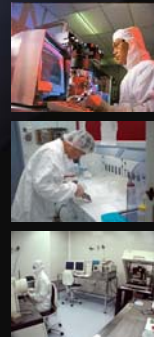


NANOFABRICATION LABORATORY

An MRI Shared User Facility

Overview:

Penn State's Nanofabrication Facility (Nanofab) is a full-service user facility providing faculty, students, and industry researchers the opportunity to perform hands-on research with some of the world's most sophisticated instruments for micro- and nano-fabrication. The Nanofab's technical support staff offers expertise in a wide range of fabrication techniques, with a primary focus on chemical and molecular scale nanotechnology and complex ferroelectric oxide devices.



Capabilities Include:

- Lithography**
 - Ebeam Writer Stepper
 - Nano Imprinter
 - Laser Writer
 - Contact Aligners
 - Resist Processing Stations
- Plasma Etching**
 - Plasma Surface Modification
 - Reactive Ion Etching
 - Deep Silicon RIE
 - Deep Oxide RIE
 - XeF2 Etch
 - MERIE Dielectric Etch
 - Polymer Etch
 - Cluster Etch System
 - Inductively Coupled Plasma Etch
- Thermal Processing**
 - Atmospheric Oxidation Furnace
 - Annealing Furnace
 - Rapid Thermal Processing
- Characterization**
 - Field Emission SEMs
 - Ellipsometers
 - Profilometers
 - Surface Particle Inspection Analyzer
 - CV/IV Test Equipment & Probe Station
 - Four Point Probe
 - Film Stress Measurement
 - Film Stack Measurement Capability
- Thin Film Deposition**
 - Electron-beam/Thermal Evaporator
 - Sputtering Systems
 - Chemical Solution Dep Station
 - LPCVD Furnace Systems
 - PECVD Cluster Tool
 - ICP PECVD
 - Atomic Layer Deposition
 - Electroplating
- Chemical Nanofabrication**
 - Glove Boxes for SAM Deposition
 - Soft Lithography Processing
 - Parylene Thermal Evaporator
 - Wet Chemical Etching

Research Nuggets:

Spectrum Sensor™ chip using nanoimprinting
Min Kyu Song, Byoungja Lee, and Bill Choi, Nanoscribe Inc., Pittsburgh, PA

Goal is to develop the mass production technology of realistic nano-optic filter using cost efficient nanoimprint lithography (NIL) and metal etching techniques.

Initial prototypes fabricated at the Penn State MRI site provided a nano-optic filter array with reverse tone step. 2. Back-scan lithography (BSL) and aluminum dry etch processes.

Application: Spectrometer-on-a-chip™ for non-invasive health monitoring, biochemical detection, and high resolution color sensing.

High-resolution color sensing (transmission, optical absorption)

Si-FILR with AI dry-etching provides a cutting edge, low cost, nano-optic filter production technology.

Micromachined 35 MHz PC-MUT Array
X. Jiang, R. Liu, X. Geng, K. Sanki, and D. Hochenberger, TFS Technologies, Inc., Erie, Pa. State College, PA

High frequency ultrasound phased array is desired for precise and rapid ultrasound Nondestructive Evaluation.

A deep reactive ion etching process was used for micromachining of both piezoelectric to fabricate 1-3 Pz/Pt piezoelectric thin film piezoelectric transducer arrays.

For the first time, a 64-channel, 35 MHz phased array was produced and characterized showing broad bandwidth (> 80%) and high sensitivity. This has significant impact on advancing the state-of-the-art phased arrays (< 20 MHz) for sophisticated ultrasound nondestructive evaluation applications.

High aspect ratio reactive ion etching of piezoelectric oxides enables new high frequency phased array ultrasound transducers with broad bandwidth.

Deterministic Nanowire Assembly
T. Mahon, M. Li, J. Kim, T. S. Mayer, and D. Keszler, Departments of Chemistry and Electrical Engineering, Penn State University, University Park, PA 16802

A key challenge in nanowire integration is the lack of scalable, high-yield directed assembly techniques that provide the requisite control over global/local position and registration/underlying circuit.

Coupling sequential delivery with a programmable e-beam voltage directs different nanowire populations to different regions of the chip and then preferentially align individual nanowires within biologically-defined structures.

Fluorescence images show high yield assembly and integration of two populations of nanowires functionalized with different biomolecules. Binding selectivity to complementary DNA targets was retained following assembly and imaging.

Hybrid nanomanufacturing processes are being developed to add new capabilities and University to silicon integrated circuit technology.

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For more detailed information, visit our website:
www.mri.psu.edu/facilities/Nanofab



Our experts are ready to help you.

High Mobility Graphene FETs with Ferroelectric Gate Oxide
X. Hong, K. Zou, S. J. Zhu, Physics Department, Penn State University, PA 16802

Electron mobility in graphene FETs is limited by various scattering sources related to the SiO₂ substrate.

We have fabricated few-layer graphene of LG FETs on epistaxial ferroelectric oxide, Pb(Zr_{0.2}Sn_{0.8})O₆ (PZT). These devices show a 10-fold increase in mobility compared to SiO₂-gated graphene FETs, approaches the intrinsic limit set by longitudinal acoustic (LA) phonon scattering at room temperature. Our results open up a new route for realizing high performance carbon based electronic devices.

NIH enables exploration of carbon-based materials such as graphene for high performance nanoelectronic devices.

Acoustic Tweezers Can Position Tiny Objects
J. Zhu, D. Ahmed, X. Mao, S. C. S. Lin, A. Lavit, and T. J. Huang, Penn State University, University Park, PA

Researchers at the Penn State MRI invented an "Acoustic Tweezers"—utilizing sound waves to manipulate particles into desired patterns on a microchip. The tweezers work virtually on all kinds of cells and other biomaterials regardless of size, shape or charge/physical properties, with a 500,000 times lower power intensity than optical tweezers, an existing patterning method. This makes them cheaper and safer, ready to be used in many applications such as tissue engineering, cell studies, and drug screening and discovery.

NIH is a place for transferring innovative ideas to reality—acoustic tweezers can be an ideal tool in biomaterial manipulation.

Silicon Immersion Gratings
Jae Gu Park & Ba Zhan, Department of Astronomy, University of Florida, Gainesville, FL; Zhana Miao, Penn State Nanofabrication Laboratory, Penn State University, University Park, PA

High resolution infrared silicon immersion grating spectrometer with R=55,000, 1.2-4 um is being developed at the University of Florida. This system can be used to search for habitable Earth-like planets around low mass red stars and to detect and characterize giant planets around young stars.

Custom designed silicon immersion grating with Au coating fabricated at the Penn State MRI site.

NIH is a venue for developing cutting edge critical astronomical instrument components for future ground and space based astronomical observations.

