Characterization Facilities and Equipment

Colorado School of Mines

- FEI Quanta 600i Environmental Scanning Electron Microscope (E-SEM)
  - Energy Dispersive Spectroscopy (EDS)
- JEOL JSM-7000F Field Emission Gun SEM (FE-SEM)
  - EDS, EBSD, Nabity NPGS E-beam Lithography
- FEI Helios NanoLab 600i Focused Ion Beam/Field Emission SEM (FIB/SEM)
  - EDS, EBSD, Omniprobe Autoprobe
- Philips CM12 Transmission Electron Microscope (TEM)
  - EDS, heating/cooling specimen holders
- Philips CM200 Transmission Electron Microscope (TEM)
  - EDS, high tilt stage
- FEI Talos F200X Transmission/Scanning Transmission Electron Microscope (S/TEM)
  - Super-X EDS for spectral imaging
- Zeiss Xradia 520 Versa 3D X-ray Microscope
- Leco interstitial analyzers
- Coating testing equipment: scratch, adhesion, wear
- Salt spray and high temperature corrosion testing
- Ellipsometer surface area analyzer
- Mass Spectrometry (MS)
  - Extrel ELQ – 400 and 400 LC/MS
  - Perkin Elmer Q-Mass 910 GC/MS and JEOL M Station
- 400 Mhz Liquid - Solids Nuclear Magnetic Resonance Spectrometer (NMR)
- Netzsch Thermal Analysis Systems
  - Dilatometry, Differential Scanning Calorimetry (DSC), conductivity
- Seiko TG/D and Cahn Thermogravimetric Analysis (TGA)
  - Fisons mass spectrometer
- Bio-Rad Fourier Transform Infrared Spectrometer (FTIR)
- 4 MTS computer-controlled, servo-hydraulic uniaxial mechanical test frame
- 2 Instron screw driven uniaxial mechanical test frame
- 4- and 3- point bend fixture (ambient and high temp)
- MTS Nano indenter
- XP sheet metal testing fixtures
- Fracture toughness and impact testing fixtures
- Bending and torsional fatigue

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Existing Equipment

- FEI Quanta 250 Field Emission Scanning Electron Microscope (FE-SEM)
  - low vacuum mode, heating/cooling stage, EDS
- JEOL Scanning Electron Microscope (SEM)
  - low vacuum mode, EDS
- AMICUS X-ray Photoelectron Spectroscopy (XPS)
- Siemens D500 X-ray diffractometer (XRD)
  - monochromator, sample spinner

• Scintag X-ray diffractometer (XRD)
  - ICDD database
• Rigaku Ultima IV X-ray diffractometer (XRD)
  - Small angle x-ray scattering (SAXS), thin film measurements
• PANalytical PW2404 X-ray fluorescence spectrometer (XRF)
  - 60 sample exchange, liquid and semi-solid capability
• Netzsch Differential scanning calorimetry/ Thermogravimetric analysis (DSC/TGA) - MS/IR
  - 20 position carousel, infrared gas identification, mass spectroscopy
• Phillips CM30 Transmission Electron Microscope
  - Electron Energy Loss Spectroscopy (EELS), EDS, heating/cooling specimen holders
• JEOL 8200 Automated Electron Microprobe
• Amray 1845 Field Emission Scanning Electron Microscope (FE-SEM)
  - EDS, EBSD
• JEOL 5910 Scanning Electron Microscope (SEM)
  - EDS
• JEOL JAMP-7830F Auger Microprobe
  - EDS, EBSD

Currently being installed in new ISU/Ames Lab Sensitive Instrument Facility (SIF)
• FEI Helios NanoLab G3 UC Dual-Beam Focused Ion Beam (FIB)
• FEI Aberration-Corrected Scanning Transmission Electron Microscope (S/TEM)
  - EELS, EDS, tomography, Lorentz microscopy, environmental specimen holders
• FEI G2 F20 Scanning Transmission Electron Microscope (S/TEM)
  - EELS, EDS, tomography/holography, Lorentz microscopy
• FEI Teneo LoVac Field-Emission Scanning Electron Microscope (FE-SEM)

In procurement
• New TEM with ASTAR Precession Electron Diffraction (PED)

Processing Facilities and Equipment

Colorado School of Mines
• VAC TEC, VCC 7740 Vertical Cathode PVD Unit
• VAC TEC, MLIV Horizontal Cathode PVD Unit
• Varian ion implantation
• Hyper ion PVD unit
• Electron beam & thermal evaporation units
• Perkin Elmer 2400-8SA RF sputtering system
• Closed field unbalanced magnetron sputtering system
• Watkins Johnson atmospheric pressure CVD unit
• Plasma enhanced CVD unit
• Laser surface modification facilities
• Extensive foundry facilities
• Complete arc-welding capability
• Laser welding system
• Solid state bonding
• Soldering and brazing capability
• Fixtures for hot cracking susceptibility testing

• Gleeble thermomechanical simulator
• Welding consumable production capability
• Wiredrawing bench
• Hot and cold rolling mills
• Thermal Technologies vacuum hot press (3300° C)
• Powder Metallurgy (PM) processing

Iowa State University
• Access to world class user facilities at Ames Laboratory, including specifically the Materials Preparation Center (MPC), recognized throughout the worldwide research community for its unique capabilities in the preparation, purification, single crystal growth, and characterization of rare earth metals, alkaline-earth metals, and refractory metal materials.
• Powder gas atomization and powder handling equipment
• Combinatorial materials synthesis techniques
• Various furnaces for different types of study at a wide range of temperatures
• Multiple types of additive manufacturing platforms
• DSI 3800 Gleeble Thermomechanical simulator
  - In procurement

Computational/Modeling Facilities and Equipment

Colorado School of Mines
• Process Simulation Software – Aspen
• Finite Element Software - ABAQUS
• Quantum Mechanical Software
  - Gaussian 94 Spartan
• Materials and Molecular Modeling Packages
  - Cerius 2
• IBM SP-Z 8-Node Parallel Supercomputer
• SGI Indiago 2 Workstation Clusters
• IBM RS-6000 Workstation Clusters

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• Condo Cluster, consisting primarily of 168 SuperMicro servers (expandable to 324 servers) each with two 8-core Intel Haswell processors, 128 GB of memory and 2.5 TB of available local disk. One large memory node has four 8-core Intel Ivy Bridge processors and 1 TB of main memory. Second large memory node has four 10-core Ivy Bridge processors and 2 TB of main memory. All nodes and storage are connected via Intel/Qlogic QDR InfiniBand (40 Mb/s) switch.
• Access to other clusters and a number of advanced workstations at ISU. Pete Collins is principal user of a cluster with six servers, each with 64 processors, 2MB cache. Five have AMD Opteron 6376 processors (2.3 GHz) and 1 has a AMD Opteron 6272 (2.1 GHz).
• Active COMSOL licenses for multiphysics computer simulation, as well as various artificial neural network and genetic algorithms codes.