



CELEBRATE

PRINCETON INVENTION

2013

Research
at Princeton



Cover image: A new type of designer material, known as a hyperuniform disordered solid, could enable technologies based on the manipulation of light rather than electrons. The structure pictured here acts as a semiconductor for light, blocking a band of frequencies from propagating from chamber to chamber through the solid while allowing higher or lower frequencies of light to pass. (Image courtesy of Paul Steinhardt, the Albert Einstein Professor in Science)



From the Dean

As one of the world's great research universities, Princeton is an engine for the generation of new ideas. Some of these ideas have the potential for becoming the new products and new industries that have consistently strengthened our nation's economy and improved the quality of life for countless citizens. By providing an environment that supports innovation, we at Princeton strive to create the conditions that facilitate the journey from the laboratory to the marketplace.

This fifth installment of Celebrate Princeton Invention showcases inventions and products that began as exploratory ideas in Princeton laboratories. In so doing, we celebrate not only the creativity and ingenuity of faculty members, students and postdoctoral researchers, but also the vital contributions of our friends in the corporate and venture capital communities, whose vision and expertise enable the challenging transition from ideas to products. We celebrate the fruitful interaction between investors, inventors and entrepreneurs, which our offices of Technology Licensing and Corporate and Foundation Relations work hard to establish and nurture.

This wonderful display of creativity and invention at Princeton is part of the seamless spectrum of activities that span apprenticeship and education in the laboratory, the formulation of fundamental theories and ideas, and the materialization of many of these ideas into new technologies and products.

Pablo Debenedetti

*Dean for Research and Class of 1950
Professor in Engineering and Applied Science*

Technologies
licensed

33

107

New
inventions
disclosed

160

Patent
applications

277

Faculty, staff and
student inventors

INCOME

from licensed technologies

\$136 million

CELEBRATE

PRINCETON INVENTION

2013

We invite you to learn more about technology transfer at Princeton
in the pages of this brochure and at
www.princeton.edu/patents.



As we prepare to celebrate our fifth year of this event to honor our University inventors, I would like to thank those of you who have joined us in past years and welcome the newcomers. Princeton is fortunate to attract superbly creative faculty members and researchers who are compelled to explore, to innovate and to incubate ideas that form the basis of new products and entire industries. We in Technology Licensing are dedicated to enabling these ideas to reach the corporate and investment community, where they can be developed into market-ready goods and services.

Over the 13 years that I have been director of Technology Licensing at Princeton, I have observed an upswing of interest among our faculty, research staff and students in transitioning their research ideas and prototypes into the marketplace. Our industry and investment partners are invaluable in this task. We view this annual gathering as an opportunity for our partners to meet Princeton inventors and learn about their innovations, and we sincerely hope that the relationships built at this event will serve as foundations for long-lasting and mutually fruitful relationships. Welcome to Celebrate Princeton Invention 2013!

John Ritter

Director, Technology Licensing

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Princeton's scientists and engineers share a passionate commitment to research that deepens our understanding of the world and improves the quality of life within it. Each year, Celebrate Princeton Invention highlights the dynamic applications and substantial benefits of discoveries produced by this University's laboratories. And it showcases the growing number of collaborations between Princeton researchers and corporate partners, who are working together to generate insights and technologies that will make a difference to the world. At Princeton, where our research and teaching missions are thoroughly intertwined, these collaborations involve not only faculty members and professional staff but also our superbly talented graduate students and undergraduates. All of us in Princeton's scholarly community welcome your interest in the exciting research conducted here, and we hope that your encounter with it may stimulate new projects, inventions and ventures in the future.

Christopher L. Eisgruber
President, Princeton University

Princeton embodies a unique mix of outstanding faculty-led research and a focus on undergraduate education. Our faculty inventors share their expertise as leaders in their fields with graduate and undergraduate students — the next generation of leaders, inventors and entrepreneurs who can use research findings to develop new practical applications that impact our everyday lives.

David S. Lee
Provost, Princeton University

Code key:

D = Disclosure
A = Application
P = Patent
L = License

Adolfson, Kristin

- Engineering Reactive Oxygen Species Metabolism With Futile Cycles (D, A)

Aksay, Ilhan

- Graphene Dispersions (A)
- Nano-Graphene and Nano-Graphene Oxide (A)
- Nanocomposite of Graphene and Metal Oxide Materials (P)
- Preparation of Hard Aggregate-Free Functionalized Graphene Pastes (D)
- Printed Electronics (A, P)

Al-Housseiny, Talal

- Leveraging Shape to Control Interfacial Instabilities (A)

Alidoust, Nima

- A New Material for Solar Energy Conversion Devices (D)
- Nickel-Lithium Oxides for Solar Energy Conversion Devices (D, A)
- Substitutionally Alloying Nickel Oxide With Lithium in High Concentrations in the Rocksalt Structure for Use in Tandem Dye-Sensitized Solar Cells and Photocatalysis (A)

Arnold, Craig

- 3-D Chalcogenide Recording Material (A)
- Linear-Translational Multi-Target Manipulator With Adjustable Temperature Control for Thin Film Deposition (D)
- Multi-Layered Chalcogenide Structure (A)
- Novel Chalcogenide Materials With Controllable Light Radiation Response Feature (D)
- Stress-Based State of Health and Charge Measurement for Intercalation Batteries (A)

Arwatz, Gilad

- Electromechanical Dispenser for Cosmetic Products (D)

Ascione, George

- Miniature Nuclear Detection Systems (MINDS) (L)

Atienza, Crisita Carmen

- Cobalt-Bis(imino)pyridine-Based Catalysts for Dehydrogenative Silylation (D)
- Dehydrogenative Silylation and Crosslinking Using Cobalt Catalysts (A)
- Hydrosilylation and Dehydrogenative Silylation Using Cobalt Catalysts (A)
- Hydrosilylation With Cobalt-Bis(imino)pyridine Complexes (D)
- Reusable, Homogeneous Cobalt-Bis(imino)pyridine Catalysts for Dehydrogenative Silylation and Tandem Dehydrogenative-Silylation-Hydrogenation (D, A)
- Saturated and Unsaturated Silahydrocarbons via Iron and Cobalt-Bis(imino)pyridine-Catalyzed Olefin Silylation (D, A)
- Selective 1,2 Hydrosilylation of Conjugated Dienes Using Fe Catalysts (D)

- Selective 1,2 Hydrosilylation of Terminally Unsaturated 1,3-Dienes Using Fe Catalysts (A)

Austin, Robert

- Bump Array Device Having Asymmetric Gaps for Segregation of Particles (A)
- Gradient Structures Interfacing Microfluidics and Nanofluidics, Methods for Fabrication and Uses Thereof (P)
- High-Efficiency Microfluidic Purification of Stem Cells to Improve Transplants (D, A)
- Method for Continuous Particle Separation Using Obstacle Arrays Asymmetrically Aligned to Fields (A, P)
- Microfluidic Processing of Leukocytes for Molecular Diagnostic Testing (D, A)
- Ratchet Bump Array (L)

Avaltroni, Michael

- Attachment of Organic Films to Metal Oxides and Metal Native Oxide Layer (L)
- Heat Transfer of Phosphonic Acids on Metal Surfaces (L)
- Osteoblast Adhesion and Spreading on the Chemical Modified Surface of Ti-6Al-4V (L)
- The Use of Derivatized Self-Assembled Phosphonate Monolayer to Enhance Bone Growth on Implant Devices (L)

Baliban, Richard

- Diagnosis of Periodontal Status Using Protein Biomarkers Within Gingival Crevicular Fluid (A)
- Processes for the Conversion of Natural Gas to Synthetic Liquid Hydrocarbons (D, A)

Bassler, Bonnie

- Biofilm Streamers Cause Catastrophic Disruption of Flow With Consequences for Environmental and Medical Systems: Role of Quorum Sensing and Treatment With Small Molecules (D)



Taking a cue from the humble leaf, researchers led by Yueh-Lin (Lynn) Loo, the Theodora D. '78 and William H. Walton III '74 Professor in Engineering, have created microscopic folds on the surface of photovoltaic material to significantly increase the power output of flexible, low-cost solar cells.

- New Agonists of Quorum Sensing in *Vibrio cholerae* (A)
- Small Molecule Antagonists of Bacterial Quorum-Sensing Receptors (A, P)
- Small Molecule Probes of the Receptor Binding Site in the *Vibrio cholerae* CAI-1 Quorum-Sensing Circuit (A)
- Small Molecules Active in Quorum Sensing for Inhibition of Biofilm Streamers (A)

Bhoj, Ajay

- Methodologies for Intelligent Device State Caching for Accelerating 3-D/2-D Device and Mixed-Mode Device-Circuit Simulation (D, A)

Bitter, Manfred

- Optimization of the Configuration of Pixelated Detectors for the X-Ray Spectroscopy of Hot Plasmas Based on the Shannon-Nyquist Theorem (A)
- Two Novel X-Ray Optical Schemes for Spectroscopy With Fast Time Resolution and Two-Dimensional Imaging With High Magnification (A)

Boaz, Nicholas

- Compositions and Methods for Hydrocarbon Functionalization (A)
- Hydrocarbon Functionalization Using Halide Salts as Catalyst (D)

Bocarsly, Andrew

- Conversion of Carbon Dioxide to Organic Products (A, P)
- An Indium Electrode-Based Electrochemical Cell for the Conversion of Carbon Dioxide Formate Salts and Acid (D, A)
- Reduction of CO₂ to Useful Products Using Alkaline Earth Metals (D)

Bolitho, Megan

- Small Molecule Probes of the Receptor Binding Site in the *Vibrio cholerae* CAI-1 Quorum-Sensing Circuit (A)

Brody, Carlos

- Voluntary Head Restraint and Automated *In Vivo* Imaging System (D, A)

Brook, Karolina

- New Agonists of Quorum Sensing in *Vibrio cholerae* (A)

Brunkhorst, Christopher

- Method and Apparatus for Pasteurizing Shell Eggs Using Radio Frequency Heating (D, A)

Brynildsen, Mark

- Engineering Reactive Oxygen Species Metabolism With Futile Cycles (D, A)

Callan, Curtis

- Method for Assessing Immune System Status (A)

Cannarella, John

- Stress-Based State of Health and Charge Measurement for Intercalation Batteries (A)

Cao, Han

- Miniature Nuclear Detection Systems (MINDS) (L)

Portable Sensors Measure Air Pollutants

Although not as well-known as carbon dioxide or methane, nitrous oxide is a significant greenhouse gas. One of its primary sources is the application of nitrogen-based fertilizers on farm fields. Yet measuring the levels of nitrous oxide in a field is difficult because today's sensors are heavy and consume large amounts of power. A portable nitrous oxide sensor, easily carried from place to place, could radically change how scientists and regulators monitor this greenhouse gas.

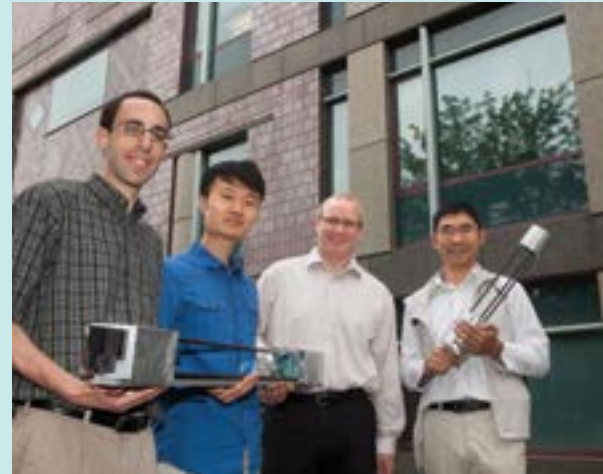
Mark Zondlo, assistant professor of civil and environmental engineering, and his team have developed a fast, sensitive and portable nitrous oxide sensor that can be carried in one hand. The sensor uses a battery-powered laser, called a quantum cascade laser, to fire a beam of light through a sample of air, while a detector measures the light absorption to deduce the amount of nitrous oxide in the air.

The group has created similar sensors that measure ammonia and carbon monoxide. The portable sensors allow measurements to be taken quickly and frequently, which could greatly expand the understanding of how these pollutants are released and how this release can be controlled. The research team tested the sensors for several weeks

earlier this year in California's San Joaquin Valley and found that they performed well compared to stationary instruments.

To give accurate measurements in rapidly changing field environments, the sensors must be calibrated frequently by measuring a known concentration of gas. The calibration equipment contributes to the large size of today's bulky sensors. The new Princeton sensor replaces the large calibration equipment with a finger-sized chamber of reference gas.

"Our sensors have precision and stability similar to the best sensors on the market today, but at a fraction of the size and electricity requirements," said Zondlo, who is affiliated with the Mid-infrared Technologies for Health and the Environment (MIRTHE) center, a multi-institution center funded by the National Science Foundation and headquartered at Princeton. Zondlo's co-inventors on the project include graduate students **Kang Sun** and **David Miller** as well as Postdoctoral Research Associate **Lei Tao** and former postdoctoral researcher **Amir Khan**.



From left to right: David Miller, Kang Sun, Mark Zondlo and Lei Tao

Carter, Emily

- Doped Cuprous Oxide as a Semiconductor for Solar Energy Conversion Devices (A)
- Hematite-Based Photoanodes With Manganese, Cobalt and Nickel Additives (A)
- Hydrogen or Lithium Doping for Wüstite-Based Photoelectrodes (A)
- Improved Thermal Stability of Ni Cermet Anodes in Solid Oxide Fuel Cells (A, L)
- Iron (II) Oxide Alloys as Semiconductors for Solar Energy Conversion Devices (A)
- A New Material for Solar Energy Conversion Devices (D)
- Nickel-Lithium Oxides for Solar Energy Conversion Devices (D, A)
- Substitutionally Alloying Nickel Oxide With Lithium in High Concentrations in the Rocksalt Structure for Use in Tandem Dye-Sensitized Solar Cells and Photocatalysis (A)
- Wüstite-Based Photoelectrodes With Lithium, Hydrogen, Sodium, Magnesium, Manganese, Zinc and Nickel Additives (A)

Chaikin, Paul

- Quasicrystalline Structures and Uses Thereof (A, P)

Chaudhuri, Sourindra

- Methodologies for Intelligent Device State Caching for Accelerating 3-D/2-D Device and Mixed-Mode Device-Circuit Simulation (D, A)

Chen, Hao

- Plasmonic Cavity With a Metallic Island Sheet and a Metallic Backplane (PCMM) (D, A)

Chen, Jiasi

- Quota Aware Video Adaptation (QAVA) (A)

Chen, Yu-Yuan

- Data Center Protection With Cyber-Physical Defenses (A)

Chiang, Katherine

- Printed Electronics (A, P)

Chiang, Mung

- A Middleware for Supporting Pricing Solutions in Broadband Networks (L)
- Quota Aware Video Adaptation (QAVA) (A)
- System and Method for Variable Pricing of Data Usage (A)
- System and Methods for Time-Dependent Internet Pricing (A, L)

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Tom Muir (left) and Miquel Vila-Perello



New Method Builds Targeted Drugs

Medicines that travel directly to a tumor or other target in the body hold great promise for the treatment of cancer and other diseases. Targeted medications have the potential to be highly effective at reduced doses, dramatically reducing side effects for the patient and improving quality of life. But attaching these “molecular address labels” to drug molecules has proved difficult. **Tom Muir**, Princeton’s Van Zandt Williams Jr. Class of 1965 Professor of Chemistry, and his collaborators Associate Research Scholar **Miquel Vila-Perello**, Postdoctoral Research Associate **Zihua Liu** and graduate student **Neel Shah** have developed a new technique for fastening these targeting molecules to drugs and building these so-called drug-antibody conjugates.

The method relies on naturally occurring proteins, called “split inteins,” found in a certain type of blue-green algae. Split inteins come in pairs that can bind each other tightly like opposing strips of Velcro. Muir’s team found an efficient way to attach one intein to the targeting molecule, which is an antibody that selectively binds to the desired cells, while using the matching intein to attach the drug molecule to it. Mixing the antibody-intein with its complementary intein, in the presence of the drug, allows the matching inteins to come together and facilitates the tight attachment of the drug to the antibody.

“With this new split intein-based method, we have an exciting and important way to generate targeted drugs,” said Muir. The research was supported by grants from the National Institutes of Health.

- A System for Offering Intelligent Flat Rate (IFR) Data Plans (A, L)
- User Interface Design for Time-Dependent Pricing (L)

Chirik, Paul

- Cobalt Phosphine Alkyl Complexes for the Asymmetric Hydrogenation of Alkenes (A)
- Cobalt-Bis(imino)pyridine-Based Catalysts for Dehydrogenative Silylation (D)
- Dehydrogenative Silylation and Crosslinking Using Cobalt Catalysts (A)
- Enantiopure Base-Metal Catalysts for Asymmetric Catalysis and Bis(imino)pyridine Iron Alkyl Complexes for Catalysis (A)
- Hydrosilylation and Dehydrogenative Silylation Using Cobalt Catalysts (A)
- Hydrosilylation With Cobalt-Bis(imino)pyridine Complexes (D)

- Iron-Catalyzed Hydrogen Isotope Labeling of Aromatic Organic Compounds (D)
- Reusable, Homogeneous Cobalt-Bis(imino)pyridine Catalysts for Dehydrogenative Silylation and Tandem Dehydrogenative-Silylation-Hydrogenation (D, A)
- Saturated and Unsaturated Silahydrocarbons via Iron and Cobalt-Bis(imino)pyridine-Catalyzed Olefin Silylation (D, A)
- Selective 1,2 Hydrosilylation of Conjugated Dienes Using Fe Catalysts (D)
- Selective 1,2 Hydrosilylation of Terminally Unsaturated 1,3-Dienes Using Fe Catalysts (A)

Chiu, YenTing

- Quantum Cascade Lasers With Improved Performance Using Interface Roughness Scattering (A)

Chou, Stephen

- D2PA and Bio/Chemical Sensing (D, A)
- Gradient Structures Interfacing Microfluidics and Nanofluidics, Methods for Fabrication and Uses Thereof (P)
- Metallic Nanostructures in Microfluidic Channels for Enhancement of Fluorescence and Raman Scattering and for Speeding of Assay Detection Time and Making of the Same (D, A)
- A Method to Enhance Assay Sensitivity by Digitally Counting Blinking Bright Spots From Single Molecule Emitters (D, A)
- Method to Enhance Assay Sensitivity by Selectively Masking Local Surface (D, A)

“Princeton University and SAP share a passion for capturing the future. In that spirit, SAP is proud to help celebrate Princeton invention. It’s the courage and boldness of innovators that drive technology to change the world, make it run better and improve people’s lives.”

Bill McDermott

Co-Chief Executive Officer, SAP

- Methods for Creating Large-Area Complex Nanopatterns for Nanoimprint Molds (D)
- Methods for Reducing Bio-Assay Processing Time (D, A)
- Methods for Reducing Charge Effects and Separation Forces in Nanoimprint (D, A)
- Nanoparticle Structures, Fabrication Methods and Applications in Chemical and Biological Sensing (D, A)
- Plasmonic Cavity With a Metallic Island Sheet and a Metallic Backplane (PCMM) (D, A)
- Structures for Enhancement of Local Electric Field, Light Absorption, Light Radiation, Material Detection and Methods for Making and Using of the Same (A)

Choueiri, Edgar

- Optimal Crosstalk Cancellation for Binaural Audio With Two Loudspeakers (L)
- Radio-Frequency-Controlled Hollow Cathode (RF-CHC) (D, A)
- Spectrally Uncolored Optimal Crosstalk Cancellation for Audio Through Loudspeakers (A)

Cohen, Adam

- Advanced Liquid Centrifuge Using Differentially Rotating Cylinders and Optimized Boundary Conditions (A)

Cohen, Samuel

- Method to Produce High Specific Impulse and Moderate Thrust From a Fusion-Powered Rocket Engine (L)
- Method to Reduce Neutron Production in Small Clean Fusion Reactors (L)

Cole, Emily Barton

- Conversion of Carbon Dioxide to Organic Products (A, P)

Coller, Hilary

- Identification of Novel Isoforms of the RECK Gene and Their Potential Utility in Diagnostic and Therapeutic Applications (D)
- Inducing Apoptosis in Quiescent Cells (A)
- Novel Isoforms of the RECK Gene for Diagnostic and Therapeutic Uses (A)

Constantin, Hannah

- Microfluidic Synthesis of Crimped Fibers (D, A)

Corney, David

- Identification of Novel Isoforms of the RECK Gene and Their Potential Utility in Diagnostic and Therapeutic Applications (D)
- Novel Isoforms of the RECK Gene for Diagnostic and Therapeutic Uses (A)

Cristea, Ileana

- Method to Increase the Infectivity of Virus Particles (L)
- Method to Produce Virus in Cultured Cells Supplemented With Alpha-Ketoglutarate (L)
- Modulators of Sirtuins as Inhibitors of Human Cytomegalovirus (L)

Crowder, Katherine

- The Use of Derivatized Self-Assembled Phosphonate Monolayer to Enhance Bone Growth on Implant Devices (L)

Danahy, Michael

- Heat Transfer of Phosphonic Acids on Metal Surfaces (L)
- Osteoblast Adhesion and Spreading on the Chemical Modified Surface of Ti-6Al-4V (L)

Darmon, Jonathan

- Iron-Catalyzed Hydrogen Isotope Labeling of Aromatic Organic Compounds (D)

Davidson, Ronald

- Transverse Focusing of Intense Charged Particle Beams With Chromatic Effects for Heavy Ion Fusion (D)

Davis, Bill

- Software for MINDS Detector (L)

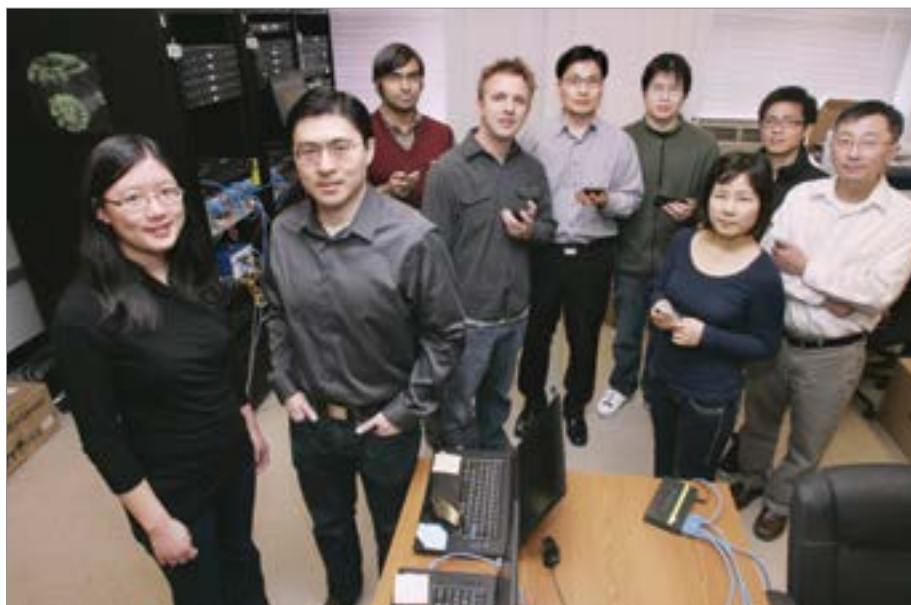
Debenedetti, Pablo

- Chiral Porous Solids for Chiral Separations (D, A)

Delgado-Aparicio, Luis

- Optimization of the Configuration of Pixelated Detectors for the X-Ray Spectroscopy of Hot Plasmas Based on the Shannon-Nyquist Theorem (A)
- Two Novel X-Ray Optical Schemes for Spectroscopy With Fast Time Resolution and Two-Dimensional Imaging With High Magnification (A)

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Mung Chiang (second from the left), the Arthur LeGrand Doty Professor of Electrical Engineering, and his team have built an algorithm and cellphone app called DataWiz that allows users to monitor and manage their data usage. The system relies on time-dependent pricing and shifting traffic to off-peak times by using incentives to encourage consumers to access the network at low-congestion periods.

Dennes, Thomas

- Enhancing Cell Growth on Synthetic Polymers: High Yield Attachment of Cell Adherent Peptide RGD Onto Polyamides via a Zirconium-Amide Complex Interface (L)
- Modular Monolayer Coatings for Selective Attachment of Nanoparticles to Biomolecules (P)
- Polymer Surface Functionalization via a Novel Adhesion Layer (L)

Detweiler, Zachary

- An Indium Electrode Based Electrochemical Cell for the Conversion of Carbon Dioxide Formate Salts and Acid (D, A)
Reduction of CO₂ to Useful Products Using Alkaline Earth Metals (D)

Ding, Wei

- Nanoparticle Structures, Fabrication Methods and Applications in Chemical and Biological Sensing (D, A)

Dismukes, Gerard Charles

- Polymorphs of Manganese Oxides as Water Oxidation Catalysts: Nano-Crystalline Pure Phases of Bixbyite Mn₂O₃ and Hausmanite Mn₃O₄ (D)

Dogariu, Arthur

- Air Laser (L)
- Standoff Detection and Imaging Using Point-and-Line-CARS (D, A)
- Systems and Methods for Lasing from a Molecular Gas (A)

Dooley, Stephen

- Measurement Process for the Determination of the Mixture-Averaged Molecular Weight of Complex Mixtures (A)

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Naveen Verma (right), an assistant professor of electrical engineering, and Branko Glišić, an assistant professor of civil and environmental engineering, are developing an inexpensive-yet-accurate sensor system for detecting defects in bridges and other massive structures. Embedded in customizable plastic sheets and made from low-cost, thin-film technology, the sensors can communicate with other sensors and differentiate between a minor and major structural problem.

“We have had an exceptional experience working with John Ritter and Princeton University Technology Licensing. John has been straightforward, fair and incredibly supportive. The Technology Licensing team has a rare understanding of the challenges that face licensees and startups, which is a great complement to the world-class research and advice we get working with Professor Ilhan Aksay and the Department of Chemical and Biological Engineering, and has allowed us to rapidly move our technology into the marketplace.”

John Lettow

President and Chief Executive Officer, Vorbeck Materials Corp.

Drescher, Knut

- Biofilm Streamers Cause Catastrophic Disruption of Flow With Consequences for Environmental and Medical Systems: Role of Quorum Sensing and Treatment With Small Molecules (D)
- Small Molecules Active in Quorum Sensing for Inhibition of Biofilm Streamers (A)

Dryer, Frederick

- Measurement Process for the Determination of the Mixture-Averaged Molecular Weight of Complex Mixtures (A)

Dural, Nezhil

- Anodically Bonded Cells With Internal Optical Elements (D)
- Atomic Magnetometry Using Multipass Cells (D, A)

Dylov, Dmitry

- System and Method for Nonlinear Self-Filtering via Dynamical Stochastic Resonance (A, P)

Edlund, Eric

- Advanced Liquid Centrifuge Using Differentially Rotating Cylinders and Optimized Boundary Conditions (A)

Efthimion, Philip

- Advanced Liquid Centrifuge Using Differentially Rotating Cylinders and Optimized Boundary Conditions (A)

Elia, Josephine

- Processes for the Conversion of Natural Gas to Synthetic Liquid Hydrocarbons (D, A)

Ell, Brian

- Micro RNAs as Functional Mediators and Biomarkers of Bone Metastasis (A)

Ellison, C. Leland

- Feedback Control of Azimuthal Oscillations in ExB Devices (A)

Robotic Bioreactor Produces Proteins

Yeast, bacteria and mammalian cells are often harnessed to act as small factories that produce drugs, biofuels and other products. **Megan McClean**, an associate research scholar in Princeton's Lewis-Sigler Institute for Integrative Genomics, has developed a system for real-time control of the amount of protein made by yeast in these biological factories.

McClean's system uses blue light to turn on protein production in these cells, which are housed in large containers known as bioreactors. The system contains detectors that sense current protein levels and either ramp up or down the production of the protein.

The system relies on a technology known as optogenetics, which involves using a beam of light to turn on or off specific genes. Optogenetics takes advantage of the fact that certain light-sensitive proteins will change shape when hit by blue light. When the protein changes shape, it becomes able to bind to a second protein that then activates the reading of the DNA that codes for the creation of a desired protein product.

McClean has attached this optogenetic "on/off" switch to a gene for a desired protein in yeast cells growing in a bioreactor, and shining blue light into the bioreactor causes a surge in production of this protein. By including a gene for a fluorescent tag, McClean can measure the emission of fluorescent light to quantify the amount of protein produced.

McClean has built this protein production control mechanism into a robotic bioreactor system that a researcher can use to produce a preset amount of protein in yeast. The researcher enters the desired quantity into a computer connected to a bioreactor. Then the blue light is turned on, activating the reading of the DNA code and the production of the protein. At periodic intervals, small amounts of cells are drawn into a detector that quantifies protein concentration by measuring the amount of fluorescence being emitted. When the fluorescence detector indicates that the preset amount of protein has been



Megan McClean

reached, the blue light turns off and production of the drug shuts down.

The system can be used to preset levels of production or to create proteins on a schedule, McClean said. "I tell the computer how much protein production I need, and when I need it, and the computer software turns on and off the blue light," McClean said. She developed the system with the help of Research Specialists **Justin Melendez** and **Michael Patel**, former Research Specialist **Benjamin Oakes**, and Associate Research Scholar **Marcus Noyes** in the Lewis-Sigler Institute.

McClean hopes that the system can be used by pharmaceutical companies to produce new products, as well as for basic research. "For example, researchers could overexpress or underexpress levels of a specific protein and then study the downstream effects," she said. Another possible use, she said, is the optimization of ethanol production for biofuels.

Erickson, Keith

- A Compiler Suite of Tools for the GNU/Linux Operating System (D)

Feibush, Eliot

- Visualization of Multivariate Data (D)

Feng, Jie

- Formation of Nano-Emulsions by Bursting Bubbles in a Liquid-Liquid Interface (D, A)

Fetterman, Abraham

- Magnetic Centrifugal Mass Filter (A)

First, Eric

- Database Screening Method for Cost-Effective Separations (D)
- Method for Identifying a Microporous Material (A)
- Method of Determining Chemical Reaction Mechanisms (A)
- A Novel Automated Computational Method for Calculating Atomic Mappings for Chemical Reactions (D)
- ZEOMICS and MOFomics (D)

Fisch, Nathaniel

- Feedback Control of Azimuthal Oscillations in ExB Devices (A)
- Magnetic Centrifugal Mass Filter (A)
- Method for the Production of Efficient High-Intensity Laser Pulses by Pulse Chirping (A)
- Method of Producing Ultra-Heavy Homogeneous Aerosol of Sub-Micron Particles, Particle Gas Target for High Density Laser Produced Plasmas and Method of Preparing Super Concentrated Jets from Dense Aerosol Suspensions (A)
- Non-Spectroscopic Method of Determining Gas Constituents Through Rotation (D)
- Optimization of Efficiency of Internal Combustion Engines via Using Spinning Gas (D)
- Optimization of Efficiency of Internal Combustion Engines via Using Spinning Gas and Non-Spectroscopic Method of Determining Gas Constituents Through Rotation (A)
- Process/Method to Enhance the Performance of Plasma-Based Particle Accelerators Using Magnetized Plasma Compression (D, A)

Magnetic Field Detector Finds Explosives

Measuring magnetism is important in applications ranging from the detection of landmines to the diagnosis of health conditions, such as epilepsy and cardiac arrhythmias, caused by disruptions in electrical signals. Over the last several years, physics professor **Michael Romalis** and his team have developed some of the world's most sensitive magnetometers.

These magnetometers are so sensitive because they quantify magnetic fields by measuring a quantum mechanical property known as spin, which is present in electrons and other subatomic particles. "Electrons respond to the presence of a small magnetic field by changing the orientation of their spin," Romalis said. "Our magnetometers measure this orientation."

In the detectors developed by the Romalis group, laser light is used to line up the spins of the electrons in a cloud of potassium gas. A second laser probes the alignment of electrons and acts as a detector to measure how the direction of spin changes in response to a magnetic field. The process includes a trick for preventing the spins from relaxing back into random directions, so it is called the spin-exchange relaxation free (SERF) regime.

Romalis' group was the first to use these magnetometers to detect brain magnetic fields, which can help diagnose disorders and contribute to basic research about how the brain works. More recently, the researchers have demonstrated the detection of explosives and of the Earth's magnetic field. This latest application involves a portable magnetometer that can be taken into the field. In addition, the magnetometers are



Michael Romalis

being developed to explore fundamental physics, said Romalis, who has been funded by the National Science Foundation, the National Institutes of Health and other federal agencies.

Today, these magnetometers are becoming commercially available through a Princeton startup, Twinleaf LLC, which was started by Romalis' former graduate student **Thomas Kornack**, and **Elizabeth Foley**. Both earned their doctoral degrees from Princeton in 2005.

Fleischer, Jason

- Flow Scanning Tomography (A)
- Improved-Resolution Light-Field Imaging (D, A)
- Incorporation of Wrinkles and Folds to Enhance Efficiency and Bendability of Plastic Solar Cells and the Method to Create Such Structures (A)
- Layered 3-D Display With a Lens (D, A)
- Rotating Flow and Structured Illumination for Optofluidic Microscope (A)
- System and Method for Nonlinear Self-Filtering via Dynamical Stochastic Resonance (A, P)
- Tilted Channels for Computational Imaging in Optofluidic Microscopes (A)

Florescu, Marian

- Cavity Architectures in Hyperuniform Disordered Materials With Complete Photonic Band Gaps (L)
- Disordered Photonic Heterostructures and Uses Thereof (L)

Floudas, Christodoulos

- Algorithms for coNTinuous/Integer Global Optimization of Nonlinear Expressions (ANTIGONE) (D, L)
- Computational Framework and Parameters for the Discovery of Therapeutic Proteins and Peptides With Post-Translational Modifications and Non-Canonical Amino Acids (D, A)
- Database Screening Method for Cost-Effective Separations (D)
- Diagnosis of Periodontal Status Using Protein Biomarkers Within Gingival Crevicular Fluid (A)

- Method for Identifying a Microporous Material (A)
- Method of Determining Chemical Reaction Mechanisms (A)
- Molecular Dynamics in Drug Design: New Generations of Compstatin Analogs (A)
- A Novel Automated Computational Method for Calculating Atomic Mappings for Chemical Reactions (D)
- Novel C3aR Agonists and Antagonists (A)
- Processes for the Conversion of Natural Gas to Synthetic Liquid Hydrocarbons (D, A)
- ZEOMICS and MOFomics (D)

Forrest, Stephen

- Apparatus and Method for Deposition for Organic Thin Films (P)
- Low Pressure Vapor Phase Deposition of Organic Thin Films (A)
- Methods for Fabricating Devices by Low Pressure Cold Welding (P)
- Organic Hybrid Planar-Nanocrystalline Bulk Heterojunctions (P)
- Organic Photosensitive Devices (P)
- Organic Photosensitive Devices Using Subphthalocyanine Compounds (P)
- Transparent Contacts for Organic Devices (P)

Friedfeld, Max

- Cobalt Phosphine Alkyl Complexes for the Asymmetric Hydrogenation of Alkenes (A)

- Enantiopure Base-Metal Catalysts for Asymmetric Catalysis and Bis(imino)pyridine Iron Alkyl Complexes for Catalysis (A)

Garcia, Benjamin

- Diagnosis of Periodontal Status Using Protein Biomarkers Within Gingival Crevicular Fluid (A)

Gawalt, Ellen

- Attachment of Organic Films to Metal Oxides and Metal Native Oxide Layer (L)
- Osteoblast Adhesion and Spreading on the Chemical Modified Surface of Ti-6Al-4V (L)
- The Use of Derivatized Self-Assembled Phosphonate Monolayer to Enhance Bone Growth on Implant Devices (L)

Gentile, Charles

- Miniature Integrated Nuclear Detection System With Improved Detection Capability (L)
- Miniature Nuclear Detection Systems (MINDS) (L)
- Stationary Flowing Liquid Lithium System for Pumping Out Atomic Hydrogen Isotopes and Ions (D, A)

Geyko, Vasily

- Non-Spectroscopic Method of Determining Gas Constituents Through Rotation (D)
- Optimization of Efficiency of Internal Combustion Engines via Using Spinning Gas (D)
- Optimization of Efficiency of Internal Combustion Engines via Using Spinning Gas and Non-Spectroscopic Method of Determining Gas Constituents Through Rotation (A)

Ghosh, Amitabha

- Quota Aware Video Adaptation (QAVA) (A)

Gleghorn, Jason

- Microfluidic Platform for the Dynamic Regulation of Mechanical Forces on Embryonic Organs (D, A)

Gmachl, Claire

- II-VI Materials Based Short and Long Wave Quantum Well Infrared Photodetectors (D, A)
- Quantum Cascade Lasers With Improved Performance Using Interface Roughness Scattering (A)
- Rotationally Asymmetric Chaotic Optical Multi-Pass Cavity (P)
- Same-Wavelength Cascaded-Transition Quantum Cascade Laser (D, A)

Goodarzi, Hani

- Methods for Discovering RNA Structural Regulatory Elements and Affecting Their *In Vivo* Function (A)

Gounaris, Chrysanthos

- Database Screening Method for Cost-Effective Separations (D)
- Method for Identifying a Microporous Material (A)
- Method of Determining Chemical Reaction Mechanisms (A)
- A Novel Automated Computational Method for Calculating Atomic Mappings for Chemical Reactions (D)
- ZEOMICS and MOFomics (D)

Greco, Todd

- Method to Increase the Infectivity of Virus Particles (L)

Gregor, Thomas

- Single Molecule Detection in Thick Biological Tissue (D)

Grisham, Larry

- A Method to Improve Voltage Holding Across Vacuum Electrical Gaps to Improve the Performance and Reduce the Conditioning Time of Devices, Such as, for Instance, Charged Particle Accelerators, by Removing Bacteria, Fungi and Other Microbial Organisms and Their Spores (D, A)

Griswold, Martin

- Feedback Control of Azimuthal Oscillations in ExB Devices (A)

Groves, John

- Assays, Methods and Compositions That Exploit a Mycobacterial Iron and Acquisition Pathway (P)
- Compositions and Methods for Hydrocarbon Functionalization (A)
- Drug Diversification via Highly Selective Metal-Catalyzed Fluorination of Complex Compounds (A)
- An Efficient, Catalytic and Scalable Method to Produce Chlorine Dioxide (A)
- An Efficient, Catalytic Method to Produce Chlorine Dioxide (L)
- An Efficient, CO₂-Mediated Method to Produce Chlorine Dioxide (D)
- Hydrocarbon Functionalization Using Halide Salts as Catalyst (D)
- Novel Metalloporphyrins and Related Metal Complexes for the Treatment of Oxidative Stress and Diseases With Oxidative Components (A, P)
- Porphyrin Catalysts and Methods of Use Thereof (P)

Code key:

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“We’ve found that Princeton is a dynamic environment for deep collaboration with our company. Among other things, our engagement with the University in the area of energy and the environment led to a forum for scholars, policymakers and industry executives to discuss the impact of distributed energy systems. Simply, invaluable!”

Ralph Izzo

Chairman, President and Chief Executive Officer, PSEG

Gudleski, Nicole

- Method to Increase the Infectivity of Virus Particles (L)

Ha, Sangtae

- A Middleware for Supporting Pricing Solutions in Broadband Networks (L)
- A System for Offering Intelligent Flat Rate (IFR) Data Plans (A, L)
- System and Method for Variable Pricing of Data Usage (A)

Nathaniel Fisch, a professor of astrophysical sciences and the director of the Program in Plasma Physics at Princeton University, and colleagues at the Princeton Plasma Physics Laboratory have developed a device and process for improving the performance of Hall thrusters, which are plasma-based propulsion systems for satellites and potentially for future space vehicles.



- System and Methods for Time-Dependent Internet Pricing (A, L)
- User Interface Design for Time-Dependent Pricing (L)

Happer, William

- Polarizing Nuclei Solids via Spin Transfer From an Optically Pumped Alkali Vapor (P)

Hasan, M.M. Faruque

- Database Screening Method for Cost-Effective Separations (D)
- Method for Identifying a Microporous Material (A)

Hawryluk, Richard

- Burn Control of Magnetic Fusion Power Plant Using Non-Axisymmetric Coils (D)

Hay, Michael

- Method of Producing Ultra-Heavy Homogeneous Aerosol of Sub-Micron Particles, Particle Gas Target for High Density Laser Produced Plasmas and Method of Preparing Super Concentrated Jets From Dense Aerosol Suspensions (A)

Hejna, Miroslav

- Hyperuniform and Nearly Hyperuniform Random Network Materials (D, A)

Hilewitz, Yedidya

- Microprocessor Shifter Circuits Utilizing Butterfly and Inverse Butterfly Routing Circuits, and Control Circuits Therefor (A, P)

Hill, Kenneth

- Optimization of the Configuration of Pixilated Detectors for the X-Ray Spectroscopy of Hot Plasmas Based on the Shannon-Nyquist Theorem (A)
- Two Novel X-Ray Optical Schemes for Spectroscopy With Fast Time Resolution and Two-Dimensional Imaging With High Magnification (A)

Holmes, Douglas

- Control and Manipulation of Flow via Elastic Deformations (A)

Hopkins, Adam

- Granular Composite Density Enhancement Process (D)

Hoyt, Jordan

- Cobalt Phosphine Alkyl Complexes for the Asymmetric Hydrogenation of Alkenes (A)
- Enantiopure Base-Metal Catalysts for Asymmetric Catalysis and Bis(imino)pyridine Iron Alkyl Complexes for Catalysis (A)

Hu, Yingzhe

- System for 3-D Position and Gesture Sensing of Human Hand (D, A)

Huang, Liechao

- System for 3-D Position and Gesture Sensing of Human Hand (D, A)

Huang, Shan

- A Newly Identified Microorganism Affecting the Nitrogen Cycle: Ammonium Oxidation Under Iron Reducing Conditions (D, A)

Huang, Xiongyi

- Drug Diversification via Highly Selective Metal-Catalyzed Fluorination of Complex Compounds (A)

Huang, Xue

- Same-Wavelength Cascaded-Transition Quantum Cascade Laser (D, A)

Hultmark, Marcus

- Surface for Drag Reduction (D, A)

Isseroff, Leah

- Doped Cuprous Oxide as a Semiconductor for Solar Energy Conversion Devices (A)

Jaffe, Peter

- A Newly Identified Microorganism Affecting the Nitrogen Cycle: Ammonium Oxidation Under Iron Reducing Conditions (D, A)

Jamkhedkar, Pramod

- Data Center Protection With Cyber-Physical Defenses (A)

Jaworski, Michael

- Heat Exchange Enhancing Insert (D)

Jeong, Hyuncheol

- Linear-Translational Multi-Target Manipulator With Adjustable Temperature Control for Thin Film Deposition (D)

Jha, Niraj

- FDR: A Fine-Grain Dynamically Reconfigurable Architecture Aimed at Reducing the FPGA-ASIC Gaps (A)
- Methodologies for Intelligent Device State Caching for Accelerating 3-D/2-D Device and Mixed-Mode Device-Circuit Simulation (D, A)
- Securing Medical Devices Through Wireless Monitoring and Anomaly Detection (A)

Ji, Hantao

- Advanced Liquid Centrifuge Using Differentially Rotating Cylinders and Optimized Boundary Conditions (A)

Joe-Wong, Carlee

- A Middleware for Supporting Pricing Solutions in Broadband Networks (L)
- A System for Offering Intelligent Flat Rate (IFR) Data Plans (A, L)
- System and Method for Variable Pricing of Data Usage (A)
- System and Methods for Time-Dependent Internet Pricing (A, L)
- User Interface Design for Time-Dependent Pricing (L)

Johnson, Brian

- Method for Nanoparticle Production and Control of Particle Size (L)

Johnson, Sarah

- Production of Biofuels, Biomaterials and Sugar Alcohols (Polyols) by a Recombinant Microorganism Expressing Enzymes (Det1 and Pho13) for NADPH Upregulation and Polyol Phosphatase (Ynl010w) for Polyol Phosphatase Dephosphorylation (D)

Jones, Frank

- Two Novel X-Ray Optical Schemes for Spectroscopy With Fast Time Resolution and Two-Dimensional Imaging With High Magnification (A)

Jurczynski, Stephan

- Hold Down Clamp With Integral Thermocouple (D)
- Stainless Steel Hotplate Heater for Long Objects (D)
- Vacuum Attachment for Collection of Lithium Powder (D)

Kaczmarczyk, Jeffrey

- Graphene Dispersions (A)

Kaganovich, Igor

- Transverse Focusing of Intense Charged Particle Beams With Chromatic Effects for Heavy Ion Fusion (D)

Kamphorst, Jurje

- Compositions and Methods for Cancer Therapy (D)

Kang, Yibin

- Micro RNAs as Functional Mediators and Biomarkers of Bone Metastasis (A)

Keith, John

- Hematite-Based Photoanodes With Manganese, Cobalt and Nickel Additives (A)

Khan, Mohammad

- Multi-Harmonic Inline Reference Cell for Optical Trace Gas Sensing (D, A)

Khodak, Andrei

- Heat Exchange Enhancing Insert (D)

Khoury, George

- Computational Framework and Parameters for the Discovery of Therapeutic Proteins and Peptides With Post-Translational Modifications and Non-Canonical Amino Acids (D, A)

Kim, Changsoon

- Methods for Fabricating Devices by Low Pressure Cold Welding (P)

Kim, Jongbok

- Incorporation of Wrinkles and Folds to Enhance Efficiency and Bendability of Plastic Solar Cells and the Method to Create Such Structures (A)

Kim, Pilnam

- Incorporation of Wrinkles and Folds to Enhance Efficiency and Bendability of Plastic Solar Cells and the Method to Create Such Structures (A)

Koch, Matthew

- Small Molecule Probes of the Receptor Binding Site in the *Vibrio cholerae* CAI-1 Quorum-Sensing Circuit (A)

Kong, Yong Lin

- Graphene Nanosensors for Non-Invasive Clinical Diagnosis and Disease Detection (D, A)

Korenykh, Alexei

- A Novel Research and Diagnostic Tool for Detection of Antiviral and Pro-Inflammatory Messenger 2-5A (D)
- Reporters for Detection of the Human Immune Messenger 2-5A for Research and Diagnostic Purposes (A)

Korkut Punckt, Sibel

- Graphene Dispersions (A)
- Preparation of Hard Aggregate-Free Functionalized Graphene Pastes (D)
- Printed Electronics (A, P)

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“Starting in the 1990s to the present time, Princeton University’s pioneering work in organic light-emitting diode technology as well as its excellent licensing and research personnel have helped support Universal Display’s technology research and development growth. Through those years, Universal Display Corporation has evolved from an R&D startup to an international licensing and material supply company in the multibillion-dollar OLED market.”

Steven Abramson
 President and Chief Executive Officer,
 Universal Display Corporation

Koyuncu, Emre

- Inhibitors of Long and Very Long Chain Fatty Acid Metabolism as Broad Spectrum Antivirals (A)
- Method to Produce Virus in Cultured Cells Supplemented With Alpha-Ketoglutarate (L)
- Methods to Enhance the Yield of Infectious Human Cytomegalovirus and Varicella Zoster Virus in Cultured Cells (L)
- Modulators of Sirtuins as Inhibitors of Human Cytomegalovirus (L)

Kruglyak, Leonid

- Peel-1/Zeel-1 A Unique and Novel Toxin Protein and Toxin Antidote for Cell Specific Ablation (D, A)

Kwong, Raymond

- Materials and Structures for Enhancing the Performance of Organic Light Emitting Devices (P)

Langish, Steve

- Miniature Integrated Nuclear Detection System With Improved Detection Capability (L)

Lee, Kyong Ho

- A Low-Power Microprocessor for Data-Driven Analysis of Analytically Intractable Physiological Signals in Advanced Medical Sensors (D, A)

Lee, Ruby

- Data Center Protection With Cyber-Physical Defenses (A)
- Microprocessor Shifter Circuits Utilizing Butterfly and Inverse Butterfly Routing Circuits, and Control Circuits Therefor (A, P)

LeRoy, Gary

- Sequence-Specific Extraction and Analysis of DNA-Bound Proteins (A)

Li, Shuguang

- Atomic Magnetometry Using Multipass Cells (D, A)

Li, Wendi (Jason)

- Structures for Enhancement of Local Electric Field, Light Absorption, Light Radiation, Material Detection and Methods for Making and Using of the Same (A)

Li, Zukui

- Diagnosis of Periodontal Status Using Protein Biomarkers Within Gingival Crevicular Fluid (A)

Liao, Peilin

- Hematite-Based Photoanodes With Manganese, Cobalt and Nickel Additives (A)

Limbach, Christopher

- Supersonic Nozzle With In-Flight Thrust Enhancement and Power Output (A)

Lin, Ting-Jung

- FDR: A Fine-Grain Dynamically Reconfigurable Architecture Aimed at Reducing the FPGA-ASIC Gaps (A)

Link, A. James

- Astexin Peptides (A)
- Astexin-1 Peptides and Methods of Using Same (A)
- Discovery of Novel Lasso Peptides From Genomic Sequence Data (D)
- Novel Lasso Peptides Astexin-2 and Astexin-3 (D)

Little, Shawn

- Single Molecule Detection in Thick Biological Tissue (D)

Liu, Jun

- Nanocomposite of Graphene and Metal Oxide Materials (P)

Liu, Wei

- Drug Diversification via Highly Selective Metal-Catalyzed Fluorination of Complex Compounds (A)

Liu, Zhihua

- Engineered Split-Inteins for the Site-Specific C-Terminal Modification of Proteins and Their Purification (L)

Loo, Yueh-Lin (Lynn)

- Incorporation of Wrinkles and Folds to Enhance Efficiency and Bendability of Plastic Solar Cells and the Method to Create Such Structures (A)
- Water-Dispersible Polyaniline Films Capable of Undergoing Stable and Reversible Polyelectrochromic Transitions (P)

Loutherback, Kevin

- Bump Array Device Having Asymmetric Gaps for Segregation of Particles (A)
- Ratchet Bump Array (L)

Lu, Chao

- 3-D Chalcogenide Recording Material (A)
- Novel Chalcogenide Materials With Controllable Light Radiation Response Feature (D)

Lu, Chien-Hung

- Improved-Resolution Light-Field Imaging (D, A)

Lunt, Richard

- Apparatus and Method for Deposition for Organic Thin Films (P)

Lustig, Daniel

- Fine-Grained CPU-GPU Synchronization Using Full/Empty Bits (D, A)

“Intel has always seen the value in working with top universities, and we are fortunate to count Princeton as one of our key academic partners. Intel has had a long and fruitful relationship with Princeton on many levels that include focused research, open research and student recruiting. We look forward to working with Princeton for many years to come as both an extension of our own internal research and as a source for top academic talent.”

John Somoza

*Program Manager, Intel Labs University
Research & Programs, Intel Corporation*

Student Entrepreneurs Take On Challenges

When **Tsvetelina (Lina) Churalska** and **Sarah Nagy** teamed up with two other Princeton students to build an energy-drink business, they quickly realized that the process was going to be more difficult than they had anticipated. “Our market research showed that people wanted something a little different than an energy drink — healthy but more refreshing,” said Churalska, a graduate student at the School of Architecture who worked with Nagy, a graduate student in the Bendheim Center for Finance. The team, which included undergraduates **Stephanie Sanders**, an undeclared major from the Class of 2016, and **Carly Paris**, an economics major from the Class of 2014, decided to refocus their energy drink into a naturally sweetened refreshment based on barley tea, which has long enjoyed a following in Asia but is relatively unknown in the U.S. market.

The team developed their business plan and sample product with the help of Princeton’s eLab, a 10-week summer program that provides eight teams with funds, laboratory space and training in serial entrepreneur Steve Blank’s Lean LaunchPad curriculum. The eLab is sponsored by Princeton’s Keller Center, which is housed in the School of Engineering and Applied Science. Other summer 2013 projects included a green grocer for underserved “food deserts,” a cloud-based mobile application for firefighters, and a 3-D printing technology that could replace traditional metal casting.

In addition to the eLab, Princeton has several student-run programs that promote entrepreneurship. The Princeton Entrepreneurship Club, or E Club, offers programs throughout the year, including a business plan competition known as TigerLaunch, an annual Princeton pitch competition, trips to startups in the Silicon Valley and New York City, classes, a speaker series, and hackathon opportunities. “E Club has a little of something for everyone,” said **E. Vivian Qu**, Class of 2014, co-president with **Rishi Narang**, Class of 2015.



From left to right: Carly Paris, Tsvetelina (Lina) Churalska and Stephanie Sanders

For students dedicated to social change, the Princeton Social Entrepreneurship Initiative (PSEI) provides numerous opportunities through the year to combine entrepreneurial thinking with social innovation to create equitable and sustainable businesses. For example, PSEI teams up with E Club to provide a social entrepreneurship track for TigerLaunch. PSEI also hosts a speaker series and brings social entrepreneurs to campus to interact with students.

Graduate students can find networking opportunities through the Graduate Entrepreneurship Forum, which offers a workshop series featuring graduate alumni who have started their own companies, work at a startup or are involved with venture capital. The forum also organizes a monthly networking happy hour.

Lyon, Stephen

- Scalable Quantum Computer Architecture With Coupled Donor-Quantum Dot Qubits (D, A)
- Triple-Sandwich Design Materials (D)

Majeski, Richard

- Self-Cooled, Recirculating, Liquid Metal Plasma-Facing Wall System for Fusion Applications (D, A)

Maksimov, Mikhail

- Astexin Peptides (A)
- Astexin-1 Peptides and Methods of Using Same (A)
- Discovery of Novel Lasso Peptides From Genomic Sequence Data (D)
- Novel Lasso Peptides Astexin-2 and Astexin-3 (D)

Malkin, Vladimir

- Method for the Production of Efficient High-Intensity Laser Pulses by Pulse Chirping (A)

Man, Weining

- Quasicrystalline Photonic Heterostructures and Uses Thereof (L)

Mandlik, Prashant

- Hybrid Layers for Use in Coatings on Electronic Devices or Other Articles (P)

Mannoor, Manu Sebastian

- Creation of Multi-Functional Hybrid Devices/Structures by Three Dimensional Integration of Individual Components Using 3-D Printing (D, A)

Martinez, Kristen

- Organic Photosensitive Devices Using Subphthalocyanine Compounds (P)

Martonosi, Margaret

- Fine-Grained CPU-GPU Synchronization Using Full/Empty Bits (D, A)

Mastrovito, Dana

- Software for MINDS Detector (L)

Mayo, Elizabeth

- Organic Photosensitive Devices Using Subphthalocyanine Compounds (P)

Code key:

D = Disclosure
A = Application
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L = License

Technology Takes 3-D Images of Living Organisms

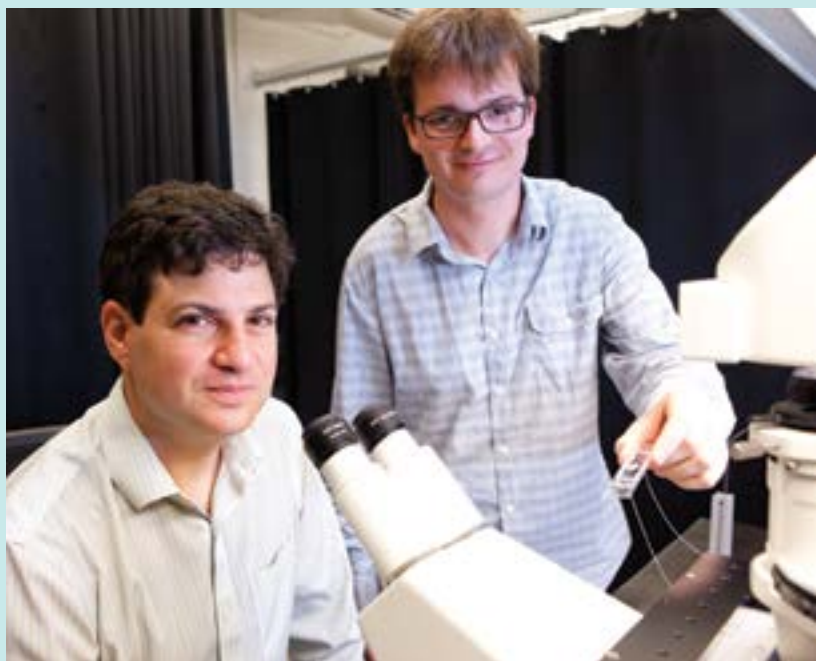
Researchers in fields ranging from toxicology to marine biology will be pleased to know that a new microscope is in development — one that produces high-quality 3-D images by observing subjects as they flow through a liquid channel beneath the microscope's lens.

The new microscope is especially useful for the life sciences, according to Associate Professor of Electrical Engineering **Jason Fleischer**, because it allows living animals to move in an aquatic, stress-free environment. Fleischer and graduate student **Nicolas Pégard** have successfully imaged flowing plant cells and the roundworm *Caenorhabditis elegans* — a prominent model organism for investigating biological systems — using their microscope. The flow allows high volumes of samples to be imaged, one after the other, and provides views from different angles that can be pieced together into a 3-D image.

Fleischer and Pégard combined technology from fluids, optics and medical imaging to create their new device. “The goal is to perform CAT scans on individual cells,” said Fleischer, “using visible light instead of damaging X-rays.”

Flow-scanning tomography is a significant improvement over previous attempts to create 3-D images at a microscopic level, which required a still object for imaging. In one past approach, the sample was fixed in a gel matrix and physically rotated to get the multiple angles necessary for a 3-D image. This method becomes difficult for scientists who want to conduct millions of biochemical tests or examine live specimens in aqueous systems. Another approach has used several fixed light sources that illuminate the subject at different angles, but the limited sampling results in low-resolution pictures.

Applications of the new technology include flow cytometry, water analysis and biomedical imaging for drug and gene



Jason Fleischer (left) and Nicolas Pégard

studies. Fleischer's group has built an integrated microfluidic device for use in standard microscopes, and biological researchers at Princeton, Rutgers University and Harvard Medical School are exploring its benefits compared to existing commercial systems.

In the meantime, Fleischer, with support from the Air Force Office of Scientific Research, is developing a multiple-lens camera that can take high-resolution 3-D images in a single shot. In addition to microscopy, this camera can be taken outside the laboratory for use in general photography, 3-D inspection, and ground- and aerial-based surveillance.

McAlpine, Michael

- Creation of Multi-Functional Hybrid Devices/ Structures by Three-Dimensional Integration of Individual Components Using 3-D Printing (D, A)
- Flexible Piezoelectric Structures and Method of Making Same (A)
- Graphene Nanosensors for Non-Invasive Clinical Diagnosis and Disease Detection (D, A)
- Piezoelectric Nanoribbons for Monitoring Cellular Deformation (D, A)

McCarty, Dennis

- Transparent Contacts for Organic Devices (P)

McClean, Megan

- Light-Induced Cell Sampling Method (A)
- Optogenetic-Protein Induction System and Robotic Chemostat Analysis Device Used to Control Protein Levels Within a Population of Cells (D)

Meixler, Lewis

- Miniature Integrated Nuclear Detection System With Improved Detection Capability (L)

Melendez, Justin

- Light-Induced Cell Sampling Method (A)
- Optogenetic-Protein Induction System and Robotic Chemostat Analysis Device Used to Control Protein Levels Within a Population of Cells (D)

Michael, James

- Air Laser (L)
- Systems and Methods for Lasing From a Molecular Gas (A)

Midwood, Kim

- Osteoblast Adhesion and Spreading on the Chemical Modified Surface of Ti-6Al-4V (L)

Miles, Richard

- Air Laser (L)
- Method for Coherent Microwave Radiation From a Laser Induced Plasma (D, A)
- Supersonic Nozzle With In-Flight Thrust Enhancement and Power Output (A)
- Systems and Methods for Lasing from a Molecular Gas (A)

Miller, David

- Multi-Harmonic Inline Reference Cell for Optical Trace Gas Sensing (D, A)

Miller, Laura

- Biofilm Streamers Cause Catastrophic Disruption of Flow With Consequences for Environmental and Medical Systems: Role of Quorum Sensing and Treatment With Small Molecules (D)
- Small Molecules Active in Quorum Sensing for Inhibition of Biofilm Streamers (A)

Misener, Ruth

- Algorithms for coNTinuous/Integer Global Optimization of Nonlinear Expressions (ANTIGONE) (D, L)

Mitrani, James

- Transverse Focusing of Intense Charged Particle Beams With Chromatic Effects for Heavy Ion Fusion (D)

Monfette, Sebastien

- Enantiopure Base-Metal Catalysts for Asymmetric Catalysis and Bis(imino)pyridine Iron Alkyl Complexes for Catalysis (A)

Morton, Keith

- Bump Array Device Having Asymmetric Gaps for Segregation of Particles (A)

Muenzel, Stefan

- Improved-Resolution Light-Field Imaging (D, A)
- Layered 3-D Display With a Lens (D, A)

Muir, Tom

- DNA Barcoding of Designer Mononucleosome and Chromatin Array Libraries for the Profiling of Chromatin Readers, Writers, Erasers and Modulators Thereof (2) (A)
- Engineered Split-Inteins for the Site-Specific C-Terminal Modification of Proteins and Their Purification (L)

Muller, Manuel

- DNA Barcoding of Designer Mononucleosome and Chromatin Array Libraries for the Profiling of Chromatin Readers, Writers, Erasers and Modulators Thereof (2) (A)

Murugan, Anand

- Method for Assessing Immune System Status (A)

Nahmias, Mitchell

- Leaky Integrate-and-Fire Laser Neuron for Ultrafast Cognitive Computing (D, A)

Nelson, Celeste

- Microfluidic Platform for the Dynamic Regulation of Mechanical Forces on Embryonic Organs (D, A)

Nelson, Jude

- Syndicate - Storage Service (D)

Ng, Wai-Leung

- New Agonists of Quorum Sensing in *Vibrio cholerae* (A)
- Small Molecule Probes of the Receptor Binding Site in the *Vibrio cholerae* CAI-1 Quorum-Sensing Circuit (A)

Nguyen, Thanh

- Piezoelectric Nanoribbons for Monitoring Cellular Deformation (D, A)

Nguyen, Thi Thanh Uyen

- DNA Barcoding of Designer Mononucleosome and Chromatin Array Libraries for the Profiling of Chromatin Readers, Writers, Erasers and Modulators Thereof (2) (A)

Nikodem, Michal

- Optical Subtraction of Molecular Dispersion Signals Enabled by Differential Optical Dispersion Spectroscopy (DODiS) (A)

Noyes, Marcus

- Comprehensive Set of Engineered Cys₂His₂ Zinc Fingers in Multiple Contents to Be Used as Modular, Targeting DNA-Binding Domains (A)
- A Multi-Reporter Selection System for the Simultaneous Positive and Negative Selection of Fine-Tuned DNA-Binding Specificity (D, A)

O'Loughlin, Colleen

- Biofilm Streamers Cause Catastrophic Disruption of Flow With Consequences for Environmental and Medical Systems: Role of Quorum Sensing and Treatment With Small Molecules (D)
- Small Molecule Antagonists of Bacterial Quorum-Sensing Receptors (A, P)
- Small Molecules Active in Quorum Sensing for Inhibition of Biofilm Streamers (A)

Ono, Masayuki

- Radiative Liquid Lithium (Metal) Divertor (D)

Pablant, Novimir

- Optimization of the Configuration of Pixilated Detectors for the X-Ray Spectroscopy of Hot Plasmas Based on the Shannon-Nyquist Theorem (A)
- Two Novel X-Ray Optical Schemes for Spectroscopy With Fast Time Resolution and Two-Dimensional Imaging With High Magnification (A)

Pégard, Nicolas

- Flow Scanning Tomography (A)
- Incorporation of Wrinkles and Folds to Enhance Efficiency and Bendability of Plastic Solar Cells and the Method to Create Such Structures (A)
- Rotating Flow and Structured Illumination for Optofluidic Microscope (A)

Code key:**D = Disclosure****A = Application****P = Patent****L = License**

“BioNano and Princeton’s Technology Licensing office have been partners since the very early stages of our development, and we continue to have an active relationship. What we have appreciated most has been the office’s understanding of how companies evolve over time, and the office’s willingness to accommodate us at every stage along the way.”

Erik Holmlin

*President and Chief Executive Officer,
BioNano Genomics Inc.*

Code key:**D = Disclosure****A = Application****P = Patent****L = License****Pelczer, Istvan**

- Nutritional Supplement/Feed Formula and Methods of Use Thereof to Inhibit Development of Osteochondrosis Dissecans (OCD) Lesions in Genetically Predisposed Young Horses (D, A)

Peng, Ruoming

- Metallic Nanostructures in Microfluidic Channels for Enhancement of Fluorescence and Raman Scattering and for Speeding of Assay Detection Time and Making of the Same (D, A)

Perez, Lark

- New Agonists of Quorum Sensing in *Vibrio cholerae* (A)
- Small Molecule Probes of the Receptor Binding Site in the *Vibrio cholerae* CAI-1 Quorum-Sensing Circuit (A)

Persikov, Anton

- Comprehensive Set of Engineered Cys₂His₂ Zinc Fingers in Multiple Contents to Be Used as Modular, Targeting DNA-Binding Domains (A)

Peterson, Larry

- Syndicate - Storage Service (D)

Peterson, Meghan Bellows

- Molecular Dynamics in Drug Design: New Generations of Compstatin Analogs (A)
- Novel C3aR Agonists and Antagonists (A)

Pfeiffer, Loren

- Method to Growth Graphene Nanocrystalline Layers on Dielectric and Semiconducting Layers (D)

Poor, H. Vincent

- Fast Method for Nonlinear Fourier Analysis on the Line (D, A)
- A Method for Securing Backscatter Wireless Communication (D, A)



Celeste Nelson (left), an associate professor of chemical and biological engineering, and Postdoctoral Research Associate Jason Gleghorn have created a microfluidic platform to study the mechanical forces on embryonic lung development. The platform can assist researchers studying the causes of fetal development disorders.

- A Scheme for Contention-Based Synchronization in FDMA Systems (D, A)
- System and Method for Initial Ranging in Wireless Communication Systems (A, P)

Pope, Michael

- Nano-Graphene and Nano-Graphene Oxide (A)

Powell, Warren

- A Method for Estimating Covariance Matrices Using an Errors-in-Variables Factor Model With Short Histories for the Purpose of Creating Portfolios for Energy Markets and Financial Products (D)

Priestley, Rodney

- Linear-Translational Multi-Target Manipulator With Adjustable Temperature Control for Thin Film Deposition (D)

Prucnal, Paul

- Leaky Integrate-and-Fire Laser Neuron for Ultrafast Cognitive Computing (D, A)

Prud'homme, Robert

- Method for Nanoparticle Production and Control of Particle Size (L)
- Printed Electronics (A, P)

Puchalla, Jason

- Bump Array Device Having Asymmetric Gaps for Segregation of Particles (A)
- Ratchet Bump Array (L)

Qi, Yi

- Flexible Piezoelectric Structures and Method of Making Same (A)

Qu, Dongxia

- Rotationally Asymmetric Chaotic Optical Multi-Pass Cavity (P)

Rabinowitz, Joshua

- Compositions and Methods for Cancer Therapy (D)
- Hypoxia and Ras Induce Lipid Scavenging (D, A)
- Inhibitors of Long and Very Long Chain Fatty Acid Metabolism as Broad Spectrum Anti-Virals (A)
- Method and Composition for Treating Cancer (A)
- Methods to Enhance the Yield of Infectious Human Cytomegalovirus and Varicella Zoster Virus in Cultured Cells (L)
- Production of Biofuels, Biomaterials and Sugar Alcohols (Polyols) by a Recombinant Microorganism Expressing Enzymes (Det1 and Pho1.3) for NADPH Upregulation and Polyol Phosphatase (Ynl010w) for Polyol Phosphatase Dephosphorylation (D)
- Treatment of Cancer by Drug-Particulate Conjugates That Are Ingested by Tumor Cells via the Intact Uptake Pathway (D)

Raitses, Yevgeny

- Feedback Control of Azimuthal Oscillations in ExB Devices (A)

Rand, Barry

- Organic Photosensitive Devices Using Subphthalocyanine Compounds (P)

Process Offers a Domestic Solution to Rising Fuel Demand

Three domestically available raw materials — coal, biomass and natural gas — may reduce the country's dependence on imports and vulnerability to volatile oil prices while addressing the increasing national fuel demand at a low financial and environmental cost.

Christodoulos Floudas in the Department of Chemical and Biological Engineering and his team have come up with a new process that can convert these raw materials into gasoline, diesel and kerosene, crucial fuels for transportation vehicles ranging from cars to rockets. The invention, developed with graduate student **Josephine Elia** and 2012 Princeton Ph.D. recipient **Richard Baliban**, includes a complete refinery that first converts the raw materials — also called feedstocks — into gases such as carbon dioxide, carbon monoxide and hydrogen in reactors. The refinery then separates out some of the carbon dioxide and other acidic gases from the main gas stream, recycling these gases back into the reactors and reducing carbon emissions into the atmosphere. The “cleaned-up” gas goes through the reactor to produce the different hydrocarbons that make up key transportation fuels.

Floudas' process includes a quantitative framework for ensuring that the refinery uses the best combination of the three feedstocks for minimal production costs, which include operation and maintenance as well as feedstock purchase and delivery. This framework also assists in limiting greenhouse gas emissions from the process.

The next move, Floudas said, is to form collaborations with companies and government entities interested in pursuing alternative energy options. His team has already partnered with security and aerospace company Lockheed Martin.

Floudas, the Stephen C. Macaleer '63 Professor in Engineering and Applied Science, has also pursued a different avenue of carbon emissions reduction. With graduate student



From left to right: Christodoulos Floudas, Richard Baliban and Josephine Elia

Eric First and Postdoctoral Research Associate **Faruque Hasan**, Floudas has created methods for engineers to characterize which materials are best for separating carbon dioxide from the gas streams of various sources, such as natural gas and coal-based power plants and cement manufacturers. His strategy focuses on zeolites and metal-organic frameworks, which are both porous structures that can extract specific gases using processes such as adsorption, in which molecules bind to a surface, or membrane structures with different pore sizes.

With his invention, Floudas can combine the materials' properties and separation processes to figure out which is the best solution for a given scenario. This can yield information not found by other means. “We have found out that what was proposed to be the best adsorber based on material properties is not necessarily the lowest cost,” he said. “So there's a tradeoff.”

Ravikumar, Arvind Pawan

- II-VI Materials Based Short and Long Wave Quantum Well Infrared Photodetectors (D, A)

Rieutort-Louis, Warren

- System for 3-D Position and Gesture Sensing of Human Hand (D, A)

Robinson, David

- Polymorphs of Manganese Oxides as Water Oxidation Catalysts: Nano-Crystalline Pure Phases of Bixbyite Mn_2O_3 and Hausmanite Mn_3O_4 (D)

Roché, Matthieu

- Formation of Nano-Emulsions by Bursting Bubbles in a Liquid-Liquid Interface (D, A)
- Rapid Characterization of the Solubility of Amphiphiles (D, A)

Romalis, Michael

- Anodically Bonded Cells With Internal Optical Elements (D)
- Atomic Magnetometry Using Multipass Cells (D, A)

Roquemore, A. Lane

- Lithium Droplet Injector (D)

Roy-Mayhew, Joseph

- Nano-Graphene and Nano-Graphene Oxide (A)

Sanz-Robinson, Josue

- System for 3-D Position and Gesture Sensing of Human Hand (D, A)

Scherer, George

- Phosphate Treatment to Reduce Salt Scaling of Concrete (D, A)

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Schmit, Paul

- Process/Method to Enhance the Performance of Plasma-Based Particle Accelerators Using Magnetized Plasma Compression (D, A)

Schneider, Hans

- Hold Down Clamp With Integral Thermocouple (D)
- Stainless Steel Hotplate Heater for Long Objects (D)
- Vacuum Attachment for Collection of Lithium Powder (D)

Schwartz, Jeffrey

- Attachment of Organic Films to Metal Oxides and Metal Native Oxide Layer (L)
- Enhancing Cell Growth on Synthetic Polymers: High Yield Attachment of Cell Adherent Peptide RGD Onto Polyamides via a Zirconium-Amide Complex Interface (L)
- Heat Transfer of Phosphonic Acids on Metal Surfaces (L)
- Modular Monolayer Coatings for Selective Attachment of Nanoparticles to Biomolecules (P)
- Osteoblast Adhesion and Spreading on the Chemical Modified Surface of Ti-6Al-4V (L)
- Polymer Surface Functionalization via a Novel Adhesion Layer (L)

- The Use of Derivatized Self-Assembled Phosphonate Monolayer to Enhance Bone Growth on Implant Devices (L)

Schwarzbauer, Jean

- Osteoblast Adhesion and Spreading on the Chemical Modified Surface of Ti-6Al-4V (L)

Scott, Benjamin

- Voluntary Head Restraint and Automated *In Vivo* Imaging System (D, A)

Scott, Steven

- Two Novel X-Ray Optical Schemes for Spectroscopy With Fast Time Resolution and Two-Dimensional Imaging With High Magnification (A)

Scott, Warren

- A Method for Estimating Covariance Matrices Using an Errors-in-Variables Factor Model With Short Histories for the Purpose of Creating Portfolios for Energy Markets and Financial Products (D)

Seidel, Hannah

- Peel-1/Zeel-1 A Unique and Novel Toxin Protein and Toxin Antidote for Cell Specific Ablation (D, A)

Liquid Light: Startup Creates Industrial Chemicals From Waste

As atmospheric carbon dioxide levels rise, Liquid Light Inc., a startup of 26 people located in Monmouth Junction, N.J., sees opportunity in carbon dioxide emissions.

The company was founded in 2009 to develop technology to produce industrial chemicals and fuels from the greenhouse gas carbon dioxide, a low-cost and abundant carbon source. Emitted from industrial plants and captured at the point of emission, carbon dioxide is the starting point for Liquid Light's novel technology, which uses electrocatalysts to convert carbon dioxide into industrial chemicals such as glycols, alcohols and carboxylic acids.

Liquid Light's technology is based on innovations developed by **Andrew Bocarsly**, a professor of chemistry, and his team of researchers. Bocarsly and a graduate student began studying methods for converting carbon dioxide to methanol in the early 1990s. The initial studies, which were funded by the National Science Foundation, involved an electrode and an inexpensive catalyst to drive the reaction. The project picked up speed in the mid-2000s when graduate student **Emily Cole** revived the project and began to explore ways to optimize the reaction with additional support from the National Science Foundation as well as the Department of Energy and the Air Force Office of Scientific Research. The team discovered their technology could produce compounds containing carbon-carbon bonds, allowing for a range of commercially valuable products to be produced.

Liquid Light's CEO is **Kyle Teamey**, an engineer and entrepreneur who approached Bocarsly in the mid-2000s to discuss commercial applications for the technology. With

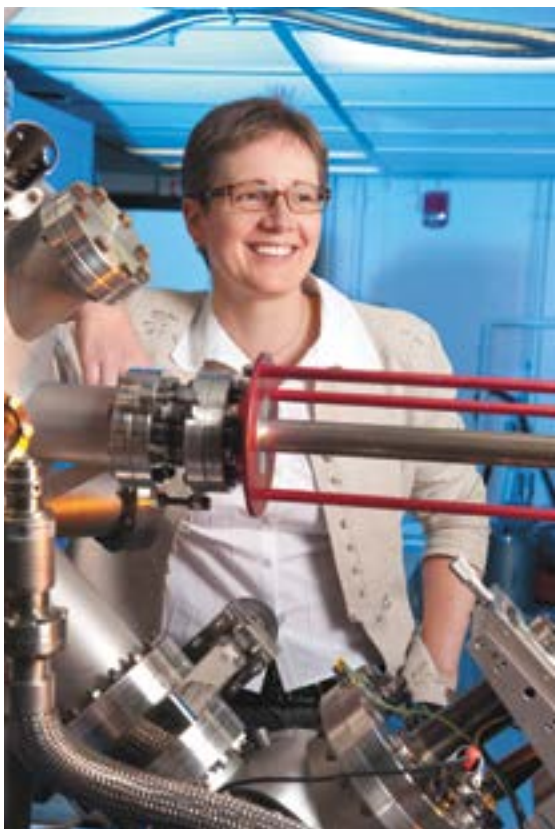


Above: Kyle Teamey (left) and Andrew Bocarsly



Inset: Emily Cole

Bocarsly, Cole —who received her Ph.D. in 2009 — and scientist **Narayanappa Sivasankar**, Teamey formed Liquid Light. “We continue to collaborate with Princeton on ways to create new products at higher yields,” Teamey said. Liquid Light's backers include VantagePoint Capital Partners, Redpoint Ventures, Chrysalix Energy Venture Capital, Osage University Partners and BP Ventures.



Claire Gmachl, the Eugene Higgins Professor of Electrical Engineering and vice dean of the School of Engineering and Applied Science, is a leader in the field of highly power-efficient quantum cascade lasers. She is using these lasers, which emit light in the mid-infrared region of the spectrum, to measure air pollution and detect carbon dioxide in the blood.

Semmelhack, Martin

- Biofilm Streamers Cause Catastrophic Disruption of Flow With Consequences for Environmental and Medical Systems: Role of Quorum Sensing and Treatment With Small Molecules (D)
- Double-Caged GABA Compounds, Bis-CNB-GABA (A)
- Double-Caged GABA: A Novel Light-Activated Probe as a Neuroscience Research Tool (D)
- New Agonists of Quorum Sensing in *Vibrio cholerae* (A)
- Small Molecule Probes of the Receptor Binding Site in the *Vibrio cholerae* CAI-1 Quorum-Sensing Circuit (A)
- Small Molecules Active in Quorum Sensing for Inhibition of Biofilm Streamers (A)

Sen, Soumya

- A Middleware for Supporting Pricing Solutions in Broadband Networks (L)
- System and Method for Variable Pricing of Data Usage (A)
- System and Methods for Time-Dependent Internet Pricing (A, L)
- A System for Offering Intelligent Flat Rate (IFR) Data Plans (A, L)
- User Interface Design for Time-Dependent Pricing (L)

Shah, Neel

- Engineered Split-Inteins for the Site-Specific C-Terminal Modification of Proteins and Their Purification (L)

Shaw, Travis

- Reduction of CO₂ to Useful Products Using Alkaline Earth Metals (D)

Shen, Yi

- Biofilm Streamers Cause Catastrophic Disruption of Flow With Consequences for Environmental and Medical Systems: Role of Quorum Sensing and Treatment With Small Molecules (D)
- Small Molecules Active in Quorum Sensing for Inhibition of Biofilm Streamers (A)

Sheng, Dong

- Atomic Magnetometry Using Multipass Cells (D, A)

Shenk, Thomas

- Human Cytomegalovirus UL128 and UL130 Proteins as Subunit Vaccine Candidates and Novel Drug Targets (L)
- Inhibitors of Long and Very Long Chain Fatty Acid Metabolism as Broad Spectrum Antivirals (A)
- Method to Increase the Infectivity of Virus Particles (L)
- Method to Produce Virus in Cultured Cells Supplemented With Alpha-Ketoglutarate (L)
- Methods to Enhance the Yield of Infectious Human Cytomegalovirus and Varicella Zoster Virus in Cultured Cells (L)
- Modulators of Sirtuins as Inhibitors of Human Cytomegalovirus (L)

Shi, Diana

- Double-Caged GABA Compounds, Bis-CNB-GABA (A)
- Double-Caged GABA: A Novel Light-Activated Probe as a Neuroscience Research Tool (D)

Shneider, Mikhail

- Method for Coherent Microwave Radiation from a Laser Induced Plasma (D, A)

Silber, Ken

- Software for MINDS Detector (L)

Silverman, Brett

- Heat Transfer of Phosphonic Acids on Metal Surfaces (L)
- Osteoblast Adhesion and Spreading on the Chemical Modified Surface of Ti-6Al-4V (L)

Singh, Mona

- Comprehensive Set of Engineered Cys₂His₂ Zinc Fingers in Multiple Contents to Be Used as Modular, Targeting DNA-Binding Domains (A)

“Collaborating with universities helps Lockheed Martin bring the best technologies to bear on our customers’ toughest problems. Strong research partnerships, like those we’ve built at Princeton, are the most effective way of turning inventions into innovations.”

Lockheed Martin Corporation

Skinner, Charles

- Method of Producing Ultra-Heavy Homogeneous Aerosol of Sub-Micron Particles, Particle Gas Target for High Density Laser Produced Plasmas and Method of Preparing Super Concentrated Jets From Dense Aerosol Suspensions (A)

Smadbeck, James

- Computational Framework and Parameters for the Discovery of Therapeutic Proteins and Peptides With Post-Translational Modifications and Non-Canonical Amino Acids (D, A)

Smits, Alexander

- Surface for Drag Reduction (D, A)

Solomon, Wayne

- Burn Control of Magnetic Fusion Power Plant Using Non-Axisymmetric Coils (D)

Steinhardt, Paul

- Cavity Architectures in Hyperuniform Disordered Materials With Complete Photonic Band Gaps (L)
- Disordered Photonic Heterostructures and Uses Thereof (L)
- Hyperuniform and Nearly Hyperuniform Random Network Materials (D, A)
- Quasicrystalline Photonic Heterostructures and Uses Thereof (L)
- Quasicrystalline Structures and Uses Thereof (A, P)

“Working closely with Princeton’s faculty and Technology Licensing, we were able to successfully transition cutting-edge technology out of the laboratory and into a breakthrough consumer product.”

Alexander Asseily

Co-founder and Chairman of the Board, Jawbone

Stillinger, Frank

- Granular Composite Density Enhancement Process (D)

Stockman, Emanuel

- Method for Coherent Microwave Radiation From a Laser Induced Plasma (D, A)

Stone, Howard

- Biofilm Streamers Cause Catastrophic Disruption of Flow With Consequences for Environmental and Medical Systems: Role of Quorum Sensing and Treatment With Small Molecules (D)
- Control and Manipulation of Flow via Elastic Deformations (A)
- Critical Drop Sizes for Manipulating Mist With Flexible Fiber Arrays (A)
- Formation of Nano-Emulsions by Bursting Bubbles in a Liquid-Liquid Interface (D, A)
- Generation of Combinatorial Microdroplets (D, A)
- Incorporation of Wrinkles and Folds to Enhance Efficiency and Bendability of Plastic Solar Cells and the Method to Create Such Structures (A)

- Leveraging Shape to Control Interfacial Instabilities (A)
- Microfluidic Synthesis of Crimped Fibers (D, A)
- Microfluidic Tensiometry by Magnetic Forcing (A)
- Rapid Characterization of the Solubility of Amphiphiles (D, A)
- Small Molecules Active in Quorum Sensing for Inhibition of Biofilm Streamers (A)
- Surface for Drag Reduction (D, A)

Sturm, James

- Bump Array Device Having Asymmetric Gaps for Segregation of Particles (A)
- High-Efficiency Microfluidic Purification of Stem Cells to Improve Transplants (D, A)
- Method For Continuous Particle Separation Using Obstacle Arrays Asymmetrically Aligned to Fields (A, P)
- Microfluidic Processing of Leukocytes for Molecular Diagnostic Testing (D, A)
- Ratchet Bump Array (L)
- System for 3-D Position and Gesture Sensing of Human Hand (D, A)

Sun, Kang

- Multi-Harmonic Inline Reference Cell for Optical Trace Gas Sensing (D, A)
- Open-Path, Optical Trace Gas Sensor With Integrated Three-Dimensional Wind Speed and Temperatures Measurements (D)

Swem, Lee

- Small Molecule Antagonists of Bacterial Quorum-Sensing Receptors (A, P)

Szefer, Jakub

- Data Center Protection With Cyber-Physical Defenses (A)

Tait, Alexander

- Leaky Integrate-and-Fire Laser Neuron for Ultrafast Cognitive Computing (D, A)

Tank, David

- Voluntary Head Restraint and Automated *In Vivo* Imaging System (D, A)

Tao, Lei

- Multi-Harmonic Inline Reference Cell for Optical Trace Gas Sensing (D, A)
- Open-Path, Optical Trace Gas Sensor With Integrated Three-Dimensional Wind Speed and Temperatures Measurements (D)

Tarver, Jacob

- Water-Dispersible Polyaniline Films Capable of Undergoing Stable and Reversible Polyelectrochromic Transitions (P)

Tavazoie, Saeed

- Methods for Discovering RNA Structural Regulatory Elements and Affecting Their *In Vivo* Function (A)

Tegenfeldt, Jonas

- Gradient Structures Interfacing Microfluidics and Nanofluidics, Methods for Fabrication and Uses Thereof (P)

Tikhonov, Mikhail

- Single Molecule Detection in Thick Biological Tissue (D)

Toroker, Maytal

- Hydrogen or Lithium Doping for Wüstite-Based Photoelectrodes (A)
- Iron (II) Oxide Alloys as Semiconductors for Solar Energy Conversion Devices (A)
- A New Material for Solar Energy Conversion Devices (D)
- Nickel-Lithium Oxides for Solar Energy Conversion Devices (D, A)
- Substitutionally Alloying Nickel Oxide With Lithium in High Concentrations in the Rocksalt Structure for Use in Tandem Dye-Sensitized Solar Cells and Photocatalysis (A)
- Wüstite-Based Photoelectrodes With Lithium, Hydrogen, Sodium, Magnesium, Manganese, Zinc and Nickel Additives (A)

Torquato, Salvatore

- Cavity Architectures in Hyperuniform Disordered Materials With Complete Photonic Band Gaps (L)
- Disordered Photonic Heterostructures and Uses Thereof (L)
- Granular Composite Density Enhancement Process (D)
- Hyperuniform and Nearly Hyperuniform Random Network Materials (D, A)

Traina, Christopher

- Modular Monolayer Coatings for Selective Attachment of Nanoparticles to Biomolecules (P)

Tsai, Scott Shao Hsiang

- Microfluidic Tensiometry by Magnetic Forcing (A)

Tung, Yei-Juhn

- Materials and Structures for Enhancing the Performance of Organic Light Emitting Devices (P)

Tyryshkin, Alexei

- Scalable Quantum Computer Architecture With Coupled Donor-Quantum Dot Qubits (D, A)
- Triple-Sandwich Design Materials (D)

Um, Eujin

- Generation of Combinatorial Microdroplets (D, A)

Umile, Thomas

- An Efficient, Catalytic and Scalable Method to Produce Chlorine Dioxide (A)
- An Efficient, Catalytic Method to Produce Chlorine Dioxide (L)

Vaccaro, John

- Hold Down Clamp With Integral Thermocouple (D)

Valeo, Ernest

- Method of Producing Ultra-Heavy Homogeneous Aerosol of Sub-Micron Particles, Particle Gas Target for High Density Laser Produced Plasmas and Method of Preparing Super Concentrated Jets From Dense Aerosol Suspensions (A)



Alexei Korenykh, an assistant professor of molecular biology, has developed a novel research and diagnostic tool for detection of an intracellular stress signal known as 2',5'-linked oligoadenylate (2-5A). Elevated 2-5A has been linked to viral infection, whereas decreased 2-5A levels or absence of 2-5A could be linked to cancers or neurodegeneration. Measurement of 2-5A levels may lead to innovative diagnostics for viral infections, cancers and inflammatory diseases.

Verma, Naveen

- A Low-Power Microprocessor for Data-Driven Analysis of Analytically Intractable Physiological Signals in Advanced Medical Sensors (D, A)
- System for 3-D Position and Gesture Sensing of Human Hand (D, A)

Vigolo, Daniele

- Formation of Nano-Emulsions by Bursting Bubbles in a Liquid-Liquid Interface (D, A)

Vila-Perello, Miquel

- Engineered Split-Inteins for the Site-Specific C-Terminal Modification of Proteins and Their Purification (L)

Wagner, Sigurd

- Hybrid Layers for Use in Coatings on Electronic Devices or Other Articles (P)
- System for 3-D Position and Gesture Sensing of Human Hand (D, A)

Wahls, Sander

- Fast Method for Nonlinear Fourier Analysis on the Line (D, A)

Wan, Jiandi

- Microfluidic Tensiometry by Magnetic Forcing (A)

Wang, Chao

- Metallic Nanostructures in Microfluidic Channels for Enhancement of Fluorescence and Raman Scattering and for Speeding of Assay Detection Time and Making of the Same (D, A)

Wang, Dai

- Human Cytomegalovirus UL128 and UL130 Proteins as Subunit Vaccine Candidates and Novel Drug Targets (L)

Wang, Eric

- Optimization of the Configuration of Pixelated Detectors for the X-Ray Spectroscopy of Hot Plasmas Based on the Shannon-Nyquist Theorem (A)

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Associate Professor of Chemistry Haw Yang and his team have developed a microscope capable of imaging tiny particles such as viruses inside cells. The microscope is able to track the real-time position of freely diffusing nanoscale particles and could be used in biomedical research and drug development.

Wang, Samuel

- Double-Caged GABA Compounds, Bis-CNB-GABA (A)
- Double-Caged GABA: A Novel Light-Activated Probe as a Neuroscience Research Tool (D)

Wang, Yin

- Dual-Modulation Faraday Rotation Spectroscopy (A)

Wei, James

- Chiral Porous Solids for Chiral Separations (D, A)

Welscher, Kevin

- Multiscale Spectral Nanoscopy (A)
- Three-Dimensional Contextualized Real-Time Tracking (3-D-CRT) Microscopy for High-Definition Dynamics and Structures (D)

Wexler, Jason

- Microfluidic Tensiometry by Magnetic Forcing (A)

Won, Sang Hee

- Measurement Process for the Determination of the Mixture-Averaged Molecular Weight of Complex Mixtures (A)

Woolley, Robert

- Radially Cooled Toroidal Field Centerpost (D)

Wysocki, Gerard

- Dual-Modulation Faraday Rotation Spectroscopy (A)
- Optical Subtraction of Molecular Dispersion Signals Enabled by Differential Optical Dispersion Spectroscopy (DODiS) (A)

Xu, Yi-Fan

- Method and Composition for Treating Cancer (A)
- Production of Biofuels, Biomaterials and Sugar Alcohols (Polyols) by a Recombinant Microorganism Expressing Enzymes (Det1 and Pho13) for NADPH Upregulation and Polyol Phosphatase (Ynl010w) for Polyol Phosphatase Dephosphorylation (D)
- Treatment of Cancer by Drug-Particulate Conjugates That Are Ingested by Tumor Cells via the Intact Uptake Pathway (D)

Yang, Fan

- Apparatus and Method for Deposition for Organic Thin Films (P)
- Organic Hybrid Planar-Nanocrystalline Bulk Heterojunctions (P)

Yang, Haw

- Multiscale Spectral Nanoscopy (A)
- Three-Dimensional Contextualized Real-Time Tracking (3-D-CRT) Microscopy for High-Definition Dynamics and Structures (D)

Yoo, Joung Eun

- Water-Dispersible Polyaniline Films Capable of Undergoing Stable and Reversible Polyelectrochromic Transitions (P)

Yu, Renyuan

- Iron-Catalyzed Hydrogen Isotope Labeling of Aromatic Organic Compounds (D)

Zakharov, Leonid

- Stationary Flowing Liquid Lithium System for Pumping Out Atomic Hydrogen Isotopes and Ions (D, A)

Zha, Yunlai

- Multi-Layered Chalcogenide Structure (A)

Zhang, Jingyuan

- Same-Wavelength Cascaded-Transition Quantum Cascade Laser (D, A)

Zhang, Meng

- Securing Medical Devices Through Wireless Monitoring and Anomaly Detection (A)

Zhou, Liangcheng

- A Method to Enhance Assay Sensitivity by Digitally Counting Blinking Bright Spots From Single Molecule Emitters (D, A)
- Methods for Reducing Bio-Assay Processing Time (D, A)
- Structures for Enhancement of Local Electric Field, Light Absorption, Light Radiation, Material Detection and Methods for Making and Using of the Same (A)

Zondlo, Mark

- Multi-Harmonic Inline Reference Cell for Optical Trace Gas Sensing (D, A)
- Open-Path, Optical Trace Gas Sensor With Integrated Three-Dimensional Wind Speed and Temperatures Measurements (D)

“Princeton University gets innovation right. The professors and students do fantastic science and engineering with the full support of University leadership. Technology Licensing is very supportive of the commercialization of new technologies and views the success of a company licensing Princeton technology as a win for the University.”

Lisa Bergson

*Chief Executive, MEECO Inc.
and Tiger Optics LLC*

This publication recognizes work conducted on Princeton inventions by current and former members of the University research community.

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Photography by: Denise Applewhite, C. Todd Reichart, Elle Starkman, Volker Steger, Brian Wilson and Frank Wojciechowski



Cover image: A new type of designer material, known as a hyperuniform disordered solid, could enable technologies based on the manipulation of light rather than electrons. The structure pictured here acts as a semiconductor for light, blocking a band of frequencies from propagating from chamber to chamber through the solid while allowing higher or lower frequencies of light to pass. (Image courtesy of Paul Steinhardt, the Albert Einstein Professor in Science)



From the Dean

As one of the world's great research universities, Princeton is an engine for the generation of new ideas. Some of these ideas have the potential for becoming the new products and new industries that have consistently strengthened our nation's economy and improved the quality of life for countless citizens. By providing an environment that supports innovation, we at Princeton strive to create the conditions that facilitate the journey from the laboratory to the marketplace.

This fifth installment of Celebrate Princeton Invention showcases inventions and products that began as exploratory ideas in Princeton laboratories. In so doing, we celebrate not only the creativity and ingenuity of faculty members, students and postdoctoral researchers, but also the vital contributions of our friends in the corporate and venture capital communities, whose vision and expertise enable the challenging transition from ideas to products. We celebrate the fruitful interaction between investors, inventors and entrepreneurs, which our offices of Technology Licensing and Corporate and Foundation Relations work hard to establish and nurture.

This wonderful display of creativity and invention at Princeton is part of the seamless spectrum of activities that span apprenticeship and education in the laboratory, the formulation of fundamental theories and ideas, and the materialization of many of these ideas into new technologies and products.

Pablo Debenedetti

*Dean for Research and Class of 1950
Professor in Engineering and Applied Science*

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