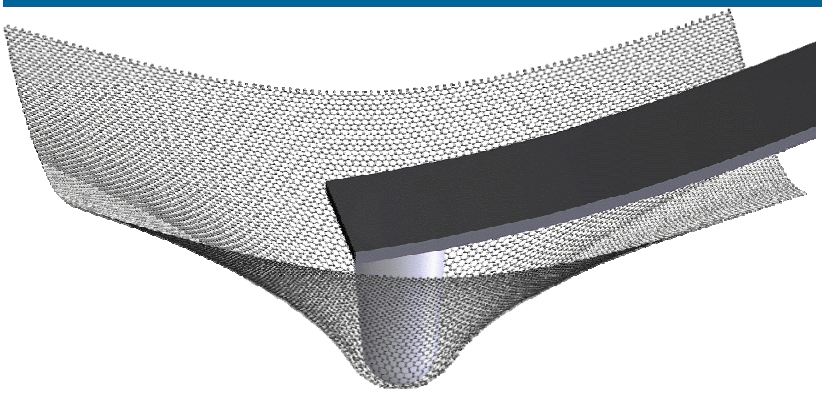
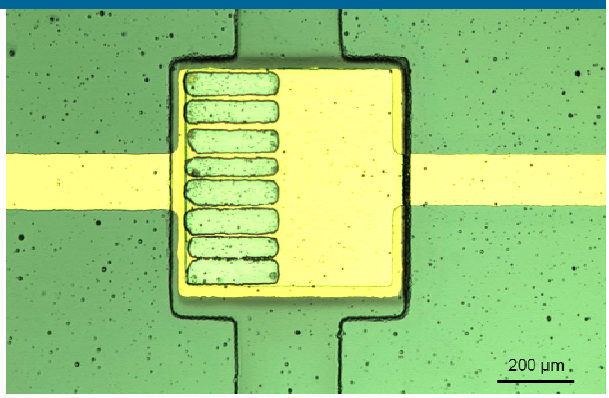
Spring 2009, Volume 1, Issue 2

Mechanical Engineering Newsletter

The Fu Foundation School of Engineering & Applied Science, Columbia University in the City of New York



A schematic image of nano-indentation of graphene --single atom thick carbon-- using an atomic force microscope with a diamond tip. Graphene is the strongest material ever measured, with an ultimate strength of 130 GPa. The result was published in Science and briefly reported in the Fall '08 ME Newsletter (Profs. James Hone and Jeffrey Kysar).



An implantable glucose microsensor: a freestanding polymer diaphragm embedded with permalloy actuation strips and a gold capacitive sensing electrode (Prof. Qiao Lin). This work won the Best Student Paper Award at IEEE NEMS '09 (see Page 2).

Message from the Chair

Dear Alumni and Friends,

Another semester has passed and we bring you another newsletter full of exciting departmental developments. You will read about Jung-Chi Liao and Elon Terrell joining our faculty, Nabil Simaan receiving a CAREER award from the National Science Foundation (NSF) to support his innovative work on surgical robots, Jim Hone's most recent publication in *Science* and his work as co-principal investigator on a new IGERT project funded by NSF, Qiao Lin's significant progress in microfluidic lab-on-a-chip research, and Arvind Narayanaswamy, who just joined us last year, receiving his first research award from NSF. As corroborated by *The Chronicle of Higher Education* (see page 8), our ME faculty is among the most productive in the nation.

Additionally, we introduced two new concentrations in *Energy Systems* and *Micro/Nanoscale Engineering* for our MS program, we are teaching five new graduate level courses in 2009, and we established an Outstanding TA Award to recognize dedication and excellence in teaching assistance. We also created a travel grant program to support doctoral candidates in presenting their research at conferences and exchanging views with fellow researchers. A number of our graduate students recently received best paper awards at international conferences, and our ASME student chapter, under an able and dynamic leadership, has been more active than ever in organizing a variety of activities.

As usual, the Columbia Engineering School Alumni Association (CESAA) will sponsor a ME Senior Dinner in early May to help celebrate the seniors' graduation together with ME faculty, staff and CESAA representatives. We are seeking a ME alumnus who will honor us with a keynote speech at the event. A half-hour talk could leave a lasting and transformative impression on the graduating ME seniors. If you are interested or would like to nominate someone, please contact me (yly1@columbia.edu) as soon as possible.

Thank you again to our alumni and other friends of the department!

Best regards,

Y. Lawrence Yao
Professor and Chair

In this issue

ME SCHOLARSHIP RECIPIENTS

Bishop Scholarship
Christopher Williams
Khaddijah Ransom
Established in 1984. Gift of Jerry (1942) and Evelyn Bishop for students in the Combined Plan Program.

Class of 1951 Scholarship
Anthona Coia
Gift of members of the Class of 1951 in commemoration of the fiftieth anniversary of their graduation.

Down Scholarship
Ken Yearwood
Gift of James (1973) and Donna Down to be awarded annually to a deserving minority undergraduate who has demonstrated academic achievement.

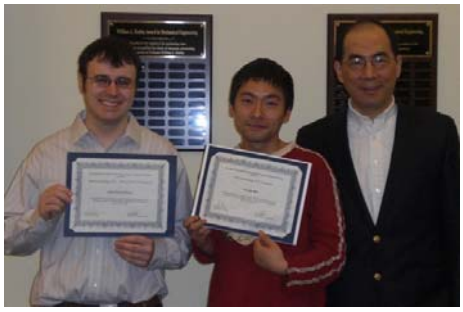
Elledge (EA) Scholarship
Emily Marquardt
Gift of Carol G. Elledge, in memory of Everard A. Elledge (1942).

Lee Memorial Scholarship
Rajiv Shah
Awarded annually to a student in the Combined Plan Program in honor of Professor Frank H. Lee.

Longobardo Scholarship
Islam Shawki
Gift of Anna Kazanjian (1949, 1952) and Guy (1949, 1950, 1962) Longobardo. Preference given to students studying mechanical engineering.

Rubinstein Fellowship
Andrea Bajo
Bequest of Leo Rubinstein (1963) and gift of Frederick Rubinstein. Awarded to deserving students studying applied mathematics or industrial design.

OUTSTANDING TA AWARD RECIPIENTS ANNOUNCED



(Left to Right) John (JP) Hilton, Yunde Shi, Professor. Larry Yao.

At the end of every course students are asked to participate in course evaluations for instructors and teaching assistants. The faculty reviews these evaluations with great care and makes every effort to apply student feedback to its developmental efforts. These evaluations are thus an integral part of the department's educational program.

The department has recently established an **Outstanding TA Award** to recognize excellence and dedication. The selection of the Outstanding TA Award was based primarily on the TA Evaluations and the recommendation of the instructor in charge of the course. The ME Graduate Committee is pleased to announce that **Yunde Shi** is the first recipient of the Outstanding TA Award for Fall 2008. He was the TA for E3601, Classical Control Systems, taught by Professor **Richard Longman**, who commented on Yunde's work ethic: "He was always ahead of schedule, prepared, and would post solutions and responded to student inquiries very quickly." In students' comments, Yunde was described as being knowledgeable, friendly, conscientious, enthusiastic, and prepared. One student commented that Yunde "goes well beyond his call of duty to provide students with everything they need to prepare for class." The Award comprises a plaque and a Bose SoundDock for iPod/iPhone.

Additionally, the committee gave **John (JP) Hilton** an **Honorable Mention**. JP also did an exceptional job as TA for E3401, Mechanics of Machines, taught by Professor **Qiao Lin**. He received a certificate of recognition.

The department would like to thank all of the students that participated in the course evaluations and congratulate Yunde and JP on a job well done.

XIAN HUANG, ME PH.D. STUDENT RECEIVED IEEE BEST PAPER AWARD

Xian Huang (pictured receiving his award), a Mechanical Engineering Ph.D. student who is advised by Professor **Qiao Lin** and conducts research in the Columbia Biofluidic Microsystems Lab, received the Best Student Paper Award at *the IEEE International Conference on Nano/Micro Engineered and Molecular Systems* (*NEMS '09,* http://www.ieee-nems.org/) that took place in Shenzhen, China on January 5-8, 2009.

Xian's paper is titled "A biocompatible affinity MEMS sensor for continuous monitoring of glucose." The paper presents a MEMS device that can be potentially implanted in subcutaneous tissue to allow minimally invasive, continuous monitoring of glucose for diabetes management. The device accomplishes glucose detection via viscosity changes of a biocompatible polymer, poly(acrylamide-*ran*-3-acrylamidophenylboronic acid) (PAA-*ran*-PAAPBA), when it binds reversibly to glucose. The viscosity changes are determined by measuring the hydrodynamic damping of the polymer solution on the vibration of a magnetically actuated microcantilever or diaphragm. Experimental results have demonstrated that the device is capable of accurately detecting glucose at physiologically relevant concentrations.

The coauthors of Xian's paper include **Siqi Li** and Professor **Qian Wang** (University of South Carolina), Professor **Jerome Schultz** (UC Riverside), and Professor Qiao Lin. The paper was selected as the Best Student Paper from 8 Finalists, which were chosen from 253 papers presented at the conference by researchers from 30 countries.

RECENT DOCTORAL GRADUATE RECEIVED 3RD PLACE AWARD AT 2008 INTERNATIONAL CONGRESS ON APPLICATIONS OF LASERS & ELECTRO-OPTICS (ICALEO)

Dr. **Andrew J. Birnbaum**, a recent graduate of the Mechanical Engineering PhD program, received a 3rd place award for his presentation, *"Pre-heated Substrate Effects on Melt-mediated Laser Crystallization on NiTi Thin Films "* at the 2008 International Congress on Applications of Lasers & Electro-Optics (ICALEO). The paper is co-authored with his thesis advisor, Prof. **Larry Yao**, as well as Prof. **James Im** of Materials Sciences, and Prof. **Ainissa Ramirez** of Yale University. Andrew's work investigates the effects of solidification rate on NiTi thin films subjected to a pulsed, melt-mediated laser crystallization technique. A high degree of control over the microstructure as well as the constitutive response of laser irradiated films is demonstrated. Andrew explained, "Due to a solid state diffusionless phase transformation, shape memory alloys (SMA's) exhibit highly non-traditional constitutive responses which effectively enable these materials to "remember" a desired geometry. Upon having been inelastically deformed, this memorized shape can be fully recovered by heating the material above a critical threshold temperature. Since this phenomena stems from atomic scale shifting, the ability to alter the material at the microstructural level is very attractive for micro-scale device realization." Andrew is currently a postdoctoral research fellow at Naval Research Lab in DC. The ICALEO is devoted to the field of laser materials processing and is viewed as the premier source of technical information in the field. For more information on ICALEO please visit www.icaleo.org.

ASME TEAMWORK: OFFICERS PLAN BUSY SPRING by David W. Norris, Columbia ASME Chapter Secretary

An unknown author stated, "The whole is greater than the sum of its parts."

The Columbia ASME chapter fully embraces this quotation and incorporates this statement into our ideology as a club. In years past, this mentality may not have been the norm; however, under the direction of this year's officers, teamwork has risen to the forefront. Many of this year's activities focus on 'bonum commune' -- the common good of the group, building the community of engineers. Activities include a student internship panel, a symposium of undergraduate research opportunities, and a community service project in April. The Columbia ASME chapter has also focused on the career development of its members with presentations from the Center for Career Education and Mechanical Engineering professors on preparation for future employment in industry and from ASME's regional Director of Community Involvement, **Burt Dicht** on engineering in the workforce. Yet it is not all work and no play for this year's officers...

A field trip to DRS Technologies in New Jersey and the end-of-year BBQ culminate this year's events for the student chapter. This year's exciting itinerary would have been impossible without the willingness and coordination of the individual officers working together as a team.

The responsibility of maintaining this community now rests with the newly elected 2009-2010 ASME Officers: Edward Kim (President), Rajiv Shah (VP), Frances Jeffrey-Coker (Secretary), Mia Harvey (Treasurer), and Alen Trubelja (Jr. Representative). There is confidence that they can continue to embrace the ideological framework of the outgoing team.

Several of the 2008-2009 ASME Officers with NASA Guest Speaker
(Left to Right) Mia Harvey (Community Relations Officer), Crystal Zhou (Treasurer), Marshall Fox (Vice President), Pat Duggan (President), NASA speaker Dr. Frank Scalzo, David Norris (Secretary)

ME STUDENT PROMOTED TO MAJOR WHILE EARNING MS

At 1530 hours on Saturday, March 6th, 2009, Mechanical Engineering Masters' student **Jonathan Belmont** was promoted to the rank of Major at a personal and moving ceremony at West Point Military Academy.

Jon graduated from West Point with a BS in Mechanical Engineering. He served two tours in Iraq (03-04 and 06-07) as a helicopter pilot and then enrolled in Columbia University's Department of Mechanical Engineering to pursue his Master's degree through an advanced civil school educational allowance. As the Army's allowance didn't cover the full tuition attending Columbia, the Mechanical Engineering department, in particular Graduate Committee Chair **Jeffrey Kysar** and Department Chair **Larry Yao**, worked with the School of Engineering and Applied Science to supplement the remaining cost in exchange for Jon taking on various responsibilities within the department, "which has been fantastic," Jon says. "It's definitely been a mutually beneficial arrangement."

A Master's degree is required for his impending post at West Point, so Jon jumped at the opportunity to study mechanical engineering at Columbia, although his next job doesn't specifically require mechanical engineering skills. "I love engineering…I remember like it was yesterday, the first day in Mechanical Engineering class, the instructor said 'you will never look at the world in the same way again'," and indeed he hasn't.

In his two years here, he has worked as a Teaching Assistant for Lab I, Lab III, and Computer Graphics. For the past year, his charge has been to design and build a well-instrumented experimental setup incorporating a new *Saturn* internal combustion engine donated by *GM* and a new *Land & Sea* dynamometer for the ME undergrad Lab. "Jon's work will continue to benefit the department for decades to come," Professor Jeff Kysar asserts.

In addition, he has volunteered in countless ways, from helping with computer setup to providing a tutorial on video editing to a staff member in need. He has also been known to leave delicious pastries at the front desk for all to enjoy, courtesy of his gastronomically talented wife, **Sara**.

During his sojourn at Columbia, Jon has enjoyed a tremendous rapport with students, staff, and faculty alike. "That's what makes him great. He's one of us. He's an extraordinary young man…When they say 'a few good men,' he's one of them," Instrument Maker **Walter Khan** says.

Professor **Nabil Simaan**, for whom Jon TA'd, says that Jon's "commitment and work ethic are unparalleled among all of the teaching assistants who previously worked with me. I consider myself lucky to have had a chance to work with him."

Lab Coordinator **Bob Stark** reports that "Jon is a natural leader and commands respect from his peers. He is also a heck of nice guy and a character filled with all sorts of colorful expressions and sayings."

Jon will be finishing his MS degree this Spring and right after taking his wife Sara and his two young kids to Disney World, he will be taking over the post of Northeast Regional Commander in the West Point Admissions Office. Larry Yao sums up everyone's sentiment: "He will be missed, but we wish him all the best and are confident that he will continue to excel in his new position."

"LUNCH WTH PROFESSORS" PROGRAM

In the Fall of 2007, the Department of Mechanical Engineering instituted an annual lunch program to encourage students to interact with their faculty advisors in an informal atmosphere. Typically, a small group of 4 to 5 student advisees are invited to lunch at a local restaurant with their faculty advisor. The response from students has been extremely positive. Junior **Jie Qi** recently attended a lunch with Professor **Jung-Chi Liao**. She reports that "We talked a lot about graduate school, how to prepare as an undergrad and what graduate life is like at various schools." Graduate student **Hildigunnur Jónsdóttir**, who dined recently with Professor **Vijay Modi** and fellow advisees (pictured right), said the lunch program "really loosens up the relationship with your advisor and takes it to a higher level in a friendly way. We get a better understanding of our advisor… and I think he understands us better when he talks to us about casual things…it really makes a difference."

(Left to Right) Jasmine Bridges, Professor Vijay Modi, Matthew Conwell, Hidigunner Jonsdottir, and Erik Huber enjoying lunch at a local restaurant

Travel Grant for Graduate Students

The Department of Mechanical Engineering has recently created a travel grant program to provide financial support to doctoral students who will be presenting their research at conferences. Each graduate student who has completed their qualifying exam and whose paper has been accepted at a conference will be eligible to apply for a one-time grant of up to one thousand dollars. This program is designed to provide students more exposure to ideas and colleagues in their research community and help them pursue a successful career in the future. To apply please visit http://me.columbia.edu/misc-pages/Forms.html

ESTABLISHMENT OF TWO CONCENTRATIONS FOR THE M.S. DEGREE IN MECHANICAL ENGINEERING

The M.S. degree in Mechanical Engineering currently requires that a student take a sequence of courses that shows a "clearly discernible specialty or concentration." In consultation with his/her advisor, an M.S. student can develop a concentration specifically tailored to his/her interests and objectives, which we refer to as the **Standard Track**.

The department has found that a significant number of M.S. students are interested in two of the many concentrations: **Energy Systems and Micro/Nanoscale Engineering.** Therefore, the department has recently established a separate track for a formal concentration in each of those two areas, referred to as **Special Tracks**. Any incoming student can now choose to apply to the Standard Track, or to a special track of Energy Systems or Micro/Nanoscale Engineering. The requirements for a Special Track are identical to those of the Standard Track, with the exception that a special track student must take at least 15 of his/her points from a list determined by a Special Track Advisor in consultation with a Special Track Advisory Committee. In addition, the name of the special track will be listed on a student's transcript.

To see the complete description and requirements for the new Special Tracks please visit:
http://me.columbia.edu/pages/academics/GraduateProgram/Masters.html

NEW ME COURSES FOR 2009

Small Scale Mechanical Behavior (MECE E8990, Prof. Jeffrey Kysar)
This course is an introduction to the mechanical behavior of small scale components, structures and devices. It includes a review of variational calculus as used to derive governing equations of beam and plate theory. Topics include deformation and vibration of beams and plates; stress, deformation, and substrate curvature in thin films; fracture, delamination, bulging, buckling of thin films; equilibrium and stability of surfaces. Also covered are small scale mechanical characterization including: nanoindentation, thin film bulge test, and electron microscopy methods.

Automotive Dynamics (MECE E4430, Prof. Reza Jazar)
Automobile dynamic behavior is divided into three subjects: vehicle subsystems, ride, and handling. Vehicle subsystems include: tire, steering, mechanisms, suspensions, gearbox, engine, clutch, etc. Regarding ride, vibrations and ride comfort are analyzed, and suspension optimization of a quarter car model is treated. Regarding handling, vehicle dynamic behavior on the road is analyzed, with emphasis on numerical simulations using planar as well as roll models.

Nanofabrication Laboratory (MECE E6710, Prof. James Hone)
This is a laboratory in techniques for fabrication at the nanometer scale. Topics include electron-beam lithography, plasma etching, 3D nanofabrication, thin film deposition, self-assembly and 'bottom up' nanofabrication. The lab covers fabrication of and testing of complete nanodevices.

Nano/Microscale Thermal Transport Processes (MECE E6720, Prof. Arvind Narayanaswamy)
This course focuses on the nano and microscale origins of thermal transport phenomena by molecules, electrons, phonons, and photons. Topics include quantum mechanics, statistical physics, density of states, kinetic theory of gases, Boltzmann transport equation (BTE), classical and quantum size effects, Landauer formalism for transport in nanostructures, and macroscopic constitutive equations from BTE. The course includes application to electronics cooling, thermoelectric and thermophotovoltaic devices, and energy conversion.

Molecular Mechanics in Biology (MEBM E4703, Prof. Jung-Chi Liao)
This course focuses on the mechanical understanding of biological structures including proteins, DNA and RNA in cells and tissues. Topics include force response of proteins and DNA, mechanics of membranes, biophysics of molecular motors, & mechanics of protein-protein interactions. The course includes an introduction to modeling and simulation techniques, and modern biophysical techniques such as single molecule FRET, optical traps, AFM, and super-resolution imaging, for understanding molecular mechanics and dynamics.

MESSAGE FROM THE EXTERNAL ADVISORY BOARD CHAIR

At the Fall meeting, the External Advisory Board (EAB) gave outgoing Chair Michael Idelchik a rousing hurrah for overseeing the EAB formation and for his leadership over the last two years.

The External Advisory Board heard from Professor Yao and the faculty on the issues, challenges and initiatives they consider particularly significant to the continued growth and academic stature of the Department.

The EAB is eager to help the Mechanical Engineering Department evaluate and consider alternatives to meet these challenges. There are growing opportunities for our Department on the horizon. The EAB discussed several of these challenges and opportunities among ourselves and then again at a meeting with members of the Faculty. Several items are:
1. There is an opportunity in the need for improvement, and remediation of our nation's infrastructure and energy system, which is supported strongly by the new administration in Washington. A Columbia Engineering response was recommended by the EAB, with joint participation in some mega projects by multiple departments.
2. Interdisciplinary programs are becoming increasingly significant and warrant special Department attention. We offered to help in any way we can since a number of the members of our Board contribute significantly to industry and academic interdisciplinary programs.

There are significant challenges still facing the Department.
1. Growth in the number of ME students, especially undergraduates, is restrained by space limitations placed on the department. This restraint will continue at least until the Manhattanville building construction releases campus space.
The Chair and Faculty suggested that the immediate response to increased growth is through the Master's Program which is less space intensive. The EAB thought this response was appropriate and wise. The Board also suggested several alternatives; one which encourages the best of our senior students to start a Senior/Masters curriculum without the need to reapply to Graduate School (eliminating GRE's). This initiative has now been approved by the SEAS and University Senate and is pending approval from the University Trustees and the NY State Department of Education.
2. Improvement in the enrollment of minority and women to increase undergraduate diversity was deemed important. Board members made suggestions based on their experience, e.g. participating in secondary school programs to identify qualified, talented students.

Finally, on a different note, EAB participation resulted in funding for one exciting student activity. A presentation by Professor Stolfi to our group outlining the progress of our students in the FORMULA SAE CLUB competition energized our interest in supporting our undergraduate students in ways beyond the all important scholarship funding, mentoring, and internship programs in all of which our members are encouraged to take part. We recommended that a presentation be made to the Columbia Engineering Alumni Association, on the Board of which Hitoshi Tanaka and I serve, to request funding support of a much needed advanced dynamometer. The Alumni Association agreed, and made a generous funding commitment to this student group.

Our Board will meet again in April. One focus of the meeting will be the current economic climate and its impact on our graduating seniors.

Your comments are most welcome. Please forward them to me and Professor Yao at seasinfo.me@columbia.edu.

Anna Kazanjian Longobardo
Chair, External Advisory Board

CAREER AWARD SUPPORTS SURGICAL ROBOTS

Nabil Simaan, assistant professor in the Department of Mechanical Engineering and director of the Advanced Robotics and Mechanism Applications (ARMA) Laboratory, has received a CAREER Award, the NSF's most prestigious award in support of junior faculty. Simaan will be developing novel, flexible snake-like robots and parallel robots that will improve success of future minimally invasive surgery paradigms. These robots will gauge their force interactions with the patient's anatomy, gather information, and then act on that information.

One of the latest surgical paradigms is NOTES, Natural Orifice Trans-luminal Endoscopic Surgery, which uses the natural openings in the body to reach the affected organ and perform surgery on it. Unfortunately, current surgical systems are bulky and can not support these new surgical paradigms. There is a need for new down-scalable surgical robots that provide access to the deepest anatomical organs with minimal damage to surrounding anatomy. For example, surgery could be performed on the abdomen by reaching through the patient's mouth, past the esophagus, and through an incision in the stomach. Such robots will be of little use if they are not equipped with some basic forms of intelligence, another aspect addressed by Simaan's CAREER proposal.

"My surgical robots will be able to perform many other surgical functions," says Simaan, "and they will safeguard against damage to the anatomy by acting as intelligent intervention and information gathering tools for assisting surgeons during increasingly complex procedures. The objective of this research is to provide the theoretical foundation for modeling and control of flexible robots for intelligent and safe interaction with the anatomy."

"Intelligence" in this case refers to the ability of these robots to gauge their force interaction with the anatomy, gather information about the anatomy, and act based on this information, he says. Screw theory and stochastic estimation methods are used for modeling the ability of these robots to estimate their wrench interaction with the anatomy by using intrinsic and extrinsic sources of information. These performance measures are used in hybrid force control algorithms that allow characterizing shape, stiffness, and anatomical constraints governing safe maneuvering of suspended organs.

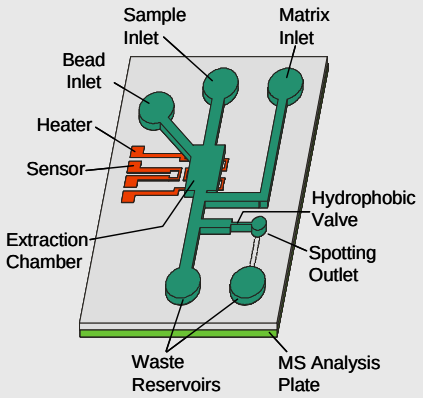
"This research will advance the field robotics by addressing control and resolution of multi-point contact problems for compliant insertion control and bracing against soft environments," says Simaan. "It promises to revolutionize medical robotics by introducing novel algorithms for designing and controlling surgical robots capable of safe interaction and manipulation of the patient's anatomy."

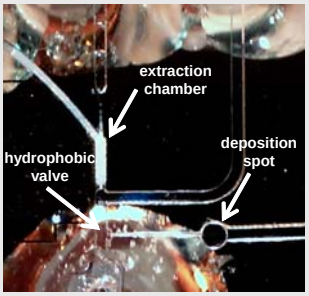
BIOLOGICAL SENSING AND MANIPULATION BY STIMULUS-RESPONSIVE MICROFLUIDICS

In the Biomedical Micro-Electro-Mechanical Systems (BioMEMS) Laboratory directed by Professor **Qiao Lin**, researchers are creating microfluidic systems that exploit aptamers for sensing and manipulation of biomolecules.

Aptamers, from *aptus* (to fit) in Greek, are single-stranded DNA or RNA oligomers that bind to chemical and biological targets via affinity interactions. Intuitively speaking, such interactions result in a conformational shape of the aptamer that uniquely fits the target, leading to highly specific binding. Aptamers can be considered a nucleic-acid analog of antibodies, with advantages such as synthetic availability, general target applicability, and tunability in target-binding characteristics.

Most interestingly, aptamer-taret binding is reversible and depends strongly on external stimuli. Recognizing the potential of such unique stimulus-responsiveness, the BioMEMS Lab is developing aptamer-based microfluidic systems that enable innovative sensing and manipulation of biomolecules. For example, Huu Nguyen, a Ph.D. student in the Lab, has recently demonstrated thermally controlled purification, enrichment and label-free detection of biomolecules using aptamers in microfluidic devices. In bioanalytical applications, biomolecules such as proteins typically exist in impure samples, and must be purified for detection and characterization. Unfortunately, standard purification techniques typically are nonspecific and involve complicated analyte retrieval procedures. These issues can be effectively addressed by Huu's devices, which are functionalized with aptamers, and integrated with MEMS temperature control and microflulidic analyte retrieval elements. During operation, analyte samples are continuously infused into the devices. Target biomolecules are captured and enriched by surface-immobilized aptamer molecules, while impurities remain in the liquid medium and removed. Next, a modest temperature change is produced by integrated temperature control, leading to thermally induced, reversible disruption of aptamer-target binding. Thus, the captured and enriched target biomolecules are released from the aptamer surfaces, and finally retrieved by microfluidics for detection by mass spectrometry. Purification, enrichment and detection of practically significant biomolecules, such as adenosine monophosphate (a regulatory metabolic hormone) and vasopressin (a peptide hormone indicative of immunological shocks), have been performed, demonstrating the potential of the devices for biomedical applications such as proteomic analysis and clinical diagnostics.





A microfluidic purification device. A sample is infused into the extraction chamber and the target analyte is captured and enriched by surface-immobilized aptamers. The micro heater produces a temperature change to release the target, which is transferred via the hydrophobic valve and spotting outlet for detection by mass spectrometry (MS).

This research is supported by the National Science Foundation and the Alternatives Research and Development Foundation, and in collaboration with the laboratory of Professor **Milan Stojanovic** at the Columbia Medical School.

Mechanical Engineering Faculty: (Front row) Richard Longman, Vijay Modi, Larry Yao, (Second row) Qiao Lin, Chee Wei Wong, Nabil Simaan, Daniel Attinger, Gerard Ateshian, James Hone, Elon Terrell, (Back row) Jung-Chi Liao, Jeffrey Kysar, Arvind Narayanaswamy, Fred Stolfi.

Gerard Ateshian recently received a grant from the National Institutes of Health (NIH) titled "FEBio – Finite Elements for Biomechanics and Biophysics," in collaboration with Professor Jeffrey A. Weiss from the University of Utah. The objective of the studies supported with this grant is to develop and provide a free, public domain finite element analysis program which is specifically designed for applications to biological tissues, including large deformations and transport of interstitial fluid and solutes. The total grant award is around $1.3M, to be shared equally between the two institutions for a period of four years. Additionally, Prof. Ateshian joined the Executive Committee of the Biomedical Engineering Society in 2008, as chair of the Finance Committee, after completing his 3-year term on the BMES Board of Directors.

James Hone is a Co-Principal Investigator on a new $3 million grant from NSF's Integrative Graduate Education and Research Training (IGERT) program. This new IGERT program at Columbia is known as the Center for Optical Techniques for Actuation, Sensing and Imaging of Biological Systems. The PI is Prof. Ken Shepard of EE Dept. This IGERT grant will train doctoral students in the application of advanced optical techniques to better understand biological systems. The goals of this multidisciplinary program recognize that progress in biology and medicine relies increasingly on methods, approaches, and strategies from the physical sciences and engineering. Prof. Hone also published another paper entitled “Mott Insulating State in Ultraclean Carbon Nanotubes” in *Science*. Please see the link for details
www.sciencemag.org/cgi/content/full/323/5910/106

Jeffrey Kysar recently received two grants from the Air Force Office of Scientific Research (AFOSR). The first entitled "Plasticity in high temperature materials: Tantalum and Monazite” has the long-term goal to successfully predict the mechanical behavior at high temperatures of various metals and ceramics of interest to the Department of Defense. Both classes of materials will be studied experimentally, analytically and numerically in the high strain and high strain gradients regimes at high temperatures for the prediction of fracture, fatigue, plasticity and strength properties. The total grant award is for $1,210,838 for a period of 5 years. The second is a grant of $332,524 to purchase equipment dedicated for testing of materials at high temperatures.

Vijay Srinivasan has been recently elected Fellow of the ASME. He also received a 25-Year Service Award from IBM, where he still plays a leading role in its Product Lifecycle Management (PLM) program. He has been an adjunct professor of the department teaching courses in computational geometry and geometric modeling for over 20 years. In 2004, he published a book on Theory of Dimensioning: An Introduction to Parameterizing Geometric Models.

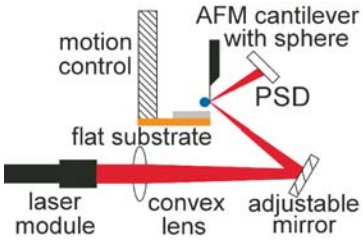
Chee Wei Wong received the 2009 3M Young Faculty Award from *3M Corporation* to examine thin-film solar photovoltaics and efficient light generation. This highly-competitive award is selected amongst young investigators across the country, and is a two-year program to examine engineered nanostructures for efficient energy conversion and transport. Not only does the program allow fundamental scientific studies, but is also a good chance to work directly with the industry on recent technologies for enhanced solar photovoltaics and light sources.

Y. Lawrence Yao was recently elected to the College of Fellows of Society of Manufacturing Engineers (SME). He joined SME in 1986 and has been active in manufacturing research since. He currently serves on the Board of Directors of the research arm of SME, North American Manufacturing Research Institute (NAMRI). This year he assumes the role of NAMRI Secretary. He will be inducted at the North American Manufacturing Research Conference (NAMRC) scheduled for May 2009 in Greenville, South Carolina. For more information on SME and the College of Fellows visit
www.sme.org/cgi-bin/awardhtml.pl?/awards/fellows08.htm&&&SME&.

Study of nanoscale thermal radiative transfer to enhance thermophotovoltaic energy conversion

Professor **Arvind Narayanaswamy** has recently received a three-year grant from the National Science Foundation (NSF) entitled "Near-field thermal radiative transfer between spherical objects." It is known that radiative energy transfer between closely spaced objects (spacing much smaller than the nominal wavelength of thermal radiation, about 10 microns at 300 K) can exceed the predictions of Planck's theory of blackbody radiation due to tunneling of electromagnetic waves from one object to another. The scarcity of reliable experimental data involving near field radiative transfer is due to the difficulty of performing experiments in the two configurations which have been analyzed theoretically; between two parallel surfaces and between a flat surface and a sphere that is small enough that it can be approximated as a point dipole.

The aim of this project is to investigate theoretically near-field thermal radiation heat transfer between closely spaced spherical objects of arbitrary diameters and to propose scaling laws for near-field thermal radiation interactions. The predictions of this theory will be tested by experimental measurements of near-field thermal radiation heat transfer between two microspheres using an experimental apparatus developed in the lab of Prof. Narayanaswamy, the schematic of which is shown in the figure, and a bi-material atomic force microscope cantilever as an ultrasensitive thermal sensor. The thermal response of a bi-material cantilever is similar to that of a bimetallic thermostat. However, the reduced dimensions of the cantilever, 200 μm in length, 40 μm in width, and 500 nm in thickness, make it a far more sensitive thermometer – it can sense temperature changes as small as 10^{-5} K. This research can find application in thermophotovoltaic (TPV) energy conversion since the enhancement due to near-field effects can increase the power density of TPV devices. Measurements of near-field radiative transfer also provide an indirect method for detecting variations of Casimir and van der Waals forces with temperature.



Schematic of experimental apparatus used for measurements of near-field radiative transfer. The focused laser and the position sensitive detector (PSD) are used to measure the deflection of the cantilever to which a microsphere is attached to the tip. As the gap between the substrate and the sphere is decreased, the sphere cools because of increased heat transfer to the substrate. This temperature change causes the bi-material cantilever to bend and this bending is picked up by the PSD.

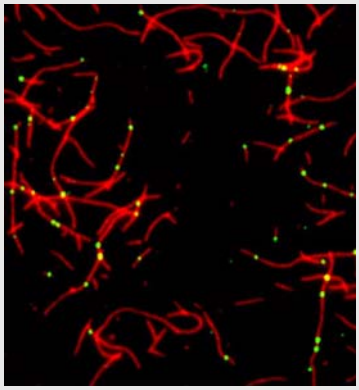
IN MEMORIAM

Dr. Vittorio (Rino) Castelli, 74, professor emeritus of mechanical engineering, died on June 10, 2008. A native of Rome, Italy, Dr. Castelli earned his M.S. and Ph.D. degrees in mechanical engineering in 1957 and 1962, respectively, from Columbia. He joined the mechanical engineering faculty and served as department chair from 1974 to 1978, before he joined the Xerox Corporation. In 1981, he was a co-founder of the Mechanical Engineering Sciences Laboratory (MESL), originally an offshoot of the Xerox Palo Alto Research Center, in Sleepy Hollow, N.Y. In 1999, the year of his official retirement from the company, he received the Xerox President’s Award. Through his theoretical and practical proficiency in the fields of fluid dynamics, electromechanics, heat transfer, elasticity and machine design, he made important contributions to the development of computer information storage disks and tape memories, automobile airbags, a large radio-telescope, and color copiers and printers. He was awarded the Egleston Medal for Distinguished Engineering Achievement in 2000 by the Columbia Engineering School Alumni Association. After his retirement, he returned to Columbia to teach his beloved lubrication course as an adjunct professor until his death. He was revered by students and professional colleagues, many of whom became personal friends for life, not only for his mathematical rigor, scientific insights and technical knowledge but also for his charisma, leadership and sense of humor.

DEPARTMENT WELCOMES NEW FACULTY

Dr. **Jung-Chi Liao** joined the Mechanical Engineering Department as an Assistant Professor in Fall 2008. He received his BS from National Taiwan University and MS and PhD degrees from Massachusetts Institute of Technology. He was formerly a research associate in the Department of Bioengineering at Stanford University, and a postdoctoral fellow at the University of California, Berkeley. His research interests are concentrated on how mechanical forces play roles in molecules and cells, using both computational and experimental methods to study molecular motors (photo) and related cellular functions. Dr. Liao's presence "will strengthen one of the department's strategic emphases on fundamental research underlying health care, drug discovery, and biological engineering. We are very pleased to have him on board," explained Department Chair, Dr. Yao. Dr. Liao is already involved in the Interdisciplinary Biosciences Program at Columbia. He commented that he is most excited about "the collaborative environment and opportunities that the department and Columbia offer."

Currently his group is building a super-resolution microscopy system based on stimulated emission depletion (STED) to observe the dynamics of molecular motors inside living cells. This super-resolution microscopy system will be able to break the diffraction limit to reach ~20 nm resolution. In addition to advancing the microscopy system, Dr. Liao is investigating how molecular motors play roles in transcriptional regulation of embryonic stem cells. Embryonic stem cells can differentiate into various types of cells, where mechanics plays important roles. The super-resolution microscopy system will be the most suitable to decipher how molecular mechanics affects the behaviors of embryonic stem cells. After six months of intensive development, his lab is now in use for experiments. Dr. Liao is also working on modeling molecular motors using computational techniques. These modeling works help understand the structure-function relationship of molecular motors, and also help promote the engineering of molecular motors for biological studies and engineering applications.



Single molecule observation: fluorescently-labeled myosin VI (green) molecular motors walking on fluorescently-labeled actin filaments (red).

Dr. **Elon Terrell** joined the department in Fall 2008 as an assistant professor. He received his PhD in mechanical engineering from Carnegie Mellon University in 2007, and MS and BS degrees in mechanical engineering from the University of Texas at Austin. His research interests involve the thermal-fluid sciences, energy, and tribology, and, in particular, research in hydrodynamic lubrication, surface engineering, and contact mechanics which can be applied to lubrication and wear in MEMS devices; efficiency and longevity maximization of energy systems; design improvement of biomedical devices, and sustainable manufacturing. Dr. Terrell is currently working on collaborative research with Argonne National Laboratory and will be applying his knowledge in tribology to that of energy systems.

One of the projects on which he is currently working involves the study of the lubricious properties of alternative fuels in diesel engines. Traditional diesel fuel has been shown to be an excellent lubricant, which is beneficial for the minimization of clogging in the injection systems. However, some alternative fuels such as biodiesel blends have been shown to cause clogging, especially at low temperatures. Therefore, Dr. Terrell has begun research with both the Engine and Emissions Section and the Tribology Section at Argonne in order to study the lubricity of various fuel blends with different additives.

Additionally, Dr. Terrell has begun research involving the study of rolling-sliding contact in the gearboxes of wind turbine power systems. Wind power is currently one of the fastest-growing sources of energy production, and is of increasing interest in society due to its prospects as a sustainable source of pollution-free energy. Although most wind turbines are designed for an operating lifetime of 20 years, a number of field investigations have demonstrated that repair and/or replacement of gearboxes is required over significantly smaller time intervals than that which is expected. Wind turbines are consistently plagued with problems with their gearbox systems, which are oftentimes subject to harsh environmental conditions and drastically varying loads which can cause severe damage to gearbox components. Such damage commonly causes the reduction of the lifetime of wind gearbox systems as well as increased costs. Because the majority of the damage modes to wind turbine power systems has to do with tribological issues in the gears and bearings, Dr. Terrell has begun research which he hopes will lead to fatigue- and failure-resistant wind turbine systems.

Dr. Terrell looks forward to beginning his work on-site at Columbia this summer, and plans to use both numerical methods and experimental testing to investigate tribological issues in diesel and wind power systems in his research laboratory, which he has named the Energy and Tribology Laboratory. He believes that his laboratory's research will lead to efficiency, longevity, and sustainability improvements in power-generating devices which incorporate both traditional and nontraditional energy sources. Dr. Yao, Chair of Mechanical Engineering, is proud to have Dr. Terrell on board as "he continues the fine tradition of this Department in tribology research, with new contributions to energy systems."

Department of Mechanical Engineering Fund

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The Department of Mechanical Engineering at Columbia has been ranked fifth in faculty productivity by ***The Chronicle of Higher Education***. In recently released data for 2007, the Department tied with Stanford University for fifth place; it ranked behind California Institute of Technology, University of California at Berkeley, Yale and MIT. The ranking is compiled over 375 universities which offer the full Ph.D. program.

"It is one objective measure that our efforts to recruit and retain faculty of the highest caliber are succeeding," said **Gerald A. Navratil**, Interim Dean of School of Engineering and Applied Science.

“I am especially pleased to note that our faculty was first in the category of *Journal Publications per Faculty*, achieving an average of 12.83 publications. We were second only to MIT in *Total Value of New Grants per Faculty* and, in addition, the impact of our faculty’s work is high. Using *Citations per Faculty* as a measure, we were exceeded only by Cal Tech and MIT,” said **Larry Yao**, the ME Department Chair.

“We are pleased with the scientific and engineering advancements brought about by our top-notch faculty members, and we continue to deliver rigorous education to our top-quality graduate and undergraduate student body, while developing strong relations with our alumni. We are confident of our growth in the years to come,” said Yao. He also noted the invaluable assistance given the department by its External Advisory Board of distinguished alumni and other leaders.

Complete results of the data and methodology behind the ranks can be viewed on the Chronicle website.

http://chronicle.com/stats/productivity/page.php?year=2007&primary=5&secondary=51&bycat=Go

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