Nanotechnology Research & Teaching Facility

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Several pieces of specialized equipment were acquired during the year. Shown above, clockwise from top left: Zeiss 1540XB three-gas, Focused Ion Beam system; Zeiss Supra 55VP Scanning Electron Microscope, capable of sub-nanometer resolution; Neocera turn-key pulsed laser deposition system with 18-inch turbo-pumped vacuum chamber; RHK Ultra-high Vacuum Scanning Tunneling Microscope with surface preparation chamber.

The Nanotechnology Research and Teaching Facility (NanoFab) hosts interdisciplinary research activities, primarily involving several College of Engineering and College of Science units, plus researchers from local universities and area electronics industries. Housed in a 35,000 sq. ft. two-story building, the facility contains a variety of specialized research and teaching sections. The 6,000+ sq. ft., Class 1000 main clean room is separated into areas for materials deposition, characterization and processing, photolithography and teaching. An additional 4,800+ sq. ft. of space is devoted to laboratories containing particular equipment and/or testing facilities

Renovations valued at $4.6 million added 11new laboratories with a total area of about 4,000 sq. ft. to NanoFab building. These included three labs to accommodate an SEM, an STM and an E-Beam writer, plus two wet chemical labs, two optoelectronics labs, a nano-giga electronics lab, a cryoelectronics lab and a nano-device lab. The labs will benefit seven Electrical Engineering faculty (two are new additions) and four Materials Science and Engineering faculty (three are new additions). Faculty associated with the Center for Nanostructured Materials (CNM) as well as other UTA faculty also have full access to the facilities. NanoFab staff provide training to UTA researchers at no cost to use the facilities.

Currently, 24 faculty and more than 100 students and post-docs use the facility. The faculty associated with NanoFab have received ~$6 million in research funding.

Research activities in the facility are conducted through mutually-beneficial associations of chemistry, electrical engineering, mechanical and aerospace engineering, materials science and physics faculty, graduate students and research assistants at UTA, as well as collaborative efforts with investigators at other universities and in the private sector. The following are descriptions of projects being conducted by Electrical Engineering Assistant Professor Michael Vasilyev.

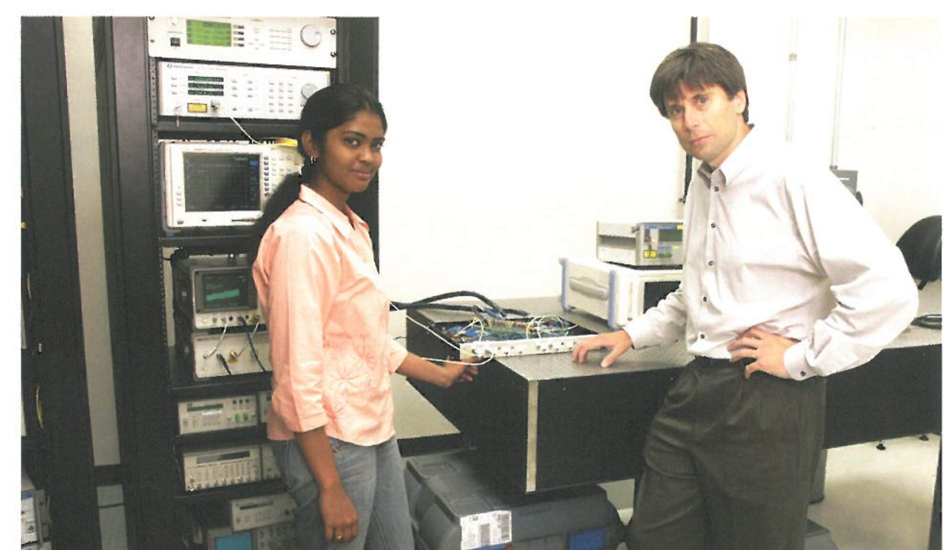
Nonlinear-optical devices for optical communication and information processing

The rapid progress in the speed of computation and signal processing realized by silicon integrated circuits is expected to slow down dramatically in the near future. This is because the nanometer-scale size of the circuit elements and their characteristic response times are approaching their limits imposed by quantum mechanics. As engineers start looking for alternatives to electronic processing, they are turning to nonlinear optics. Indeed, the high frequency of light waves allows one to pack thousands of times more information into the light compared to the electronic signal. The low-loss transmission media such as optical fibers, along with wide-band optical amplifiers, let the lightwave signals propagate over thousands of miles without significant degradation. However, the current show-stopper preventing the use of optics in signal processing is the difficulty of making optical decision circuits which require nonlinear input-output relation similar to that of electronic diodes and transistors. This functionality is the scope of nonlinear optics, and the focus of research carried out by the group led by Dr. Vasilyev.

Dr. Vasilyev and his collaborator, Dr. Taras I. Lakoba at the University of Vermont, have recently invented a new all-optical decision circuit that can simultaneously process optical signals carried by many different wavelengths, resulting in a hundred-fold increase of signal-processing capacity. Such functionality was not possible to achieve in any existing nonlinear-optical materials, because the nonlinear response needed for making the decision also inevitably mixes the signals from different wavelengths, making the output incomprehensible. The solution proposed by the team is a new type of nonlinear medium that has not existed in nature. The new artificial medium, by design, separates the effect of optical nonlinearity needed for making the decision from the nonlinear crosstalk effects corrupting the signal. Dr. Vasilyev's group, in collaboration with Dr. Nikolai Stelmakh of UTA's Electrical Engineering Department, is currently working on fabrication of this novel medium and demonstrating the decision-circuit operation in the lab. This technology is valuable for high-speed information processing, as well as for improving reach, capacity and flexibility of optical communication networks.

Nanoscale quantum optics is another of Dr. Vasilyev's projects, this one carried out in collaboration with Dr. Prem Kumar at Northwestern University. By placing a tiny light emitter such as a quantum dot or a fluorescent polymer molecule into a nanometer-scale cavity, a virtually complete control over the properties of the emitted light can be obtained. As a result, it's possible to make an optical switch controlled by just a few photons or a laser producing single photons on demand. The former of these devices is important for integrating the optical signal-processing functions on a chip. The latter is indispensable for ensuring unconditional security of optical communications (quantum cryptography) and is also very promising as a building block for the most advanced computing technology on the horizon, the quantum computer.

The research by Dr. Vasilyev's lab is supported by the National Science Foundation, Lockheed Martin Corporation and UTA's Research Enhancement Program.



Graduate student Sravanthi Thotakura and Dr. Michael Vasilyev prepare to test an optical amplifier prototype for their 10 Gb/s recirculating-loop testbed. The testbed is used to study the operation and cascadability of the novel devices performing nonlinear-optical signal processing of high-speed signals carried by multiple wavelengths.

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