Geckos are able to adhere strongly and release easily from surfaces because the structurally anisotropic fibers on their toes naturally exhibit force anisotropy based on the direction of articulation. Hence, 10 μm diameter semicircular PDMS fibers, with varying amounts of contact area on the two faces, were investigated to ascertain whether fiber shape can be used to gain anisotropy in shear and shear adhesion forces. Testing of fiber arrays against a flat glass puck showed that shear and shear adhesion forces were two to five times greater when in-plane movement caused the flat face, rather than the curved face, of the fiber to come in contact with the glass puck, clearly demonstrating how fiber shape may be used to influence the properties of the adhesive. This result has broad applicability, and by combining the results shown here with other current vertical and angled designs, synthetic adhesives can be further improved to behave more like their natural counterparts.


*Langmuir, 28, 8746–8752 (2012).*

Funded by: Institute for Collaborative Biotechnologies, through ARO.
Rapid, Sensitive, and Quantitative Detection of Pathogenic DNA through Microfluidic Electrochemical Quantitative Loop-Mediated Isothermal Amplification

Genetic detection of pathogens at the point of care (POC) has become increasingly important in applications ranging from molecular diagnostics and food safety testing to environmental monitoring and homeland security. To this end, we have developed the microfluidic electrochemical quantitative loop-mediated isothermal amplification (MEQ-LAMP) system—an integrated microfluidic platform for the rapid, sensitive, and quantitative detection of pathogenic DNA, offering a powerful alternative to PCR in terms of sensitivity, reaction speed, and amplicon yield, and can be applied to non-denatured genomic DNA samples under isothermal reaction conditions. This amplification technique also employs six different primers, conferring exquisite specificity and enabling MEQ-LAMP to readily distinguish pathogens of interest from non-target genomic DNA. As a demonstration of the platform effectiveness, we report the direct and quantitative detection of as few as 16 copies of genomic DNA of Salmonella enterica enterica Typhimurium—a pathogen that causes food poisoning—in less than an hour.

K. Hsieh, et. al., Plaxco and Soh groups, UCSB. Work partially performed at UCSB Nanofabrication Facility.

Overview of the MEQ-LAMP. A) Reaction performed within a single-chamber microfluidic chip, which functions as both the LAMP reaction well and the electrochemical measurement cell. B) The MEQ-LAMP reaction solution contains an electrochemically active DNA-binding compound methylene blue. Prior to amplification, MB is free in solution and thus generates a redox current (left). As the LAMP reaction progresses, MB intercalates into the newly formed, double-stranded product (middle), decreasing the observed redox current (right). C) In the complete MEQ-LAMP system, the microfluidic chip is connected to a potentiostat for current measurement. D) Real-time redox current measurements produce a current trace as a function of the reaction time.

Gold nanoparticles convert TiO$_2$ into a panchromatic photoconductor

Devices fabricated by embedding Au nanoparticles in TiO$_2$ show significant additional photoconductances (~30%) when illuminated by light with photon energies well below the band gap. The photoconductance is found to track the plasmonic absorption/extinction spectrum of the AuNPs faithfully. This impressive change in photoconductance is ascribed both to quantum tunneling of hot electrons from the metal directly into the conduction band of the TiO$_2$ for those electrons with energies lower than the 0.9 eV needed to overcome the barrier and to energetic electrons going over the barrier transport. All of these electrons originate as electron-hole pairs in the gold NPs produced by plasmonic excitation and decay. Device impedance measurements carried out in the dark and under illumination with UV and red wavelengths reinforce this mechanism.

Syed Mubeen, Gerardo Hernandez-Sosa, Daniel Moses, Joun Lee, and Martin Moskovits, UC Santa Barbara

Work performed at The UC Santa Barbara Nanofabrication Facility

Frequency dispersion in III-V metal-oxide-semiconductor capacitors

Extensive research activities have focused on developing dielectrics, such as Al$_2$O$_3$ and on In$_{0.53}$Ga$_{0.47}$As for metal-oxide-semiconductor field effect transistors (MOSFETs). One of the most important unresolved issues remains the lack of understanding of the large frequency dispersion that is observed in accumulation, for dielectrics on n-In$_{0.53}$Ga$_{0.47}$As. This dispersion is particularly severe for more highly scaled, high-capacitance-density metal-oxide-semiconductor capacitor (MOSCAP) structures, such as the one shown in Fig. 1.

In this work, we propose a recombination-controlled tunneling model to explain the strong frequency dispersion (Fig. 2). In this model, the parallel conductance is large when, at positive gate biases, the metal Fermi level lines up with a large density of interface states in the semiconductor band gap. We show that the model explains in a semi-quantitative manner the experimentally observed capacitor characteristics.

Fig. 1: Capacitance voltage characteristics of a MOSCAP with a 3 nm Al$_2$O$_3$ dielectric fabricated in UCSB’s NanoFab. The Al$_2$O$_3$ was deposited with a new ALD tool.

Fig. 2: Recombination controlled tunneling mechanism for communication between the gate metal and the interface states.

Susanne Stemmer (UCSB), Varistha Chobpattana (UCSB), and Siddharth Rajan (OSU)
Work performed at UCSB Nanofabrication Facility


Research supported by NSF, ONR and SRC.
Spin wave modes in ferromagnetic tubes

Coplanar waveguides coupled by microstructured, ferromagnetic, Co$_{90}$Ta$_5$Zr$_5$ tubes that support resonant magnetostatic waves have been fabricated and tested. These structures are potentially important for on-chip tunable filters.

Periodic boundary conditions dictated by the tube perimeter and applied to magnetostatic surface waves quantitatively account for the experimentally observed frequencies of excited modes, despite the contorted tubular shape. The tubular topology appears to be more important than the shape details.

Taras Shevchenko - National University of Kyiv, Ukraine, Stanford University
Work performed at UCSB

The shorted ends of two coplanar waveguides are coupled by a ferromagnetic “tube.” Top view SEM (a) and SEM micrograph of structure cross section (b). Schematic of fabricated structure (c).

Computing prime factors with a Josephson phase qubit quantum processor

A quantum processor (QuP) can be used to exploit quantum mechanics to find the prime factors of composite numbers. Two advantages of superconducting qubit architectures are the use of conventional microfabrication techniques, which allow straightforward scaling to large numbers of qubits, and a toolkit of circuit elements that can be used to engineer a variety of qubit types and interactions. Here we demonstrate a nine-quantum-element solid-state QuP. To demonstrate this we run a three-qubit compiled version of Shor’s algorithm to factor the number 15, and successfully find the prime factors 48% of the time. Improvements in the superconducting qubit coherence times and more complex circuits should provide the resources necessary to factor larger composite numbers and run more intricate quantum algorithms.

Erik Lucero et. al. Martinis, Cleland Groups, UCSB
Physics Department
Work performed at UCSB Nanofabrication Facility

Funded by IARPA through ARO

**Figure a** Photograph of the sample, fabricated with aluminum (colored) on sapphire substrate (dark). **Figure b** Schematic of the QuP. Each phase qubit Qi is capacitively coupled to the central half-wavelength bus resonator B and a quarter-wavelength memory resonator Mi. The control lines carry GHz microwave pulses to produce single qubit operations. Each Qi is coupled to a superconducting quantum interference device (SQUID) for single-shot readout.
Split-gate Light Emitting Field Effect Transistors

SG-LEFETs provide a powerful pathway to actively control charge injection to enable high efficiency electroluminescence. The split gate architecture can overcome the passive response of an ambipolar material to a continuous distribution of the gate voltage. Thus, transport can be independently chosen as either n type, p type, or both. By breaking the continuous channel, the brightest luminescent area was positioned far from the metal source-drain contacts. With the SG, field-induced carriers over the first gate can efficiently capture oppositely charged field-induced carriers over the second gate. The most important aspect of the SG architecture is that geometric design dramatically shifts the highest efficiency from the lowest current regime with very low brightness to the regime with maximum injection current, hence largest brightness

Ben, Bang-Yu Hsu and Alan, J. Heeger, UCSB
Work partially performed at UCSB
Nanofabrication Facility


Brightness and electroluminescence spectra of the split-gate LEFETs
In the SWEEPER project we have realized 2-dimensional free space beam steering by means of an integrated silicon-on-insulator (SOI) chip. Beam steering in the longitudinal direction is achieved by vertical grating couplers: changing the wavelength of the light will change the output angle. In the lateral direction beam steering is achieved by controlling the phase of the output of an array of these grating couplers: an optical phased array. We have demonstrated a 16-channel SOI device with thermo-optic phase tuners. The beam has a width of $0.6^\circ \times 1.6^\circ$ and can be steered over $20^\circ \times 14^\circ$. We also realized an 8-channel hybrid silicon 1D beam steering device with integrated single-wavelength source and on-chip optical amplification.

J.K. Doylend, et. al. Coldren and Bowers groups, UCSB Work partially performed at UCSB Nanofabrication Facility

Optics Express, 19 (22), 21595 (2011)

DARPA Sweeper program
Nonpolar GaN VCSEL: First Demonstration

We have demonstrated the first-known nonpolar m-plane GaN-based VCSEL, achieving room-temperature electrically-injected lasing at ~412nm. Nonpolar GaN has the potential to significantly increase GaN VCSEL performance over polar devices, including higher gain leading to lower threshold currents and higher efficiency devices.

Additionally, nonpolar GaN VCSELs exhibit the unique feature of polarization locking, whereby all the devices are polarized in the same direction, with the electric field aligned along the a-direction of the GaN wurtzite crystal structure.

We also demonstrate a novel method for VCSEL fabrication, where the bulk GaN substrate is removed and the cavity length is defined by photoelectrochemical (PEC) etching, giving precise control of cavity length.

Casey Holder, Daniel Feezell, James S. Speck, Steven P. DenBaars, Shuji Nakamura, UCSB
Work partially performed at UCSB Nanofabrication Facility

Light-Current curve and lasing spectra at room temperature pulsed operation.
Electron spin resonance of nitrogen-vacancy centers in optically trapped nanodiamonds

Using an optical tweezers apparatus, we demonstrate threedimensional control of nanodiamonds in solution with simultaneous readout of ground-state electron-spin resonance (ESR) transitions in an ensemble of diamond nitrogen vacancy color centers. Despite the motion and random orientation of nitrogen-vacancy centers suspended in the optical trap, we observe distinct peaks in the measured ESR spectra qualitatively similar to the same measurement in bulk. Accounting for the random dynamics, we model the ESR spectra observed in an externally applied magnetic field to enable dc magnetometry in solution. We estimate the dc magnetic field sensitivity based on variations in ESR line shapes to be approximately 50 μT/(Hz)^{1/2}. This technique may provide a pathway for spin-based magnetic, electric, and thermal sensing in fluidic environments and biophysical systems inaccessible to existing scanning probe techniques.

V. Horowitz, et.al. Awschalom Group, UCSB
Work partially performed at UCSB Nanofabrication Facility

III-V MOS Transistors

III-V compound semiconductor channel materials are being investigated for use in VLSI ICs at scaling generations at and beyond 9 nm. III-V channel materials offer the potential for significantly increased drive currents due to lower transport effective mass. The main goal of this project is to demonstrate that highly scaled III-V MOSFETs can provide greater drive current than comparable Si devices. Efforts in this project have focused on demonstration of a 22 nm device using process modules which could, with appropriate industrial development, be scaled to 9 nm.

Recently, we have demonstrated a high performance III-V MOSFET using substitutional-gate and MBE source drain regrowth, which shows 1.0 mS/μm peak transcondance at $V_{ds} = 0.5$ V and 0.8 mA/μm on-current at $V_{gs} - V_{th} = 0.8$ V and $V_{ds} = 0.5$ V.

S. Lee, A. Carter, J. Law, et. al. Rodwell Group, UCSB
Work performed at UCSB Nanofabrication Facility
Planar waveguides with ultra-low propagation loss are necessary for the long propagation distances and high quality factor resonators used in photonic rotational velocity sensors, true-time-delay networks, optical buffers, and narrowband photonic filters. The history of optical fiber loss reduction suggests that a large modal overlap with undoped silica is a path to ultra-low propagation loss. In this work, we demonstrate a wafer-bonded silica-on-silicon planar waveguide platform with record low total propagation loss of $0.045 \pm 0.04$ dB/m near the free space wavelength of 1580 nm. Using coherent optical frequency domain reflectometry, we characterize the group index, fiber-to-chip coupling loss, critical bend radius, and propagation loss of these waveguides.

J. Bauters, et.al. Bowers/Blumenthal, UCSB
Work partially performed at UCSB Nanofabrication Facility

Planar waveguides with less than 0.1 dB/m propagation loss fabricated with wafer bonding

A schematic overview of the processes used to fabricate the waveguides discussed in this paper. e.i and e.ii illustrate the two upper cladding approaches

Total propagation loss (circles) vs. wavelength for a 50-nm-thick by 6.5-μm-wide waveguide with PECVD oxide upper cladding. The solid lines are fits of Gaussians (absorption loss) and a polynomial (scattering loss) to the data. The color key gives the loss type colors and the center wavelengths of the various Gaussian fits.
Record Microwave Power Performance for N-Polar GaN MISHEMTs Grown by MOCVD on SiC

In this work, we demonstrate record RF power performance of N-polar AlGaN/GaN metal–insulator–semiconductor high-electron-mobility transistors (MISHEMTs) grown by metal–organic chemical vapor deposition (MOCVD) on semi-insulating SiC substrates at 10 and 4 GHz. Additionally, an Al2O3-based etch-stop technology was demonstrated for improving the manufacturability of N-polar GaN HEMTs with SixNy passivation. The reported output power densities of 16.7 W/mm at 10 GHz and 20.7 W/mm at 4 GHz represent the highest reported values so far for an N-polar device, at both of these frequencies. The improvements achieved in the RF output power density when compared with previously reported N-polar MISHEMTs can be attributed to high breakdown voltage of N-polar devices grown by MOCVD and high thermal conductivity of the SiC.

S. Kolluri, et. al. Mishra Group, UCSB
Work performed at UCSB Nanofabrication Facility

High efficiency white LEDs with 90 C deposited single-crystal ZnO current spreading layers

Highly efficient white light-emitting diodes (LEDs) can reduce energy use in interior, automobile, and display lighting. A common approach to efficiently generate white light is to couple a yellow-emitting phosphor with a high-brightness blue gallium nitride (GaN) based LED. The ultimate performance depends on converting electrical energy to photons, and on extracting those photons to the phosphor, and out of the LED package. To efficiently accomplish this, current should be injected uniformly into the active layer of the GaN LED substrate while maintaining optical transparency. Heteroepitaxial ZnO transparent current spreading layers with were deposited on GaN-based light emitting diodes using aqueous solution phase epitaxy at temperatures below 90 C. White LEDs with ZnO layers provided high luminous efficacy—157 lm/W at 0.5A/cm2, and 84.8 lm/W at 35A/cm2, 24% and 50% higher, respectively, than devices with ITO layers. The improvement appears to be due to the enhanced current spreading and low optical absorption provided by the ZnO.

A. Reading, et. al.
DenBaars/Nakamura Groups, UCSB
Work performed at UCSB Nanofabrication Facility

Yield improvement of memristive devices

L. Gao, F. Alibart, G. Adam, B. Hoskins, and D. B. Strukov

Resistive (“memristive”) switching, the reversible modulation of electronic conductivity in thin films under electrical stress, has been observed in a wide range of material systems. Research activity in this area has been traditionally fueled by the search for a perfect electronic memory candidate, but recently it opens doors to new applications in reconfigurable and neuromorphic computing. In our most recent works we designed a simple algorithm to tune the device resistance (Fig.1) and we also improved device yield by creating nanoscale electrode protrusions with e-beam lithography (Fig.2).

Fig. 1. Demonstration of the algorithm to tune the resistive state of the device to 7, 15, 30, 60 or 120 μA within an accuracy of 1% using the algorithm shown in the top inset.

Fig. 2. (Left) Yield improvements from ~60% for the blanket film devices to about 95% for the devices with protrusion. (Right ) Cross-view of protrusion device.


L. Gao, F. Alibart, et. al. Strukov Group, UCSB
Work performed at UCSB Nanofabrication Facility

work supported by NSF and AFSOR
Electromechanical resonance behavior of suspended single walled carbon nanotubes under high bias voltages

The fundamental electrical and electro-mechanical properties of carbon nanotubes (CNTs) continue to expose interesting underlying physics. In this work, we characterize the nanoelectromechanical response of suspended individual CNTs under high voltage biases. An abrupt upshift in the mechanical resonance frequency of approximately 3 MHz is observed at high bias. While several possible mechanisms are discussed, this upshift is attributed to the onset of optical phonon emission, which results in a sudden contraction of the nanotube due to its negative thermal expansion coefficient. This, in turn, causes an increase in the tension in the suspended CNT, which upshifts its mechanical resonance frequency. This upshift is consistent with Raman spectral measurements, which show a sudden downshift of the optical phonon modes at high bias voltages. Using a simple model for oscillations on a string, we estimate the effective change in the length of the nanotube to be $\Delta L/L \approx -2 \times 10^{-5}$ at a bias voltage of 1 V.

M. Aykol, et. al. Cronin Group, University of Southern California
Partial work performed at UCSB Nano Facility

This research was supported in part by (ONR) Award No. N000141010511, (DOE) Award No. DE-FG02-07ER46376, and (NSF) Award No. CBET-0854118.

J. Micromech. Microeng. 21 085008 (2011)
Stability of Tensile-strained Ge Studied by Transmission Electron Microscopy

Tensile-strained germanium has been studied recently as a possible laser material due to its nearly-direct bandgap and the compatibility with CMOS technology. Theoretically, 1.4% biaxial tensile strain could produce a direct bandgap in Ge. In this work, three-dimensional strain in Ge waveguides was introduced by SiNx stress liners, which are widely used for CMOS. Ge waveguides, with widths from 0.5 micron to 80 micron, were patterned and coated with thick strained SiNx with stress of 1 GPa or 2 GPa. By Ramam spectroscopy we observed a Ge peak shift of up to 11 cm$^{-1}$. From this shift we expected direct bandgap emission. However, photoluminescence (PL) showed weak signals in highly strained waveguides and little wavelength shift in weakly strained waveguides. To study the strained Ge interface, we performed a time-dependent damage study under TEM irradiation on two 0.5 μm-width waveguides. We found that highly strained Ge interfaces were susceptible to damage under ebeam irradiation, and that dislocations propagated deep into the waveguide, suggesting possible limits to achievable strain and laser performance.

Meng Qi, et. al. Wistey Group, Notre Dame, EE Dept.
Work partially performed at UCSB Nanofab Facility

Silicon-Germanium Technology and Device Meeting (ISTDM), 4-6 June 2012

Ge waveguide buried in 2GPa compressive SiNx

Time dependent damage study of Ge/SiNx interface by HRTEM. 1) Relaxed strain. No obvious damage. 2) Weakly strained waveguide. Damage found within 2-3 nm from interface. 3) Highly strained waveguide, severe damage can be found propagating into deep area along with exposure time.
Ultrafast Thermal Dynamics in ErAs:GaAs Photoconductive Switches

The goal of this work is to use photoconductive switches with an ErAs:GaAs active medium for the study of ultrafast heating dynamics. The dynamics are measured through thermal monitoring of the central electrode during transmission of RF electrical pulses with laser thermoreflectance. Key results include observations of picosecond Joule heating [bottom left figure], tracking pulse propagation and attenuation of electrical pulses by probing different positions on the electrode [bottom right figure], and ultrafast thermal diffusion in the gold [not shown].

B. Vermeersch, et. al. UC Santa Cruz
Work partially performed at UCSB Nanofabrication Facility

XIV International Conference on Phonon Scattering in Condensed Matter (PHONONS 2012), Ann Arbor, Michigan USA, July 2012
A new technique called nanoimprinting by melt processing (NIMP) has been developed to print large area nanopatterns with varied feature sizes over underlying topographies with a high degree of fidelity. This will be highly beneficial to scientists working in a diverse field of science and technology for developing versatile nanostructures. The key development in this technique involves using plasticizer (diphenyl isophthalate) mixed with low molecular weight polymer (15,000 Mw PMMA) to enable improved polymer wettability for lower pressure imprinting at the melting temperature of the plasticized polymer.

Imprinting pressures and temperatures for Native polymers versus plasticized polymers. Temperature and pressure needed for complete filling is reduced at all Molecular weights.

Simultaneous imprinting of micron-sized (large) features and nano-scale features using the NIMP technique.

J. Thomas, et. al. University of Central Florida
Work partially performed at UCSB Nanofabrication Facility

The purpose of the project is to improve AFM performance by increasing the detection bandwidth and lowering the detection noise to allow higher imaging speeds and fidelity. Scaling down the size of the probe increases their mechanical resonance while reducing their thermal noise.

We have fabricated probes 10x smaller than the state-of-the-art. Like their predecessors, these novel probes have been fabricated on silicon wafers. However, entirely different processes are required because the novel probe geometries are smaller than the variations inherent with the previous probe fabrication techniques. Preliminary results indicate that the process is commercially viable.

The novel small probes consist entirely of silicon for a high and repeatable mechanical quality. Their spring constants are tunable for a variety of imaging modes and the tips are atomically sharp. They can be coated or doped with materials to accommodate most AFM applications.

Hector Cavazos, Asylum Research Corporation
Work performed at Stanford University and UC Santa Barbara Nanofabrication Facilities
Nanomechanical resonators have been used to weigh cells, biomolecules and gas molecules, and to study basic phenomena in surface science, such as phase transitions and diffusion. These experiments all rely on the ability of nanomechanical mass sensors to resolve small masses. Here, we report mass sensing experiments with a resolution of 1.7 yg (1 yg = 10^{-24} g), which corresponds to the mass of one proton. The resonator is a carbon nanotube of length ~150 nm that vibrates at a frequency of almost 2 GHz. This unprecedented level of sensitivity allows us to detect adsorption events of naphthalene molecules (C10H8), and to measure the binding energy of a xenon atom on the nanotube surface. These ultrasensitive nanotube resonators could have applications in mass spectrometry, magnetometry and surface science.

Chaste, et. al. Catalan Institute of Nanotechnology, CIN2(ICN-CSIC), Campus de la UAB, 08193 Bellaterra, Barcelona, Spain
Work partially performed at UCSB nanofabrication facility

Nature Nanotechnology 7, 301 (2012)

Δf0 versus time at 4.3 K when naphthalene molecules are being dosed. Red arrows point to the shifts of the resonance frequency consistent with the adsorption of C10H8 molecules.
Widely Tunable Compact Monolithically Integrated Photonic Coherent Receiver

Coherent optical systems are of great interest for future fiber optic deployment, due to their high spectral efficiencies and the ability to mitigate signal degradation through available access to both optical phase and amplitude information. One of the main challenges in creating a compact monolithically integrated receiver is implementing a widely tunable, low noise, and high power local oscillator (LO).

In this work, a monolithically integrated, photonic, dual polarization capable coherent receiver, with an on-chip widely tunable local oscillator laser has been fabricated and tested. A 20-Gb/s operation with nonreturn-to-zero-quadrature phase-shift-keyed signal, and local oscillator tuning over 40 nm of input wavelength span has been demonstrated.

Steven B. Estrella, et. al. Freedom Photonics
Work partially performed at UC Santa Barbara Nanofabrication Facility

Wide Area SWIR Arrays and Active Illuminators

SWIR imaging provides information that cannot be obtained in the visible or thermal IR regions. Due to its longer wavelength, compared to visible light, it can be used to see through haze. In addition, it provides additional contrast not available in the visible wavelengths. Furthermore, in contrast to other infrared bands (mid-wavelength infrared and longwavelength infrared), the SWIR band utilizes reflected light instead of emitted light and therefore looks more like imaging in the visible waveband.

For NIR/SWIR illumination at wavelengths in the 800 nm to 1100 nm range, FLIR has developed a 2W illuminator system. This illuminator is composed of a 1 mm 2x2 array mounted on a submount and soldered onto a copper heatsink and is designed to operate up to 70 C using passive cooling.

Michael MacDougal, et. al., FLIR EOC, LLC
Work partially performed at UCSB Nanofabrication Facility

Compact, Low Cost Waveguide Based Optical Spectrometer for Detection of Chemical/Biological Agents

Conventional optical spectrometers that are based on bulk optical components tend to be relatively large and expensive compared to the other components used in systems designed for detecting chemical/biological agents. Microspectrometers based on focusing waveguide gratings incorporate both spectral dispersion and focusing functions into a single component that can be fabricated hundreds at a time at the wafer level using nano-imprint lithography techniques. These types of spectrometers are ideal for integration into micro-fluidic systems because the signals can be directly coupled into the planar waveguide. The ultimate goal of this project is to develop a waveguide grating based instrument platform capable of high resolution spectroscopic interrogation of multiple sample channels. We demonstrate preliminary data from a prototype system and compare resolving power and system size with commercial spectrometers.

Compactor Instrument platform based on a planar waveguide spectrometer. Light is focused onto the sample grid of a disposable chip. Optical signals from multiple samples are collected, dispersed, and focused onto an image sensor using a focusing waveguide grating.

FWGs nanoimprinted and etched into the waveguide material from e-beam lithography masters. One master to produce many copies for low cost production.

Comparison of resolving power and range of various spectrometers. The results of our devices are labeled as SSI000006_F10. The boxes represent the relative size of the instrument footprints.

Brent Bergner, Ivan Avrutsky, et. al., Spectrum Scientific Inc. and Wayne State University
Work partially performed at UCSB Nanofabrication Facility

Optical Bistability in a SiliconWaveguide Distributed Bragg Reflector Fabry–Pérot Resonator

Bistability occurs in devices that are composed of a material with nonlinear optical response. In the bistable regime, the output power of the device ceases to be uniquely determined by the input power because multiple powers within the cavity satisfy the resonance condition. Bistable devices are a versatile foundation for optical signal processing because they display both nonlinearity and hysteresis. This allows for the realization of photonic circuitry with functions including switching, memory, combinatorial and sequential logic, and modulation.

In this work we demonstrate optical bistability in a waveguide Fabry–Pérot resonator created from a pair of distributed Bragg reflectors within a strip waveguide. This design has the advantage of maintaining the small footprint and high packing density of a periodically structured dielectric waveguide, while taking advantage of the reduced power consumption featured in devices based on resonant cavities.

A. Grieco et. al., Fainman Group, UCSD
Work partially performed at UCSB Nanofabrication Facility

J. Light. Tech., 30(14), 2012
MEMS tunable VCSEL light source for ultrahigh speed and long range centimeter class OCT imaging

We demonstrate a new wavelength swept light source technology, MEMS tunable VCSELS, for OCT imaging. The VCSEL achieves a combination of ultrahigh sweep speeds, wide spectral tuning range, flexibility in sweep trajectory, and extremely long coherence length, which cannot be simultaneously achieved with other technologies. A prototype VCSEL is optically pumped at 980nm and a low mass electrostatically tunable mirror enables high speed wavelength tuning centered at ~1310nm with ~110nm of tunable bandwidth. Record coherence length >100mm enables extremely long imaging range. By changing the drive waveform, a single 1310nm VCSEL was driven to sweep at speeds from 100kHz to 1.2MHz axial scan rate with unidirectional and bidirectional high duty cycle sweeps. We demonstrate long range and high resolution 1310nm OCT imaging of the human anterior eye at 100kHz axial scan rate and imaging of biological samples at speeds of 60kHz – 1MHz.

Benjamin Potsaid, Vijaysekhar Jayaraman, Praevium and Thor Labs
Work partially performed at UCSB Nanofabrication Facility

High-Frequency (>50 MHz) Medical Ultrasound Linear Arrays Fabricated From Micromachined Bulk PZT Materials

High-frequency, wideband ultrasound transducer arrays can provide the necessary spatial resolution for applications in dermatology, ophthalmology, and other medical disciplines for which high-quality subsurface imaging is required. Unlike high-frequency single-element transducers, one of the major challenges in developing high-frequency ultrasound transducer arrays is the patterning of small-scale features within the array. For example, linear arrays designed for 50-MHz operation should have array elements with a pitch of 36 µm and a kerf width of 12 µm. Linear arrays made from micromachining bulk PZT at frequencies over 50 MHz have been developed using a DRIE dry-etching technique. The arrays consist of 32 elements with an element width of 24 µm and a kerf width of 12 µm. The element length is 4 mm, and the thickness is approximately 32 µm. Values for the −6-dB bandwidth and two-way insertion loss are about 40% and 26 dB, respectively.

C. Liu, et. al., Shung Group, USC
Work partially performed at UCSB Nanofabrication Facility

IEEE Trans on Ultrasonics Ferroelectrics and Frequency Control, 59(2), 315 (2012)
Graphene is an extraordinary two-dimensional (2D) system with chiral charge carriers and fascinating electronic, mechanical and thermal properties. In multilayer graphene, stacking order provides an important yet rarely explored degree of freedom for tuning its electronic properties. These multilayer graphenes are also expected to exhibit rich novel phenomena at low charge densities owing to enhanced electronic interactions and competing symmetries. Here we demonstrate the dramatically different transport and electronic structure properties in TLG with different stacking orders. At the Dirac point, B-TLG remains metallic, whereas r-TLG becomes insulating. In magnetic fields, well developed quantum Hall (QH) plateaus in r-TLG split into three branches at higher fields. Such splitting is a signature of the Lifshitz transition, a topological change in the Fermi surface, that is found only in r-TLG. Our results underscore the rich interaction induced phenomena in trilayer graphene with different stacking orders.

W. Bao, et. al. C.N. Lau group UC Riverside Work partially performed at UCSB Nanofabrication Facility

*Nature Physics, 7, 948 (2011)*
Low Threshold Electrically-Pumped Hybrid Silicon Microring Lasers

Microring and microdisk-based photonic devices with small-cavity design recently have been used to realize a variety of functionalities in photonic integrated circuits. Microring-based modulators, optical buffers, memories, add-drop filters, etc. have been demonstrated. Microrings are also an attractive structure for the design of on-chip lasers. Ring cavities with their travelling wave resonance modes do not require feedback mirrors, and multiple ring lasers can be coupled to a single bus waveguide for wavelength division multiplexing applications. We have significantly improved performance of a compact hybrid silicon microring lasers obtained by selectively reducing the volume of active region through undercutting of the multiple quantum well (MQW) region to force carriers to flow toward the outer edge of the microring for better gain/optical mode overlap. We observe a reduction of the threshold of over 20% and up to 80% output power enhancement.

Di Liang, et. al, HP Laboratories
Work partially performed at UC Santa Barbara Nanofabrication Facility

Measured photocurrent (laser power) for early devices with 2.8um wide active regions and for improved devices where active region undercutting reduced the active width to 1.5um. A dramatic improvement in power and efficiency is seen.