

Materials Science Lab Equipment

STRUCTURE/COMPOSITION

X-ray Diffraction (XRD) (Shimadzu). The x-ray diffractometer is useful for structural and compositional determination of materials. X-rays interact with charge density, and will reflect coherently off of ordered arrays of atoms, resulting in peaks of intensity at the correct angles (corresponding to the different periodicities present in the sample). It is primarily used to identify the crystal structures and lattice constants of inorganic substances and frequently enables you to identify the materials present in the sample from this, but will also give information about ordering in polymer and other organic materials, albeit with lower signal. (Askeland 3-9, Callister 3.16W on website and cd)

Fourier Transform Infrared (FTIR) Spectrometer (Bruker). The molecular bonds in (usually organic) materials can vibrate around their characteristic length or angle in response to stimulation by the energy in infrared radiation. The vibrating bond dissipates energy by emitting radiation of its own at a frequency characteristic of that particular bond and its surroundings. The radiation that is absorbed or transmitted can therefore be used to determine which combinations of bonds are present in the sample, giving a characteristic spectrum that can be used to identify the organic compound.

X-ray Fluorescence (XRF) (Innov-X). The XRF system provides compositional information by collecting characteristic x-rays that are emitted from a sample following excitation of atomic electron energy levels by an x-ray source. XRF testing only takes a few minutes, so it is the fastest way to get compositional information on certain materials (great for metals). XRF is also used to detect the presence of hazardous materials (e.g., lead) in polymeric components or environmental samples.

Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Spectrometer (EDS) (JEOL and Thermo Noran). A beam of electrons is accelerated and focused onto the surface of your sample, exciting the emission of secondary electrons from the sample which are detected and used to image the topography of the sample surface with resolution down to tenths of microns (1 millionth of a meter) scale. Can show: grain structure (etched sample), micro-scale structure, surface treatments, fracture details.

In conjunction with SEM, some of the electrons will interact with the sample, causing the sample to emit characteristic x-ray radiation which can show the composition of the sample both on the macro-scale and with nearly the same resolution as the imaging part of the SEM (ie micro-scale composition). (Callister 4.9)

Optical Microscopes (Leica and Olympus). Visual imaging down to 10's of micron scale. Particularly useful for metallographic analysis of polished and etched specimens. (Callister 4.9)

THERMAL PROPERTIES

Thermogravimetric Analyzer (TGA) (TA Instruments)

The TGA detects the change in mass of a sample as function of temperature (or time) under a controlled atmosphere. Its principal uses include measurement of a material's thermal stability and composition. TGA may be used to measure water loss or solvent loss with temperature, and weight gain by oxidation at elevated temperatures. With an externally applied magnetic field, the TGA can be used to measure the Curie temperature of some samples.

Thermomechanical Analyzer (TMA) (TA Instruments). Thermomechanical analyzers (TMAs) are used to measure a variety of material properties, including coefficients of thermal expansion (CTE), melting temperatures (though this is better done with the DSC below), glass transition temperatures, heat deflection, and elevated temperature creep or stress relaxation behavior.

Differential Scanning Calorimeter (DSC) (TA Instruments). The differential scanning calorimeter (DSC) measures the energy absorbed (endotherm) or produced (exotherm) as a function of time

or temperature. It is used to characterize melting, glass transitions, heat capacity, crystallization temperature, percent crystallinity (polymers), resin curing, loss of solvents, and other processes involving an energy change.

MECHANICAL PROPERTIES

(Askeland Ch. 6 and 7, Callister Ch.6 and 8)

Universal Mechanical Testers (Instron). Measure the mechanical behavior and properties (stress vs. strain, elastic modulus, tensile strength, fracture strength, ductility, yield strength, etc) of bulk materials in compression, extension, or bending. The one in the mat. sci. lab is for relatively strong or stiff materials (metals, engineering polymers, ceramics). If you have a material that is too soft for this one, talk to the materials science staff about using the mini Instron in AC429.

Environmental chamber for Instron. Test samples at temperatures between -80 °C and 300 °C.

Impact Tester (Instron). Identifies the ability of materials to absorb energy during fracture or to withstand impact in a variety of configurations.

Rockwell Hardness Tester. Determines the hardness of a material (its resistance to surface deformation or abrasion) on the Rockwell hardness scale. Produces 0.1mm to mm scale indentations.

Durometer Hardness Testers. Measures the hardness of polymeric specimens on Shore A and Shore D scales.

Microhardness Tester (Buehler). Determines the hardness of a material on the Vickers or Knoop hardness scale with indentations on the order of tens of microns. Useful to discriminate between different constituents.

ELECTRICAL PROPERTIES

Four point probe. Determines the electrical conductivity (or resistivity) of solid samples or thin films by applying an electrical current and measuring the voltage drop.

Sample Preparation/Processing equipment:

Sonicator (surface cleaning)

Furnaces (melting, sintering, reacting, refining)

Ovens (drying, melting, reacting)

Polishers (creating a smooth surface for single crystal x-ray scattering, microhardness testing, grain boundary identification on SEM)

Rolling mill (cold working metals)

Horizontal band saw (cutting samples)

Precision saw (cutting ceramics, most metals, some composites and polymers)

Laboratory press with heated platens

Mounting presses (encapsulating small samples in polymer for cutting/polishing)

Ball mill (for grinding)

Sputter coater (preparing non-conductive specimens for SEM analysis)