

1. Pls Own Lab Facilities

1.1. Fabrication facilities and equipment

The equipment in the clean room is listed as follows:

- *Thermal processing*
 - 1 Diffusion furnace set (Thermco 4000 4-tube furnace)
 - 1 Alloying furnace
- *Deposition & etching*
 - 1 Sputter
 - 1 Thermal evaporator
- *Lithography*
 - 3 Mask aligners (1 Karl Suss MJB 3 and 2 Cobilt)
 - One home-built imprinter with alignment function
 - 3 Hot plates
 - 2 spinner coaters
- *Imaging and metrology*
 - 1 Imaging shearing microscope w/video system (Vickers)
 - 1 Inspection microscope
 - 1 Ellipsometer (Gaertner)
 - 1 Surface profilometer (DEKTAK)
 - 1 Digital scanning electron microscope (Amray)
- *Miscellaneous*
 - 2 Deionized water production system
 - 4 Wet chemistry stations
 - 4 Laminar flow hoods
 - 1 Sectioner (Philtex)
 - 1 Spin rinser/dryers (Laurell)
 - 1 Portable X-ray diffractometer
 - Wafer storage boxes, chemical safety cabinets, safety shower, etc

It is worth noting that UMass has approved construction of a new class 100 clean room in the 1800 sq ft among the 3000 sq ft space. The design phase has finished and the project is expected to start in early Dec. 2015 and finish in summer of 2016. Also approved is purchasing of the following major new equipment through the Massachusetts Life Science Center:

- Evaporator
- Sputter minicluster
- Deep reactive ion etcher
- Reactive ion etcher
- Wafer bonder
- Electroplating
- Optical microscope with interference prism.

The procurement department at UMass is working with vendors in placing the orders. This process is synchronized with the progress of clean room construction. Upon completion, part of the fabrication equipment in the old 900 sq ft clean room will be moved into the new space. The equipment budgeted through the Massachusetts Life Science Center will be open for other users as well.

1.2. Electrical Measurement Equipment (some shared with Dr. Yang):

- MMR Variable Temperature Microprobe System (Testing device with 4 probes under Temperature range of 70K-730K, Vacuum or Different gas environments)
- Two general purpose probe stations: Semiprobe wafer probe station with high power compound microscope, temperature stage (ambient to 200 oC, ± 0.5 oC accuracy), 4 tri-axial probers and procard adapter
- Keysight B1500A with four High Resolution Source Monitor Units (B1517A)
- Keysight B1500A with four Mid Power Source Monitor Units (B1511B)
- Keysight B1530A Waveform Generator/Fast Measurement Unit (10ns, 200 MSa/s)
- Keysight MSOX3104T Oscilloscope: 1 GHz, 4 plus 16 Digital Channels
- Semiprobe wafer probe station with high power compound microscope, temperature stage (ambient to 200 °C, ± 0.5 °C accuracy), 4 tri-axial probers and procard adapter.
- HP/Agilent 4156B Precision Semiconductor Parameter Analyzer with 4 high resolution SMUs, 2 VMUs and 2 VSUs.
- Agilent 8133A 3 GHz Pulse Generator that provides pulses with programmable period from 333 ps to 30 ns, full 3 GHz pulse capability on all channels (rise time <60 ps)
- Agilent 33250A pulse generator, with minimum 8 ns pulse width and 5 ns edge time
- Agilent 54855A 20 GSa/s 4-Channel Infiniium Oscilloscope (6 GHz Bandwidth)
- Agilent 4275A multifrequency LCR C-V meter
- Tektronix 576, Tektronix 370A curve tracers.
- Several function signal generators
- Several Agilent / HP 34401A Digital Multimeters
- Several DC power supplies
- Several voltage and current source meters.
- 3 lower-end wafer probe stations (Wentworth, etc.)
- 1 four-point probe (VEECO FPP-100)
- 1 Semiconductor compound tester (HP 4061A)
- 1 Mercury probe for in-process MOS testing (MS1)

1.3. Physical Characterization Tools

- *Magnetic property Measurement Systems (MPMS XL7)*
 - Support of all measurements: AC, DC, Reciprocating Sample;
 - Minimum continuous operating temperature: 1.9K;
 - Maximum magnetic field: 7 Tesla.
- *Perkin Elmer Diamond Differential Scanning Calorimetry (DSC):*
 - Scanning rates (0.01 to 500 oC/min);
 - Temperature range -170 to 730 oC (0.1 oC accuracy and 0.01oC precision)
- *Perkin Elmer Pyris 1 Thermogravimetric Analyzer(TGA):*
 - Microbalance: Sensitivity: 0.1 μ g, Accuracy: 0.02% Precision: 0.001%;
 - Temperature range 20 to 1000 oC (0.1 oC accuracy and 0.01oC precision)

2. Shared Facilities on UMass Amherst Campus:

Clean room at the Center for Hierarchical Manufacturing (CHM) at UMass Amherst, located in the building of Conte National Center for Polymer Sciences; the shared measurement facility in Marcus 4; and shared physical characterization facilities in Conte building.

2.1. Fabrication facility

There is a 1,400 sq. ft., class 100 clean room at CHM with the following equipment (categorized by the functionality). There are also another two soft all clean room with a total area of about 650 sq. ft. in the same building.

- *Deposition and etching*
 - AJA International Orion 8 Sputtering System
 - CHA Electron Beam Evaporator with Cryopump
 - Cambridge Nanotech Atomic layer deposition (ALD)
 - STS Vision 310 PECVD System
 - STS Vision 320 RIE System
 - March Instruments PM-600 Plasma Treatment System
 - Wafer Etching Hood
- *Lithography*
 - JEOL JSM-7001F E-beam Writer
 - Suss MicroTec MA6 Mask Aligner
 - OAI 1000 Watt DUV Exposure System
 - Brewer Science CEE 100CB Spin Coater
 - Blue M Convection Oven
 - Developer Hood
- *Metrology & Imaging*
 - Gaertner L116C Ellipsometer
 - Dektak 3 Profilometer
 - Olympus BH2 Microscope with Infinity 2 Digital Camera
 - Nikon Optophot Microscope with Infinity 2 Digital Camera
 - JEOL JSM-7001F SEM (same as for EBL)
- *Other Chemical hoods*
 - Laminar Flow Bench
 - Solvent Rinse Hood
 - Wafer Cleaning Hood (RCA cleaning)
- *Nanoimprint Lab*
 - Nanonex Nanoimprinter (NX-2000)
 - Molecular Imprints (IMPRIO 55)

2.2. Shared Measurement Equipment in CHM

- Wentworth MP-2300 Probe Station
- Keithley 4200 SCS Parametric Analyzer

2.3. Shared Measurement Equipment in Marcus 4

We purchased the following electrical measurement equipment through the Mass Life Science Center, which are fully functioning. We have full access to them.

- *Cascade probe stations*
 - Cascade SUMMIT 12000B-M Semi-Automatic Station Platform, with MicroChamber.
 - Cascade SUMMIT 11000B-AP Manual Station Platform, with MicroChamber, AttoGuard, and PureLine Technology.

- *Wire bonder (2 units)*
- *Agilent measurement equipment*
 - Oscilloscope, 4+16 channel, 1 GHz (4 units)
 - Infiniium MSO - 4 GHz, 10/20 GSa/s, 4+16 Ch
 - Probe Amplifier - InfiniiMax, 3.5 GHz with connectivity kits (2 units)
 - 10 MHz to 67 GHz PNA-X network analyzer with accessories
 - Tx/Rx mm-wave modules that extend up to 1.1 THz through several stages (2 units for each stage)
 - PSG analog signal generator
 - PXA Signal Analyzer
 - 10 MHz to 26.5 GHz SNS Noise Source
 - Function/Arbitrary Waveform Generator, 80 MHz (3 units)
 - Banana - Triax Adapter for 4-wire (Kelvin) connection (10 units)
 - Power Sensor, 50 MHz to 50 GHz, -70 to -20 dBm
 - Waveguide Power Sensor, 75 to 110 GHz, -30 to +20 dBm
 - Handheld Digital Oscilloscope, 200MHz (2 units)
 - LCR Meter, 3 GHz
 - Logic Analyzer, 204 channel, 4 GHz timing, 250 MHz state, 1 M depth
 - 17-channel single-ended flying leads probes, connects to 40-pin LA cable (12 units)
 - DC power supply. Triple output: 0- +25V, 0-1A; 0- -25V, 0-1A; 0- 6V, 0-5A (10 units)

2.4. Shared Physical Characterization Facilities on UMass Amherst Campus

2.4.1. W. M. Keck Electron Microscopy Center

- *Transmission Electron Microscopes (TEMs)*
 - JEOL-2000FX
 - JEOL-100CX
 - FEI-Tecna 12
- *Scanning Electron Microscopes (SEMs)*
 - FEI-Magellan400
 - JEOL-6320JXV
 - JEOL-JSM5400
- *Laser Scanning Confocal Microscopes*
 - ZEISS-Meta510
 - Leica
- *Optical/Fluorescence Microscopes*
 - Nikon-E600
 - ZEISS

2.4.2. W. M. Keck Nanostructures Laboratory

- DI Dimension-3000 and Dimension-3100 AFM
- DI Nanoscope-IV Multimode AFM
- Olympus Optical Microscope
- Leica Confocal Optical Microscope
- Sopra Variable Angle Spectroscopic Ellipsometer
- Veeco Dektak Stylus Profilometer
- Filmetrics Optical Profilometer

2.4.3. Interface Analysis Laboratory

- 2 Physical Electronics Model 5100 X-Ray Photoelectron Spectroscopy (XPS) spectrophotometers

2.4.4. X-ray Laboratory

- Small and wide-angle x-ray scattering (SAXS-WAXS)
- Powder x-ray diffraction

3. Other accessible resources:

- National Labs: The PI can submit proposals to gain access to the e-beam writer with stitching function at the Molecular Foundry at Lawrence Berkeley National Laboratory or to Brookhaven National Laboratory. The PI is a current user of both the fabrication and TEM facilities in the Center for Functional Nanomaterials at Brookhaven National Lab.
- Computers: The Department of Electrical & Computer Engineering runs a professionally staffed Engineering Computer Services facility, with over a hundred computer systems installed in the College of Engineering. Computer systems, including Windows, Linux and SUNs are readily available in the department.
- Machine shops: There are three machines shops at UMass Amherst campus (one in Electrical Engineering, one in Mechanical Engineering and one in Physics). PI has access to all of them to machine home-made parts or systems.
- Offices: Each PI has a faculty office of ~180 sq. ft. (Marcus Hall), and each has ~350 sq. ft. office area (also Marcus Hall) for students. Both equipped with printers, telephone, and computers with Internet access.
- Staff service: The ECE Department has assigned a book keeper for the PIs. The department also has administrative assistants for secretarial work, and technicians for lab maintenances.