Mechanical Stability

Corrosion

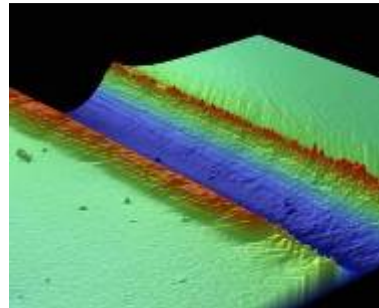
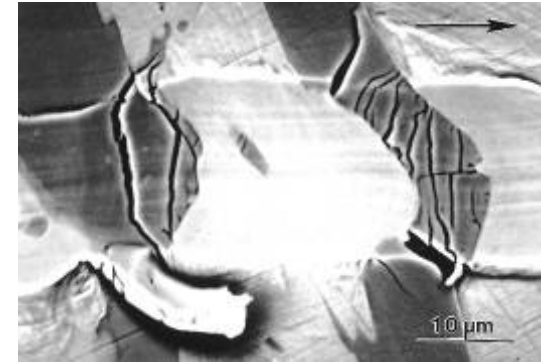
- SECERF
- Corrosion:
 - Potentiostats
 - Galvanostats
 - Electrochemical Impedance Spectroscopy
- Critical Pitting Temperature
- Critical Crevice Corrosion
- Stress Corrosion Cracking

Cathodic & Intermittent Cathodic Protection of Coastal Bridges (with Oregon DOT)



Wear (Abrasion and Erosion)

- *Sliding, scratch, pin-on-disc, pin-on-drum, DSRW, impact-abrasion, impeller wear, jaw crusher, jet-erosion, slurry wear, corrosion-wear, erosion & abrasion modules for SECERF.*



HPHT FATIGUE FACILITY

- **Facility Specifications**

- Frequency

- Rotating bend from the drill string passing around bends. (1-3 Hz)

- Vibrational fatigue loading including:

- lateral vibration (rattling in the hole, 0.5 – 10s of Hz)
 - torsional vibration (from drill bit stick and slip 0.05 – 0.5 Hz)
 - axial vibration (impacting hard formations 1-10 Hz)

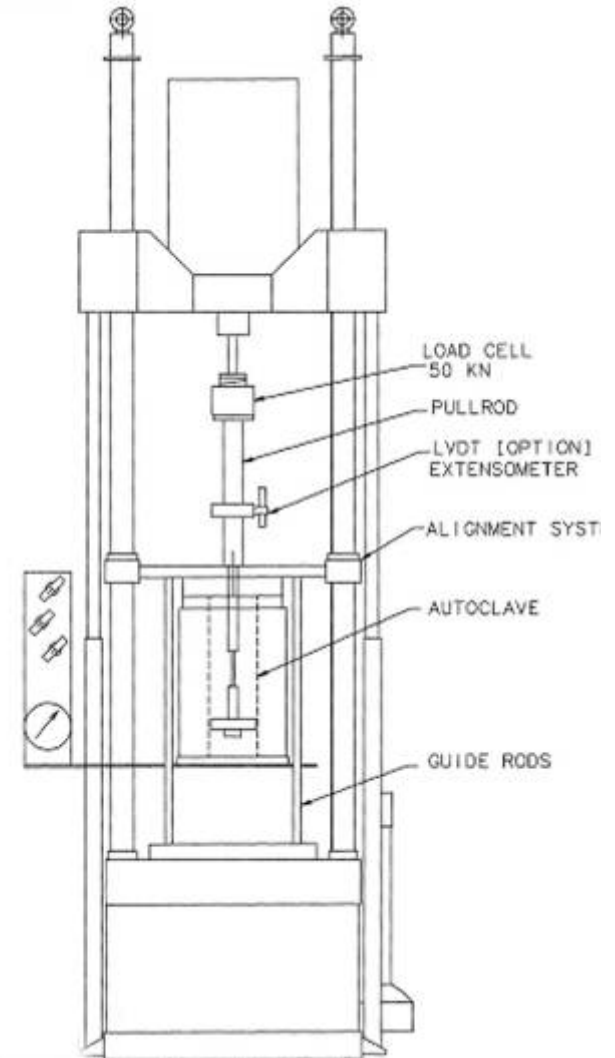
- Temperature 500F.

- Pressure 30,000 psi

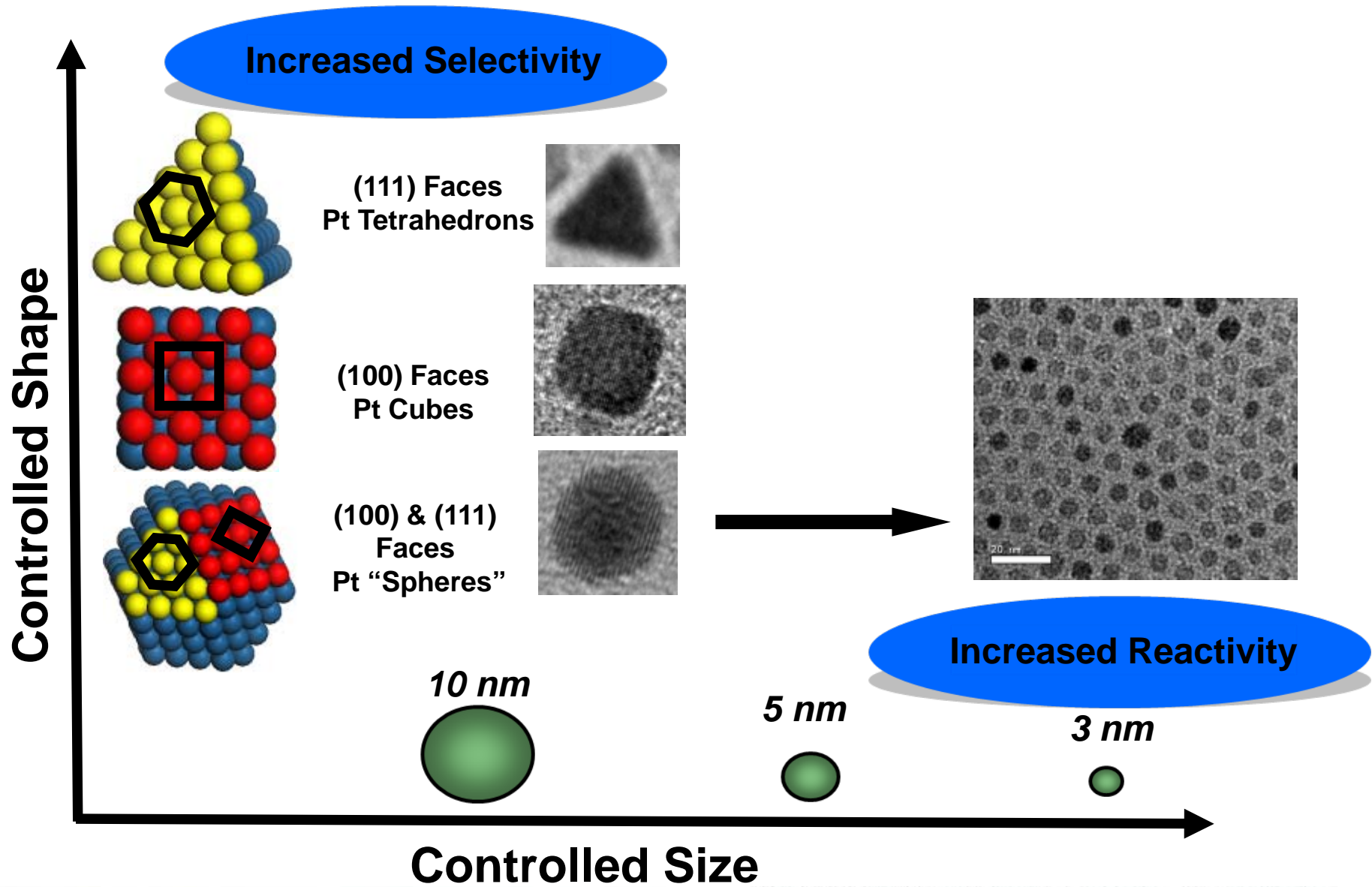
- H₂S

- **FY09 procurement and safety permitting**

- **Expected on line in FY10**



Optimizing Catalysts for Performance

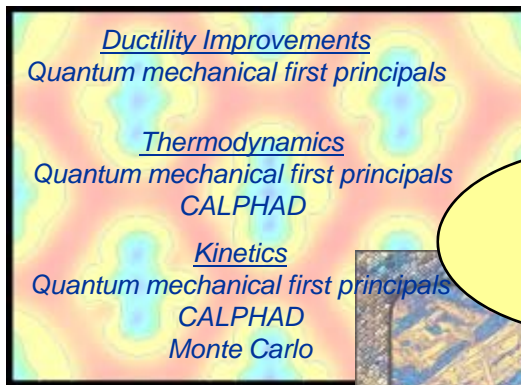


Examples of Current Materials Research...



Computational Materials Design with Experimental Verification

- Goal: Develop refractory metal based alloys utilizing an integrated design approach that combines computational materials development with experimental verification
 - The push towards higher operating temperatures creates a need for new and affordable structural materials with requisite microstructural and mechanical stability that can be effectively produced in large sections.

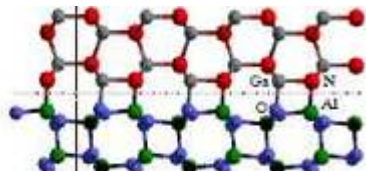


Grain Boundary Segregation
Molecular Dynamics

Experiments

Creep
Quantum mechanical first principals
CALPHAD

High Temperature Oxidation
Quantum mechanical first principals
CALPHAD

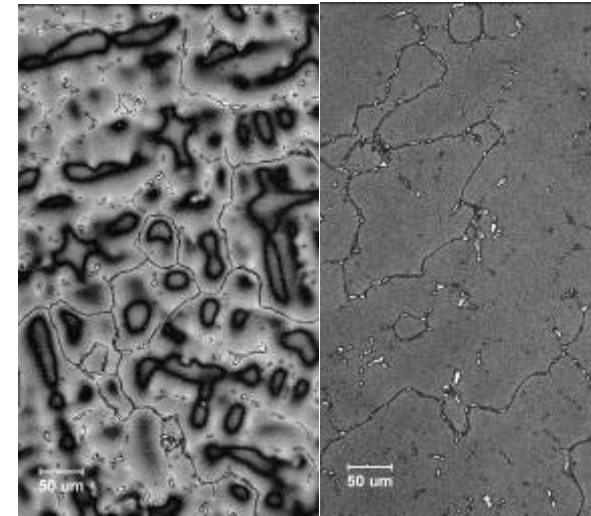
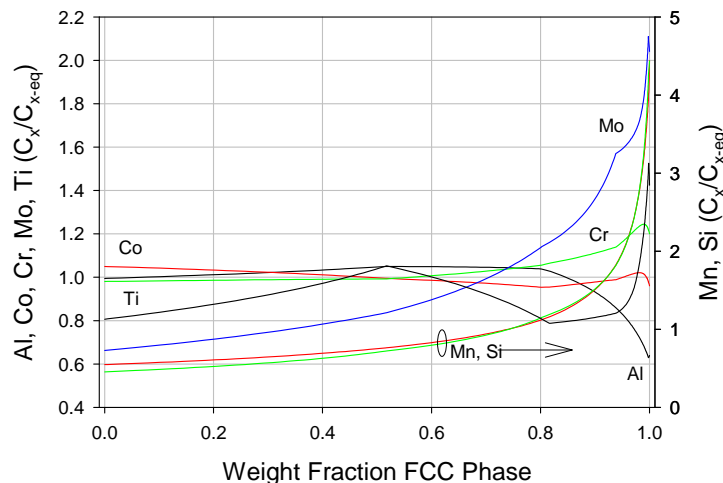


Brittle – Ductile Transition
Molecular Dynamics
Dislocation Dynamics



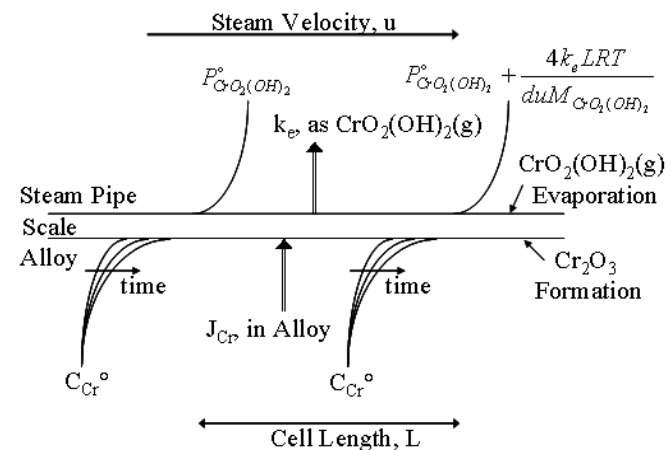
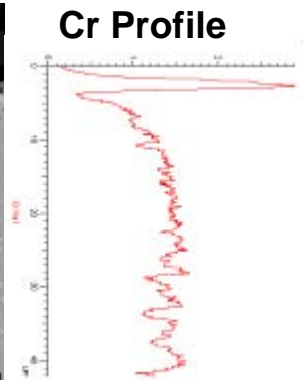
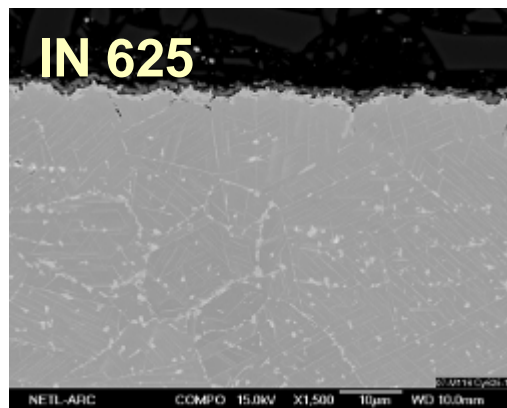
Process Development for USC Turbine Materials

- Goal: To develop cast versions of wrought Nickel-base super alloys for application as casing components for the next generation of Industrial Steam Turbines.
 - Compositional design for castability, while retaining required performance metrics.
 - Optimized processing schedule to ensure production efficiency and economics.



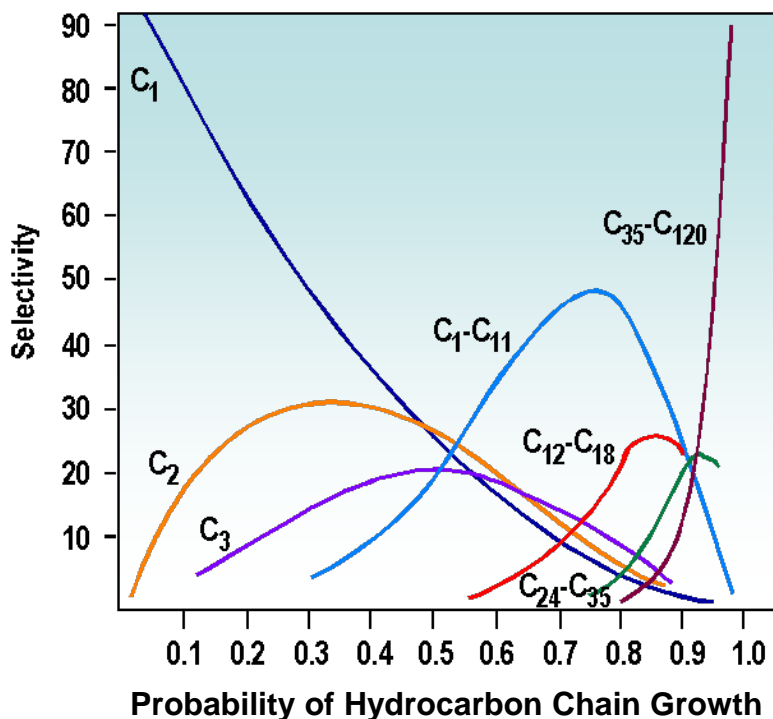
Materials Performance in Advanced Combustion Systems

- Goal: Understand the impact of advanced combustion environments on the selection and service life of boiler and turbine materials of construction
 - Ultra SuperCritical Combustion: 760°C; 35 MPa
 - Oxyfuel Combustion for Carbon Capture: impact of low-nitrogen environment and flue gas recycle on corrosion in retrofit and greenfield boiler systems



Contaminant Resistant Catalysts for CBTL

- Goal: To investigate the effects of coal and biomass contaminants as well as variable syngas proportions on the performance and lifetime of Fischer-Tropsch catalysts used to convert syngas to liquid synfuels. Lessons learned will be used to design improved catalysts for this application.



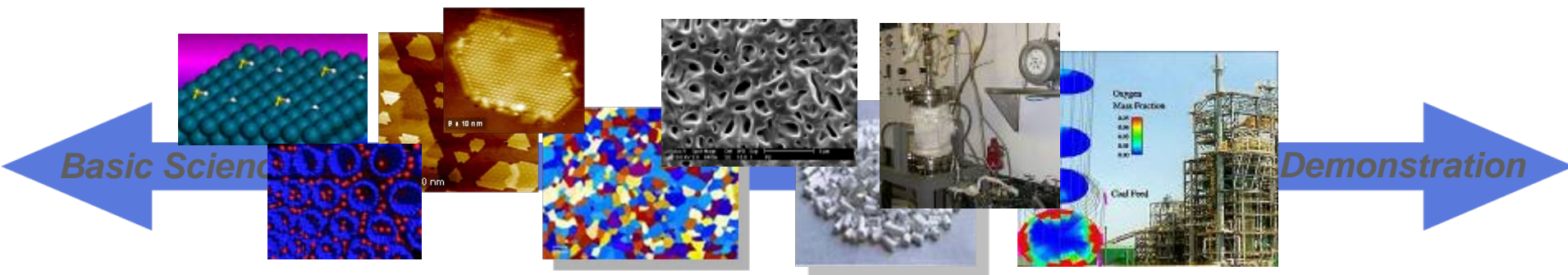
Materials Development & Performance for Extreme Drilling Conditions

- Goal: Understand failure mechanisms and correlate microstructural and environmental factors that influence failure in order to develop materials with improved performance capabilities.
 - HPHT Sour Environments: $T > 400^{\circ}\text{F}$, $P > 20,000\text{ psi}$; with H_2S and CO_2 present
 - Crack initiation \rightarrow localized corrosion
 - Crack propagation \rightarrow HE, SCC, Corrosion Fatigue, Fatigue, and mixed mode failures



Materials to Enable Tomorrow's Energy Technologies

- **New Materials to meet specific performance criteria.**
- **Materials processing strategies for optimum efficiency and economics.**
- **Materials performance assessment for severe service environments.**
- **Performance + Reliability + Economics = NETL's Materials Research Focus.**



For More Information:



U.S. Department of Energy
National Energy Technology Laboratory

CYNTHIA A. POWELL, Ph.D.
Office of Research & Development

1450 Queen Ave. SW
Albany, OR 97321

Office: 541-967-5803
Mobile: 541-207-7392
Fax: 541-967-5845
cynthia.powell@netl.doe.gov

