

Facilities, Equipment and Other Resources

TEXAS STATE UNIVERSITY

Laboratory

The Ingram School of Engineering, Texas State University has state-of-the-art laboratories in the areas of ‘Maker Space’, ‘Advanced Composites Lab’, ‘Additive Manufacturing Lab’, ‘Robotics’, ‘Microelectronics Manufacturing: Clean Room’, ‘Ceramics Engineering’, ‘Foundry and Metal Casting’, and ‘Material Testing’. The equipment in these labs can be viewed at the link: <https://www.engineering.txstate.edu/Facilities.html> and <https://www.txst.edu/technology/facilities.html>

Software

Specialized software available includes TRIOS used for data analysis on TA Instrument’s thermal characterization equipment; Creo and Solidworks used for 3D CAD modeling and simulation; Multi-purpose Testware used for data acquisition and analysis for MTS Corporations’ 810 Material Test System; CeastVIEW 5.94 5E for data acquisition and analysis for Instron/CEAST 9340 low-velocity impact system; and ANSYS used for FEA of 3D models.

A short description of the equipment and specifications in these labs is listed in this document (pages 2-8).

1. Advanced Composites Lab: <https://composites.engineering.txst.edu/about.html>
2. Maker Space: <https://www.engineering.txst.edu/makerspace.html>
3. Analysis Research Service Center (ARSC): <https://sro.txst.edu/sro-facilities/sro-arsc.html> .

1. ADVANCED COMPOSITES LAB

This is Dr. Jitendra Tate's lab which has state-of-the-art equipment for processing (sonicator, high shear mixer, three roll mill, ball mill, and centrifugal planetary mixer), fabrication (fully automatic compression press, vacuum assisted resin transfer molding (VARTM), and prepreg calendaring machine), and characterization (MTS Servohydraulic test system, Instron low-velocity impact, MTS Exceed test system, United test system, Thermomechanical analyzer-TMA, Simultaneous DSC/TGA (SDT), Viscometers, Optical microscope, and UL-94 fire test setup) of advanced composites. The lab capabilities can be viewed at: <https://composites.engineering.txst.edu/equipment.html>

Major Equipment at Advanced Composites Lab (Ingram Hall 1308 and 1202F)

CHARACTERIZATION

MTS (Material Test System) Corporation, Servo Hydraulic Test System, Model: 810 system, FlexTest SE Controller – PLUS

This MTS Servo Hydraulic Test System used to evaluate mechanical properties under tension, compression, flexure, shear, interlaminar shear, fracture, and fatigue loading.

Specification: Loading Capacity-100KN
 Clamping Pressure- 3000psi
 Range of Frequency- 0-100

MTS Exceed Series 40 electromechanical load frames (10kN)

This MTS Exceed Series 40 electromechanical load frames is ideal for performing accurate and repeatable monotonic testing on specimens ranging from thin film plastics to composites and alloys.

Specification: Force Capacities-5N to 600kN (load, position, strain control)
 Maximum test speed: 508 mm/min (20 in/min)

UNITED Deluxe SMART Table Model Electromechanical Testing System (50 kN)

Within its particular classification, each UNITED testing system is designed, engineered and guaranteed to deliver the performance and results required by applicable ASTM, DIN, AFNOR, ISO, contractor or government test specifications.

Specification: Force Capacity: 50 kN
 Crosshead Speeds: 0.0017 to 500mm/min

Instron CEAST 9340 Drop Impact Test System (low velocity impact)

This equipment is used low velocity impact tests on plates, film specimens and tridimensional parts of plastics and composite materials. Instrumented tests give details from initial contact to final breaking of specimen with impact force/energy vs time curve.

Specification: Max. Energy- 0.3-405J
 Max. drop height- 0.03-1.1m
 Max impact velocity- 0.77-4.85 m/s

TA Instruments Thermomechanical Analyzer, Model: Q400EM

Thermomechanical Analyzer is an analytical instrument used to test physical properties of many different materials. The TMA instrument works in conjunction with a controller and associated software to make up a thermal analysis system. Generally it used for measurement of coefficient of thermal expansion.

Specification: Temperature range: -150° to 1000°C
 Force range- 0.001 to 2N

TA Instruments Discovery SDT 650 - Simultaneous DSC-TGA

The new Discovery SDT 650 provides a true simultaneous measurement of heat flow (DSC) and weight change (TGA) on the same sample. A heat flux DSC design with separate sample and reference pans is used and is calibrated for heat flow measurements using sapphire.

Specifications: Vacuum: 50 micro-Torr
Temperature Range: Ambient to 1500 °C
Sample Weight Capacity: 200mg

VISCOTESTER and REHEOMETER

The Thermo Scientific HAAKE Viscotester units can be used for tests and comparative measurements for quality control according to recognized standards. The HAAKE Viscotester is a classical rotational viscometer that measures the resistance of a test substance against a pre set speed. The resulting torque or resistance measures the viscosity of the fluid. The higher the torque, the higher the viscosity. Due to the standardized geometry, the shear rates generated can only be determined precisely for Newtonian substances.

HAAKE VISCOTESTER DL – VERSION

Specifications: Viscosity Range: 15 mPas – 2,000,000 mPas
Spindles L1 to L4

<https://assets.thermofisher.com/TFS-Assets/MSD/Specification-Sheets/AN53357-viscotester-e-d-c-product-specifications.pdf>

HAAKE VISCOTESTER 7 R+

Specifications: Viscosity Range: 20 mPas – 40,000,000 mPas
Spindles R1 to R7

<https://assets.fishersci.com/TFS-Assets/CCG/EU/Thermo-Scientific/brochures/Viscotester%20brochure.pdf>

HAAKE Viscotester iQ Rheometer

PROCESSING

Wabash, Inc. Fully Automatic Hydraulic Compression Press Model G30H-18-C

Wabash Hydraulic Compression Press used for making compression molding of composites, plastics, and rubber parts. The hydraulic system produces faster closing and opening speeds, making it ideal for use with many of today's advanced molding compounds.

Specification: Clamp Force- 0 to 30 ton
Size of platens- 18"×18"
Max. Temperature – 500°F

Mini-Jector, Inc. Tabletop Plastics Injection Molding Machine, Model 55 (4 oz)

This is small injection molding machine mainly used for instructional purposes and to produce dogbone plastics specimens for tension testing.

Specification: Clamping Force- 11.75 tons
Max. Operating temperature- 700° F
Shot Capacity- 1 oz/cycle

Thermo Electron Corporation, Single screw extruder, Model: Haake PolyLab OS Rheodrive 4

Common applications of such a device are for extrusion of thermoplastic compounds on a variety of constant cross sections such as cylindrical or thin films. Rheological testing and characterization of such materials is the

primary purpose of this machine. Two different screws and two different extruding dies (1 & 3 mm) are available. This machine is equipped with a metering feeder for variable rate stock input into the melt chamber.

Specification: Max. speed- 250 rpm
 Max. torque- 160 Nm
 Max. operating temperature- 450 °C.

Thermo Electron Corporation, Twin screw extruder, Model: Process 11

The compact co-rotating 11mm twin screw extruder is designed with a unique monocoque housing that is suitable for compounding thermoplastic polymers. In addition to its water cooled primary feed port it contains 3 multifunction barrel ports for additional feeding and venting. Its barrel is separated into 8 sections to facilitate temperature profiles.

Specifications: Throughput: 2.5kg/h
 Barrel Length: 40L/D

Conair, SL2.5 - SlimLine Series Desiccant Dryer

SlimLine™ dryers use a continuous supply of clean, dehumidified compressed air at 100 psi {6.9 bar} to dry material. The standard dryer produces a dewpoint of 0°F {-18°C} which is sufficient for most drying applications. Units are capable of delivering nominal throughput rates ranging from 0.25 {0.11} to more than 50 lb/hour {23 kg/hour}.

Specifications: Drying Temperature: 38° - 177°C
 Hopper volume ft³ {L}: 0.125 {4}

Dispersion of Nanoparticles: The following equipment is used for the dispersion of nanoparticles such as nano clay, nanographene (NGP), and multiwall carbon nanotubes (MWCNT) in polymer resins.

Sonics and Materials, Inc., Sonicator, Model: Model: VCX 750

This device is an ultrasonic processor used to exfoliate and disperse nano-particles within a liquid polymer. It can output up to 750 W of power, at a maximum vibrational frequency of 20 kHz. It is possible to process volumes of liquid from 250 mL up to 1 L.

THINKY, Japan, Planetary centrifugal mixer (with vacuum), Model: ARV-310

The primary use of this device is to mix initiated resin at atmospheric pressure or under vacuum pressures. The unit can operate from 200-2000 RPM, and can achieve vacuum pressure of 5 torr.

EXAKT 50i Three Roll Mill, Aluminum Oxide and Chrome Plated Hardened Steel Rollers

The EXAKT 50 I is a small batch producer with small three roll mill frame offers the ability to disperse a wide variety of products. This unit has specific controls for energy input and output to achieve homogeneous particle sizes and distributions in the matrix.

Specifications: Throughput: 0.02-7 liters/hour
 Roller length: 150mm
 Motor Power: 0.15 kW

IKA® Labor Pilot 2000/4 Shear Mixer(DR configuration)

The LABOR-PILOT is designed for solid-liquid mixing, homogenizing, emulsifying, suspending and wet milling. It is suitable for wide range of applications, particularly in the chemical, cosmetic, pharmaceutical, plastics, colours and food industries; with six interchangeable modules. This device is a mechanical mixing device used primarily to disperse nano-particles within a liquid polymer. The machine can operate at 3160-13750 rpm, at a maximum product temperature of 120 °C. Machine specifications cite an output of 350 liters/h product output. In-hopper secondary mixing is also possible with IKA RW20 mixer with digital control.

Specifications: Flow Rate (max.): 300l/h
 Tip Speed: 23.5 m/s
 Motor Power: 1.5 kW

The following are **Commercial Off-the-shelf 3D Printers** that will be used to print test samples of the newly developed thermoplastics nanocomposites.

Lulzbot 3 D Printers (Commercial Off-the-shelf) – 3 printers

The Lulzbot 3D printer are integrated with automatic bed leveling systems, all metal LulzBot v2 Hot Ends, and heated PEI print surfaces. Perfect for both large and small objects, the heated PEI build surface keeps your 3D printed objects in place when hot and releases when cool. It is also compatible with a large variety of different materials.

Specifications: Top Print Speed: 200 mm/sec
 Layer Thickness with 0.5 mm nozzle: 0.050 mm to 0.5 mm
 Print Area: 280 mm x 280 mm x 250 mm

1. One printer dedicated to high-temperature materials such as PEEK and PEKK
2. One printer dedicated to Magnetic Field Assisted Additive Manufacturing-MFAAM
3. One printers dedicated to general materials

Stereolithography SLA Printer mUve 3D LCD 2K Pro

The mUve 3D 2K Pro is an LCD-based Open-source, table-top stereolithography printer package. It utilizes a high-output LED array with a parallel lens system bringing the strongest UV delivery possible on a 5.5” output. Open electronics and Rasberry Pi 3 main system running nanoDLP make it customizable and upgradeable. Hence, it is perfect to work with almost all custom resins.

Specifications: Printing Dimensions: 121mm x 68 mm x 200 mm @47.25 microns X/Y
 Layer Thickness: 0.05mm-0.3mm
 Exposure Time: ≥2.5s/layer
 Z-Axis: 12mm Ball Screw

Clay Printer

VormVrij® Company’s LUTUM® 4M is an open form, 3-axis benchtop printer with an auger-fed nozzle, the only dedicated 3D clay printer with a stable and variable output, quick cartridge change, Hiwin mechanics, plus Iigus chainlink and data cables that are built from heavy 4 mm thick powder coated steel parts for maximum print stability.

Specifications: Build volume: 25 x 25 x 40 cm.
 Extruders: 18/10 Stainless Steel Screw and Nylon barrel
 Printing volume: 250x250x400mm LWH
 Nozzle diameter: 3mm standard
 Layer resolution: min 0.5mm - max 3mm
 Max speed: 150mm / s with accelerated velocity printing.
 Materials: earthenware, stoneware, refractory clays etc.

These sites have additional info: <https://vormvrij.nl/lutum/products/lutum-4m/> ; <https://vormvrij.nl/download/datasheets/datasheet-LUTUM-4M.pdf> ;
<https://www.voxelmatters.com/vorm-vrij-launches-new-lutum-m-series-clay-3d-printers/>

3. Ingram Hall Makerspace comes under the Ingram School of Engineering.

<https://www.engineering.txst.edu/makerspace.html>

Ingram Hall Makerspace is housed on the first floor of Gloria and Bruce Ingram Hall on Texas State University Campus. Figure 1 shows the general layout of the Ingram Hall Makerspace in IGRM 1201 and 1202.

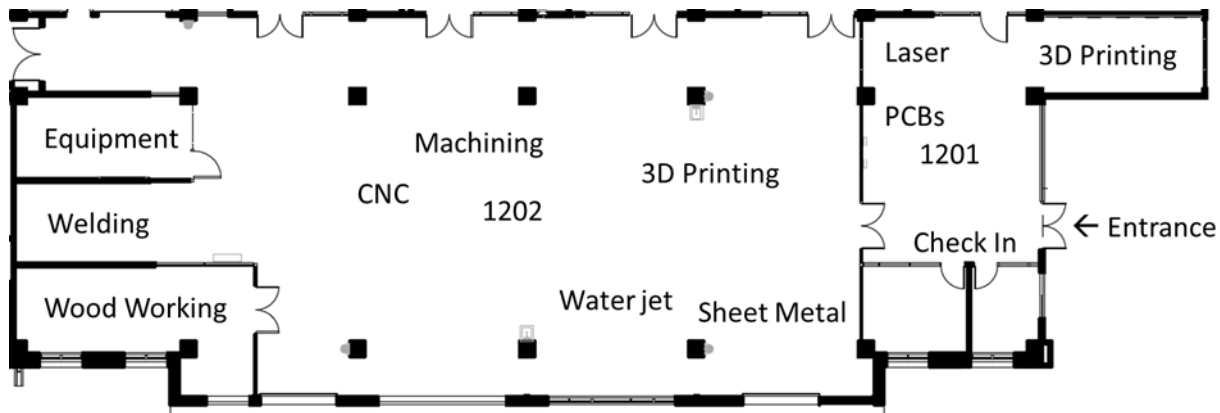


Figure 2: General Layout of Ingram Hall Makerspace

This combined space is over 6,000 square feet. The Ingram Hall Makerspace also has large roll up doors on the window side of the space, leading out to a patio area. The roll up doors will make it easier to bring large items and equipment in and out of the space. Some of the equipment will be on casters and can be rolled out the large roll up doors onto the patio area to add additional work space as needed.

Machining and 3D Printing

- Z-Corp 450 Colored Rapid Prototyping Machine
- HASS VF-3TR CNC Mill
- ST-30Y HASS CNC Lathe
- HAAS MiniMill
- PRSalphac CNC
- Tormach PCNC 440 Mini mill
- HAAS SL10 CNC lathes.
- Plasmacam: 2D CNC plasma cutter
- Metal Cutter Series Compact Fiber Laser
- 3D systems Invision rapid prototyping machine.
- 48 Craftbot XL 3-D Printers
- 12 Craftbot Three dual head 3-D Printers
- Wardjet model Z45 abrasive waterjet cutter
- ERECTORBOT 3D PRINTER EB644 - 6'x4'x4'
- Portable Paint booth SPB52F
- Laser Scanner

Wood Shop

- 3D systems Invision rapid prototyping machine.
- Jet Oscillating Spindle Sander Model 708404
- Table saw Model CNS175-TGP52
- Floor Standing Drill Press
- 13-1/2 Inch Throat Cap, Step Pulley Vertical Bandsaw and extra blades Model 414500

- Belt and disk sander Model 708599K and Scroll Saw with Stand Model 727200K
- 12 Inch Disc Sander with Open Stand
- 12 Inch Sliding Dual Bevel Compound Miter Saw Model 707120
- Closed Stand Planer/Molder Model 708524
- 12" Planer/Jointer Model 708475
- Belt and disk sander

Metal Working

- Metal / Wood Vert Bandsaw
- Horizontal/Vertical Band Saw
- Abrasive Chop Saw and Cutoff Wheel
- Circular Cold Saw & Coolant & extra blades
- 20" Variable Speed Drill Press
- 10" Grinder and stand
- 10" Wire Wheel/Grinder and stand
- Metal Belt Sander
- 15 Ton Hydraulic Press
- 8" Buffer and stand and extra buffing wheels
- Abrasive Blast Cabinets
- 5 Station Hydraulic Ironworker
- Tube Bender
- Slip Roll Machine
- Sheet Metal Break
- 24" Planishing Hammer
- Sheet Metal Shear
- English Wheel
- Ring Roller

Welding

- MIG Welder
- Bench Oven with storage unit and exhaust adaptor
- Electric Arc Welding
- Hand Plasma Cutter
- TIG welder
- Oxy/Acet Torch

Equipment in Machine Shop

- Lathe: JET Equipment and Tools
- Mill: JET Equipment and Tools, turret milling machine Model #JTM-4US
- Press Drill: Wilton, Type 20606
- Horizontal Mill: Milwaukee, Model H
- Shaper: Smith & Mills
- Bench Grinders