Institute for Electronics and Nanotechnology (IEN)

Description of IRI

The vision of the Institute for Electronics and Nanotechnology (IEN) is for Georgia Tech to be recognized as a regional, national and global leader in researching, developing and deploying nanotechnology and nanoscience solutions to challenges of global significance. To achieve this vision, IEN constitutes a **focal point for nanotechnology and nanoscience research at Georgia Tech** by providing necessary information, facilities and infrastructure and facilitates **innovation in micro/nano-enabled electronics and photonics** by catalyzing and translating research, connecting Georgia Tech researchers, companies and government agencies, and preparing the workforce.

To achieve above goals, IEN maintains extensive shared-use laboratories and cleanrooms for the synthesis, fabrication and characterization of nanomaterials, nanostructures, nanodevices and nanosystems. These facilities are used by more than 700 researchers on an annual base. The IEN core nanofabrication and –characterization facilities are part of the NSF-funded National Nanotechnology Coordinated Infrastructure (NNCI), a network of 16 academic sites and their partners, that open their nanotechnology facilities to external users from academia, industry and government labs.

IEN catalyzes novel interdisciplinary research activities in Micro/Nano-enabled Electronics & Photonics by organizing workshops and providing seed funding. It supports established programs and centers by providing research and office space, financial resources, as well as administrative and technical staff support.

Facilities & Resources

As one of Georgia Tech's Interdisciplinary Research Institutes, the IEN operates and supports the region's most extensive nanotechnology core research laboratories in several campus buildings. Faculty and student offices, as well as individual PI laboratories, are found in close proximity to facilities within the Pettit and Marcus buildings to foster peer-to-peer networking and collaboration.

Building	**Laboratories**
Marcus Nanotechnology Building	Inorganic (Class 100) and Organic (Class 1000) Cleanrooms, Material Characterization Facility
Pettit Microelectronics Building	Cleanroom (Class 100), Teaching Cleanroom, Laser Machining Lab
Calloway Manufacturing Research Center	Packaging Research Center (PRC)
Technology Square Research Building	Georgia Electronic Design Center (GEDC)
Bunger Henry Building	Photovoltaics, Compound Semiconductors
Van Leer Building	Photovoltaics, Material Growth

Micro/Nanofabrication Cleanrooms

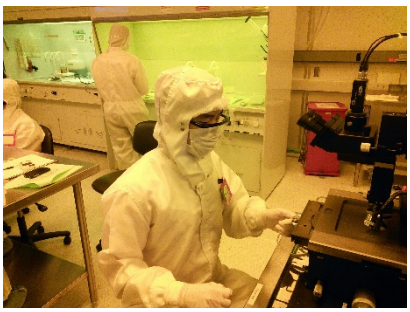
Hands-on, shared user cleanroom space totals 28,500 square feet in the Marcus and Pettit buildings. These cleanrooms are general use for electronics, MEMS, photonics, and materials research, along with a specialized Organic Cleanroom for work at the interface between fabrication and life sciences. Marcus also contains a 5,500 square foot characterization suite (see section Material Characterization Facility) designed for high-resolution imaging and microscopy tools, and an additional 13,000 square feet of shelled-out cleanroom space for expansion. The Packaging Research Center consists of 13,400 square feet dedicated

to System-on-Package (SOP) and other emerging microsystems, while the Georgia Electronic Design Center has 16,500 square feet focused on high frequency, broadband, mixed signal devices, circuits, and systems. Additional laboratories under IEN control include the Laser Machining Lab for micro-machining of diverse materials (polymers, glasses, ceramics, metals, and organics) using UV and IR laser sources, and a Teaching Cleanroom dedicated to support advanced training and lab courses taught in the areas of CMOS fabrication, MEMS, and micro/nanoelectronic processing by GT academic units.

Marcus Nanotechnology Building

All of the more than 200 individual tools (all with 100 mm substrate capability, and some that accommodate larger) within the IEN micro/nanofabrication cleanrooms are accessible to both internal and external users for hands-on use. Training requests, scheduling, and routine communications are all handled through a web-based interface, and in-the-lab access is controlled with an in-house developed electronic access control system which documents all usage for subsequent billing and statistical analysis. The major tool categories are:

- Lithography/Patterning: UV Photolithography (365nm, 405nm, 248nm), Nano-imprint, E-beam Lithography, Inkjet Printing, Soft Lithography, Nanoscribe 3D Direct Laser Write Lithography
- Dry Etching: Silicon/Polysilicon DRIE (Bosch process), Silicon/Polysilicon DRIE (cryogenic process), Silicon/Polysilicon RIE, Silicon Dioxide (quartz, fused silica) DRIE, Silicon Nitride DRIE (CxFy), III-V Semiconductor DRIE (Cl_2, BCl_3, $SiCl_4$), RIE (CH_4, H_2); DRIE (HBr); Metal RIE (Cl_2, BCl_3)
- Wet Etching: Semiconductors, Dielectrics, Metals, Organic Materials
- High Temperature Processes: Oxidation (wet & dry), Annealing, Polymer Curing, Diffusion Doping (solid-source), Drive-in, Sintering, Rapid Thermal Processing
- Thin Film Deposition: RF/DC Sputtering, Co-sputtering, Evaporation, ALD, PECVD, APCVD, LPCVD
- Polymer Deposition: Spin Coating, Spray Coating, CVD (Parylene)
- Plating: Electroplating (Cu, Ni, Au, Pt, PbSn), Electroless Plating (Ni, Au)
- Packaging: Wire bonding, Wafer bonding, Anodic bonding, Thermal compression bonding, Eutectic bonding, Flip-Chip bonding, Chemical Mechanical Polishing, Lapping, Lamination, 300-mm substrate and interposer processing; Assembly and Reliability Testing



IEN Teaching Cleanroom

The IEN cleanroom facilities and associated Material Characterization Facilities (MCF) are equipped to produce and characterize most standard materials, as well as many non-standard processes and novel materials.

- Semiconductors: Si (crystalline Si, amorphous Si, poly Si), Ge, III-V compounds (GaAs, GaN, AlN, AlGaN), organic semiconductors (P3HT, pentacene), LiNb
- Dielectrics: Silicon oxide (thermal oxide, PECVD oxide, TEOS oxide), Silicon nitride (PECVD nitride, LPCVD nitride), Silicon oxynitride, Silicon Carbide, Quartz, Fused silica, Pyrex, Sapphire, Ceramics
- Metals: Al, Cu, Au, Cr, Ti, W, Ni, Mo, Pt, Fe, Ir, Pd, Ag, alloys
- Polymers: Parylene (encapsulation), photoresist (positive, negative), soft materials, biologicals
- Nano Structures: Graphene, Carbon Nanotube, MoS_2, SiGe Nanowire, Si Nanowire, Metallic nanoparticles, Semiconductor nanoparticles (quantum dots)
- ALD Materials: Al2O3, TiO2, HfO2, SiO2, ZrO2, ZnO2, Pt
- Nanomaterial Composites: Carbon, glass, boron nitride, polymer nanofibers in resins

The cleanroom operations team is comprised of 20 members with more than 200 years of combined experience with the installation, maintenance, and training of micro- and nanoscale fabrication and metrology equipment. Three additional staff members are responsible for overall building management and operations. This staff represents diverse experience and educational disciplines with 7 possessing advanced technical degrees. Many of the staff have valuable experience gained from previous positions in industry or as tool service engineers.

Material Characterization Facility (MCF)

The Institute for Electronics and Nanotechnology (IEN) and the Institute for Materials (IMAT) manage a shared-access Materials Characterization Facility (MCF) available to GT users and non-GT users from academia, industry and government agencies on an hourly rate basis.

The MCF shared-user labs house more than 20 high-end microscopy, spectroscopy, and diffraction tools for measuring a wide variety of materials and structures. Included in these major tools are 5 SEM's, 4 TEM's, 3 XRD's, 2 XPS systems and additional instruments for surface science, scanning probe microscopy, and optical spectroscopy/measurement. The MCF also has a fully-outfitted lab for sample preparation of hard materials. Details on each of the instruments can be found at: http://mcf.gatech.edu.

The facility is headquartered in the Marcus Nanotechnology Building on the GT campus in Atlanta, GA and its instruments are available 24 hours/day, 7 days/week on a first-come/first-served scheduling basis. The full-time staff - which has an average of ~20 years experience in microscopy and characterization - provides comprehensive consulting, training, and analysis assistance to more than 500 users annually.

Broader Impact - Education

IEN is home to the NNCI's (National Nanotechnology Coordinated Infrastructure) national education and outreach (E&O) office which coordinates the E&O programs of the 16 NNCI sites. IEN's E&O goal is to offer programs that integrate research into educational experiences that will develop a workforce pipeline in STEM and nanoscale science and engineering in particular. The E&O office has a very active engagement program which directly reaches several thousand individuals each year. Both NNCI and IEN have extensive experience with providing outreach to the K-12 community and general public. We strongly believe that such outreach is critical in enhancing the STEM pipeline and we offer programs to excite and educate secondary students about the education and career opportunities of STEM and nanoscale science and engineering. IEN engagement encompasses a variety of K-12 programs for both teachers and students including professional development workshops for educators. We offer a Research Experience for Undergraduates program each summer to expose students to cutting-edge nanoscale research. IEN provides technical workshops and short courses reaching graduate students, post-docs, faculty, government, and industry which focus on the equipment and processes of the user facility. These workshops are a combination of lecture and lab to demonstrate the capability and research applications possible. The purpose of these are twofold: educate current and potential users about the capabilities of the suite of instruments available within IEN and inform attendees about the current and potential applications of processes. IEN has both a tabletop SEM and portable AFM that can be used in undergraduate and graduate courses. In addition, these instruments can travel to K-12 schools and community colleges.