The College of Polymer Science and Polymer Engineering (CPSPE) in conjunction with the Institute of Polymer Science and Polymer Engineering (IPSPE) hosts several core advanced infrastructural facilities driven by the resident expertise of over 40 faculty and full time technical staff for strong industrial interactions in polymers. These Research, Development and Innovation (RDI) facilities exist in the form of an Institute, Centers, and Individual Faculty resources, all of which are leveraged for strengthening industrial interactions and projects. These RDI resources and facilities are engaged in activities ranging from development of advanced materials and their processing methods to characterization of material properties all the way up to device prototype development. A categorized summary of the RDI resources and facilities are provided below.

1. Centers at National Polymer Innovation Center (NPIC):

Multiple centers are co-located at the NPIC, a newly constructed facility dedicated to strategic center development activities at CPSPE. The NPIC is a unique facility consisting of a two sections. Section I has a high-bay area specifically for prototype development of large prototype processing equipment while Section II consists of two floors of advanced RDI Center related laboratories. Currently, two active Centers are operating at the NPIC. These are the Scalable Nanomanufacturing Center (Miko Cakmak, Director) and the Akron Functional Materials Center (AFMC, Co-Directors, Alamgir Karim and Matthew Becker). These mission, facilities and research at these two centers are described below. A third Center for Biomaterials and Medicine (CBMM, Co-Directors Matthew Becker and William Landis) is currently under development in partnership with The Austen BioInnovation Institute of Akron.

[A] Scalable Nanomanufacturing Center (Miko Cakmak, Director)

Research, Development and Innovation (RDI) Theme

The most critical fundamental science underlying the development of future R2R flexible electronic film technology include materials design and synthesis, mechanics of dispersion of functional micro- and nano-particles, thermodynamics of phase behavior and dynamics of polymer-, particle- and/or phase- and orientation under the influence of external fields. From the engineering standpoint the challenge exists in implementing the manufacturing of elements of future devices utilizing nanostructured materials by rapid manufacturing processes. This stems from the fact scale up of batch processes to generate structures optimized for desired function has not been adequate technologically or economically. The Roll-to-Roll (R2R) manufacturing methods are ideally suited to address these challenges. Attainment of the requisite knowledge and abilities requires engineering of appropriate RDI platforms. In situ characterization by suitable instrumentation of the R2R process is also needed to develop process models for the complete optimization of the manufacturing process.

Critical Technology Development

Successful implementation of R2R manufacturing to produce functional materials including flexible electronics must have the following elements: New materials forming the
Facilities at College of Polymer Science and Polymer Engineering

matrix with added desired functionality and process elements that apply these materials at high enough speeds to ultimately make the process commercially viable. The functional materials used in roll to roll processing steps process preferably should be photocurable or do not exhibit volumetric shrinkage during solidification/immobilization steps through evaporation/reaction both to speed the R2R process and to maintain the integrity of the structure that were developed. The R2R process should preferably incorporate external electrical, magnetic, and thermal fields during fabrication to "direct" the self organization in favor of increase the order in the applied films and maximize desired functionality in the resulting devices. Furthermore, the materials should self-organize in the relatively short processing time to provide locked-in functional structures.

Roll to Roll Process (R2R) Process for Electromagnetic Field Assisted Self organization: A recently designed and constructed pilot scale roll to roll manufacturing line specifically for development of functional films under external fields has been developed and tested (Figure A.1). This 70 ft. long ($1.5M) R2R manufacturing machine (schematically shown below) became operational in the Fall of 2010 in our (UA) facilities via a major development undertaking supported by the State of Ohio Third Frontier Program.

This facility is a strategic University of Akron effort to help accelerate Flexible electronics industrial cluster formation in Northeastern Ohio coordinated by Nortech, a regional technology economic development organization. This versatile pilot machine is designed to produce novel functional materials containing nanoparticles with a wide variety of physical properties, including electrical and magnetic components (Figure A.2). These include nano-sized metals, dyes, quantum dots etc. for the development of the flexible electronic/photonic devices including high capacity storage media. This machine is able to cast one, two or three layer solutions directly onto a carrier film that is carried by a nonmagnetic carrier steel belt. It has a section where a spatially and/or temporally varying electric field is applied to the liquid precursor being carried. The R2R machine was designed such that UV light mounted on
a carrier platform can be situated immediately downstream of the electrical field application zone to facilitate rapid immobilization of the structure just created. The same UV light carrier can also be situated downstream of magnetic field application zone to achieve the same effect for this purpose. The magnet for this machine has 2.2 Tesla field strength capacity, sufficient for most field alignment needs in functional films. Further downstream an oscillating thermal gradient system is situated, similar to directional crystallization and zone refinement for defect free semiconductors and metal respectively. It consists of a sequence of 20 alternating hot–cold zones, each of which allows for application of narrow heated zone with quartz heater/parabolic mirror and cold water circulation zone. This thermal processing zone is oriented normal to the carrier propagation direction and as the material slowly progresses along the R2R platform, machine it experiences an oscillating moving temperature gradient that is known to provide defect free / minimal defect films.

These capabilities enable pilot scale processing to obtain large area continuous directed assembly of functional films with desired properties suited for components to be integrated into functional devices. For example, the generation of large area single crystal cylindrical phases of the block copolymers (BCP) containing magnetic domains that can be field ordered using magnet in this R2R line. This concept is currently considered for high capacity storage media manufacturing.

With the set-up we can fabricate macroscopic large area multilayer films that are anywhere from centimeters to inches in width in this continuous deposition process. We have tested unique aspects of film thickness control in a gradient wedge architecture for high-throughput study of BCP film ordering properties. The wedge film deposition apparatus construction, illustrated in Figure A.3, is designed with exceptionally tight dimensional tolerances with exquisite control on gradient film thickness properties from nanometers to micrometers as illustrated.

**METROLOGY FOR MEASUREMENTS AND CHARACTERIZATION**

**Real time Measurements during Field Assisted Self assembly (off line)**

In order to understand the fundamental behavior of materials during the application of external electric and magnetic fields followed by immobilization through UV curing or solvent evaporation, we developed a highly instrumented metrology system shown in Figure A.4. This system was purposefully designed to simultaneously track in and out-of-plane film birefringence, solvent type and drying weight loss, and thickness measurements in real time while controlling the environmental temperature. The in-plane and out-of-plane optical retardations are measured by sending highly collimated beam of white light through the cast solution/monomers at 0° and 45° to the normal of the film.
At the receiving end parallel and cross polarization states intensity vs. wavelength is captured and analyzed using spectrometers. This system also measures the thickness of the cast liquid during the course of drying and/or curing using laser micrometers that track both the top surface of the cast liquid as well as top surface of the substrate without the liquid. An electronic balance whose top surface holds the casting platform through four posts simultaneously monitors the weight of the cast liquid. As shown in this figure the liquid of interest is sandwiched between two transparent conductive sheets (e.g. ITO coated glass or ITO coated PET sheet). It will allow us to study the dynamics of the structural reorganization during the application of electric field followed by the solidification stage by the application of UV curing. The data acquisition rate is fast enough to track the material parameters in real time allowing us to explore temporal variations of the electrical field strength and its type (AC and its various profiles, DC, biased DC) on the development of optical anisotropy through birefringence measurements. In figure A.4 is illustrated typical data obtained on Polyamic acid solution undergoing solvent evaporation and imidization. While the in plane birefringence remain near zero, out of plane birefringence start increasing at the time where thickness data begin to level off indicating reorientation of the polymer chains to preferably orient in the plane of the film. These types of data will be obtained to track the orientation behavior under electric field.

Ultra High Speed IR Spectroscopy / Optical Birefringence combination system (Off line)

High Speed birefringence described in the previous section is a good measure to quantify the overall optical anisotropy of the liquids and solids. However, it does not provide segment specific information. IR dichroism technique has been quite effective in tracking the orientation of individual chemical segments within complex chain structures in the past. We recently designed and constructed a hybrid acquisition system where spectral birefringence technique and IR dichroism techniques are combined. The dual beam ultra high speed scanning IR spectrometry system (Manning technologies) allows rapid acquisition of IR spectra at 1000 scans/second in two mutually perpendicular polarizations simultaneously. This instrumentation will be critical to fundamental understanding of orientation behavior of monomers, polymer segments and nanoparticles in electric field, allowing us to map the dynamics of orientation of chemical groups’ real time. These data will be helpful in correlating the material orientation and disorientation following field switch on-off, helping us to optimize formulations (e.g. viscosity control, or thermal or UV cure kinetic control through chemical alterations) and help optimize spe-
cific segments of the R2R machine (e.g. Length of the applied external field zone as well as process conditions of line speed, temperature, UV intensity etc).

**On-Line Spectral Birefringence measurement**

We recently developed a fully automated sensor system to measure the optical retardation at 10 samples/s rate and implemented on a melt casting line combined with a Machine direction stretching system. This is also based on the spectral birefringence technique mentioned earlier. As part of this proposed research, we will implement this spectral birefringence system with scanning head to continuously monitor the films produced for their optical retardation.

**Hierarchical Structure Characterization**

The structure and properties of the oligomers and membranes will be characterized using thermal analysis by differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA), dynamic mechanical analysis (DMA), X-ray diffraction (XRD), small angle X-ray scattering (SAXS), scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM) and mechanical property testing (tensile and flexural fatigue measurements) to understand the polymer structure and properties. The membranes will also be characterized by rotational small angle neutron scattering (r-SANS) in conjunction with grazing incidence small angle x-ray scattering and grazing incidence small angle neutron scattering (GISAXS/GISANS). The combination of r-SANS and GISAXS/GISANS will provide 3-D detail of the internal structure and homogeneity of nano- and microstructure of the membranes

**[B] AKRON FUNCTIONAL MATERIALS CENTER (AFMC) [Web-site under development http://www.uakron.edu/afmc/][Co-directors: Alamgir Karim and Matthew Becker, Center Co-ordinator: Katie Martin martin6@uakron.edu]**

The Akron Functional Materials Center (AFMC) is a joint initiative between the College of Polymer Science and Polymer Engineering at the University of Akron and the Austen BioInnovation Institute in Akron (ABIA). Located in the heart of The University of Akron campus and adjacent to the Polymer Engineering Academic Center in the NPIC it incorporates a multi-laboratory facility featuring state-of-the-art research instrumentation for high-throughput and combinatorial methods for rapid materials development, processing, screening and optimization. In addition, the AFMC focuses on several functional materials of strategic interest all emerging areas involving functional polymeric materials. These include energy management (capture/production, transport, storage), advanced materials for communications, biomaterials of interest to orthopedics, wound healing and tissue engineering, and in the future, nanomedicine and bioelectronics devices needs. Several levels of project engagement are possible with AFMC including open source to IP controlled projects. Current industrial members of AFMC include: The University of Akron, Austen BioInnovation Institute in Akron (ABIA), ATRP Solutions, Avery Dennison, BASF Corporation, Coloplast, DOW Corning Corporation, EXXON Mobil Corporation, Kraton Polymers, LLC, Lubrizol Corporation, Polyone Corporation, Schneller, Terumo Corporation and United Technologies Research Center (UTRC).
Brief summary of instrumentation available and under development at the AFMC include:

One and two-axis flow coater

This customized instrument is used for uniform as well as gradient coating of polymer film deposition on variety of substrates. Maximum substrate dimensions are 6" x 6". With the help of programmable accelerating stage thickness gradient of above one order of magnitude (e.g. 10 -100 nm) can be obtained on a single substrate. The stage can be programmed to generate uniform thickness as well as step and continuous thickness gradient films. Two varieties of the flow coaters include single and double axis programmable stage.

UVO wand for surface energy gradient

Any UV-ozone (UVO) sensitive substrate/polymer coating/self assembled monolayer’s can be cured or oxidized in gradient manner or uniformly using the aluminum encased UV wand with 1 mm slit opening in conjunction with an accelerating stage. The UVO exposure time and distance from substrate dictate the final surface energy/dose of the substrate. Substrates with surface energy gradients from 20-76 mJ/m² can be produced with this instrument.

Syringe pumps and composition gradient mixers

With the programmable pumps and indigenous chaotic mixer assembly, composition gradient solutions or films of two or more polymer solutions and viscous polymer / monomer mixtures / additives can be prepared. A truly combinatorial sample can be prepared using this technique in conjunction with the flow coater, UV wand or gradient heating stage.

Thermal zone annealing setup

Samples are annealed by passing them over heating and cooling zones. This indigenous method features a novel sharp heating zone that generates very sharp (>50 °C /mm) gradient zone. Samples can be annealed in vacuum or inert gas environment. It has been observed that directed morphologies can be obtained with crystalline polymers, block copolymers and polymer blend films with this setup that are inaccessible with other annealing methods.
Programmable static zone thermal oven

Several digital static thermal ovens for curing and annealing of various materials/films feature a programmable PID controller. Samples can be annealed in vacuum or inert gas environment.

Gradient heating stage with chiller

This instrumented aluminum heating rod and active liquid cooling tubing at its two ends generates controlled continuous thermal gradients. Samples can be annealed under vacuum or an inert gas environment. A thermal gradient of about 60 °C can be readily generated across the heating and cooling ends.

UV etcher

UV sensitive polymers e.g. PMMA / monomers / materials can be etched out or cross-linked with this setup. Sample chamber can be purged with inert gas or vacuum.

Solvent mixture vapor annealing with dual mass flow controllers

Homopolymer, block copolymer or polymer blend films can be annealed in specific solvent vapor environment controlled by gas mass flow controllers in a chamber, with or without heating stage and under applied magnetic field.

IR camera

This IR imaging camera is a useful tool to determine exact temperature of the sample annealed using thermal zone annealing and gradient heating stage.

Atomic Force Microscope (AFM)

The characterization of the surface topography and phase contrast is done with help of two high quality Atomic Force Microscopes (AFM): Nanoscope V and Dimension ICON with PeakForce. The latest Dimension ICON is equipped with a large stage chuck with 200mm (8-inch) diameter, which can travel 6.06 inch (X direction) by 7.283 inch (Y direction). The microscopes can operate in three modes of data collection: Contact, TappingMode, and ICON uses Force Imaging: PeakForceTM QNMTM. The PeakForce mode allows High- Resolution Mapping of Modulus and Adhesion through direct force control with indigenous features stage. It keeps indentations small for higher resolution and non-destructive imaging. The samples can be characterized with detec-
8
dition in modulus in widest operating range from soft gels (~1 MPa) to rigid polymers (>20 GPa).

Other capabilities of our AFMs compile into set of interleave scanning modes that allow measuring of: magnetic properties with Magnetic Force Microscopy, electrical properties with Electric Force Microscopy and Tunneling AFM (TUNA).

The ICON AFMA for all scanning modes is equipped with fluid cell, heating and cooling stage (controlled environment, temperature range: heater: ambient to 250°C; heater/cooler: -35 °C to 100°C), and a perfusion cell.

**Optical microscope with X-Y-Z automated stage and fluorescence and polarization attachments**

Two Olympus optical microscopes for auto-focus and automated large area imaging in programmed manner are available with bright field, dark field, FITC, TRITC etc. One of the microscopes is inverted for biological samples. More of these microscopes are available in Dr. Karim’s and Dr. Becker’s laboratories with many advanced features, available for AFMC projects.

**Texture analyzer**

A versatile tool for measuring various mechanical properties of bulk and thin film materials. Single point analysis capability makes it indispensable for gradient combinatorial samples. Measurement capabilities include work of adhesion, elastic modulus under compression or tension, peak tack, peel strength, 90 degree peel test of various adhesives. 3 and 4 point bending tests is also possible.

**Optical interferometer for film thickness and R.I. measurement**

This instrument is a useful tool for robust and ultra fast measurement of thickness and optical constants of polymer films. Samples can be homopolymers, blends, block-copolymer, multilayer or composite film in the range of few nanometers to hundreds of microns. The light source covers UV and visible spectra.

**Strain-induced elastic buckling instability for mechanical measurements (SIEBIMM)**

Measuring mechanical properties of a thin film is a big challenge due to its low strength that prohibits use of conventional mechanical testers. At the same time, nanoindentation is difficult as it is model dependent and knowledge of indenter tip shape is needed. In this indigenously developed SIEBIMM technique, polymer thin films are coated on a mechanically robust elastomeric flexible substrate with. Tensile and compression stress applied on the composite sample leads
to a unique buckling pattern of the top layer film which is used to calculate its mechanical bending (Young’s modulus) properties.

2. Institute of Polymer Science and Polymer Engineering Facilities (IPSPE)

A variety of standard and advanced instruments are available through the IPSPE. These facilities and capabilities are listed below, along with any special features.

2.1 IPSPE Facilities located at Department of Polymer Science

Advanced Microscopy Laboratory

Scanning Transmission Electron Microscope

- FEI-Philips scanning transmission electron microscope, Model Tecnai T12T/STEM
- Located in Room GDYR-108
- Accelerating voltage of 20-120 kV
- Line resolution 2 Angstrom and point resolution 3.4 Angstrom
- Magnification range of 35-600,000X
- The specimen can be tilted in two directions, around the x-axis up to ±70 degrees and around the y-axis up to ±30 degrees.
- Photomicrographs can be taken on film or recorded digitally.
- It is used in electron energy-loss spectroscopy and imaging studies.

Field Emission Scanning Electron Microscope

- Model JEOL-7401 Japan Electron Optics Laboratory (JEOL)
- Located in room GDYR-109.
- Accelerating voltage of 0.5-35 kV.
- Magnification range of 15-600,000
- Genesis X-ray microanalysis systems with EDS detector
- The specimen can be tilted up to 90° in one direction.
- The microscope is interfaced with a scanner-computer system that provides digital electron microscope images to be printed on paper.

Transmission Electron Microscope (TEM)

Vender: JEOL.
Model: JSM-1230
- 120KV illumination system
- Single-Tilt/Rotation stage
- Maximum magnification of 500K
Facilities at College of Polymer Science and Polymer Engineering

- Maximum resolution of ~1nm
- Wide range of diffraction techniques
- Genesis X-ray microanalysis systems with EDS detector
- Bottom Mount CCD camera with 2048X2048 pixels

**Polarized Light Microscope**

- Model Labophot-Pol Nikon
- Located in room GDYR-105
- Can be used to obtain photomicrographs using positive/negative Polaroid or 35mm films

**Optical Microscope**

- Olympus BX-51
- equipped with Mettler Hot Stage
- Located in room GDYR-105
- Can be used to obtain high resolution digital images and video

**Vacuum Evaporator**

- Model JEE-4C JEOL
- Located in room GDYR-105.
- Used in the preparation of specimens for transmission electron microscopy by casting carbon and metal films under high vacuum.

**High Vacuum Evaporator**

- Model DV-502A Denton
- Located in room GDYR-105.
- Used for evaporation and casting of films of carbon, metals, and dielectrics.

**Ultramicrotome**

- RMC Model CRX-PC
- Located in room GDYR-109
- Used for the preparation of ultrathin sections of polymers for transmission electron microscopy and for polishing the surface of polymer samples for scanning electron microscopy.

**Sputter Coater**

- SPI
- Located in room GDYR-105
Facilities at College of Polymer Science and Polymer Engineering

- Used to coat specimens with gold, gold/palladium or other metal before examining the specimens in the scanning electron microscope.

**Photographic Darkroom**

- Located in room GDYR-106.
- Used for developing and printing of optical and electron micrographs.

**Electronics Shop**

The Electronics Shop is located in the Goodyear Polymer Center in room GDYR-826. The shop is open to the faculty and students in Polymer Science.

The function of the shop is to provide a variety of electronic-related services, electronic maintenance of scientific equipment, and to design and fabricate specialized laboratory instrumentation as required.

**Glassblowing Shop**

The Glassblowing Shop is located in the Goodyear Polymer Center in room GDYR-205. The shop is open to the faculty and students in the Institute of Polymer Science, and to other members of the University.

**Equipment**

- Lathe – Litton glassblowing lathe – Model HTJ093
- Annealing Oven – Wilt Electric Annealing Oven – Model 200
- Wet Saw – Pistorius wet cut-off machine – floor Model M-0060
- Wet Sander - Wilt Wet Belt Sander – Model 4106

**Machine Shop**

The function of the shop is to provide mechanical maintenance of scientific equipment and specialized building systems.

- Clausing Colchester 15” lathe
- Clausing 13” lathe
- Horizontal cut off saw
- Oxygen and Acetylene torches
- Bridgeport Milling Machine
- Lincoln Electric Precision TIG/Stick 275 Amp Welder
- Vertical Band Saw

**Molecular Characterization Laboratory**
Facilities at College of Polymer Science and Polymer Engineering

GPC - Room Temperature Instrument

Typically running with THF mobile phase with two choices of detector arrangements

A. Viscotek Triple Detector operation, TriSEC
   • Waters Differential Refractometer, Model 410
   • Viscotek Viscometer, Model 100
   • Wyatt Dawn EOS light scattering@90º angle

   The PC based data system uses a Viscotek 3-detector interface and TriSEC software. Data analysis can also accommodate both universal calibration (2 detectors) and conventional calibration (1 detector) but these require that current column calibration data be on file.

B. Wyatt Multi-Angle Laser Light Scattering, MALLS
   • Waters Differential Refractometer, Model 410
   • Wyatt Dawn EOS light scattering employing 15 angles

   The PC based data system uses Wyatt ASTRA software.
   
   Note: both Viscotek and Wyatt claim absolute results for their respective approaches to molecular weight measurement.

Brookhaven Research Goniometer and Laser Light Scattering System

Supports both static and dynamic light scattering measurements (Dynamic Light Scattering, DLS also referred to as Photon Correlation Spectroscopy (PCS) or Quasi-elastic Light Scattering (QELS)).

Wyatt Dawn EOS Batch Mode Light Scattering

Weight average molecular weight determination by light scattering utilizing the Dawn EOS multi-angle instrument in batch mode in lieu of chromatography.

1. Batch Mode: the flow cell is removed and samples in solution in scintillation vials are measured directly.

2. Micro-Batch Mode: samples in solution are pumped through the flow cell.

Hewlett Packard Model 8453 UV/VIS Spectrophotometer

wavelength range 190-1100nm

Digilab Excalibur FTS 3000 series FTIR Spectrometer with Win-IR Pro Software.
Facilities at College of Polymer Science and Polymer Engineering

**Bruker TENSOR 27 FTIR Spectrometer with OPUS software.**

**Rame-Hart Model 500 Advanced Goniometer with DROPimage Software**
Measurement of interfacial tension and contact angle by image analysis.

**Malvern Instruments Zetasizer Nano-ZS90 and MPT-2 Titrator**
Particle size measurement and zeta potential.

**TA Instruments Model Q2000 DSC**
With LNCS liquid nitrogen cooling accessory for use down to –180°C.

**TA Instruments Model Q500 TGA**

**Knauer Membrane Osmometer**

**Knauer Vapor Pressure Osmometer**

**Wescan Recording Osmometer**

**Perkin-Elmer LS-5 Fluorescence Spectrophotometer**

**Mettler Toledo AX105 Delta Range Balance**
Max 31/110 g, d=0.01mg/0.1 mg.

**Magnetic Resonance Center**

The University of Akron Magnetic Resonance Center (MRC) is a jointly managed facility between the Department of Chemistry, the Institute of Polymer Science and Polymer Engineering and other departments. The Center consists of 9 NMR systems ranging from 200 MHz to 750 MHz, and is located in Knight Chemical Lab and Goodyear Polymer Science buildings. For details of the center, check:

The following three instruments are available in the Goodyear Polymer Center 103A.

**Varian NMRS 500 (5 ch)**

This is a Research grade 5 channel instrument equipped for double and triple resonance experiments in both solids and liquids. It includes a suite of probes to do essentially every useful permutation of triple resonance experiments, including 1H/13C/X (where X covers essentially the entire range of nuclear resonance frequencies). The instrument was purchased to
perform diffusion experiments with high gradient strengths (120 Gauss/cm), and very high temperature (up to 250 deg. C) solution and solids experiments.

**Varian NMRS 500**

This is a Research grade 2 channel instrument for H/X double resonance experiments. It is equipped with a robotic sample changer, auto-tune and auto-shim capabilities for continuous unattended instrument optimization and operation. This instrument's configuration will alternate between robotic operation of 10- and 5-mm dual broadband probes (based on demand).

**Varian MERCURY 300**

This NMR instrument is a 300 MHz spectrometers equipped to observe 1H/19F and 13C/31P. In addition to routine 1-D 1H and 13C spectra, homo- and heteronuclear decoupling, APT, DEPT, COSY, HETCOR (Heteronuclear shift correlation), homonuclear-2DJ, NOE Difference and saturation experiments etc., can be performed.

### 2.2 IPSPE Facilities located at Department of Polymer Engineering

**Extensive Compounding, Microscopy, Thermal, Scattering Facilities**

- 2 Compression Presses
- 2 Drill Presses
- 2 Roll Mill
- 28 Ton VanDorn INJECTION MOLDER
- 3 Brabender Mixers
- 35-TON VACUUM COMPRESSION PRESS
- Acetylene Torch
- Advanced Vacuum Systems Vacuum Chamber
- Aerogel Apparatus
- Akron Milacron S Pak 100 Single Screw Extruders (2)
- ARES Rotational Rheometer with LN2 Capability
- Atlas Weatherometer
- Battenfeld 80 Ton INJECTION MOLDERS
- Biaxial Stretcher
- BOHLIN-ROSAND RH2100 Capillary Rheometer
- Bridgeport EZ Tech CNC Mill
- Brookfield DVII+ Pro Viscometer
- Bruker AXS X-Ray
- Carver Compression Press
- CH Instruments Electromical Workstation
- Clausing Lathe
- Composite Machines Lathe
Facilities at College of Polymer Science and Polymer Engineering

CRYO ULTRAMICROTOME
Dayton Shear Brake
DSM MicrInjection Molder
Dynatup Impact Tester
Edwards Sputter Coater
Electrospin Station
Espec Temperature/Humidity Chamber
Farrell Banbury Mixer
Film Casting Line
Filmetrics Sample Camera
Forced Air Oven
GE X-Ray
Gemini Rotational Rheometer
Glove Box Train for manufacture of Prototype Solar Cells
Haake MINILAB MICRO COMPOUNDER
HP Impedance Analyzer
HYDRAULIC LAB PRESS MODEL 25-12 HC
Illinois Instruments OXYGEN PERMEATION
IMS 5 Gal Tumbler
Indusco Punch
Instron 1000 Tensile Tester
Instron 4204 with Temperature Chamber
INSTRON MODEL 5567
Iwamoto Bi-Axial Stretcher
Jet Cleaner
Keithley 4 point conductivity Probe
KO Lee Surface Grinder
Labconco Glove Box
Laborlux Microscope
Laborlux Optical Microscope with video System
Lambda Physik LPX200 Laser System
Laser Table
Lincoln Electric Welder
Logan Lathe
Machine Shop
Magneto Optical Instrument
Manual Bridgeport Mill
March Plasma Systems Plasma Coater
MaxiBlast Media Cleaning Cabinet
MER Mechanical Fatigue Tester
MESSER C KNIFEMAKER
Micromeritics TriStar II BET Instrument
Millermatic 252 Welder
Miter Band Saw
MOISTURE Balance OMNIMARK
Neuport Aire Table + Laser
Facilities at College of Polymer Science and Polymer Engineering

NICOLET 380 FT-IR SPECTROMETER with Microscope
Nikon Microscope
Nikon UM2 Microscope
Nordson Spray Booth
Novascan PSD Digital UV Ozone System
Novatec Resin Drier (2)
NuArc Metal Halide Imaging System
OLYMPUS BX51 OPTICAL MICROSCOPE
Olympus Microscope
Olympus Microscope
Olympus Microscope
Parr Pressure Reactor
Pelletizer
Perkin Elmer DIAMOND DMA
Perkin Elmer DSC
Perkin Elmer DSC7
Perkin Elmer TGA7
Perkin Elmer TMA7 Thermomechanical Analyzer
Powermatic Band Saw
Q200 MODULATED DIFFERENTIAL SCANNING CALORIMETER
Quantachrome Ultrapync 1200e
Quantum Design 600 Magnetic Property Measuring System
Quesant Scanning Probe Microscope
R&D Parts Washer
Raman Microscope
Rame Hart Contact Angle Goniometer
Rand Castle Micro Film Extruder
Rheometrics RMS800 Rheometer
Rigaku X-Ray
RMS 800 Rotational Rheometer
ROSAND RH7 CAPILLARY REHEOMETER
Schwabenthan Polystate 200 Press
Scribner Fuel Cell Test Station
SINGLE SCREW Extruder
Single Screw Extruder Attachment for Brabender
Small angle Light Scattering
Strand Grinder
Surface Profiler
Szegvari Attritor Media Mill
TA DSC 2920
TA Instruments Thermogravimetric Analyzer Q50
TA Instruments G2 ARES with LN2
TA Instruments Q 800 Dynamic Mechanical analyzer
TA Instruments Q2000 DSC
TA Instruments Q500 TGA
TA TGA Model 2050
Facilities at College of Polymer Science and Polymer Engineering

Taber Abrader
Taber Abrader
Thermo Haake Mini Lab
Thermo Prism Twin Screw Extruder
TURBO SPUTTER COATER
Twin Screw Extruder (2)
Ultrasonic Assisted Extruder
Ultrasonic Assisted Film Caster
Uniaxial Mechanical Electro Optical Film Stretcher
US Stoneware Ball Mill
Van Dorn 55 Ton Injection Molder
Varian CP3800 GC
VEECO AFM
VISCTECH MOONEY VISCOMETER
Walk in Despatch Oven
Waters HPLC System
Wayne BLOWN FILM LINE
Weima Grinder
Winsmith 50 Gallon Tumbler
Woolam Ellipsometer
Zwick Abrader

4. The Applied Polymer Research Center (APRC)

The Applied Polymer Research Center (APRC) is a contract services facility operated by The University of Akron's College of Polymer Science and Polymer Engineering located at the Department of Polymer Science. We have been serving the industrial community, especially rubber and plastics, for over 50 years.

The Center currently performs 300-400 projects a year, under complete confidentiality to the client. Projects are generally initiated and completed under a purchase order agreement.

With a full-time professional staff, and a half-million dollar inventory of modern instrumentation, the Center is dedicated to performing sophisticated and timely contractual technical services for industrial and government clients. In addition to dedicated resources maintained by the Center, the laboratory has access to highly sophisticated instrumentation through the College of Polymer Science and Polymer Engineering, and will interface with a staff of over 30 highly specialized faculty to solve more complex polymer related problems.

Our goal is to test your materials and provide analysis of the data that is meaningful to your business. Give us a call and we will discuss your needs! Our instrumental facilities are listed below:
Facilities at College of Polymer Science and Polymer Engineering

Chromatography Instrumentation

- HPLC: Varian Model 240 High Pressure Liquid Chromatograph
- GC: Varian CP-3800 Gas Chromatograph
- GC/MS: Thermo Fisher Focus DSQII
- GPC: Waters 515 Pump with 2414 Refractometer for THF/DMF/Toluene

Infrared (IR) Spectroscopy Instrumentation

- Thermo Electron Nicolet 4700 Fourier Transform Infrared Spectrophotometer
- SensIR Technologies DuraScope ATR

NMR Instrumentation (available in collaboration with the Molecular Spectroscopy Laboratory)

- 1 - Varian INOVA 750 MHz (Solid + Liquid)
- 2 - Varian NMRS 500 MHz (Solid + Liquid)
- 1 - Varian INOVA 400 MHz (Liquids)
- 2 - Varian Mercury 300 MHz (Liquids)
- 1 - Varian INOVA 200 MHz (Solids)
- 1 - Chemagnetics 200 MHz (Solids)

Miscellaneous Equipment

- Mettler Toledo DL31 Water Analyzer
- Buchi Rotavapor
- Melt Flow Index Instrument
- Brookfield Viscometers

Thermal Analysis Instrumentation

- DSC: TA Instruments Q200 Differential Scanning Calorimeter
- TGA: TA Instruments Q50 Thermogravimetric Analyzer
- DMA: TA Instruments RSA3 Dynamic Mechanical Analyzer
- DMA: Rheometrics Mark V Dynamic Mechanical Thermal Analyze
- Melt flow index Dynisco Polymer Test

Instrumentation

- Instron Tensile Test Machine Model 5567 - Load Cell Range to 6500 Lbs
- Alpha Technologies T-10 and T-2000 Tensiometers
- Rex Digital Durometers with Computer Interface - Shore A, C
Rubber Mixing, Characterization and Testing Equipment

- Midget Banbury - 225 grams (1/2 #)
- Mooney viscosity: Alpha Technologies MV 2000
- Cure rheometry: Alpha Technologies MDR 2000
- Advanced Polymer Analyzer Model 2000
- Brabender Intelli-Torque Plasti-Corder
- Wallace Rapid Plastimeter
- 2 Roll Rubber Mills

5. The Akron Polymer Training Center (APTC)

The Akron Polymer Training Center (APTC) is the training division of the College of Polymer Science and Polymer Engineering. Poised to meet the needs of our changing environment, the center strives to be the world's leading provider of effective workforce development and training. The University of Akron’s 18,500-sq ft. Akron Polymer Training Center (APTC) is both a teaching and conference facility, serving the region’s academic and industrial needs.

Our equipment and resources are listed below:

Rubber Equipment

- Hunter hydraulic press, 30 tons
- Wabash compression press, 25 tons
- TMI flex tester
- Relco die cutter
- Wilson Rockwell hardness tester
- TMI tear testing machine
- Monsanto capillary rheometer
- Denver XL-3100 gram scale
- Mettler HK 160 gram scale with shield
- Monsanto T-10 tensometer
- QUV accelerated weathering tester
- MacBeth lablite
- Ray-Ran melt indexer
- TMI notching cutter
- Taber #5130 abrasion tester
- RX-86 sieve shaker
- TMI izod impact tester
- O Haus gram scale
- Tinius Olsen stiffness tester
- Fisher Johns melting point tester
- Denver instrument moisture analysis
- Lindberg / Blue M oven
- 12" rubber cutter
Facilities at College of Polymer Science and Polymer Engineering

Rubber City Machinery, 2 Roll Mill, Variable Friction Ratio
Reliable 2 Roll Mill, Variable Friction Ratio
1.67 Liter Banbury Internal Mixer
24”x24” Automatic Heated Press, Custom Built
18”x18” Automatic Heated Press, RCM
2” Rubber Extruder
Qty 2, Monsanto R100 Oscillating Disk Rheometers (1 working)
Monsanto Mooney Viscometer
Atom Hydraulic Sample Cutter
Alpha Mooney Viscometer
Alpha Moving Die Rheometer
Aluminum Block Oven
Large Oven
Alpha Tensiotometer
Huang Drum Abrader
12”x12” Carver Heated Press, Manual
6”x6” Carver Heated Press, Manual
Monsanto T10 Tensiometer (not working)
Monsanto T2000 Tensiometer (working but not used, no longer supported)
DeMattia Flex Tester (working but dangerous)
Water Chiller and TCU for Mills, Internal Mixers and Extruder

Plastics Equipment

IMS, 2-1/2 ton chiller
Orbit vacuum former
3” puller
Akron Milicron Single Screw PAK 350 Extruder
Spare two-stage screw for 2-1/2” NRM
Small water cooling trays
2” Berlyn pelletizer
Single station Sterlco
IMS dual station Sterlco
Barrel tumble device
170 ton Van Dorn injection molding machine
85 ton Van Dorn injection molding machine
IMS desiccant dryer
Granutech grinder
PPE dehumidifying dryer
A-frame and 1 ton hoist
Small lab size vacuum loaders