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## From the Director

I would like to highlight an integral facet of CNST's dynamic, multidisciplinary research environment — the CNST Visiting Fellows program. This program is designed to encourage outstanding, senior researchers from academic, industrial, and government laboratories world-wide to come to the CNST to collaborate with our research staff. Researchers selected to be CNST Visiting Fellows may collaborate with us for extended periods via regular, short-term visits, and/or may work in residence full-time; for example, during a year-long sabbatical. We can even offer financial support through a variety of mechanisms. To learn more, you should contact directly the staff member with whom you are interested in collaborating.

– Robert Celotta, CNST Director

## New Staff at the CNST

Jacques Miltat joined the CNST as a Visiting Fellow in the Electron Physics Group, on sabbatical leave from his post as Directeur de Recherche at the Centre National de la Recherche Scientifique in Paris, France. Jacques, who has a Ph.D. in Materials Science from Oxford University, has broad expertise in magnetic domains, domain walls, lines and Bloch points, as well as magnetoelasticity, microplasticity, and micromagnetic simulations. Jacques is collaborating with the CNST's Mark Stiles on theoretical studies of nanomagnetism and magnetic imaging.

Robert Rudnitsky joined the CNST management and Center Office staff as a Scientific Advisor to the Director. Prior to coming to NIST, Robert worked as a Physicist with the U.S. State Department in the Office of Space and Advanced Technology, where he chaired the U.S. National Nanotechnology Initiative (NNI) Global Issues in Nanotechnology Working Group, which coordinates United States Government international activities related to nanotechnology. While at State, he was also elected to chair the international Organisation for Economic Cooperation and Development (OECD) Working Party on Nanotechnology. Robert has a Ph.D. in Applied Physics from Stanford University, where he investigated single molecule binding force detection of cadherins, a cellular adhesion protein. His expertise is in MEMS, microfluidics, biophysics, cellular mechanics, biomaterials, and sensors. Robert will provide CNST management with scientific, policy, and operational advice.

Russ Hajdaj is making a transition within the CNST, leaving the NanoFab staff to join the Center Office as the CNST Safety Officer and Property Manager. Russ will continue to provide orientation and safety training to NanoFab users, while overseeing the CNST safety program. In his new position, Russ will also be responsible for managing the CNST property and precious metals programs.

## Project Leader Profile – Fred Sharifi

In many ways, one of the Project Leaders working in the CNST's new Energy Research Group has turned full circle in his career.

"I started my career as a low-temperature physicist, doing measurements on superconducting devices at ten milliKelvin," said Dr. Fred Sharifi. "I was looking at macroscopic quantum effects, some of the more esoteric aspects of quantum measurement theory, trying to answer the question whether quantum mechanics applied to macroscopic systems. In the process, I made measurements on very small scale devices. This was back in the days before things were called nano – they were actually nanostructures, very small Josephson structures. They were rather difficult and tedious measurements at very low temperatures."

Fast forward a couple of decades or so, and the same scientist finds himself working in a new lab, and on the other end of the thermal spectrum. He is building a new device designed to precisely measure temperature differences of just a few milliKelvin on a nanoscale sized sample under heat loads from room temperature to 300 °C. Those measurements are key in developing thermoelectric devices to exploit waste heat and in turn, increase the amount of electrical power available for use from any heat source.

"Thermoelectrics hold great promise to increase our efficient use of energy on so many scales, from large to small," explains Dr. Sharifi. "Take our current way of generating power. The best conversion efficiency in electricity generating turbines is about forty to fifty percent. Finding a way to incorporate thermoelectrics at the final stages of that energy conversion could make a huge difference. When you consider even a small increase of just one to two percent for a plant generating a gigawatt of electricity, that's a lot of power."

The challenge is increasing the efficiency of present day thermoelectrics — which now typically recover and convert about 5% of the thermal waste energy — to the point it becomes commercially and economically feasible to mass produce. To do so, researchers must unlock the most efficient conversion number over an extremely small variance in temperature – while examining structures of just a few nanometers.

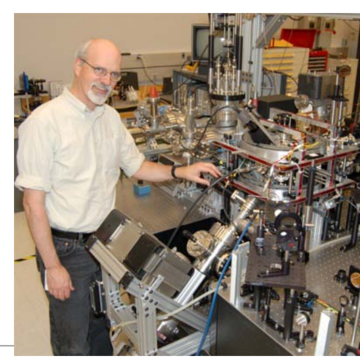
CNST Project Leader Fred Sharifi

"If we can understand what goes on in a nanoscale thermoelectric, we can apply that to much larger structures," Sharifi said.

The difficulty in measuring both temperature and conversion efficiency is increased by two related factors. Thermoelectrics generate power the way they do because electrons travel from the hot end of a temperature gradient to the colder end. One of the best known scientific applications of this idea is the Cassini spacecraft, which uses a thermoelectric to convert heat from a small onboard reactor and the cold of space to generate power. However, when this principal is applied to nanoscale materials, the temperature gradient is extremely small, and so are the voltages that are produced.

To address that challenge, Sharifi is constructing a heat pipe that will encompass the thermoelectric and isolate the measurement devices that could influence the amount of heat and voltage flowing through the sample. That will allow Sharifi to obtain precise measurements through the entire temperature gradient. The new heat pipe is actually an improved version of a system the scientist built in his last assignment.

Sharifi envisions a day in which the average person might actually use a thermoelectric device to power the electrical accessories in their car. "We've already used a thermoelectric to harvest waste heat from an exhaust system in a test project," he said. "A future commercialized version would do away with the belt-driven alternator in your car, which would lead to better gas mileage and higher energy efficiency."



## Honors and Awards

### CNST Staff Members Reach Service Milestones

Jabez McClelland achieved a significant milestone — 25 years of federal service. Jabez has served NIST in positions ranging from postdoctoral researcher to Group Leader, and in the process has advanced the science of laser cooling and trapping of atoms, spin-polarized electron scattering from laser excited atoms, laser focused atom deposition, and metastable atom lithography. Among other honors, Jabez has received both the Department of Commerce Gold and Silver Medals, is a Fellow of both the American Physical Society and the Optical Society of America, and is a recipient of the Sigma Xi Award for Excellence in Science. Congratulations, Jabez!

Lloyd Whitman is also observing a significant anniversary – 20 years with the federal government. Lloyd began his career as an NRC Postdoctoral Research Associate at NIST, then spent almost two decades at the Naval Research Laboratory where he led a multidisciplinary group investigating nanoscience, biotechnology, and microsystems. He returned to NIST as the CNST Deputy Director in April of 2008. Lloyd has over 150 publications and patents, and has received numerous awards during his career, including the Navy Meritorious Civilian Service Award. Congratulations, Lloyd!

## Research Highlights

### CNST Researchers Propose a New Method for Nanoscale Spectroscopy

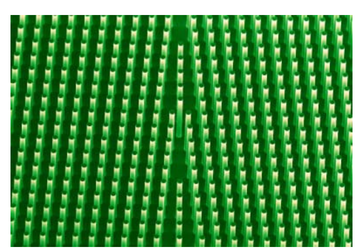
CNST researchers Marcelo Davanço and Kartik Srinivasan have developed a new method to efficiently collect and analyze light from nanoscale emitters. Future generations of sensors and optical information processing devices may depend on the optical properties of single atoms. As a practical route to developing such technologies, solid state systems have been developed that exhibit many of the important properties of single gas phase atoms, but are challenging to characterize. Such solid state light emitters encompass a range of structures, including quantum dots, single molecules, and impurity centers in crystals. It can be very difficult to measure the emission from these nanostructures above the background noise. For emitters embedded in a semiconductor, this problem is further compounded by the strong reflection of light at the interface between the semiconductor and the surrounding air, which limits transmission into the air and therefore the collection of emitted light using conventional optics. The CNST researchers are developing a new measurement method predicted to greatly increase the efficiency of optical spectroscopy from such embedded single emitters. The team used detailed electromagnetic simulations to design an optical fiber "taper waveguide" structure capable of improving collection efficiencies by as much as an order of magnitude. This structure consists of a standard 125 μm-diameter, single mode optical fiber that is gradually tapered down to a diameter of about 1 μm along an approximately 1 cm-long section, creating a "waist" that can be put in proximity to the semiconductor device containing the emitter. Their simulations for various geometries, recently published in *Optics Express,** show how optimally-designed tapered waveguides effectively collect light emission from embedded emitters.
*Efficient Spectroscopy of Single Embedded Emitters Using Optical Fiber Taper Waveguides, M. Davanço and K. Srinivasan, Optics Express 17(13), 10542-10563 (2009).

## New in the CNST NanoFab

### Thin Film Processes with Stress Level Characterization

The NanoFab staff has completed work on building a comprehensive list of more than 30 thin films, including metals, oxides, and nitrides, all of which were characterized for stress level using our Flexus wafer curvature analyzer.

### High Aspect Ratio Etching



The NanoFab staff has also developed a series of new processes involving high aspect ratio etching for a wide variety of applications, including electromechanical, biotech, and filtering devices. The new processes reduce the sidewall scallop size in "Bosch" deep Si etching, which can be used to make high aspect ratio Si structures with sub-micron features.

**Random Notes**

The thermal evaporator is being converted to an e-beam evaporator, so a second e-beam evaporator will soon be online. The cleanroom's Heidelberg laser patter generator now has a 4 mm write head that will allow for shorter write times for geometries one micrometer and larger; the 2 mm write head is still available for higher resolution writing.

## Outreach and Events

The NanoFab's outreach campaign has exhibited at twelve venues to date. Visit our booth at the following upcoming conferences:

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| October | 22-25 | American Society for Nanomedicine | Potomac, MD |
| November | 8-13 | AVS-56 International Symposium and Exhibition | San Jose |
| November | 30-Dec. 4 | Materials Research Society | Boston |

To discuss potential projects at the CNST NanoFab, contact manager Vince Luciani. If you will be visiting NIST and would like a tour of the NanoFab and/or our research laboratories, contact Lloyd Whitman.

## Upcoming CNST Seminars

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| **October 13, 2009** | **10:30 a.m.** |
| Topic: | Metal-insulator Transition in Thin Film Vanadium Dioxide |
| Speaker: | Dmitry Ruzmetov, Postdoctoral Fellow, Harvard University, |
| Location: | Bldg. 217, H107 |
| Contact: | Alec Talin |

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| **October 30, 2009** | **10:30 a.m.** |
| Topic: | Gallium Arsenide Deep-center Laser |
| Speaker: | Janet Pan, Yale University |
| Location: | Bldg. 217, H107 |
| Contact: | Kartik Srinivasan |

For the complete list of CNST Seminars, browse http://www.cnst.nist.gov/seminars/presentation.html

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