giving evidence of considerable elastic stiffening. Our pulses have central frequencies $\sim$ propagation in water, ethylene glycol and glycerine. We measure a longitudinal sound velocity for glycerine of 2800 m/s, 32% larger than low frequency values, bulk optical reflectivity caused by the pulses can also be detected if the layer is transparent to the probe wavelength (407 or 815 nm). We look at the pulse variation in optical reflectivity at the interface. In thicker layers, including the GaAs substrate and liquid layers on top of the SiO$_2$ process generate quasishear and quasilongitudinal acoustic pulses that propagate in both materials. Pulse echoes in the thin (0.2 micron) SiO$_2$ layer cause a variation in optical reflectivity at the interface. In thicker layers, including the GaAs substrate and liquid layers on top of the SiO$_2$ surface, variations in the bulk optical reflectivity caused by the pulses can also be detected if the layer is transparent to the probe wavelength (407 or 815 nm). We examine the effects of propagation in water, ethylene glycol and glycerine. We measure a longitudinal sound velocity for glycerine of 2800 m/s, 32% larger than low frequency values, giving evidence of considerable elastic stiffening. Our pulses have central frequencies $\sim$ 50 GHz. A more modest 4.6% increase in the longitudinal sound velocity for water (1552 m/s) is also observed. In spite of this notable stiffening, no shear waves were observed in any of the liquids studied, indicating that propagation is still within the hydrodynamic regime.

Supported by JSPS L05532

8:48AM A38.00003 Electromagnetic stimulation of the ultrasonic signal for nondestructive detection of the ferromagnetic inclusions and flaws, PETER FINKEL, Drexel University — It was recently shown that thermal or optical stimulation can be used to increase sensitivity of the conventional nondestructive ultrasonic detection of the small crack, flaws and inclusions in a ferromagnetic thin-walled parts. We proposed another method based on electromagnetic modulation of the ultrasonic scattered signal from the inclusions or defects. The method is applied to imaging a variety of objects including a thin layer, a thick layer, pairs of layers, layers with differing colloidal concentrations and spheres. The experimental results show agreement with the theory of ultrasonic potential imaging that gives the recorded signal as proportional to the integral of the concentration of colloids over the pressure gradient in the ultrasonic wave.

9:00AM A38.00004 Resonant Ultrasound Spectroscopy Characterization of Annealing and Grain Growth in Copper, GUNES KAPLAN, TIM DARLING, KATHERINE MCCALL, Physics Department, University of Nevada, Reno — Resonant Ultrasound Spectroscopy (RUS) is used for determining the bulk elastic properties of a solid material with known dimensions, density and shape from its characteristic vibration frequencies. RUS characterization of polycrystalline materials is based on the assumptions of material uniformity, and the existence of isotropic polycrystal-averaged moduli. The elastic properties of a polycrystalline material depend on the material’s microstructure, which can be changed by heat treatment. In this present work, RUS has been applied to heat treated polycrystalline copper specimens; measurements of the resonance frequencies as a function of heat treatment were obtained and used to derive elastic constants. The elastic constants are correlated to the average grain size in the sample, determined by a visual measurement. We find that when the grain size reaches 10% of the sample dimension, elastic constant fit errors suggest that the sample is losing uniformity. We also discuss a number of measurement results that depend on details of the sample mounting and transducer placement.

9:12AM A38.00005 Vibrational Modes of MEMS based Directional Sound Sensor, TIMOTHY SHIVOK, BYUNGKI KIM, JOSE SINIBALDI, GAMANI KARUNASIRI, Naval Postgraduate School — A directional sound sensor was fabricated using micro-electromechanical system (MEMS) technology based on the operational principle of Ormia ochracea fly's hearing organism [1]. The fly uses coupled bars hinged at the center to achieve the directional sound sensing by monitoring the difference in vibration amplitude between them. The MEMS design employed in this work consisted of a 1x2 square millimeter polysilicon membrane hinged at the center. The membrane was positioned about 2 micrometers above the substrate by using a sacrificial silicon dioxide layer. The membrane has two primary vibrational modes (rocking and bending) which were analyzed by finite element analysis and found to be at 2.5 kHz and 8 kHz. The incident sound waves cause the two sides of the membrane to oscillate with slightly different amplitudes due to the arrival time difference. In this abstract, the vibrational modes of the system measured using electrical and sound sources will be presented. The experimental data were found to be in good agreement with the modeling. [1] R.N. Miles, et. al.: “Mechanically coupled ears for directional hearing in the parasitoid fly Ormia ochracea,” J. Acoust. Soc. Am., 98, 3059, (1995).

9:24AM A38.00006 Development of a new ABS Acoustic Bubble Spectrometer system, XIONGJUN WU, Dynaflo Inc, JAMES PEREA, MICHEL TANGUAY, CHAO-TSUNG HSIAO, GEORGES CHAHINE — Dynaflo has developed an acoustic bubble spectrometer based device, the ABS Acoustic Bubble Spectrometer, that measures bubble size distributions and void fractions in liquids based on the measurement of sound propagation through the liquid in the original system, a pair of hydrophones is used to transmit and receive short monochromatic bursts of sound at different frequencies through the liquid. These signals are processed and analyzed to obtain the frequency dependent attenuation and phase velocities of the acoustic waves. Subsequently, the bubble size distribution is obtained following solution of an inverse problem. In the new system, we have utilized multiple hydrophone pairs that have different frequency response ranges to cover a wider range of bubble size measurement. A transmission signal amplifier is integrated into the system to improve the signal noise ratio. We have also implemented an adaptive control scheme that automatically adjusts the transmitting signal strength and acquisition resolution to optimize the measurement process and used a rectangular and a sine acoustic wave pattern to improve accuracy of signal analysis.
Numerical modeling of the impact of the propagation of a finite wave in a bubbly media on the Acoustic Bubble Spectrometer ABS©. MICHEL TANGUY, GEORGES CHAINE, Dynaflow Inc — The propagation of acoustic waves in bubbly media has been extensively studied over the years. Several methods have been developed for the inversion of the propagation characteristics in order to compute the size and number of bubbles present in the field. At the core of these inversion methods are the assumptions that bubbles are homogeneously dispersed and behave in a steady-state monochromatic linear fashion. However, instruments designed for the detection and measurements of bubbles (such as Dynaflow’s Acoustic Bubble Spectrometer ABS©) are limited to the use of finite duration and amplitude signals. Consequently, the transient characteristics of the bubble field can provide a significant impact on the received signal. We will present some recent work in the numerical modeling of transient and finite amplitude effects and their impact on the received signals and inversion procedure.

Resolving dynamics of acoustic phonons by surface plasmons, JINCHENG WANG, CHUNLEI GUO, University of Rochester — In this work, we employ surface plasmons as a sensitive probe technique to detect acoustic phonons in metal films following impulsive optical excitation. Surface plasmons are shown to have an enhanced sensitivity in detecting acoustic phonons in metals. Our study shows that the surface plasmon technique is a promising tool to detect small optical or mechanical property changes in metals at a miniature scale, suitable for a variety of applications, such as sensors and MEMS.

Long Range Surface Plasmon Fluorescence Spectroscopy, AMAL KASRY, WOLFGANG KNOLL, Max Planck Institute for Polymer Research — Surface plasmon modes, excited at the two sides of a thin metal layer surrounded by two (nearly) identical dielectric media interact via the overlap of their electromagnetic fields. This overlap results in two new-coupled modes, a short and a long-range surface plasmon (LRSP). We demonstrate that combining the LRSP optics with fluorescence spectroscopy can result in a huge enhancement of the fluorescence signal due to the enhanced optical field of the LRSP at the metal dielectric interface, and to its increased evanescent depth into the analyte. This was demonstrated for the detection of the fluorescence intensity of chromophore labeled protein bound to the surface sensor. Beside that, some fundamentals were studied leading to some interesting difference between SPFS and LRSPFS.

Evanescent field response to patterned features on a planar waveguide measured with a buried detector array1. MATTHEW STEPHENS, GUANGWEI YUAN, AHMAD AL-OMARI, KEVIN LEAR, DAVID DANDY — The evanescent field of an appropriately designed waveguide can be very sensitive to the local refractive indices of the cladding layers surrounding the core. In this study, a planar waveguide has been fabricated on a chip that contains buried p-Si photo-detectors, located about 1 micron from the waveguide core and arrayed down the length of the waveguide. Local changes in the index of the upper cladding, such as the formation of an adlayer, result in signal changes at the detector. The buried detector format provides significant opportunities for localized detection of chemical or biological analytes in complex milieu through monitoring of the evanescent field. To test the responses to refractive index changes in the upper cladding, small photoresist features were fabricated on the surface of the waveguide. This material was selected because it is easily patterned, its thickness can be tightly controlled, and its refractive index is similar to that of biological molecules. The results of the experiments measuring evanescent field intensity as well as detector fabrication details will be presented; these results are compared with parallel numerical modeling studies.

AlGaN based Tunable Hyperspectral Detector: Growth and Device Structure Optimization, NEERAJ TRIPATHI, JAMES R. GRANDUSKY, VIBHU JINDAL, FATEMEH SHAHDEPOUR-SANDVIK, College of Nanoscale Science and Engineering, University at Albany, L. DOWDELL BELL, Jet Propulsion Laboratory, California Institute of Technology, COLLEGE OF NANOSCALE SCIENCE AND ENGINEERING, UNIVERSITY AT ALBANY TEAM, JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY COLLABORATION — We report on fabrication and growth optimization of an AlGaN/GaN based tunable hyperspectral detector. III-Nitride based detectors possess the potential to detect a large portion, from UV to IR, of the electromagnetic spectrum. Control over the detection wavelength with applied bias across an AlInGaN heterostructure can provide a compact tunable hyperspectral detector eliminating use of filters and gratings which make current tunable detectors bulky. Challenges involved in the development of the device include controlled deposition and characterization of thin layers of AlGaN, N with good control of varying from 0% to 100% and back to 0%. Performance of such detector is greatly affected by the thickness and quality of the thin heteroepitaxially grown layers which control the dark current and operating voltage of the device. We will present the electric of growth conditions and heterostructure parameters such as composition and thickness on the device performance.

Dielectric Effects in Electro-optic Field Sensors, ANTHONY GARZARELLE, DONG HO WU, Naval Research Lab, RANDALL HINTON, Temple University — The use of electro-optic (EO) crystals for electromagnetic field detection is an attractive alternative to conventional techniques, due to their compactness, large intrinsic bandwidth, and ability to measure field amplitude and phase with minimum field perturbation. In our LiNbO₃ sensors, anomalously large detection sensitivities were observed, which were found to be due to dielectric relaxation effects within the crystals. In this presentation, we demonstrate these effects, their impact on the EO sensor responsivity, and discuss implications for improving future EO field sensors.

Monday, March 5, 2007 11:15AM - 2:15PM –
Session B38 GIMS DBP: Focus Session: Bioinstrumentation and Biophotonic Technologies
Colorado Convention Center 501

Fourier-Domain Biophotoacoustic Sub-surface Depth Selective Amplitude and Phase Imaging of Turbid Phantoms and Biological Tissue, SERGEY TELENKOV, Imaging Diagnostic Systems, Inc. — A novel photothermoacoustic imaging modality utilizing a frequency-swept (chirped) intensity-modulated laser source and coherent frequency domain signal processing ("biophotoacoustics") was introduced for non-invasive imaging of biological tissues. The developed frequency-domain imaging system takes advantage of linear frequency modulation waveforms to relate depth of tissue chromophores to the frequency spectrum of the detected acoustic response and of a narrow signal detection bandwidth to improve signal-to-noise ratio (SNR). Application of frequency-domain photothermoacoustic (FD-PTA) imaging was demonstrated using turbid phantoms and ex-vivo specimens of chicken breast with embedded absorbing inclusions simulating tumors.

This work was done in collaboration with Andreas Mandelis.
11:51AM B38.00002 An application of fast response Polarized Light Microscopy

KANTHA, DAVID VAN WINKLE, Department of Physics, Florida State University and MARTECH — A fast response polarized light microscope was designed based on the algorithm by Shrihak et al (Applied Optics, vol. 42, 3009-3017). A pulsed laser beam was passed through two Pockels cells aligned at different angles with respect to optical axis. The retardance of the Pockels cell was controlled by external switches and power supplies. The electronics circuit in the system allows change of the retardance of the Pockels cell each millisecond for four milliseconds. In four milliseconds, four images of a birefringent sample, formed by different states of polarized light are recorded. The images are added appropriately to calculate retardence amplitude and phase by using codes written in imageJ software. The microscope was used to show the retardance and phase of a rabbit muscle fiber. Recordings were also taken of the contraction of Vorticella convallaria but the changes were too fast to yield retardance images. This type of microscope can be used to study different kinds of biological functions that change on a timescale slower than four milliseconds but faster than two seconds.

12:03PM B38.00003 Evaluation of optical excitation conditions for ruthenium complex for biosensor optodes

SEAN PIEPER, Elec. and Comp. Engr. Dept. CSU, ZHONG ZHONG, Chemical Engineering Dept. CSU, KEVIN L. LEAR, Elec. and Comp. Engr. Dept. CSU, KEN REARDON, Chemical Engineering Dept. CSU — Development of a fiber optic biosensor incorporating genetically engineered enzymes which catalyze chlorinated ethenes in an oxygen-consuming reaction for in situ monitoring of groundwater contaminants motivates optimization of optical excitation conditions. These conditions affect the sensitivity, signal-to-noise ratio, and optical service life impacting the quality of the overall biosensor. Optodes are generally comprised of a fluorophore conjugated with a polymer as a substrate cross linked at the distal end of a fiber optic. We investigate the excitation conditions of tris(4,7-diphenyl-1,10-phenanthroline) ruthenium(II) chloride (Ru(dpp)3) conjugated with poly(vinyl alcohol) (PVOH) as an optode. A reported advantage of Ru(dpp)3 is that it has no emission spectral shift occurring under varying chemical and environmental conditions. Photostability degradation due to photobleaching of Ru(dpp)3 as a substrate is explored by varying the optical irradiance of the fluorophore containing optode. Other issues relating to practical implementation of Ru(dpp)3 as oxygen sensitive biosensors will be discussed.

12:15PM B38.00004 Two-Photon Microscope with Spectral Resolution

RUSSELL FUNG, MIKE MEL-NICHUK, ANURAG CHATURVE, DEVIN GILLMAN, VALERICA RAICU, Department of Physics and Department of Biological Sciences, University of Wisconsin-

MADISON — Two-photon microscopy combines the distribution of single-photon microscopy, it is faster, there is less background, reduced photobleaching, and using near-infrared laser light (to produce visible fluorescence signal) allows deeper penetration into thick samples. We have built a two-photon microscope based on a novel design that uses a diffractive optic, a nondescanned detection scheme and an EM-CCD camera to produce spectrally resolved fluorescence images of samples after only one full scan of the sample and with relatively high speed. Our design is readily extended to incorporate control in the excitation channel through pulse shaping using spatial filtering in the frequency domain. This microscope, in conjunction with Fluorescence Resonance Energy Transfer (FRET) between fluorescent tags, has been used to detect interactions between proteins in various systems including yeast (Saccharomyces cerevisiae) cells. Also, its exquisite sensitivity makes it suitable to spectrally resolve signals from single quantum dots and single molecules.

12:27PM B38.00005 Exploration of detection sensitivity of biomarker acetone in aqueous samples using cavity ringdown spectroscopy

ARMSTRONG MBI, CHUJI WANG1, Department of Physics and Astronomy, Mississippi State University — Breath acetone is a biomarker for diabetes (Type 1). Currently, high sensitivity breath gas analysis is mainly performed by gas chromatography-mass spectrometry (GC-MC). We are developing a potable ringdown spectrometer for diabetes diagnostics using non-invasive breath gas analysis. The ringdown spectrometer consists of a compact Nd: YAG laser source operating at 266 nm, a atmospheric gas cell of 43 cm in length, a miniature detector, and a data processing section. In this work, the exploration of detection sensitivity of acetone in aqueous samples using cavity ringdown spectroscopy is presented. Pure acetone is diluted in distilled water in different concentrations ranging from 0.5 drop/liter to 8 drops/liter, or 730 ppbv - 12 ppmv in gas phase. The instrument performance using two sampling methods is evaluated. With the mirror reflectivity of 99.98%, the spectrometer demonstrates a detection limit of acetone of 450 ppbv (based on 1-σ), which is slightly lower than the threshold number of acetone concentration in normal human breath. Preliminary results from actual breath gases are also presented.

1(Author to whom correspondence should be made)

12:39PM B38.00006 Optofluidic intracavity spectroscopy of single cells in a passive Fabry-Perot resonator

HUA SHAO, WEINA WANG, Electrical and Computer Engineering Department, Colorado State University, SUSAN LANA, Animal Cancer Center, Colorado State University, KEVIN LEAR, Electrical and Computer Engineering Department, Colorado State University — Considerable effort has been devoted to analyzing complex biological systems such as living cells by combining photonic and microfluidic techniques. Cells in biocavity lasers developed by Gourley et al produced rich multimode spectra that multivariate analysis correlated with the cell type. Optofluidic intracavity spectroscopy (OFIS) reported here operates on a similar principles but does not require gain media. It measures transmission spectra of individual cells in a passive Fabry-Perot (FP) cavity. Non-normal incidence identified the relative order of the various transverse modes to verify the applicability of different simplified models of the cavity modes. Distinctive spectral features, including transverse mode spacing and the number of modes were used to differentiate red and white human blood cells, for example. OFIS measurements of canine leukocyte cells produced repeatable transmission spectra. Continuing investigations on the capability of OFIS to distinguish cancer cells will be reported.

12:51PM B38.00007 Magnetically Directed Cell Co-Localization

JOHNS Hopkins University, YOOJIN AN, CHRISTOPHER CHEN, University of Pennsylvania — The ability to control the movement and location of biological cells has led to novel approaches to several areas of interest, from tissue engineering to the study of cell-cell interactions. We have introduced ferromagnetic nanowires as a tool for cell targeting; their high remanent magnetization allows cells bound to nanowires to be manipulated in low-strength magnetic fields. Micropatterned magnetic structures generate magnetic fields that can precisely guide cells to predetermined positions on substrates in culture, and cells can be restricted to localized areas through chemical functionalization of the substrate. We have used these directed cell assembly techniques to organize cells into a variety of patterns with a single cell type, and have extended its utility to include two cell types. We have created regular arrays of cells in which heterotypic cell pairs are magnetically trapped at each array site. This method of producing large numbers of isolated heterotypic cell pairs is potentially useful in studies of cell-cell interactions between different cell types.

1:03PM B38.00008 Detection of cancer protein using Spectroscopic Ellipsometry as Surface Plasmon Resonance Mode

YUNBOG KIM, DONGYUL JI, Seoul National University, Department of Physics Education and Nano Systems Institute, Seoul 151-748, Korea, MIN-AH WOO, MYUNGHAING CHO, Seoul National University, College of Veterinary Medicine and Nano Systems Institute, Seoul 151-748, Korea — Since the first application of surface plasmon resonance (SPR) for biosensing almost two decades ago, SPR has made great strides in terms of both the instrumentation and the application. We used spectroscopic ellipsometry as an SPR sensor to detect the reaction of HER2 protein of SKBR3 cancer cells with its antibody. Since the Psi value of ellipsometry is related to the reflectivity of P wave, the surface plasmon signal can be measured using spectroscopic ellipsometry. A glass plate coated with 50 nm-thick gold film was dipped in HER2 antibody solution for 1 hour. The substrate was then dipped in a soup containing broken SKBR3 cells to induce HER2 antibody-antigen reaction. The pure gold film exhibited a SPR peak at 2.04 eV. After the adsorption of HER2 antibody, the peak shifted to 1.99 eV. After dipping in the soup of SKBR3 cells, the peak shifted to 1.96 eV. We believe this shift is due to the change in surface plasmon caused by binding of HER2 protein and antibody. The AFM images of the samples supported our conclusion. Our result adds an example to the possibility of using spectroscopic ellipsometry as an SPR mode for detecting cancer cells.
1:15PM B38.00009 Holography with Low Energy Electrons1. TATIANA LATYCHEVSKAIA, GREGORY STEVENS, ANDREAS PLUECKTHUN, HANS-WERNER FINK. Physics Institute, University of Zurich — Coherent low energy electrons of 60-200 eV kinetic energy and sub-nanometer wavelength provide a tool to record holograms of individual bio-molecules, such as DNA or viruses. From the recorded holograms, the three-dimensional shape of the molecules can be numerically reconstructed. The experimental setup as well as the numerical reconstruction of low energy electron holograms from individual bio-molecules shall be discussed. Since most biological objects are transparent for electrons they introduce only a phase shift to the incident electron wave. We present a method to not only retrieve the absorbing (as most known methods do) but also the phase properties of the object wave. Finally, we present a general solution of the long-standing twin image problem in holography. It is applicable to any type of holography independent of the wavelength used and the nature of the wave, be it light, electrons, x-rays or any other coherent radiation.

1The work is part of the Project SIBMAR within the frame of the “New and Emerging Science and Technology” European Programme.

1:27PM B38.00010 In-line Phase Contrast Imaging of Soft Tissue in the Mammalian Cochlea . LIXIN FAN, Northwestern University Feinberg School of Medicine, 200 E. Superior St., Chicago, IL, 60611, C. RAU, Advanced Photon Source, Argonne National Lab, 9700 S. Cass Ave. . Argonne, IL 60439, I. ROBINSON, Frederick Seitz Materials Research Laboratory, University of Illinois at Urbana-Champaign, 104 S. Goodwin Ave., Urbana, IL61801, C.-P. RICHTER, Northwestern University Feinberg School of Medicine, 200 E. Superior St., Chicago, IL, 60611 — Soft tissue has been visualized in a mammalian cochlea with hard X-rays in-line phase contrast imaging at the UNICAT beamline 34 ID-C, APS. The sensation of hearing results from a series of complex events that transform acoustic pressure waves into the perception of sound. During the normal hearing process, sound energy is converted to mechanical energy by the middle ear, which then is converted to motions in the structures of the cochlea. To date, many aspects of the sound induced vibrations are still unclear. Firstly, mechanics of the cochlea are likely to changes by the manipulations, and secondly, cochlear micromechanics are unexplored for the cochlear middle section. Therefore, our objective is to measure the motion patterns of cochlear tissues in a closed cochlea. Thick mammalian cochlear slices have been imaged and were compared with those obtained by light microscopy. Furthermore, intact cochlea have been imaged to identify the soft tissue structures involved in the hearing process.

1:39PM B38.00011 Dental Photothermal Radiometry: Theoretical Analysis. . ANNA MATVIENKO, RAYMOND JEON, ANDREAS MANDELIS, Center for Advanced Diffusion Wave Technologies, University of Toronto, Canada, STEPHEN ABRAMS, Four Cell Consulting, Toronto, Canada — Dental enamel demineralization in its early stages is very difficult to detect with conventional x-rays or visual examination. High-resolution techniques, such as scanning electron microscopy, usually require destruction of the tooth. Photothermal Radiometry (PTR) was recently applied as a safe, non-destructive, and highly sensitive tool for the detection of early dental demineralization, artificially created on the enamel surface. The experiments showed very high sensitivity of the measured signal to incipient changes in the surface structure, emphasizing the clinical capabilities of the method. In order to analyze the biothermophotonic phenomena in a tooth sample during the photothermal excitation, a theoretical model featuring coupled diffuse-photon-density-wave and thermal-wave fields was developed. Numerical simulations identified the effects on the PTR signal of changes in optical and thermal properties of enamel and dentin as a result of demineralization. The model predictions and experimental results will be compared and discussed.

1:51PM B38.00012 ABSTRACT HAS BEEN MOVED TO J21.00010 —

2:03PM B38.00013 ABSTRACT HAS BEEN MOVED TO J21.00009 —

Monday, March 5, 2007 2:30PM - 5:06PM —
Session D38 GIMS: Nanoinstrumentation for Biological and Other Applications Colorado Convention Center 501

2:30PM D38.00001 Assembly of a minimal protocell . STEEN RASMUSSEN, Los Alamos National Laboratory, PROTOCELL ASSEMBLY TEAM TEAM — What is minimal life, how can we make it, and how can it be useful? We present experimental and computational results towards bridging nonliving and living matter, which results in life that is different and much simpler than contemporary life. A simple yet tightly coupled catalytic cooperation between genes, metabolism, and container forms the design underpinnings of our protocell, which is a minimal self-replicating molecular machine. Experimentally, we have recently demonstrated this coupling by having an informational molecule (8-oxoguanine) catalytically control the light driven metabolic (Ru-bpy based) production of container materials (fatty acids). This is a significant milestone towards assembling a minimal self-replicating molecular machine. Recent theoretical investigations indicate that coordinated exponential component growth should naturally emerge as a result from such a catalytic coupling between the main protocellular components. A 3-D dissipative particle simulation (DPD) study of the full protocell life-cycle exposes a number of anticipated systemic issues associated with the remaining experimental challenges for the implementation of the minimal protocell. Finally we outline how more general self-replicating materials could be useful.

2:42PM D38.00002 High throughput electronic cell identification techniques for microfluidic systems . DAVID WOOD, University of California - Santa Barbara, GARY BRAUN, JEAN-LUC FRAIKIN, LOREN SWENSON, NORBERT REICH, ANDREW CLELAND, Departments of Physics, Chemistry and Biochemistry, University of California - Santa Barbara — We address the problem of whole-cell identification using an all-electronic microfluidic approach, with potential applications to cell sorting. We present the development of a radiofrequency microsensor, capable of detecting cells or cell labels in a microfluidic system. This device has demonstrated detection of individual cellular labels at throughputs of 30,000 labels/s in a single microfluidic channel. We also present the development of digital barcodes, which can be used to label cells for identifying individual strains in a diverse population. These barcodes were developed using fully-scalable lithographic techniques, providing a means for low-cost, large volume production. We have demonstrated biological functionalization of these barcodes as well as readout, using our radiofrequency microsensor, at throughputs greater than 1,000 labels/s.

2:54PM D38.00003 Dynamic Detection of a Single Bacterium: Nonlinear Rotation Rate Shifts of Driven Magnetic Microspheres . BRANDON H. MCNAUGHTON, RODNEY R. AGAYAN, RAOUl KOPelman, University of Michigan — We report on a new technique which was used to detect single Escherichia coli that is based on the changes in the nonlinear rotation of a magnetic microsphere driven by a magnetic field. The presence of one Escherichia Coli bacterium on the surface of a 2.0 micron magnetic microsphere (with an aluminum “nanocap” that indicates the microsphere’s orientation) caused an easily measurable change in the drag of the system and, therefore, in the nonlinear rotation rate. The straightforward measurement uses standard microscopy techniques and the observed average shift in the nonlinear rotation frequency changed by a factor of ~3.8 (Arxiv preprint cond-mat/0610144). Further miniaturization will allow for dynamic detection of viruses and potentially even biomolecules in fluidic environments.
3:06PM D38.00004 Nanolaser spectroscopy of Normal and Genetically Defective Mitochondria: New Biostatistical Tool for Studying Disease, PAUL GOURLEY, JUDY HENDRICKS, Sandia National Labs, ROBERT NAVIAUX, MICHAEL YAFFE, UC San Diego — We report an analysis of wild and mutant strains of mitochondria from yeast cells using nanolaser spectroscopy to measure cytochrome density and its statistical variation in the population. The first strain 110 was derived from wild-type strain 104 (Saccharomyces cerevisiae) by removal of its mitochondrial DNA (mtDNA), resulting in loss of all mtDNA-encoded proteins and RNAs, and loss of the pigmented, heme-containing cytochromes a and b that can be detected in the laser spectra. Histograms of laser wavelengths produced by wild-type mitochondria produced peaked distributions, while mutant mitochondria exhibit asymmetric, highly skewed distributions. Surprisingly, all of these distributions exhibit extended tails and can be self-consistently fit with log-normal distribution functions. In striking contrast, the mitochondrial diameters (measured separately by microscopy) exhibit normal Gaussian distributions. These results indicate that the nanolaser spectra are useful for quantifying cytochrome content in mitochondria and may have important implications for quantifying defects in mitochondria that manifest human disease.

3:18PM D38.00005 Gas sensing behavior of individual carbon nanotube field effect transistors, MICHAEL STADERMANN, ALEXANDER ARTYUKHIN, OLGICA BAKAJIN, ALEKSNANDR NOY, Lawrence Livermore National Laboratory — Carbon nanotube field effect transistors (FETs) have been found to be gas sensors with amazing sensitivity. Thus far, however, the exact sensing mechanism of the devices remains unknown. Recent results indicate that the analytes may bind to defects in the nanotubes and change their conductance through charge transfer, but all of these measurements have been performed in networks of carbon nanotubes, in which the mechanism of detection strongly suggests that the electric potential inside a conical nanopore. Possibilities of constructing a chemical oscillator with tens of Hz operating frequency will be presented as well. We will also discuss application of this oscillating system to building a synthetic stochastic sensor. Since the system operates far from equilibrium, we expect it to be very sensitive to any changes/perturbations, e.g. presence of molecules that we want to detect. The mechanism of detection strongly suggests that the sensor will respond to a whole variety of organic molecules with little modification.

3:30PM D38.00006 Large-scale assembly of CNT based DNA sensor array on SiO2 substrate, JOOHYUNG LEE, BYUNG YANG LEE, DONG JOON LEE, KYUNGEUN BYUN, SEUNGHUN HONG, School of Physics and Astronomy, Seoul National University — DNA sensors based on CNTs have been attracting attention similar to their possible applications such as genotyping, disease diagnosis, etc. Previous works were mostly based on CNTs functionalized with DNA molecules. However, a major bottleneck holding back their practical applications has been a lack of mass production method of such sensors. Furthermore, immobilization of DNA on CNTs using linker molecules can severely degrade their electrical properties. Herein, we report a new method to fabricate a large-scale array of CNT-based DNA sensors on SiO2 and glass substrates. In this method, non-polar molecular patterns guide the assembly of CNTs onto uncoated bare surface regions (Nature Nanotechnology 1, 66 (2006)). After fabrication of electrodes on the CNT patterns, we further functionalized the bare surface regions with single-stranded (ss) PNAand successfully demonstrated detection of target ss-DNA with high sensitivity. Since we functionalize the bare surface between CNTs, this process can be applied to virtually any nanotubes circuits on SiO2 or glass substrates to fabricate DNA sensors.

3:42PM D38.00007 Calcium Induced Voltage Gating and Negative Incremental Resistance in Single Conical Nanopores, ZUZANNA SIWY, MATTHEW POWELL, University of California, Irvine, MICHAEL SULLIVAN, George Mason University, CHRISTINA TRAUTMANN, Gesellschaft fuer Schwerionenforschung, ROBERT EISENBERG, Rush Medical College — We will present a nanopore device working in an ionic solution that has transport characteristics similar to unjunction transistors working in electronic circuits, namely negative incremental resistance and voltage dependent ion current fluctuations. Our device consists of a single conical nanopore in solutions containing potassium chloride and sub-millimolar concentrations of calcium and cobalt ions. We will talk about importance of electrostatic and chemical interactions of translocating ions with pore walls. We explain the transport effects on the basis of transient binding of calcium ions to chemical groups on the pore walls that cause transient changes in electric potential inside a conical nanopore. Possibilities of constructing a chemical oscillator with tens of Hz operating frequency will be presented as well. We will also discuss application of this oscillating system to building a synthetic stochastic sensor. Since the system operates far from equilibrium, we expect it to be very sensitive to any changes/perturbations, e.g. presence of molecules that we want to detect. The mechanism of detection strongly suggests that the sensor will respond to a whole variety of organic molecules with little modification.

3:54PM D38.00008 Protein denaturing on Nanospheres, JAMES FORREST, JONATHAN TEICHROEB, University of Waterloo — We have used localized surface plasma resonance (LSPR) to monitor the structural changes that accompany thermal denaturing of Bovine Serum Albumin(BSA) adsorbed onto gold nanospheres of size 5nm-60nm. The effect of the protein on the LSPR was monitored by visible extinction spectroscopy. The position of the resonance is affected by the conformation of the adsorbed protein layer, and as such can be used as a very sensitive probe of thermal denaturing that is specific to the adsorbed protein. The results are compared to detailed calculations and show that full calculations can lead to significant increases in the agreement between the experimental and theoretical results. The results also show that full calculations can lead to deviations in the agreement between the experimental and theoretical results. The results also show that full calculations can lead to significant increases in the agreement between the experimental and theoretical results. The results also show that full calculations can lead to deviations in the agreement between the experimental and theoretical results. The results also show that full calculations can lead to significant increases in the agreement between the experimental and theoretical results. The results also show that full calculations can lead to deviations in the agreement between the experimental and theoretical results. The results also show that full calculations can lead to significant increases in the agreement between the experimental and theoretical results.
4:30PM D38.00011 Nano-Optics for Chemical and Materials Characterization, MICHAEL BEVERSLUIS, STEPHAN STRANICK, National Institute of Standards and Technology — Light microscopy can provide non-destructive, real-time, three-dimensional imaging with chemically-specific contrast, but diffraction frequently limits the resolution to roughly 200 nm. Recently, structured illumination techniques have allowed fluorescence imaging to reach 50 nm resolution [1]. Since these fluorescence techniques were developed for use in microbiology, a key challenge is to take the resolution-enhancing features and apply them to contrast mechanisms like vibrational spectroscopy (e.g., Raman and CARS microscopy) that provide morphological and chemically specific imaging. We are developing a new hybrid technique that combines the resolution enhancement of structured illumination microscopy with scanning techniques that can record hyperspectral images with 100 nm spatial resolution. We will show such superresolving images of semiconductor nanostructures and discuss the advantages and requirements for this technique. Reference: 1. M. G. L. Gustafsson, P. Natl. Acad. Sci. USA 102, 13081-13086 (2005).

4:42PM D38.00012 Simultaneous Surface-Enhanced Raman Scattering Imaging and Spectroscopy in Confocal Mode, DENIS PRISTINSKI1, MELEK EROL2, HENRY DU1, SVETLANA SUKHISHVILII2, Stevens Institute of Technology — Noble metallic metal nanoparticles deposited on a planar substrate facilitate ultra-sensitve measurements via surface-enhanced Raman scattering (SERS) spectroscopy. Due to the random nature of nanoparticle immobilization, the variation of interparticle distance and possible aggregate formation cause significant fluctuation in SERS signal intensity across the substrate. To study the nature of these intensity fluctuations we have built a microscope capable of simultaneous imaging in epi-fluorescent mode and spectroscopy of a point of interest in confocal mode. Two excitation beams from the same laser (DPSS 532 nm) are mixed to expose the imaged area and to focus on the point of interest through high N.A. objective. The scattered light collected by the same objective is filtered and split between a cooled CCD camera for imaging and a fiber-connected spectrometer for confocal mode spectroscopy. Positively charged Ag nanoparticles prepared by polyelectrolyte-assisted reduction were deposited on glass substrate and used for the assessment of uniformity of SERS signal from subsequently adsorbed anionic molecules and for the identification of proteins. 1 Department of Chemical, BioMedical, and Materials Engineering 2 Department of Chemistry and Chemical Biology

4:54PM D38.00013 Initial Development of a sub-micron Angle Resolved Photoemission Microscope, AARON BOSTWICK, 1Advanced Light Source, Lawrence Berkeley National Laboratory, JESSICA MCCHESTNEY, 2Department of Physics, Montana State University, ELI ROTTENBERG, 1Advanced Light Source, Lawrence Berkeley National Laboratory — abstract— We have begun initial development of a sub-micron angle resolved photoemission microscope. The current test system consists of an SES-200 detector and a zone plate based focusing system operating at 180eV photon energy. We have measured angle resolved spectra using the SES-200 angle-dispersive collection mode at resolution of ~500nm. We have used this to show orientational contrast on highly oriented pyrylytic graphite (HOPG). The domains on HOPG are on the order of 1-20 microns and are well orientated along the c-axis but show random azimuthal order. We are able to clearly image these domains even though they show no chemical contrast, and can measure the single crystal based structure on disordered polycrystalline sample. We believe this demonstrates the promise of such a system for the measurement of materials which cannot be found in bulk single crystals.

5:06PM D38.00014 Probing the breakup of high-speed liquid jet by ultrafast x-ray microimaging, JIN WANG, Argonne National Laboratory — High-pressure high-speed sprays have vast industrial and consumer applications that penetrate to very aspect of the society. Despite their longstanding multitude of uses, the fundamental physics that governs the spray flow formation in high-speed jets is not well understood. Experimentally, the difficulty is due, in large part, to a lack of information about the composition of spray plumes close to the nozzle, such as liquid breakup mechanism and spray mass distribution. Traditional visualization tools like visible-light-based imaging have not been effective. To date, theoretical and computational studies of the sprays have proven to be extremely difficult, if not impossible, to carry out. We report here the development of x-ray-based microimaging technique to visualize the breakup of optically opaque high-speed jets in the near-nozzle region. The quantitative near-nozzle spray characteristics can serve to validate primary liquid breakup models and be used as indispensable initial and boundary conditions for spray atomization processes in further downstream areas.

5:18PM D38.00015 Probing Magnetic Materials Using Synchrotron Radiation and Phase Retarding Optics, JONATHAN LANG, Advanced Photon Source, Argonne National Laboratory — Synchrotron radiation has become an essential tool in the study of magnetic materials. The utility of x-ray measurements arises from the fact that the resonant and polarization properties observed near core-level resonances probe the valence-electron spin and orbital properties in an element specific manner. Critical to enabling such studies, however, has been the ability to easily manipulate the polarization of the x-ray beam. Circularly polarized x-rays play a particularly important role, due to their coupling to the net ferromagnetic moment in a material. This talk will focus on how phase retarding optical elements can be used to tailor the focus on how phase retarding optical elements can be used to tailor the x-ray beam polarization in order to enable various types of magnetic measurements. Examples of magnetic spectroscopy, scattering, and imaging measurements employing such optics will be presented.

5:30PM D38.00016 Probing the breakup of high-speed liquid jet by ultrafast x-ray microimaging, JIN WANG, Argonne National Laboratory — High-pressure high-speed sprays have vast industrial and consumer applications that penetrate to very aspect of the society. Despite their longstanding multitude of uses, the fundamental physics that governs the spray flow formation in high-speed jets is not well understood. Experimentally, the difficulty is due, in large part, to a lack of information about the composition of spray plumes close to the nozzle, such as liquid breakup mechanism and spray mass distribution. Traditional visualization tools like visible-light-based imaging have not been effective. To date, theoretical and computational studies of the sprays have proven to be extremely difficult, if not impossible, to carry out. We report here the development of x-ray-based microimaging technique to visualize the breakup of optically opaque high-speed jets in the near-nozzle region. The quantitative near-nozzle spray characteristics can serve to validate primary liquid breakup models and be used as indispensable initial and boundary conditions for spray atomization processes in further downstream areas.

8:00AM H38.00001 Probing Magnetic Materials Using Synchrotron Radiation and Phase Retarding Optics, JONATHAN LANG, Advanced Photon Source, Argonne National Laboratory — Synchrotron radiation has become an essential tool in the study of magnetic materials. The utility of x-ray measurements arises from the fact that the resonant and polarization properties observed near core-level resonances probe the valence-electron spin and orbital properties in an element specific manner. Critical to enabling such studies, however, has been the ability to easily manipulate the polarization of the x-ray beam. Circularly polarized x-rays play a particularly important role, due to their coupling to the net ferromagnetic moment in a material. This talk will focus on how phase retarding optical elements can be used to tailor the focus on how phase retarding optical elements can be used to tailor the x-ray beam polarization in order to enable various types of magnetic measurements. Examples of magnetic spectroscopy, scattering, and imaging measurements employing such optics will be presented.

8:36AM H38.00002 Probing the breakup of high-speed liquid jet by ultrafast x-ray microimaging, JIN WANG, Argonne National Laboratory — High-pressure high-speed sprays have vast industrial and consumer applications that penetrate to very aspect of the society. Despite their longstanding multitude of uses, the fundamental physics that governs the spray flow formation in high-speed jets is not well understood. Experimentally, the difficulty is due, in large part, to a lack of information about the composition of spray plumes close to the nozzle, such as liquid breakup mechanism and spray mass distribution. Traditional visualization tools like visible-light-based imaging have not been effective. To date, theoretical and computational studies of the sprays have proven to be extremely difficult, if not impossible, to carry out. We report here the development of x-ray-based microimaging technique to visualize the breakup of optically opaque high-speed jets in the near-nozzle region. The quantitative near-nozzle spray characteristics can serve to validate primary liquid breakup models and be used as indispensable initial and boundary conditions for spray atomization processes in further downstream areas.

8:48AM H38.00003 X-ray imaging of nickel-based microstructred superalloys using synchrotron radiation, NAJI HUSSEINI, DIVINE KUMAH, CODRIN CIONCA, ROY CLARKE, Physics Department, University of Michigan, JIANZHUANG YI, CHRISTOPHER TORBET, J. WAYNE JONES, Material Science and Engineering, University of Michigan — Nickel-based superalloys are used in harsh environments such as airplane turbines and nuclear power plants for their high temperature stability and resilience to oxidation and corrosion. These superalloys grow via directional solidification along the <001> orientation and assume a dendritic morphology along <100>, concentrating Ni into the dendrites and TaC elsewhere. 200 μm thick samples of Rene N5 were imaged in a transmission setup at Sector 7 of the Advanced Photon Source with high-intensity synchrotron radiation. The recorded intensity maps contain information about the elemental concentration with sub-micron resolution, enhanced by phase contrast near sharp compositional variations. These maps show vacancies and cracks in addition to linearly decreasing concentrations of Re and W out from the center. Interferences seen while rotating the sample reveal misorientations of the cores and strain between dendrites, while a full rotation permits 3D tomography. One-second exposure times allow observation of in situ crack propagation induced by an ultrasonic fatiguer.
Quantitative strain analysis of single crystals using x-ray topography

Y. ZHONG, Y.S. CHU, A. T. MACRANDE, Argonne National Laboratory, S.F. KRASNICKI, Carnegie Institution of Washington — The x-ray topography technique images diffraction intensity variations of a crystal. The use of a CCD camera enables the measurement of different spatial resolutions. Currently an x-ray topograph with spatial resolution of 1 micron has been achieved, but the quantitative data analysis has not been explored widely. Quantitative strain analysis on these images extends new capabilities in crystal study. We have developed methods to quantify strain information through topography data. We will present these methods and discuss related practical issues, such as advantages, sensitivities, and limitations. We first introduce the azimuthal rotation method, suitable for strain components along the surface normal direction. The analysis requires accurate image registration; therefore we use the cross correlation method. Next we introduce a method to obtain quantitative strain tensor using bright field lattice refinement. The application of these methods on materials study is shown.

Absorber Materials for Transition-Edge Sensor X-ray Microcalorimeters

ARI-DAVID BROWN, SIMON BANDLER, REGIS BREKOSKY, JAMES CHERVENAK, FRED FINKBEINER, NAOKO IYOMOTO, RICHARD KELLEY, CAROLINE KILBOURNE, FREDERIC PORTER, NASA Goddard Space Flight Center, ENECTAL FIGUEROA-FELICIANO, Massachusetts Institute of Technology, TAREK SAAB, University of Florida, JOHN SAUDER, NASA GSFC,University of Illinois — Arrays of superconducting transition-edge sensors (TES) can provide high spatial and energy resolution for x-ray astronomy. High quantum efficiency and uniformity of the TES can be improved by using a suitable absorber material, in which absorber x-ray stopping power, heat capacity, and thermal conductivity are relevant parameters. Here we compare these parameters for bismuth and gold. We find that the thermal conductivity of these materials is highly dependent upon the thin film deposition technique. Furthermore, we briefly discuss the performance of our x-ray detectors when they possess cantilevered evaporated Bi/Au, electroplated Bi/Au, and electroplated Au absorbers.

Electronic Structure Studies of Ce-doped Gamma Detector Materials

ANDREW CANNING, Computational Research Division, Lawrence Berkeley National Laboratory. ROSTYSLAV BOUTCHKO, STEPHEN DERENZO, Life Sciences Division, LBNL, LIN-WANG WANG, Computational Research Division, LBNL, MARV WEBER, Life Sciences Division, LBNL — Cerium doped materials such as the Lanthanum Halides represent some of the brightest known scintillators for the detection of gamma rays. The scintillation process in Cerium doped materials corresponds to the transition from a 5d to 4f state on the Cerium atom where the 5d and 4f states lie in the gap of the host materials. We find good agreement with experimental results for the systems studied in particular for the Lanthanum Halides. Our theoretical calculations will be used as a first step screening for candidate new detector materials. This work is funded by the Dept. of Homeland Security, Domestic Nuclear Detection Office.

Gamma-Ray Compton Light Source Development at LLNL

FREDERICK HARTMANN, SCOTT ANDERSON, DAVID GIBSON, CHRIS HAGMANN, MICAH JOHNSON, IGOR JOVANOVICH, MIKE MESSELLER, JASON PRUET, MIRO SHEROVITZ, AARON TUREMAINE, DENNIS MCNABB, CRAIG SIDERS, CHRIS BARTY, LNL — A new class of tunable, monochromatic gamma-ray sources capable of operating at high peak and average brightness is currently being developed at LLNL for nuclear photo-science and applications. These novel systems are based on Compton scattering of laser photons by a high brightness relativistic electron beam produced by an rf photoinjector. Key technologies, basic scaling laws, and recent experimental results will be presented, along with an overview of future research and development directions.

Design and characterization of a compact multi-detector gamma array for studies of induced gamma emission: spontaneous decay of 178m2Hf as a test case

R. UGOROWSKI, R. PROPI, S.A. KARAMIAN, D. GÖHLKE, J. LAZICH, N. CALDWELL, R.S. CHAKRAWARTHY, M. HELBA, H. ROBERTS, J.J. CARROLL — Recent scientific attention has focused on the m2 isomeric state of Hafnium, 178m2Hf. The spontaneous decay of 178m2Hf takes the form of a cascade of gamma photons, totaling 2.4 MeV of energy per nucleus, or approximately 1.3 GigaJoules/gram. If all the decays were simultaneous, exawatt (1018) energy outputs could be realized. A class of isomers called “K-isomers” has been studied to determine the possibility of x-ray-induced decay of the excited isomeric state. The photons, totaling 2.4 MeV of energy per nucleus, or approximately 1.3 GigaJoules/gram. If all the decays were simultaneous, exawatt (1018) energy outputs could be realized. A class of isomers called “K-isomers” has been studied to determine the possibility of x-ray-induced decay of the excited isomeric state. The purpose of the “miniball” detector system was to separate out possible induced cascades from the spontaneous decay cascades using nuclear calorimetry, in order to settle a recent scientific controversy involving claims of induced decay and counter-claims of null results.

Submicron Resolution Neutron Radiography

R. GREGORY DOWNING, National Institute of Standards and Technology, Gaithersburg, MD 20899 — Imaging diverse materials such as biological and electronic samples at nanometer scales is of current importance; however, capable analytical tools are few. An entirely novel position sensitive neutron detector was conceived based upon illumination of a thin converter with x rays that diametrically emitted two particles. The converter is carefully aligned between facing position-sensitive particle detectors. The neutron-induced reaction particles strike both detectors in near temporal unison. The nanosecond difference in arrival time uniquely reveals the energy of each particle. Knowing the initial energies of the particles from fundamental physics, the geometry of the system, and the residual energy of the particles then the precise spatial coordinates of the neutron reaction are determined. The data are deconvolved to form a temporal and spatial map of the neutron field illuminating the area of the converter. This detector promises spatial resolution that ranges from a few micrometers to tens of nanometers, an improvement 10 to over 100 times existing systems. Applications for the detector include radiography and tomography for a host of organic and inorganic material studies. A trial demonstration at the NCNR will utilize an intense conditioned neutron beam and high speed data processing capabilities.
10:24AM H38.00011 Scientific Opportunities at OPAL, the New Australian Research Reactor, ROBERT ROBINSON, Bragg Institute, ANSTO — Australian physics is entering a new “golden age,” with the startup of bright new neutron and photon sources in Sydney and Melbourne, in 2006 and 2007 respectively. The OPAL reactor and the Australian Synchrotron can be considered the greatest single investment in scientific infrastructure in Australia’s history. They will essentially be “sister” facilities, with a common open user ethos, and a vision to play a major role in international science. Fuel was loaded into the reactor in August 2006, and full power (20MW) achieved in November 2006. It is our plan to commence beamtime to external user program in mid 2007, but commissioning experiments will have taken place well before then. The first three instruments in operation will be a high-resolution powder diffractometer (for materials discovery), single-crystal diffractometer (for small-molecule crystallography) and a strain scanner (for mechanical engineering and industrial applications). These will be closely followed by four more instruments with broad application in nanoscience, condensed-matter physics and other scientific disciplines. Instrument performance will be competitive with the best research-reactor facilities anywhere. To date there is committed funding for 9 instruments, with a capacity to install a total of ~18 beamlines. An update will be given on the status of OPAL, its thermal and cold neutron sources, its instruments and hopefully the first data.

Tuesday, March 6, 2007 11:15AM - 2:15PM — Session J38 GIMS: Focus Session: X-ray and Neutron Instruments and Sciences II Colorado Convention Center 501

11:15AM J38.00001 Picosecond X-ray Pulse Generation at the Advanced Photon Source¹. DENNIS MILLS, Argonne National Laboratory — Synchrotron radiation from storage ring-based facilities typically has a pulse length of many tens to many hundreds of picoseconds. In an effort to improve the temporal resolution of the study of dynamic and transient properties, the APS has been exploring the possibilities of producing short (a few picosecond) pulses though transverse deflection of the particle beam via radio frequency cavities installed in straight sections of the storage ring. These cavities produce a longitudinally coordinated vertical momentum to particle bunch that, when passed through an insertion device, then emits radiation with similar properties. Slits can then be used to time slice the beam or crystal optics can be employed to temporally compress the chirped radiation beam. Several approaches for the implementation of this capability at the APS will be discussed along with the expected performance.

¹Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

11:27AM J38.00002 TEMPO Beamline at the Soleil Synchrotron Radiation Source. FAUSTO SIROTTI, CNRS - Soleil Synchrotron, MANUEL IZQUIERDO, MATHIEU SILLY, FRANCOIS POLACK, CHRISTIAN CHAUVET, Soleil Synchrotron — TEMPO is a soft X-rays beamline now opening to the user community at the French synchrotron radiation source Soleil.[1] The two experimental stations will be based on photoelectron spectroscopy and will be mainly devoted to kinetic and dynamic studies of the electronic and magnetic properties of surfaces and interfaces. The high flux coupled to the energy resolution of the electron energy analyzer equipped with a new time resolved detector will allow the user to perform the following kind of investigations using photoelectron spectroscopy: i) the evolution of the chemical environment (surface coordination, chemical bonding with different elements) of selected chemical species at the surface using spectroscopic signatures; ii) the dynamics of magnetization reversal in nanostructures, using the temporal characteristics of Soleil at the scale of tens of picoseconds; iii) excited states using synchrotron pulses in the temporal range of a picosecond with pump-probe experiments with two photons (laser + synchrotron radiation). The beamline design and the technical solutions adopted for time resolved experiments will be presented along with the first results. [1] http://www.synchrotron-soleil.fr/anglais/science-and-users/experiments/tempo/index.htm

11:39AM J38.00003 Using crystal optics as a guard aperture in coherent diffraction imaging experiments¹ . XUANHUI XIAO, HANFEI YAN, MARTIN DE JONGE, YUNCHENG ZHONG, YONG CHU, QIN SHEN, Advanced Photon Factory, Argonne National Laboratory — A crucial issue in coherent x-ray diffraction imaging experiments is how to increase the signal-to-noise ratio when measuring relatively weak diffraction intensities from a nonperiodic object. To achieve such a goal, a guard aperture that can block the unwanted parasitic scattering from the beam-defining aperture is necessary. The conventional guard-edge-type aperture, however, is not only to allow and may produce secondary scattering from itself. In this presentation we present a novel crystal guard aperture concept, in which a pair of multiple-bounce crystal optics is employed [Xiao et al, Opt. Lett. 31, 3194(2006)]. Different from the guard-edge-type aperture, the crystal guard aperture does not produce secondary scattering and therefore guarantees super-clean incident beam. The effectiveness of the crystal guard aperture method has been verified by the theoretical analysis and simulations based on Fresnel propagations of a dynamically diffracted Bragg wave. Recent coherent diffraction experiment results also confirmed the validity of this new guarding scheme.

¹Use of Advanced Photon Source is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

11:51AM J38.00004 Phase retrieval from coherent x-ray diffraction data utilizing pre-determined partial information². SANG SOO KIM, HYON CHOL KANG, SHASHI MARATHE, SU NAM KIM, DO YOUNG NOH², Gwangju Institute of Science and Technology, ALEC R. SANDY, Argonne National Laboratory, SURESH NARAYAN, DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, GWANGJU INSTITUTE OF SCIENCE AND TECHNOLOGY COLLABORATION, ADVANCED PHOTON SOURCE, ARGONNE NATIONAL LABORATORY COLLABORATION — We developed a phase retrieval algorithm that utilizes pre-determined partial phase information to overcome insufficient oversampling ratio in diffraction data. Implementing the Fourier modulus projection and the modified support projection manifesting the pre-determined information, a generalized difference map and HIO (Hybrid Input-Output) algorithms are developed. Optical laser diffraction data as well as simulated x-ray diffraction data are used to illustrate the validity of the proposed algorithm, which revealed the strength and the limitations of the algorithm. Finally, the proposed algorithm is applied to reconstruct images from coherent x-ray diffraction data of Au patterns. The proposed algorithm can expand the applicability of the diffraction based image reconstruction.

²NRL program, KOSEF
²corresponding author

12:03PM J38.00005 Nano-Scale Resolution Spectro-Microscopy by Coherent X-ray Diffraction.¹ C. SONG, D. RAMUNNO-JOHNSON, H. JIANG, A. MANCUSO, J. MIAO, Physics and Astronomy, UCLA, M. DE JONGE, C. RAU, D. PATTERSON, I. MCNULTY, Advanced Photon Source, ANL — Coherent x-ray diffraction microscope, with its spatial resolution limited only by signal-to-noise ratio, has paved a route to a generic nano-scope resolved from crystalline specimens and destructive sample preparation. We advanced it further as a versatile spectro-microscopy. By using stark contrast in x-ray scattering lengths in the vicinity of atomic absorption edges, we could identify elements distribution at a nanometer scale. As the element specificity is acquired from direct x-ray absorption, it provides full flexibility for ab initio imaging. Successful results on elemental mapping of nano-structures and single biological cells from 1-3 keV range coherent x-ray source will be presented.

¹This work was supported by NSF and DOE
12:15PM J38.00006 Diffuse scattering due to nanoprecipitation in Ni-Al-Si alloys, ROZALIYA BARABASH, G. ICE, E. SPECHT, ORNL Oak Ridge TN, P. ZSHACK, APS Argonne IL — Ni-Al-Si alloys demonstrate the tendency to the formation of L1_0 ordered coherent precipitates. Diffuse X-ray scattering around both the fundamental and superstructure reflections is analyzed both theoretically and experimentally for Ni-Al-Si single crystal alloys with coherent ordered precipitates after stress annealing. The shape of the coherent precipitates is observed. The shape of the coherent precipitates is asymmetric with a 15% elongation along the stress annealing direction. Research at ORNL sponsored by the Division of Materials Sciences and Engineering, Office of Basic Energy Sciences U.S. Department of Energy, under Contract DE-AC05-00OR22725 with UT-Battelle and at APS under contract No. V-31-109-ENG-38.

12:27PM J38.00007 Studies of stressor effects on silicon nanostructures using synchrotron X-ray nanodiffraction1, ZHOUNGOU CAI, Argonne National Laboratory, ASHESH PARikh, Texas Instruments Inc., PAUL EVANS, University of Wisconsin-Madison — Scaling in the semiconductor industry has been accomplished by reduction in gate length and oxide thickness to enable large-scale decreases in device area and improved transistor performance. Strained silicon offers improved mobility at no significant additional costs. Fundamental understanding of the structural equilibrium between the silicon and the stressors at the device level is critical in manipulating properties for performance gains. The inhomogeneous strains in the silicon channel of nanotransistor devices due the epitaxy and lattice mismatch between Si and SiGe were individually studied using X-ray nanodiffraction at the Advanced Photon Source. Diffraction intensity from the strained silicon of less than 1x10^{-16}µm^2 and the SiGe stressor were mapped in reciprocal space around the points of (004), (115), and (-115). Lattice bending up to a few degrees at both sides of the Si/SiGe interface were measured, and the associated strains were quantitatively extracted in functions of the lattice curvature. The effect of the size of stressors was also studied. This work was supported by U. S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

12:39PM J38.00008 X-ray photon correlation spectroscopy in microfluidic systems, ANDREI FLUERASU, European Synchrotron Radiation Facility, Grenoble — We present a new experimental method that combines X-ray photon Correlation Spectroscopy (XPCS) and microfluidics and allows the direct measurement of the mesoscale dynamics of various soft matter systems (e.g. colloids, polymers, biological molecules like proteins, RNA, etc.) under flow conditions. Such a setup reduces the risk of beam damage and also allows time-resolved studies of various processes taking place in mixing flowcells. In the experiments reported here, we have used colloidal suspensions of hard-sphere systems, and studied their Brownian dynamics under laminar flow. Our experimental results and theoretical predictions show that the diffusive (Brownian) dynamics of the colloids can be decoupled from the flow-induced, convective dynamics.

12:51PM J38.00009 Development of new x-ray absorption spectroscopy measurement, HOYOUNG JANG, JIN-SIK LEE, KYUNG-TAE KO, Department of Physics and eSSC, Pohang University of Science and Technology, Pohang, Korea, HANGIL LEE, JAE-YOUNG KIM, Pohang Accelerator Laboratory, Pohang University of Science and Technology, Pohang, Korea, KI BONG LEE, JAE-HOON PARK, Department of Physics and eSSC, Pohang University of Science and Technology, Pohang, Korea — The x-ray absorption spectroscopy (XAS) is a powerful tool to probe electronic structure of valence states. However, its conventional measurements such as total electron yields or fluorescence yields often restrict sample conditions due to surface sensitivity and charging effects in an insulator or self-absorption effects, respectively. As an alternative, we found to extract XAS spectra from soft x-ray reflectivity measurements for transition metal compounds. We performed the soft x-ray reflectivity measurements on reference transition metal oxides, CO and NiO, at Co and Ni L_3,2-edge, respectively, and successfully extracted the XAS spectrum using Kramers-Kronig relation from the reflectivity data. In the measurements, the scattering angle was set to be in specular conditions. Considering that the reflectivity is a photon-in and photon-out experiment, this result suggests an alternative to obtain XAS spectra for systems, in which the conventional XAS measurements are not applicable.

1:03PM J38.00010 Overcoming Experimental and Intrinsic Broadening in Excited State Spectroscopies using Richardson-Lucy Deconvolution, W.T. ELAM, T.T. FISTER, G.T. SEIDLER, K.P. NAGLE, J.J. KAS, University of Washington, J.O. CRÖSS, Advanced Photon Source, Argonne National Laboratory — The oscillatory signature of the photoelectron interference phenomenon central to core shell spectrosocopies is frequently broadened by experimental or intrinsic (i.e., core-hole lifetime) energy resolutions, limiting the interpretation of the measurement. For example, this problem occurs in x-ray absorption fine structure (XAFS) measurements of heavy elements where the core-hole lifetime is very short (h-bar/core-hole ≥ 5eV), and also in non-resonant x-ray Raman scattering measurements where the instrumental resolution (typically ~1 eV) can be nearly an order of magnitude larger than the intrinsic energy resolution. Given the small statistical uncertainties in typical XAFS data and in recent XRS measurements using dedicated multielement spectrometers, the question naturally arises as to deconvolving the data with respect to the known instrumental or intrinsic resolutions. Here, we demonstrate that the Richardson-Lucy iterative algorithm provides a robust maximum likelihood method for addressing this issue in both XAFS and XRS. We demonstrate this method on core-hole broadened Ag XAFS data and experimentally broadened diamond and graphite XRS data.

1:15PM J38.00011 Organic-modified and biological silica studied by synchrotron x-ray pair distribution function measurements, ELAINE DIMASI, Brookhaven National Laboratory, CLAYTON JEFFRYES, GREGORY RORRER, Oregon State University, DAVID BELTON, CAROLE PERRY, Nottingham Trent University — Biominalarization is a process by which living organisms create composite organic/mineral tissues which have hierarchical structures on micron and submicron scales. Fine control over mineral phase and morphology make biomineralization an important inspiration for materials science. It is often not appreciated that even amorphous minerals such as silica can exhibit hierarchical structures and structural materials. One difficulty is that the molecular structures of amorphous phases can be hard to elucidate. We are exploring the use of pair distribution function measurements from synchrotron x-ray scattering to study silica structures, comparing both synthetic organic-modified silicas and germanium-containing biosilica from diatoms. The raw scattering patterns show clear differences. We will discuss how these data can be scrutinized to determine what differences may be created at the molecular level by different silicification processes.

1:27PM J38.00012 Non-Resonant Inelastic X-Ray Scattering and Energy-Resolved Wannier Function Investigation of d-d Excitations in NiO and CoO1, B.C. LARSON, J.Z. TISCHLER, Oak Ridge National Lab., P. ZSCHACK, APS, WEI KU, Brookhaven National Lab., C.C. LEE, Tamkang Univ. — We have investigated dipole-forbidden d → d excitations in the non-resonant inelastic x-ray scattering (NIXS) spectra of NiO and CoO. The spectral weight of these Mott-gap excitations vanishes at small q, but dominates the large-q NIXS spectra and is highly anisotropic with well-defined nodal directions. Theoretical analyses based on energy-resolved Wannier functions within LDA+U have shown the origin of the anisotropy to be selection-rules reflecting the underlying cubic point group symmetry. The measured and calculated orientation anisotropies of the NIXS spectra will be discussed and the anisotropies for NiO and CoO will be compared to demonstrate that such measurements represent sensitive probes of weak symmetry breaking in particle-hole wave functions.

1Research at ORNL and BNL sponsored by the DOE BES Division of Mat. Sciences & Eng. Research by CCL at BNL supported in part by the NSC Research Abroad Program of Taiwan. Measurements were made at the Advanced Photon Source, supported by the US DOE.
1:39PM J38.00013 Wave-optical simulation of hard X-ray nanofocusing by precisely figured elliptical mirrors1. ALBERT MACRANDE, CAMERON KEWISH, LAHSEN ASSOUFID, JUN QIAN, Argonne National Laboratory — Computer simulations of nanofocusing by elliptical mirrors are presented wherein the diffraction and propagation of coherent hard X-rays are predicted using wave-optical calculations. Surface height data acquired via microstitching interferometry were used to calculate the complex pupil function of a mirror, taking into account the Fresnel reflectivity and treating the surface topography as an aberration to a perfect elliptical mirror. The reflected wavefield amplitude and phase downstream of the mirror were obtained by numerically evaluating the Fresnel-Kirchhoff diffraction integral. Simulated intensity profiles, and contours (isophotes) around the focal plane are presented for coherent illumination by a 15 keV point source, which indicate nearly diffraction-limited focusing at the 40 nm level. The effect of high spatial frequency microroughness on nanofocusing was investigated by low-pass filtering the Fourier spectrum of the residual height profile. Simulations using the filtered metrology data revealed that roughness length scales shorter than 0.1 nm have a minor effect on the focal spot size and intensity.

1This work supported under contract number DE-AC-02-06CH11357 between UChicago Argonne, LLC and the Department of Energy.

1:51PM J38.00014 Producing small size parallel x-ray beam by multi-plate crystal cavity with compound refractive lenses, S.-Y. CHEN, Physics Department, National Tsing Hua University, Y.-Y. CHANG, M.-T. TANG, YLI STETSKO, National Synchrotron Radiation Laboratory Center, M. YABASHI, Spring-8/RIKEN, H.-H. WU, Y.-R. LEE, National Tsing Hua University, B.-Y. SHEW, National Synchrotron Radiation Research Center, S.-L. CHANG, Physics Department, National Tsing Hua University — To produce a coherent and extremely parallel x-ray source for advanced experiments, multi-plate crystal cavities consisting of compound refractive lenses were prepared on silicon wafers by lithographic techniques. The crystallographic orientation of the crystal is the same as that reported for x-ray resonators (Phys. Rev. Lett. 94, 174801, 2005). X-ray (12 4 0) back diffraction from these monolithic silicon crystal devices clearly showed interference fringes due to cavity resonance through the compound refractive lenses (CRL). However, the expected focusing effect from the CRL was not observed, but rather beam compression was detected. That is, the incident x-ray beam size of about 90 µm across the CRL was reduced to 20 µm. The beam size remained the same at different positions along the transmitted beam direction. Namely, a small sized parallel x-ray beam was produced. The origin of this beam compression mechanism is believed to be due to the competition between the multiple back reflection of the crystal cavity and the focusing of the CRL, in addition to crystal absorption.

Tuesday, March 6, 2007 2:30PM - 5:30PM —
Session L38 GIMS: Focus Session: Advances in Scanned Probe Microscopy I: Low Temperatures, Manipulation, and Optical Methods I Colorado Convention Center 501

2:30PM L38.00001 An ultrahigh vacuum, variable temperature scanning tunneling microscope, E.W. HUDSON, W.D. WISE, KAMALESH CHATTERJEE, M.C. BOYER, MIT — We will discuss the design and operation of an ultrahigh vacuum, variable temperature (2 K ~ 300 K) scanning tunneling microscope (STM) system. The STM has been designed to minimize tip-sample displacements with thermal variation, allowing the tracking of single atoms over a wide range of temperatures. We will first describe STM details such as sample holder and capacitive position sensor design, as well as tip shielding to reduce scanner cross-talk. We will then discuss elements of the support system, including a low-temperature sample storage area to allow quick sample exchanges, a variable temperature cleaver and a novel counterweight system for quickly and safely lifting and lowering the experimental dewar. Finally, we will point out some common problems found in STM systems and show how we diagnosed and solved these problems.

2:42PM L38.00002 Scanning tunneling microscopy in high magnetic fields below 1 Kelvin, ANDREAS HEINRICH, DONALD EIGLER, CYRUS HIRJIBEHEDIN, MARKUS TERNES, CHRISTOPHER LUTZ, IBM Research — We have developed a scanning tunneling microscope (STM) which operates in a novel range of experimental parameters: ultra-high vacuum, low temperatures and high magnetic fields. Such operating conditions make the Zeeman energy for a typical magnetic system significantly larger than the thermal energy and hence one can resolve spin excitations in individual magnetic systems. In order to achieve temperatures below 4K we employ a pumped 3-He reservoir where we liquefy the 3-He with Joule Thomson expansion (without the use of a pumped 4-He reservoir). We can routinely operate the STM at 0.6K in magnetic fields up to 7T. It turned out to be surprisingly difficult to vibrationally decouple the STM from the high magnetic field, which was achieved only after investigating the low-temperature magnetic properties of all the components of the STM. This machine has been used for about 5 years to study atomic-scale magnetic systems and some examples will be discussed.

2:54PM L38.00003 Construction of a sub-Kelvin ultra-high vacuum scanning tunneling microscope in high magnetic field, UNGDON HAM, Department of Physics and Astronomy, University of California, Irvine, CA 92697-4575, USA, XI CHEN, Department of Physics, Tsinghua University, Beijing 100084, P.R.China, B. HUNSTON, STEPHEN KATZ, Department of Chemistry, University of California, Irvine, CA 92697-2025, USA, ANDRA MARKANDER, CAMERON KEWISH, LAHSEN ASSOUFID, JUN QIAN, Argonne National Laboratory — We describe the design of a versatile ultra-high vacuum (UHV) STM system capable of ultra low temperatures (~20 mK) and high magnetic fields (15 T). A bakeable UHV dilution refrigerator (DR) was designed adopting a Joule-Thomson He3 condenser for low-noise closed-cycle operation, while maintaining the operation of a traditionally pumped 1 K pot. The entire STM module can be transferred from an upper room temperature chamber, where the sample and tip are easily exchanged, into the DR in UHV. The sample holder has five isolated electrical contacts which are also used for kinematic mounting of the sample. This allows 4 probe electrical measurements to be performed simultaneously with STM measurements for microscopic transport studies. To achieve a stable environment, we use 3 stages of vibration isolation with a combination of active and passive feedback loops. Current progress will be discussed in relation to design goals.

This work is supported in part by the Office of Naval Research and Korea Research Foundation.
3:18PM L38.00005 Atomic constructions using a scanning tunneling microscope. APARNA DESHPANDE, JOEL VAUGHN, SAW-WAI HLA, Ohio University — We demonstrate an atomic scale construction scheme, which is performed at an area as small as a few tens of nanometer square. In this atomic scale construction site, all the basic building blocks, single atoms, are extracted locally from the substrate using a scanning-tunneling-microscope tip. These extracted atoms are then precisely positioned on the surface to form desired structures. After the completion of the construction, the remaining debris are removed and the undesired holes near the construction site are filled with atoms/clusters to tidy up the area. This entire construction scheme closely resembles our real-world construction process and can be considered as its atomic scale analog. This work is supported by NSF grant DMR-0304314 and US-DOE grant DE-FG02-02ER46012.

3:30PM L38.00006 Scanning Tunneling Microscope Manipulation of $\beta$-Carotene on Au(111) at 4.6 K , TIMUR SKEINI, VIOLETA IANCU, SAW-WAI HLA, Ohio University — The properties of isolated and clustered $\beta$-carotene molecules adsorbed on a Au(111) surface were investigated using a low temperature scanning tunneling microscope (STM) at 4.6 K in a ultra-high-vacuum condition. A sub-monolayer coverage of all trans- $\beta$-carotene molecules were deposited on Au(111) via thermal evaporation using a custom-built Knudson cell. On Au(111), the $\beta$-carotene molecules can be found as a form of a cluster, as well as, isolated single molecules. Furthermore, the $\beta$-carotene molecules can have both trans and cis conformations on this surface. In order to probe the mechanical stability of the molecules and molecular clusters, we employ STM manipulation procedures. Lateral manipulations of the molecules across the surface with the STM-tip reveal that the molecules are rather stable. Furthermore, the STM manipulation experiments on $\beta$-carotene clusters often result in lateral displacement of the entire cluster indicating strong interactions between the neighboring molecules within the cluster, but a weak molecule-surface interaction. Moreover, by injecting the tunneling electrons into the molecules, the rotation of a cis $\beta$-carotene has been able to induce in a controlled manner on the surface. This work is supported by the US Department of Energy, Basic Energy Sciences grant number DE-FG02-02ER46012.

3:42PM L38.00007 Vertical Atom Manipulation on GaN(000\text{\textgamma}) Surface at Low Temperature , DANDA P. ACHARYA, KENDAL CLARK, SAW W. HLA, OU — We report single atom manipulation on a GaN(000\text{\textgamma}) surface at 4.6 K by using a low temperature scanning tunneling microscope (STM) tip. The nitrogen polar Ga rich GaN samples are grown on sapphire substrate by using r.f. N-plasma molecular beam epitaxy (MBE). Low temperature STM images of GaN (000\text{\textgamma}) surface reveal a novel reconstruction with a basis of 12 x 12 unit cell. For the manipulation experiment, the STM tip is first coated with Ga atom by using a controlled tip-sample contact. Using a vertical manipulation technique with the STM-tip, individual Ga atom from the tip is transferred to the GaN (000\text{\textgamma}) surface on one atom-at-a-time basis. The successful atom deposition is confirmed by subsequent STM imaging. Here, the controlled STM tip-sample contact plays a crucial role in an atom deposition process. This procedure allows construction of nanostructures on a MBE grown semiconductor surface with atomic scale precision. This work is financially supported by a NSF-NIRT grant no. DMR-0304314.

3:54PM L38.00008 Design and Construction of a UHV-LT-STM for Tip-Enhanced Optics. , D.R. DAUGHTON, D. LEE, N. EZEH, J.A. GUPTA, Department of Physics, The Ohio State University — The combination of optical techniques and scanning tunneling microscopy (STM) provides insight into a diverse set of physical processes including surface chemistry, surface-photon interactions, and spin scattering in semiconductors. We have designed and built a novel, cryogenic temperature, ultrahigh vacuum STM which utilizes a maneuverable high numeric aperture lens in proximity to the tunnel junction. The microscope currently operates at a base temperature of 12.5 K with 10 pm tip stability. Our initial efforts are focused on studies of photo-chemical reactions and chemical identification by tip-enhanced Raman spectroscopy (TERS). Chemically-etched Ag tips are optimized for field enhancement with characterization by scanning electron microscopy and collection of the plasmon emission from the tip. The optical setup for TERS has been tested utilizing the surface-enhanced Raman signal from the laser dye Rh6G. The field enhancement of metallic nanostructures can be tuned with atomic manipulation for single molecule spectroscopy and near-field microscopy. http://www.physics.ohio-state.edu/~jagupta

4:06PM L38.00009 Stress Imaging in Indented Si Wafers by Confocal Raman Microscopy , JEROEN SCHOENMAKER, Surface and Microanalysis Science Division - NIST - Gaithersburg, MD., ROBERT F. COOK, Ceramics Division - NIST - Gaithersburg, MD., LUKAS NOVOTNY, The Institute of Optics, U. of Rochester, Rochester, NY., STEPHAN J. STRANICK, Surface and Microanalysis Science Division - NIST - Gaithersburg, MD. — Controlling stress and strain, and consequently, carrier mobility in semiconductor devices is one of the main goals of recent electronics industry. On the other hand, fracture propagation is commonly related to performance degradation in microelectronic and microelectromechanical (MEMS) devices. As miniaturization reaches submicron scales, characterization tools with improved resolution and capable to detect buried surfaces is required. In this work we present confocal Raman imaging in Si wafers to analyze stress and fracture by means of hyperspectral measurements (typically 128x128 spectra). We analyzed indented Si wafers presenting wide range of plastic deformation and fractures. Wide scans (up to 150x150 $\mu$m$^2$) as well as high-resolution scans depict the stress distribution around indented regions and side fractures. Some of the samples were covered with 8 nm of Ti deposited in LN$_2$ temperature. In these samples we acquired hyperspectral images in subsurface conditions and detected possible influences of thermal budget in the stress distribution. We also demonstrate depth sensitivity in a vertical scan. Images suggest 0.3 $\mu$m resolution.

4:18PM L38.00010 Tip Enhanced Raman Scattering of Strained Silicon with Single and Multiple Probe Scanned Probe Microscopes. , AARON LEWIS, Nanomics Imaging Ltd. — Raman spectroscopy is an effective tool for the identification and analysis of molecular components of complex materials. The spatial resolution of Raman spectroscopy is limited by the wavelength of the light. One approach to overcome this drawback is Surface Enhanced Raman Scattering (SERS). This technique uses nanometric interactions between metal structures and surfaces to effect enhancement of the Raman signals. An important mechanism for enhancement originates from an electrostatic lightning rod effect due to the excitation of localized surface plasmon resonances. This is accomplished in a scanned probe microscope context by employing an ultra-sharp metalized tip that is brought into a focused laser spot on the sample surface thereby enhancing the Raman signal. In this technique also known as Tip Enhanced Raman Scattering (TERS) the electrical field is locally enhanced near the sharp metalized tip. Rastering the sample should then allow for Raman imaging with nanometric resolution. Within this context it will be shown that multiple probe scanned probe microscopes have considerable potential in such tip enhanced applications.

4:30PM L38.00011 High Efficiency Surface Plasmon Enhanced Near-field Scanning Optical Microscope Probe Development. , R.E. HOLLINGSWORTH, G.J. NUEBEL, ITN Energy Systems Inc, I.C. SCHICK, P.D. FLAMMER, J.T. MARTINEAU, M.A. HUROWITZ, R.T. COLLINS, Colorado School of Mines — We present results from the development of novel, high throughput near-field scanning optical microscope (NSOM) probes based on excitation of surface plasmons. The probe consists of an opaque noble metal film with a bullseye grating cavity on the input surface, and a sharp metal post on the output surface. The post is centered inside the inner grating ring and surrounded by a sub-wavelength ring aperture. The grating structure couples incident photons into surface plasmon waves. The transmission efficiency is enhanced for wavelengths where the plasmon is resonant with the cavity. Topographic and optical resolutions are determined by the sharpness of the metal post. This design is anticipated to provide the high spatial resolution of an apertureless NSOM combined with the experimental convenience of an aperture NSOM. Experimental and computational results from test structures will be presented. This material is based on work supported by the National Science Foundation under Grant No. DMI-0522291.
4:42PM L38.00012 A Silicon MEMS Probe Integrated with Light Emitting Nanoparticles on Tip for Near-field Scanning Optical Microscopy 1, X. ZHANG, K. HOSHINO, L. ROZANSKI, D. VANDEN BOUT, The University of Texas at Austin — We have built a nanoscale light emitting diode (LED) on a silicon MEMS probe for near-field scanning optical microscopy (NSOM). The LED was made of semiconductor nanoparticles electrostatically trapped between a pair of silicon electrodes located on the tip. The probe was microfabricated on a Silicon-on-Insulator (SOI) wafer. The facing electrodes were made by cutting a lithographically patterned device layer using a focused ion beam (FIB). When the voltage was applied, the nanoparticles were polarized and attracted to the gap along the electric field gradient. Basic parameters of a nanoparticle-trapped LED were measured. The probe was attached to a tuning fork and mechanically oscillated. The resonant frequency of the tuning fork was originally about 100KHz and was dampened to 93.0KHz with the probe attached. As the tip approaches the surface of the sample, a drag force acting on the tip changes the oscillating amplitude; measured as a voltage signal from the fork, which in feedback allows the tip to be positioned in the near-field, roughly 5-10nm from the surface. Successful fabrication of the light emitting NSOM probe leads to integrated “light-source free” optical scanning arrays suitable for novel applications in nanomaterial characterization and biology.

1The authors would like to acknowledge the support from NSF, Wallace H. Coulter Foundation, and UT Research Grant.

4:54PM L38.00013 Spectroscopic near-field microscopy using frequency combs in the mid-infrared, MARKUS BREHM, ALBERT SCHLIESSER, FRITZ KEILMANN, Max Planck Institute of Biochemistry, Martinsried (Muenchen), Germany — We introduce a new concept of spectroscopic scattering-type near-field optical microscopy that records 200 cm$^{-1}$ broad infrared spectra at each pixel during scanning. Two coherent beams with harmonic frequency-comb spectra are employed, one for illuminating the scanning tip, the other as reference for multi-heterodyne detection of the scattered light. Our implementation yields amplitude and phase spectra centered at 950 cm$^{-1}$ infrared.

5:06PM L38.00014 Element specific imaging by STM combined with synchrotron radiation light, TOYOAKI EGUCHI, TAICHI OKUDA, TAKESHI MATSUMIKA, AKIRA KATAOKA, AYUMI HARASAWA, KOTONE AKIYAMA, TOYOHIKO KINOSHITA, YUKIO HASEGAWA, The Institute for Solid State Physics, The University of Tokyo — Atomically resolved imaging with a capability of elemental identification is one of the ultimate goals in the development of microscopy. Using scanning tunneling microscopy (STM), which provides us atomically resolved surface images, many attempts have been performed for elementally contrasted images. However, since STM basically probes electronic states near the Fermi energy, it is difficult to obtain definite “fingerprints” of elements. Here, we report on a new method to obtain elemental information by STM combined with synchrotron radiation light. We found that, by exciting core electrons with the soft-X-ray irradiation and detecting emitted electrons with the STM probe tip, we can obtain X-ray absorption spectra bearing elemental information of the sample. From the photo-induced current measured during the tip scanning over the surface, element specific images were obtained. An estimated spatial resolution of the chemical imaging is less than 20 nm, better than that achieved by photoemission electron microscopy.

5:18PM L38.00015 Waveguide Characterization Using Shear Force Scanning Optical Microscopy, RONGJIN YAN, G. YUAN, R. POWNALL, K. LEAR, Elec. & Comp. Engr. Dept. Colorado State University — Waveguide characterization is an essential task in the development of photonic integrated circuits for a variety of applications, including biosensors and next generation optical interconnects. A shear force SOM (scanning optical microscope) is being developed for characterization waveguide evanescent fields as well as scattered light in both the near field and the far field. These methods correspond to photon scanning tunneling microscopy, proximity scanning optical microscopy, and scatter imaging, respectively. Shear force feedback eliminates noise due to scattered light introduced by a second light source required for conventional optical feedback systems based on reflective cantilever waveguides. Additionally, the shear force feedback configuration simplifies raster scanning of the probe rather than the sample allowing easier coupling to multiple waveguides on the sample. The distribution of scattered light intensity can be correlated with features in the evanescent fields that may prove useful for waveguide sensors.

Tuesday, March 6, 2007 5:45PM - 6:45PM —
Session M38 GIMS: GIMS Business Meeting Colorado Convention Center 501

5:45PM M38.00001 GIMS Business Meeting —

Wednesday, March 7, 2007 8:00AM - 11:00AM —
Session N38 GIMS: Focus Session: Advances in Scanned Probe Microscopy II: Force Methods Colorado Convention Center 501

8:00AM N38.00001 AFM/STM with sub-Angstrom modulation, MARKUS TERNES, IBM Almaden Research Center and EPF Lausanne — Atomic manipulation of single atoms and molecules by scanning probe microscopy enables the assembly of structures at the single-atom scale - the ultimate lower size limit. However, it has been difficult to answer the simple question: How much force does it take to manipulate atoms and molecules on surfaces? To address this question, we combine scanning tunneling microscopy and frequency modulated atomic force microscopy. To enable simultaneous detection of the tunneling current and frequency shift we utilize the q-plus sensor design, in which a metallic STM tip is mounted on a cantilever made from a quartz tuning fork. The instrument operates in ultra-high vacuum at liquid helium temperature. High mechanical stability together with a stiff cantilever design, which avoids snap to contact between sample and tip, allows us to use very small modulation amplitudes of 25 pm normal to the surface.

To detect such a small amplitude with a piezoelectric cantilever requires a low-temperature preamplifier stage. Mapping the frequency shift at different heights above the sample surface allows us to calculate the vertical forces acting between tip and surface. This data is then used to determine the full 3D interaction potential between the tip and a single adsorbate on a clean metallic surface by integrating the forces normal to the surface. A small amplitude is essential to achieve 10 pm resolution in all spatial directions necessary to discriminate between long range and short range forces. With this method we are able to determine the vertical and lateral forces that are required to move individual cobalt (Co) atoms and carbon monoxide (CO) molecules across a copper (111) surface. The lateral forces, which are responsible for moving the adsorbates, are one to two orders of magnitudes smaller than the forces that act in conventional atomic force microscopy with atomic resolution.
8:36AM N38.00002 Atomically-resolved surface imaging by low temperature atomic force microscopy using a quartz resonator. YUKIO HASEGAWA, TOSHI AN, TAKAHIRO NISHIO, TOYOAKI EGUCHI, M. ONO, KOTONE AKIYAMA, The Institute for Solid State Physics, The University of Tokyo — We have developed a frequency-modulation atomic force microscope (FM-AFM) using a length-extension quartz resonator as a force sensor. Atomically-resolved images of the Si(111) 7x7 surface were obtained with the AFM in UHV both at room temperature [1] and 5 K. The high resonance frequency (~1 MHz) of the resonator improves the sensitivity to its deflection. Its self-sensing property eliminates the cumbersome optical alignment, which is usually required in conventional AFMs, and thus it can be easily installed into a low temperature system. The high stiffness of the resonator enables us to operate with a very small oscillation amplitude; less than 0.1nm, and thus to detect a short-range force effectively, such as a covalent bonding force, which is crucial for the highly resolved imaging. For the probe tip, a tungsten wire was attached at the end of the resonator and sharpened by focused ion beam. The native oxide layer covering the tip was removed by in-situ field ion microscopy. [1] T. An, T. Eguchi, K. Akiyama and Y. Hasegawa, APL 87, 133114 (2005).

8:48AM N38.00003 Imaging of electronic defect states in SiO2 and HfSiOx films with sub-nanometer spatial resolution by two-way Single Electron Tunneling Force Microscopy. J.P. JOHNSON, N. ZHENG, C.C. WILLIAMS, University of Utah — Electronic defects in dielectric materials are currently in sharp focus, for nano-technology and quantum information processing. A novel technique has been developed for imaging these states with sub-nanometer spatial resolution. It can be applied to completely non-conducting dielectric films, in contrast to the STM. The method is based on force detected single electron tunneling events to and from the defect states [1-3]. The exponential dependence of the tunneling rate on tip-sample gap provides the same spatial resolution as STM. An oscillating AFM tip is scanned at constant height above the sample surface. A high voltage waveform, synchronous with the tip motion, is applied. When the tip is above an accessible state, individual electrons shuttle between tip and state with the applied voltage (300 Hz). The two-way tunneling causes a detectable change in tip resonance. Images of SiO2 and HfSiOx films show a repeatable, random array of individual “point-like” defect states, some with sub-nanometer width. Spectroscopic measurements of the defect energy are also performed by this approach. The new method and an analysis of the defects in SiO2 and HfSiOx will be presented. [1] E Bussman et al., Appl. Phys. Lett. 85, 2538 (2004) [2] E Bussman and CC Williams, Appl. Phys. Lett. 88, 263108 (2006) [3] E Bussman et al., Nano Lett. 6, 2577 (2006)

9:00AM N38.00004 Detection of Embedded nanostructures by Electrostatic Force Microscopy. ZONGHAI HU, YUANZHEN CHEN, MICHAEL FISCHBEIN, ROBIN HAVENER, MARIJA DRNDIC, University of Pennsylvania — Non-destructive imaging of embedded structures with high lateral resolution is of great technological interest. Scanning probe microscopy is generally thought to be sensitive only to surfaces. We report that electrostatic force microscopy (EFM) can be used to study electrostatic inhomogeneities hundreds of nanometers below a uniform sample surface with sub-micron lateral resolution. The sub-surface material can be in liquid phase. Our experimental and simulation results show that the EFM signal depends on many factors such as the distance between the tip and the sample, the depth, dielectric constants, and the carrier density of the embedded inhomogeneities. Potential applications of this technique will also be discussed. 3This work was supported by ONR and NSF.

9:12AM N38.00005 Sinc or Sine? The Band Excitation Method and Energy Dissipation Measurements by SPM. STEPHEN JESSE, SERGEI KALININ, Oak Ridge National Laboratory — Quantitative energy dissipation measurements in force-based SPM is the key to understanding fundamental mechanisms of energy transformations on the nanoscale, molecular, and atomic levels. To date, these measurements are invariably based on either phase and amplitude detection in constant frequency mode, or as amplitude detection in frequency-tracking mode. The analysis in both cases implicitly assumes that amplitude is inversely proportional to the Q-factor and is not applicable when the driving force is position dependent, as is the case for virtually all SPM measurements. All current SPM methods sample only a single frequency in the Fourier domain of the system. Thus, only two out of three parameters (amplitude, resonance, and Q) can be determined independently. Here, we developed and implemented a new approach for SPM detection based on the excitation and detection of a signal having a finite amplitude over a selected region in the Fourier domain and allows simultaneous determination of all three parameters. This band excitation method allows acquisition of the local spectral response at a 10ms/pixel rate, compatible with fast imaging, and is illustrated for electromechanical and mechanical imaging and force-distance spectroscopy. The BE method thus represents a new paradigm in SPM, beyond traditional single-frequency excitation.

9:24AM N38.00006 Spring constant calibration of AFM cantilevers with a piezolever transfer standard. D. HURLEY, E. LANGLOIS, G. SHAW, J. KRAMAR, J. PRATT, NIST — Accurate determination of forces in the AFM requires knowledge of the cantilever spring constant k_c. We describe a method to measure k_c, traceable to SI units. The transfer standard was a commercial piezo-resistive cantilever (“piezolever”) calibrated by the NIST electrostatic force balance (EFB). The active piezolever device eliminates the need to measure the optical lever sensitivity. The method does not depend on cantilever geometry and determines k_c under loading conditions. The calibrated piezolever was used to measure cantilevers with nominal values of k_c from 0.2 to 40 N/m. Measured values differed by as much as 300 % from the nominal values. Values of k_c were also obtained with four other methods: thermal noise, geometric (Sader), nanoindentation loading, and direct EFB loading. Differences between the direct EFB and piezolever results ranged from 15-20 % for the stiffest cantilevers to <1 % for the most compliant. Experimental issues critical to accurate measurements with each method will be discussed. Methods will also be compared in terms of implementation in other laboratories.

9:36AM N38.00007 High Speed Scanning Property Measurements. DAVID SHUMAN, RAMESH NATH, University of Connecticut, RAMAMOORTHY RAMESH, University of California, Berkeley, BRYAN HUEY, University of Connecticut, UNIVERSITY OF CONNECTICUT COLLABORATION, UNIVERSITY OF BERKELEY COLLABORATION — Atomic Force Microscopy (AFM) is a ubiquitous surface science tool, but the slow speed of standard equipment remains a continuing limitation for widespread application. A novel AFM variation is reported here for High-Speed Scanning Property Mapping (HS-SPM), uniquely allowing full-frame nanoscale-resolution image acquisition in <3 seconds with tip speeds >1 cm/sec. Using off-the-shelf commercial equipment, the method combines acoustic and AFM concepts: the sensitivity of AFM-cantilever contact resonances to materials properties, and conversely the insensitivity of these resonances to contact force variations due to rapidly raster scanning an AFM probe. The method is applicable to a broad range of materials and properties, as demonstrated by mechanical property maps of bacterial membrane fragments and integrated circuits; magnetic property maps of domains in magnetic hard drives; and movies of ferroelectric domain reading and writing with sub-second frame rates for dynamic domain nucleation and growth studies. HS-SPM thereby provides a novel yet off-the-shelf solution for both significantly enhanced throughput in nanoscale materials property mapping, as well as dynamic surface studies with previously inaccessible time constants.
10:00AM N38.00009 Cantilever mean deflection: average tip-sample force in tapping mode spectroscopy, F. MICHAEL SERRY — In tapping mode AFM spectroscopy, tip-sample interaction is nearly always studied in cantilever amplitude and phase. Theory shows that the mean deflection is another quantity that carries a wealth of information about the interaction (1). However, mean deflection remains largely unexplored in experiments. One historic reason is tapping mode was invented to avoid relying on static (mean) deflection of cantilever in contact mode AFM. Mean deflection is easier to measure with softer cantilevers, and becomes more important with smaller amplitudes. We present mean deflection data which often contain features with no readily decipherable counterparts in amplitude or phase; validate some theoretical results; and possibly contradict others. The data (vs. mean tip-sample separation) provide a direct, intuitive, experimental proof that phase follows the polarity of average tip-sample force (2). However, the slope of this data does not always follow that of the phase. Average force often plateaus as mean separation reduces and even approaches zero, which may help explain why similarly high-quality images are frequently possible across a range of amplitude setpoint values. (1) A. San Paulo, R. Garcia, Phys Rev B (64), p193411, 2001. (2) R. Garcia, A. San Paulo, Phys Rev B (60), p4961, 1999.

10:00AM N38.00010 ABSTRACT WITHDRAWN —

10:00AM N38.00011 Monotonic and fatigue tests of amorphous silicon nanostructures using atomic force microscope, CHERAMANI GAIRE, D.-X. YE, T.-M. LU, G.-C. WANG, Dept. of Physics, Rensselaer Polytechnic Institute, Troy, NY, C. R. PICU, Dept. of Mech. Engg., Rensselaer Polytechnic Institute, Troy, NY — The plastic deformation and the failure properties of a-Si slanted nanostructures (one- and two-armed) fixed at one end to the substrate, grown by oblique angle physical vapor deposition, have been studied with the use of AFM. Monotonic loading/unloading tests were carried out to determine the elastic and plastic failure properties. We also developed the fatigue test methodology suitable for nanoscale specimens with the use of AFM. The AFM was used for imaging (to locate) as well as for loading the structures in monotonic bending and force (stress) controlled cyclic loading/unloading mode until the specimen failed completely. A novel way was used to identify the failure of the specimens during the fatigue test. The post-test analysis of the failure surface was done through SEM imaging. The possible inhibition of the brittleness of the a-Si samples with the reduction of the size and damage evolution during fatigue test on the nanoscale specimens will also be discussed.

1Supported by NSF grant No. CMS-0324490.

10:36AM N38.00012 Enhanced compositional sensitivity in atomic force microscopy by the excitation of the first two flexural modes, RICARDO GARCIA, NICOLAS F. MARTINEZ, SHIVPRASAD PATIL, JOSE R. LOZANO, Instituto de Microelectronicas de Madrid, CSIC — We demonstrate that the compositional sensitivity of an atomic force microscope is enhanced by the simultaneous excitation of its first two normal eigenmodes\(^1\). The coupling of those modes by the non-linear probe-surface interactions enables to map compositional changes in several conjugated molecular materials with a phase shift sensitivity that is about two orders of magnitude higher than the one achieved in amplitude modulation atomic force microscopy.


1This work was financially supported by the European Commission (FORCETOOL, NMP4-CT-2004-013684).

10:48AM N38.00013 Systematic Variations in Apparent Topographic Height as Measured by Non-contact Atomic Force Microscopy, DENG-SUNG LIN, Institute of Physics, National Chiao-Tung University, Taiwan, T.-C. CHIANG, Department of Physics, University of Illinois at Urbana-Champaign, USA, K.M. YANG, J.Y. CHUNG, M.F. HSIEH, S.S. FERNG, Institute of Physics, National Chiao-Tung University, Taiwan — A flat Si(100) surface is prepared with neighboring n- and p-doped regions. The contact potential difference between the tip and the two well-defined regions of similar material is utilized to examine the effects and interplay of essential tip-sample forces in atomic force microscopy. Measurements with a frequency-modulated non-contact atomic force microscope (nc-AFM) show large apparent topographic height variations across the differently doped regions. The height differences depend on the bias polarity, bias voltage, radius, and conducting state of the tip. The functional relationships are well explained by integrated model calculations. These findings provide a coherence scenario of nc-AFM operation under these essential forces and facilitate quantitative understanding of the systematic errors in surface topographic height measurement commonly performed in nanoscience.

Wednesday, March 7, 2007 11:15AM - 2:03PM —
Session P38 GIIMS: Sensors and Signal Analysis Colorado Convention Center 501
11:15AM P38.00001 An Ultra-Wideband Cross-Correlation Radiometer for Mesoscopic Experiments. — RYAN TOOSEN, CYRUS HASELBRY, HUA QIN, MARK ERIKSSON, ROBERT BLICK, University of Wisconsin at Madison — We have designed, built and tested a cross-correlation radiometer for detecting statistical order in the quantum fluctuations of mesoscopic experiments at sub-Kelvin temperatures. Our system utilizes a fully analog front-end—operating over the X- and Ku-bands (8 to 18 GHz)—for computing the cross-correlation function. Digital signal processing techniques are used to provide robustness against instrumentation drifts and offsets. The economized version of our instrument can measure, with sufficient correlation efficiency, noise signals having power levels as low as 10 fW. We show that, if desired, we can improve this performance by including cryogenic preamplifiers which boost the signal-to-noise ratio near the signal source. By adding a few extra components, we can measure both the real and imaginary parts of the cross-correlation function—improving the overall signal-to-noise ratio by a factor of sqRT[2]. We demonstrate the utility of our cross-correlator with noise power measurements from a quantum point contact.

11:27AM P38.00002 Monochromatic Photo-Field Electron Emission Sources. — THEODORE VECCHIONE, GARY HEMBREE, UWE WEIERSTALL, JOHN SPENCE, Arizona State University Department of Physics, NIGEL BROWNING, Lawrence Livermore National Laboratory — Laser-pulsed photo-field-emission sources with high coherence and brightness are needed for time-resolved electron microscopy. Our ongoing work explores the possibility of using sharpened semiconductor electron emitters to achieve this goal. Intrinsic GaAs-field-emission sources have been prepared from cleaved needles that are clipped into refractory metal holders. These needles are chemically sharpened and surface cleaned by field-desorption and electron-bombardment heating. Field emission I-V curves have been analyzed, with and without laser illumination, which demonstrate a range of metallic and semiconductor characteristics. He-Ne laser illumination has been observed to increase field emission currents by more than an order of magnitude. The band structure of a semiconductor can be used to create a lower bound on the energy of photo-excited field-emitted electrons, producing a beam whose energy width is E=Eg-hv (bandgap Eg). Energy analysis is planned using a hemispherical analyzer, aimed at achieving an energy spread less than the 0.26 eV of conventional W tips. Calculations are underway to understand complications arising from surface effects and bulk transport. NNSA award DE-PS52-05NA funds this research.

11:39AM P38.00003 Design and Fabrication of Piezoresistive Micractilevers for Low Temperature Torque Magnetometry. — DAN J. HILLS, JACK K. LUO, CHRISTOPH BERGEMANN, University of Cambridge — Piezoresistive microneedle are experimental simple and highly sensitive way of measuring the magnetization of small < (100 mm)3 samples. These devices — micromachined from crystalline silicon — were originally designed as probes for atomic force microscopy, but were implemented by several researchers as torque sensors. Here we present newly designed and fabricated levers with properties optimized for torque measurements, including specifically those at low temperatures. In particular they may be used for de Haas- van Alphen measurements in high magnetic fields. Torque magnetometry detection of quantum oscillations is a potentially advantageous method for materials with anisotropic Fermi surfaces, existing in very small crystals or platelets. In addition, several other potential applications exist for torque measurements using levers of the same or similar design. Our designs couple high sensitivity with very small lever deflections in order to minimise torque interaction effects arising from field corrections introduced by the cantilever movement. Lever heat-sinking is also considered so as to maximum the sensing current that may be used, and hence the sensitivity, while maintaining the sample at low temperature.

11:51AM P38.00004 New de Haas-van Alphen effect measurement electronics. — PATRICK ROURKE, ALIX MCCOLLAM, STEPHEN JULIAN, University of Washington — We have implemented a new data collection infrastructure for measurements of de Haas-van Alphen oscillations in metals. Traditionally, such measurements require large banks of costly lock-in amplifiers, in order to measure on several harmonics of a fundamental excitation frequency at once for a given crystal sample. By moving to a high-quality analog-to-digital-converter/software lock-in algorithm set-up we are able to realize significant improvements in parallel data collection, configurability, data quality and cost. These performance gains will be illustrated through examples of measurements we have performed on various strongly correlated electron systems.

12:03PM P38.00005 Permanent Magnet with Very Low Field Gradient (0.1G/mm) for NMR Spectroscopy. — OGNJEN ILIC, Harvard College Student, DAVID ISSADORE, Research Assistant in the Division of Engineering and Applied Sciences, TOM HUNT, Research Assistant in Physics, ROBERT WESTERVELT, Mallinkrodt Professor of Applied Physics and of Physics, Nuclear Magnetic Resonance (NMR) is a powerful analytical tool for obtaining chemical, physical and structural information. To produce the uniform fields required, NMR experiments typically employ large, expensive electromagnets and shimming coils. We have developed a small permanent magnet with an iron yoke that produces a field of ∼10 kG with gradient < 0.1G/mm across a 6 mm region for a total field homogeneity of 10 ppm. The system consists of two parallel cylindrical NdFe permanent magnets, 50mm in diameter and 25mm thick, separated by 4mm. The magnets are surrounded by hollow low-carbon steel cylinders with steel caps on each end of the yoke. By adjusting the distance between the yoke caps and the magnet we cancel first-order field strength variations, as shown in simulations. This design is an important innovation for low cost, benchtop NMR systems. *Supported by the NCI MIT-Harvard CCNE.

12:15PM P38.00006 Identifying the Constituents of and Transformations in Diatomaceous Earth and Polysiloxane Foams Through the Use of Electron Paramagnetic Resonance Spectroscopy. — MICHAEL BLAIR, ROSS MUIENCHAUSEN, BRYAN BENNETT, JAMES SMITH, THOMAS STEPHENS, WAYNE COOKE, Los Alamos National Laboratory — The chemical aging of polymeric materials is largely governed by the characteristics of the storage environment. For polysiloxane foams, the diatomaceous earth (DE) filler is a small component of the foam, but it plays a large role in the handling of water in the system. The DE filler can act as either a “source” or a “sink” for water via both chemical hydroxylation/ dehydroxylation and physical adsorption/ desorption processes, depending on the processing history and storage conditions. We have used electron paramagnetic resonance (EPR) spectroscopy to examine composite foam material as well as the DE filler alone. Intense, broad (400 Gauss) resonances were recorded at room temperature as a function of the microwave power at X-band frequency. The observed spectra have been assigned to the iron oxide compounds goethite, lepidocrocite, hematite, and magnetite based upon the measured EPR spectra of these minerals. As the presence or absence of free H2O and the temperature of processing and storage also affects the interconversion of these various iron oxides, we indicate how this process can be followed by monitoring changes in the EPR spectra.

12:27PM P38.00007 Time resolved measurements of single electron tunneling events. — JULIE LOVE, MICHEL DEVORET, ROBERT SCHOELKOPF, Yale University — We have observed time resolved single electron tunneling events in a metallic thin film circuit. Using a radio frequency single electron transistor (RF-SET) capacitively coupled to a single electron trap (a circuit consisting two small metallic islands and two tunnel junctions) we are able to measure tunneling events on the 10 microsecond time scale. In the 400 microsecond average lifetime of the charge state with one excess electron on the trap island, 80 data points with SNR=10 can be obtained. We will present these measurements along with comparisons to cotunneling (quantum tunneling) and Orthodox (thermal tunneling) theories. The dynamics of cotunneling has never before been studied in an experimental system. These time domain measurements also demonstrate the possibility of measuring the higher moments of charge noise in a metallic system.
12:39PM P38.00008 Noise Characteristics of Nanocluster-Based Chemiresistors, WALTER KRUPPA, RONALD RENDELL, ARTHUR SNOW, EDWARD FOOS, MARIO ANCONA, Naval Research Laboratory — Thin films of metallic nanoclusters interspersed between interdigitated electrodes are the basis of a promising chemiresistor technology known as MIME sensors. The chemical vapor detection limit of these sensors is set by their signal-to-noise ratio at low frequencies where the noise is found to be 1/f in nature. In this work we explore the experimental dependences of the 1/f noise on various material parameters such as nanocluster core diameter, shell thickness and shell composition. Among other things, we find that the 1/f noise decreases by more than three orders of magnitude as the core diameter increases and the shell thickness decreases, observations that are expected to be important for sensor design. The data are found to fit the well-known Hooge formula and this allows the intrinsic strength of the 1/f noise to be gauged using the Hooge parameter. For the interpretation one needs to know the number of electrons participating in the transport and we discuss how this can be obtained through simulation using the orthodox theory of Coulomb blockade. This factor is then shown to be crucial for understanding the trends in our noise data.

12:51PM P38.00009 Stray Light Correction as a Deblurring Problem, JOHN HORNSTEIN, Naval Research Laboratory — The problem of correcting for stray light is shown to be a type of deblurring problem. When the optical system is linear, correcting for stray light reduces down to a convolution approach. As such, it is an ill-posed inverse problem, in which the goal is to estimate the true radiance on the instrument’s entrance aperture from the signals registered by its detectors. Optical ghosts and out of field and out of band stray light are all included in this formulation. They are due to the non-ideal character of the optical impulse response function, which, in turn, is proportional to the system’s point spread function. Backgrounds due to thermal emission within the optical system or from the radioactivity of its components are not included, since they are independent of the true scene. Several standard techniques of solving ill-posed inverse problems are being tested for correcting for stray light in spectral imagers. Results obtained via Backus-Gilbert estimation are reported here.

1:03PM P38.00010 The Physical Origin of the Forward Character of the Electromagnetic Optical Theorem, MATTHEW BERG, CHRISTOPHER SORENSEN, AMIT CHAKRABARTI, Kansas State University — Particles or scatterers, both spherical and nonspherical in shape, are often encountered in the natural environment. Examples include atmospheric clouds and aerosols. The scattering of sun light by these particles produces radiative forcing effects that influence the Earth’s climate. Additionally, electromagnetic scattering can offer an unintrusive way to study the physical properties of a scatterer including its shape, size and composition. Extinction is the process by which radiant energy is removed from an incident field due to the scattering and absorption of the field by a system of scatterers. The extinction cross section $\sigma_{\text{ext}}$ measures the total power removed from the incident light and hence, is a quantity of interest in many electromagnetic scattering applications. A well-known relationship, called the optical theorem, relates $\sigma_{\text{ext}}$ and the amplitude of the scattered field in the exact forward direction. This work investigates the physical origin of the forward character of the optical theorem using computer simulations of simple scattering systems. The conclusion is that the optical theorem derives its forward character from the interference of the incident and scattered fields. This energy flow is seen to consist of opposing directions of flow that cancel each other in all but the forward direction when integrated to yield $\sigma_{\text{ext}}$.

1:15PM P38.00011 Generating, and Processing, Quadrature Signals in Interferometry, DAVID VAN BAAK, TeachSpin, Inc. and Calvin College — The Michelson interferometer is well-known for its ability to produce sinusoidal signals or ‘fringes’ in response to changes in the optical path difference between its arms. Less well known is the ‘other output’ of a Michelson interferometer, where a second set of fringes can be observed. In the simplest case of a lossless interferometer, these standard and non standard output signals are complementary, and therefore redundant. This presentation points out that the use of a lossy metal film beamsplitter in an interferometer renders the two output signals non-redundant; they can in practice be made to occur in phase quadrature. This immediately makes a Michelson interferometer sensitive to the direction, as well as the rate, of change of optical path difference. Remarkably simple modelling makes it possible to extract the phase shift of the beamsplitter, and the instantaneous phase difference in the interferometer, from the pair of output signals. The method is illustrated via the quantification of magnetostriiction by interferometry.

1:27PM P38.00012 The effect of the energy and the momentum resolution on the extraction of Eliashberg function from angle-resolved photoemission spectroscopy, TTEU CHIEN, HONG LIU, WARD FLUMMER, University of Tennessee, Knoxville TN — The effects of energy and momentum resolution on the extraction of Eliashberg function from angle-resolved photoemission spectroscopy (ARPES) have been examined. The advantage of ARPES is that it can obtain the information of the dispersion of quasiparticles with energy and momentum resolutions. Moreover, recently, Eliashberg function can be directly extracted from the ARPES data by means of Maximum Entropy Method (MEM). The data near the Fermi energy are very important for the extracting procedure, and, unfortunately, are severely affected by the energy resolution. The case study here is the electron phonon coupling system — Be(0001) surface. MEM works improper when the energy resolution is larger than 10 meV. A truncation method was proposed to make MEM can work with worse energy resolution up to 30 – 40 meV. This method reduces the needs of ultra-high energy resolution of the instrument used in ARPES experiment.

1:39PM P38.00013 Spectral Weight Oracle: Model-Independent Sum Rule Analysis Based on Limited-Range Spectral Data, ALEXEY KUZMENKO, DIRK VAN DER MAREL, FABRIZIO CARBONE, University of Geneva, FRANK MARSGILIO, University of Alberta — Partial sum rules are widely used in physics to separate low- and high-energy degrees of freedom of complex dynamical systems. Their application, though, is challenged in practice by the always finite spectrometer bandwidth and is often performed using risky model-dependent extrapolations. We show that, given spectra of the real and imaginary parts of any causal frequency-dependent response function (for example, optical conductivity, magnetic susceptibility, acoustical impedance etc.) in a limited range, the sum-rule integral from zero to a certain cutoff frequency inside this range can be safely derived using only the Kramers-Kronig dispersion relations without any extra model assumptions. This implies that experimental techniques providing both active and reactive response components independently, such as ellipsometry in optics or simultaneous measurement of attenuation and speed of sound in acoustics, can extrapolate-independent determination of spectral weight ‘hidden’ below the lowest accessible frequency.

1:51PM P38.00014 Experimental Confirmation of Backscattering Enhancement Induced by a Photonic Jet, ALEXANDER HEIFETZ, KEVIN HUANG, ALAN SAHAKIAN, XU LI, ALLEN TAFOVE, VADIM BACKMAN, Northwestern University — We report experimental confirmation of backscattering enhancement induced by a photonic jet emerging from a dielectric sphere, a phenomenon recently predicted by theoretical solutions of Maxwell’s equations. To permit relatively straightforward laboratory measurements at microwave frequencies rather than visible light, we appropriately scaled the original conceptual dimensions of the dielectric microsphere and its adjacent perturbing nanoparticle (located within the microsphere’s photonic jet). Our experiments verified the existence of enhanced position-dependent backscattering perturbations by the adjacent particle. Our measured backscattering perturbations agreed well with prior theory and with additional finite-difference time-domain computational models of the complete microsphere test geometry.
Third, high frequency displacements of surfaces have been detected using the STM tip as a nanomechanical displacement detector, resulting in spatial resolution comparable to that available in conventional STM. Second, shot noise in the tunnel current has been measured at high frequencies.

To demonstrate broadband rf-STM operation, several experiments have been performed. First, radio-frequency reflectometry has been used to image surfaces, with electronic bandwidths in typical STM experiments extending only up to \( \sim 10 \) kHz. Here, a novel approach to attain time resolution in STM is demonstrated. The impedance of the tip-sample tunnel junction in the M \( \Omega \) range is matched close to 50 \( \Omega \) by employing a LC tank circuit, which allows for bandwidths up to 20 MHz.

Over the last 40 years the peak brightness of new synchrotron radiation sources has increased on average by an order of magnitude every 24 months!! By comparison, Moore’s Law states that the number of transistors on an integrated circuit “only” doubles every 24 months. This talk will report on the physics and enabling technology of the latest round of brightness improvements, which have been achieved in the IR and THz range at Jefferson Lab but whose principles are extendable to light sources at shorter (uv to x-ray) wavelengths. Examples of scientific applications will also be given. The JLab facility is based on an energy recovered linac (ERL), rather than a storage ring. The power is then enhanced by multiparticle coherent effects, while the source size is smaller because the horizontal emittance is approximately equal to the vertical emittance (round beams). In addition the bunch lengths are in the 100’s of femtosecond range, allowing ultrafast phenomena to be studied. Finally, unlike conventional linac-based machines an ERL can operate continuously.

Abridged version of the presentation given by Dr. Jae Mok. Yi and Jung Ho Je in X-ray Imaging Center of POSTECH, Korea. This research has been carried out in collaboration with Dr. Yuncheng Zhonga and Hanfei Yan in X-ray Science Division of Argonne National Laboratory and Dr. Jae Mok. Yi and Jung Ho Je in X-ray Imaging Center of POSTECH, Korea.

Supported by the U.S. Dept. of Energy contract DE-AC02-06CH11357.

1 Work supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

Supported by ONR, AFSOR, NVESD, The Commonwealth of Virginia and DOE.
8:12AM U38.00002 Very high frequency (VHF) self-sensing nanoscale cantilevers and their mass sensing applications in ambient conditions. , MO LI, Kavli Nanoscience Institute and Department of Applied Physics, California Institute of Technology, HONG TANG1, Kavli Nanoscience Institute and Department of Physics, California Institute of Technology, MICHAEL ROUKES, Kavli Nanoscience Institute and Departments of Physics, Applied Physics, and Bioengineering, California Institute of Technology — We report the development a new class of self-sensing, nanometer-scale cantilevers with fundamental-mode mechanical resonances up to very high frequencies (VHF). The sensors employ integrated piezoresistive displacement transducers; we show that, at the nanoscale, these are optimally realized using thin, metallic-density films. Our approach enables detection of VHF cantilever vibrations, to date as high as 127 MHz, at the thermomechanical noise limit. Displacement sensitivity of 39 fm/Hz^{1/2} and extremely low 1/f noise are attained. Our smallest devices have lateral dimensions approaching the mean free path at atmospheric pressure; hence their high quality factors are preserved in ambient. Measurements of molecular chemisorption onto polymer-coated nanocantilevers yield unprecedented mass resolution below 1 attogram (10^{-18} g) level at atmospheric pressure and room temperature.

1Currently at Electrical Engineering, Yale University

8:24AM U38.00003 High Frequency Cantilevers for Magnetic Resonance Force Microscopy1, CHRISTIAN DEGEN, MARTINO POGGIO, BEN CHUI, JOHN MAMIN, DAN RUGAR, IBM Research Division, Almaden Research Center, San Jose, CA 95120 — We are exploring the possibility of using high frequency cantilevers for detection of magnetic resonance spin signals, possibly at the Larmor frequency of nuclear spins. For this purpose we have fabricated smaller, 20 micron long cantilevers that resonate at frequencies near 1 MHz. Operating at 4K, these levers can have surprisingly high Q values, over 300,000, and can achieve force noise levels in the few attonewton range, despite their rather high stiffness of about 0.1 Newton per meter. We discuss some experimental challenges that will be increasingly important for future generations of cantilevers with even smaller dimensions. Finally we look ahead into what we might expect when such high sensitivity, nanomechanical resonators become tightly coupled to small ensembles of nuclear spins.

1Supported by the DARPA QuIST program, the Swiss National Science Foundation and the NSF through the Stanford Center for Probing the Nanoscale

8:36AM U38.00004 Construction of a Low Temperature Capable Frequency-Modulation Magnetic Resonance Force Microscope1 , SANGGAP LEE, SUN HO WON, SEUNG-BO SAUN, SOONCHIL LEE, Department of Physics, Korea Advanced Institute of Science and Technology — We constructed a low temperature capable frequency-modulation magnetic resonance force microscope (FM-MRFM) and applied to detecting electron spin resonance signals from tiny DPPH particles with ease in control and thereby improved signal-to-noise ratio. The electronics was composed of a spin-polarization modulator, a cantilever-oscillation feedback gain controller, and a phase-locked loop (PLL) FM demodulator. The controller kept the cantilever oscillating at its resonance frequency by positively feeding back to a piezo-actuator the gain-controlled drive signal phase shifted by 90 degrees with respect to the cantilever oscillation in the PLL circuit. The modulator generated waveforms to modulate the strength or frequency of the radio-frequency field in phase with the drive signal. The whole setup enabled to sense as readily as spins resonate by tracking the cantilever resonance frequency without breakdown in fastidious conditions. We will discuss the details and features of our microscope and furthermore ongoing MRFM results.

1This work was supported in part by KIMM in Korea.

8:48AM U38.00005 MRFM System Design for the Study of Organic Materials . DORAN SMITH, DAVID KIM, U.S. Army Research Laboratory — We will present an overview of our program to develop an MRFM system specialized for the study of organic materials at 4 K. The system uses the SPAM geometry and the CERMIT protocol and is predicted to be capable of imaging organic materials in 3D. The MRFM probe head design will be overviewed and progress toward system completion will be discussed.

9:00AM U38.00006 Progress on Magnetic Resonance Force Microscopy Detection of Statistical Polarization of Electron Spins , K.C. FONG, I.H. LEE, P. BANERJEE, YU. OBUKHOV, D. PELEKHOV, P.C. HAMMEL, Department of Physics, Ohio State University, 191 West Woodruff Ave., Columbus OH 43210 — Here we report our experimental progress on detecting statistical polarization of electron spins. In the condition of low external magnetic field and high temperature, polarization on due to Boltzmann factor could be small, i.e. \( \mu B / k_B T \ll 1 \). The \( \sqrt{N} \) statistical polarization can dominate the Boltzmann polarization when the spins ensemble is sufficiently small. With its unprecedented force sensitivity, Magnetic Resonance Force Microscopy (MRFM) has demonstrated the capability to observe this self-polarizing nature of spins via the i-OSCAR detection protocol\(^1\). Our efforts to use MRFM to detect this statistical polarization will be presented.


9:12AM U38.00007 Cross Polarization Imaging with Magnetic Resonance Force Microscopy , KAI W. EBERHARDT, QIONG LIN, ANDREAS HUNKELER, URBAN MEIER, BEAT H. MEIER, ETH Zurich — Cross Polarization (CP) is a standard method in Nuclear Magnetic Resonance Spectroscopy (NMR) for signal enhancement of nuclei with a low gyromagnetic ratio and was recently applied in MRFM [1]. We demonstrate two techniques based on CP. In the first we perform frequency-swept CP to enhance the polarization of low-\( \gamma \) S-spins. In the second method the S spins are used as a polarization sink for the high-\( \gamma \) I-spins coupled to them. The I-spins can be completely depolarized by adding phase-jumps to the frequency-sweep of the S-spin channel, allowing that their presence is detected indirectly via the high-\( \gamma \), often more abundant I-spins with improved SNR. 1D images with \( \mu \)-resolution of a \( KPF_6 \cdot CaF_2 \) sample are presented for both techniques. In the example the depolarization scheme allowed for an order of magnitude signal-to-noise ratio enhancement over direct detection. [1] Q. Lin et al., Phys. Rev. Lett. 2006, 96, 137604.

9:24AM U38.00008 Near-field scanning microwave microscope with separated excitation and sensing probes . KEIJI LAI, M.B. JI, N. LEINDECKER, M. KELLY, Z.X. SHEN, Stanford Univ. — We present here the design and experimental results of a near-field scanning microwave microscope (NSMM), currently working at a frequency of 1GHz. The coplanar waveguides were patterned onto the silicon nitride cantilever interchangeable with AFM tips, which are robust for high speed scanning. Our microscope is unique in that the sensing probe is separated from the excitation electrode to significantly suppress the common mode signal. The reflected signal, at the same time, can be used for the feedback of height control in a non-contact mode. In the contact mode which we are currently using, the contrast comes from both the sample topography and the difference of the complex dielectric constant. Our NSMM shows the ability to achieve high resolution microwave images on nano-particles, nano-wires, and biological samples with mostly topographical contrast, as well as buried structures with mostly electrical contrast. Numerical analysis of the tip-sample interaction was also performed and will be discussed in detail.
9:36AM U38.00009 Ferromagnetic resonance force microscopy of a permalloy film, E. NAZARETSKI, I. MARTIN, J.D. THOMPSON, R. MOVSHOVICH, Los Alamos National Laboratory, D.V. PELEKHÖV, P.C. HÄMMEL, P. WİGEN, Ohio State University, M. ZALALUTDINOV, SFA Inc., T. MEWES, University of Alabama, J. BALDWIN, B. HOUSTON, Naval Research Laboratory — We describe Ferromagnetic Resonance Force Microscopy (FMRFM) experiments performed on a 50 nm thick permalloy film. We have studied the evolution of the FMRFM force spectra as a function of the temperature. The temperature-dependent studies show a decrease of the ferromagnetic resonance field with increasing temperature which we attribute to the temperature-dependent changes of the saturation magnetization. The experiments demonstrate the potential of FMRFM to study temperature dependent ferromagnetic resonance phenomena. We analyzed the FMRFM force spectra evolution as a function of the probe-film distance and performed numerical simulations of the intensity of the FMRFM probe-sample interaction force. Excellent agreement between the experimental data and the simulation results provides the new insight into the mechanism of the FMR mode excitation in an FMRFM experiment.

9:48AM U38.00010 Magnetic particle imaging with a cantilever torque magnetometer, JOHN MORELAND, JASON ECKSTEIN, NIST, Boulder, CO, YUSHUN LIN, SY-HWANG LIOU, Department of Physics, University of Nebraska, Lincoln, NE, STEVEN RUGGIERO, Department of Physics, University of Notre Dame, Notre Dame, IN — We have demonstrated magnetic particle imaging with a cantilever torque magnetometer. Imaging is based on measuring the harmonic content of the magnetic moment of a particle driven to saturation by an applied ac magnetic field while adjusting the zero point of the field gradient with a slowly sweeping dc magnetic field. Large field gradients (> 100 T/m) necessary for high resolution imaging can be generated by operating electromagnets with ferrite cores and thus there is the potential for submicrometer image resolution. Results on an array of 50 μm Permalloy dots patterned on microcantilevers will be reported.

10:00AM U38.00011 Resonant Measurement of Coupling Forces Between Two Microcantilevers, ONUR BASARIR, KAMIL L. EKINCI, Dept. of Aerospace and Mechanical Eng., Boston University — Here we studied the nature of nonlinear coupling forces between two microcantilevers. We employed a resonant measurement technique similar to that used in non-contact atomic force microscopy (NC-AFM). A stiff cantilever, which was driven at its resonance at a constant amplitude, was brought to the close vicinity of a second cantilever excited by thermal noise. A spectral analysis of the displacement signal of the driven cantilever revealed the effects of the coupling forces at the sum and difference frequencies of the resonances of the two microcantilevers. From this, the resonance frequency and the quality factor of the thermally excited cantilever were extracted. As the nominal distance between the two cantilevers was reduced, we observed an increase in the dissipation as well as a shift in the resonance frequencies. We shall discuss how these observations may lead to a better understanding of the coupling forces.

This work is supported by National Science Foundation under grant number CMS-0324416.

10:12AM U38.00012 Functional Probes for Scanning Probe Microscopy, KOTONE AKIYAMA, IMR, Tohoku University, TOYOAKI EGUCHI, TOSHU AN, ISSP, The University of Tokyo, YASUNORI FUJIKAWA, IMR, Tohoku University, YUKIO HASEGAWA, ISSP, The University of Tokyo, TOSHIKO SAKURAI, IMR, Tohoku University — For superior performance of scanning probe microscopy, we are working to fabricate functional probes. For Kelvin probe force microscopy, we fabricated a metal-tip cantilever by attaching a thin metal wire to a regular Si cantilever and milling it by focused ion beam (FIB)1. By using the W tip with a curvature radius of 3.5 nm, we obtained the potential profile of Ge/Si(105) surface in atomic resolution within the energy range of 2.5–3.5 V. To find a better cantilever for the photo radiation-light-irradiated scanning tunneling microscopy which aims at atomically resolved elemental analysis, we fabricated a glass-coated W tip using FIB2. It is found that the glass coating blocks the unwanted secondary electrons, which come from large area of the sample, by a factor of 40 with respect to the case no coating. Using the tip to detect the electrons emitted just below the tip, we obtained element specific images with a spatial resolution better than 20 nm under the photo irradiation whose energy is just above the adsorption edge of the element. K. Akiyama et al., RSI 76, 033705 (2005) 2 T. Eguchi, K. Akiyama et al., PRL 93, 266102 (2004) 3 K. Akiyama et al., RSI 76, 083711 (2005) 4 T. Eguchi, K. Akiyama et al., APL, in press.

10:24AM U38.00013 Determination of the cross-sectional area of the indenter in nano indentation tests, WEIDIAN SHEN, JEREMY MCMINIS, RENE CROMBEZ, EVA MONTALVO, Surface Science and Nano-Tribology Laboratory, Department of Physics and Astronomy, Eastern Michigan University — To measure the hardness and elastic modulus of a composite system in the nano scale the precise determination of the cross-section area of the indenter tip at different heights is a key. A method of using scanning probing microscopy to image the tip, and then using its analysis software, Histogram program and Bearing curve, combined with the information of the area of each pixel, to determine the cross-section area at different heights is introduced in this presentation. Compared with other techniques, it is simple, straightforward, and readily provides a precise relationship between the cross-sectional area and the height.

Support of this work by Office of Naval Research (ONR) is greatly appreciated.

10:36AM U38.00014 In-situ observation of the transformation process into the nano-contact of single shell carbon fullerene using TEM-STM, MAKOTO YOSHIDA, YOSHIIKO KURUI, Department of Physics Tokyo Institute of Technology, YOSHIFUMI OSHIMA, Department of Materials Science and Engineering Tokyo Institute of Technology, KUNIO TAKAYANAGI, Department of Physics Tokyo Institute of Technology, CREST JST TEAM — In this study, we proposed the simple fabrication method of the single shell carbon fullerene (SSF) from an amorphous carbon between two gold electrodes by applying the bias voltage. The STM system which was combined with TEM system was employed as applying the bias voltage and observing the fabrication process in high vacuum condition (about 10−6 Pa) at room temperature. As the applied bias voltage was increased, the transformation into the SSF via the glassy carbon was caused. It was found that transformation into the SSF occurred above 0.6 V. In this method, we obtained the SSF which was range from C60 to C260. This proposal method is very easier than the previous techniques for obtaining the SSF between two metallic electrodes, for example the combination of the synthesis and evaporation of the SSF, and very useful for researching the electrical conductance property such as the structure effect, the effect of the connection way between both metallic electrodes.

10:48AM U38.00015 Quantitative imaging of lateral stiffness using sub-Ångstrom oscillation amplitude nc-AFM, MEHRDAD ATABAK, SEVIL OZER, Bilkent University, Turkey, H. OZGUR OZER, Trinity College, Dublin 2, Ireland, AHMET ORAL, Bilkent University, Turkey, SPM GROUP, BILKENT UNIVERSITY TEAM — The specially designed and constructed a nc-AFM, capable of measuring lateral stiffness in a lateral scale with minimal distance with a single nanometer, which is aligned at the side of a home-made tungsten cantilever with typical stiffness of about 150 N/m. To improve the sensitivity, a RF circuit is designed to inject RF current into the laser diode. The frequency and the amplitude of the RF current can be adjusted to optimize the noise reduction. Using this technique a noise level of ~1×10−4 A/√Hz is obtained. The cantilever is dithered in lateral direction respect to the sample with sub-Ångstrom oscillation amplitudes (A0 = 0.25 Å) at a frequency, well below the resonance frequency and the changes in lateral oscillation amplitudes. The amplitude at the tip, which is altered by the tip-sample distance, is detected from the interferometer output using a lock-in amplifier. We present the performance of our microscope and lateral stiffness images as a function of tunnel current (relative tip-sample distance) on HOPG surface.
11:15AM V38.00001 Mechanical effects of strong measurement: back-action noise and cooling.
KEITH SCHWAB, Cornell University — Our recent experiments show that it is now possible to prepare and measure mechanical systems with thermal occupation factors of N~25 and perform continuous position measurements close to the limits required by the Heisenberg Uncertainty Principle (1). I will discuss our back-action measurements with nanomechanical structures strongly coupled to single electron transistors. We have been able to observe the stochastic back-action forces exerted by the SET as well as a cooling effect which has analogies to cooling in optical cavities. Furthermore, I will discuss progress using optical fields coupled to mechanical modes which show substantial cooling using the pondermotive effects of the photons impacting a flexible dielectric mirror (2). Both of these techniques pave the way to demonstrating the true quantum properties of a mechanical device: squeezed states, superposition states, and entangled states.


11:51AM V38.00002 An apparatus for measuring short-range deviations from Newtonian gravity including a magnetic force calibration.
ANDREW GERACI, DAVID WELD, Dept. of Physics, Stanford University, JOHN CHIAVERINI, Los Alamos National Laboratory, SYLVIA SMULLIN, Dept. of Physics, Princeton University, AHARON KAPITULNIK, Depts. of Physics and Applied Physics, Stanford University — Several recent theories suggest that new physics related to gravity may appear at short length scales. For example, light moduli or particles in “large” extra dimensions could mediate macroscopic forces of (super)gravitational strength at length scales below a millimeter. We have built an apparatus utilizing cryogenic micro-cantilevers capable of measuring atto-Newton forces [1], which now includes a magnetic analog for force calibration. Our most recent experimental constraints on Yukawa-type deviations from Newtonian gravity will be presented.

References:

12:03PM V38.00003 ABSTRACT WITHDRAWN —

12:15PM V38.00004 Feedback Control and Characterization of a Microcantilever Using Optical Radiation Pressure.
DAVID WELD, AHARON KAPITULNIK, Stanford University — We describe a simple method for feedback-regulation of the response of a microcantilever using the radiation pressure of a laser. A modified fiber-optic interferometer uses one laser to read out the position of the cantilever and another laser of a different wavelength to apply a force that is a phase-shifted function of that position. The method does not require a high-finesse cavity, and the feedback force is due solely to the momentum of the photons in the second laser. The feedback phase can be adjusted to increase or decrease the microcantilever’s effective quality factor $Q_{eff}$ and effective temperature $T_{eff}$. We demonstrate a reduction of both $Q_{eff}$ and $T_{eff}$ of a silicon nitride microcantilever by more than a factor of 15 using a root-mean-square optical power variation of ~2 $\mu$W. This technique was developed to control the response of a cantilever used as a force sensor in a next-generation test of Newtonian gravity at length scales of 20 $\mu$m. Additionally, we suggest a method for determination of the spring constant of a cantilever using the known force exerted on it by radiation pressure.

12:27PM V38.00005 SQUID-based magnetic thermometry for fundamental physics and applications below 1 K.
R. SULTAN, R. RAHAMAN, F. BASET, B. L. ZINK, University of Denver — One approach to sensitive thermometry below 1 K is to measure the temperature-dependent magnetization of a paramagnet using a SQUID. Devices based on bulk materials (such as cerium manganese nitrate) and superconducting transformers provide some of the most sensitive thermometers available for dilution-refrigerator temperatures. Microcalorimeter x-ray or $\gamma$-ray detectors can be made using the same concept, with a small erbium-doped gold paramagnet (again prepared using bulk techniques) measured with a thin-film dc SQUID magnetometer. In this talk we describe our recent work toward a SQUID-based magnetic thermometer fabricated entirely using thin-film techniques. This thermometer has potential applications not only for high spectral-resolution x-ray detectors, but also for fundamental measurements of thermal transport in thin-films and nanostructures. We will discuss optimization of a low-noise dc SQUID and its coupling to the sensor, the choice of a paramagnetic thin-film, and the performance of the thermometer for various applications.

12:39PM V38.00006 Shot Noise Thermometry down to 10 mK.
LAFE SPIETZ, NIST, ROBERT SCHOECKOPF, Yale University — We report measurements of the Shot Noise Thermometer (SNT), a primary thermometer based on the electronic noise from a tunnel junction, in the range from 10 mK to 200 mK. We demonstrate operation of the SNT down to 10 mK with 10% accuracy at the lowest measured temperature. At 10 mK, where for a measurement frequency of $f=450$ MHz, $hf = 2.5k_B T$, we demonstrate that, provided that quantum corrections are taken into account, the SNT continues to be a practical thermometer. We also show that self-heating is not a measurable problem and demonstrate a simplified readout of the SNT.

12:51PM V38.00007 A new approach to the measurement of relaxation heat capacity.
JONATHAN B. BETTS, ALBERT MIGLORI, IZABELA STREO, National High Magnetic Field Laboratory, Pulsed Field Facility, LANL, Los Alamos, NM 87545, SCOTT RIGGS, National High Magnetic Field Laboratory, DC Field Facility, Tallahassee, FL 32310 — We have developed low-addenda calorimeters for the 300mK – 380K temperature range. The low addenda produces a calorimeter relaxation response with exceptionally low scatter, typically less than one part in 1000. Such low scatter exposes small errors in the usual logarithmic variation of temperature with time, and because of the low scatter, small corrections to this function can be made consistently, increasing our heat-capacity precision by an order of magnitude. We also present a calorimeter design for measuring small micro-liter liquid samples using the relaxation method in the 300K – 400K temperature range.

This work was carried out under the auspices of the National Science Foundation and the US Department of Energy.
A new thin film nanocalorimeter for measuring the heat capacity of 50nm films from 300mK to 500K.

Daniel Queen, Frances Hellman, University of California, Berkeley — Low stress silicon nitride is used in a variety of MEMS devices as an important mechanical membrane material. The high Debye temperature of the silicon nitride makes it an ideal material for use in a MEMS based calorimeter. Microfabrication techniques provide for a high degree of reproducibility between devices on a single silicon wafer. Microlithometers based on low stress silicon nitride have been successfully used to measure the heat capacity of 200nm films and small single crystals (~50 micrometers) for over a decade. We report results on a scaled down calorimeter for measurements of 50nm thin films. By scaling down the device, we have reduced the background addenda by an order of magnitude as compared to previous designs. The resulting decrease in die size allows us to use the nanocalorimeter in confined spaces such as small bore magnets and beam lines.

1:15PM V38.00009 New design of a microcalorimeter with enhanced accuracy through the consideration of thermal loss of the membrane platform. K. S. SuH, H. J. Kim, J. W. Kim, Y. D. Park, Kee Hoon Kim, CSMR and FPRD Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea — We report on the development of a Si/N/Si based microcalorimeter for measuring specific heat of small samples in a wide temperature range. By using well-known MEMS fabrication techniques [1], the heater and sensor elements are integrated on the Si-N membrane. The fabricated calorimeter is operated by a custom-made program based on the curve fitting method [2]. By comparing measured thermal conductance (λ) from the membrane platform to the thermal reservoir in three different designs, we find λ can critically affect the accuracy of measurement, and that the geometry of metal lines is a key parameter to control. Based on those findings, we provide a new design of microcalorimeter resulting in the specific heat of Cu (~300 μJ) consistent with literature values within 5% in a temperature range between 20 and 300 K.


1:27PM V38.00010 Nonlinearity in the effect of an inhomogeneous Hall angle, Daniel W. Koon, St. Lawrence University — The differential equation for the electric potential in a conducting material with an inhomogeneous Hall angle is extended to the large-field limit. This equation is solved for a square specimen, using a successive over-relaxation [SOR] technique for matrices of up to 101x101 size, and the Hall weighting function — the effect of local pointlike perturbations on the measured Hall angle — is calculated as both the unperturbed Hall angle, tan ΘH, and the perturbation, δ tan ΘH, exceed the linear, small angle limit. Preliminary results show that the Hall angle varies by no more than 5% if both | tan ΘH | < 1 and | δ tan ΘH | < 1. Thus, previously calculated results for the Hall weighting function can be used for most materials in all but the most extreme magnetic fields.

1:39PM V38.00011 Electrical measurements of parametric resonance in silicon cantilevers. Michael Requa, Kimberly Turner, University of California, Santa Barbara — Micro- and nano-scale mechanical oscillators, in particular cantilevers, show great promise as highly sensitive mass sensors for their small inertial mass and high Q-factors. Sensitivity to environmental factors (force and mass) are limited by thereshold of the resonant frequency measurement in such systems. Experimental investigations to the frequency resolution of bistable nonlinear dynamics for resonators exhibiting parametric resonance have been performed. Using Lorentz interactions for excitation and detection, the all electrical measurements of such oscillations in nonlinear dynamics require nontrivial instrumentation demonstrated in this work. Frequency resolution of 100 parts in 1 billion in vacuum are demonstrated at room temperature suggesting potential enhancements over more conventional harmonic resonant techniques.

2:30PM W6.00001 Keithley Award Talk. Kent Irwin, National Institute of Standards and Technology — Superconducting transition-edge sensors (TES) operated at temperatures below 1 K are a sensitive tool for the detection of electromagnetic radiation from microwaves through gamma rays, and for the measurement of the energy of particle interactions and nuclear decays. They have evolved beyond the research and development phase, and they are being used in applications as diverse as astronomy, nuclear and particle physics, and materials science. The low noise, low source impedance, and low operating temperature of superconducting quantum interference devices (SQUIDs) make them the preamplifier of choice for TES devices. In order to realize their full potential, it has been necessary to develop arrays of thousands of SQUID-coupled transition-edge sensors. Due to constraints on cryogenic wiring and circuit complexity, SQUID multiplexing is necessary to realize these advances. In this talk, I will describe the development of large arrays of TES detectors integrated with multiplexed SQUID amplifiers. SQUID multiplexers use an orthogonal basis set (usually time- or frequency-division) to encode the signal from many input channels into a single wire. I will discuss both fundamental limits and practical issues of implementation, including bandwidth-limiting filters, power dissipation, and crosstalk. I will highlight work done by our group at the National Institute of Standards and Technology to develop time-division multiplexed arrays of thousands of SQUID amplifiers, and collaborations with different groups to integrate them into large arrays of TES sensors for a variety of applications. I will also discuss future trends, including the development of microwave techniques to read out even larger arrays of SQUID amplifiers in high-Q resonant circuits.
3:06PM W6.00002 Cold Probes of the Hot Universe, CAROLINE KILBOURNE, NASA Goddard Space Flight Center — High-resolution x-ray spectroscopy is becoming a powerful tool for studying the hot (1 - 100 MK) and dynamic universe. The grating spectrometers on the XMM and Chandra satellites have sparked a new era in x-ray astronomy, but there is need to deploy instrumentation that can provide higher spectral resolution with high throughput in the Fe-K band (around 6 keV) for extended sources. These new spectrometers will be based on arrays of microcalorimeters operated at 0.1 K and below. A microcalorimeter measures a small amount of heat in a weakly heatsunk thermal mass by sensing a temperature change in the presence of thermodynamically unavoidable temperature fluctuations. Low temperature operation is required in order to minimize this thermal noise and to reduce the heat capacity. The most advanced microcalorimeter technology to date is based on using a temperature-dependent resistance for the thermometer element, either a semiconductor thermistor or a superconducting transition-edge sensor (TES). At Goddard, we have been developing microcalorimeters for x-ray astrophysics since our pioneering work in 1984, and we have pursued both silicon and TES technology, and optimizations for different telescopes and energy bands. In our latest TES design, we have achieved a resolution of 2.5 eV at 6 keV. I will review the microcalorimeter research at Goddard and will discuss prospects for getting such an instrument deployed in orbit.

3:42PM W6.00003 The Cosmic Microwave Background, PAUL L. RICHARDS, University of California, Berkeley — Measurements of the Cosmic Microwave Background (CMB) provide our earliest direct information about the evolving Universe. This talk will begin with a summary of how the CMB was produced and why it is important. The focus will then shift to the nature of the experimental challenge of extracting cosmological information from the CMB. Examples will be given of technology development in small-scale experiments leading to major space missions which produce definitive data sets. The millimeter-wave spectral range of the signals corresponds to the crossover between coherent (radio) techniques and bolometric (optical) techniques. These challenges have stimulated enormous development of bolometric detectors, which are used to measure both the spectrum and the anisotropy of the CMB. The next generation of CMB experiments will require a new generation of bolometric detectors in large format arrays. This year, the Keithly Prize is given to Kent Irwin for ideas that have made this next step possible.


4:54PM W6.00005 Quantum Calorimeter Gamma-ray Detectors: New Tools for Non-proliferation, BARRY ZINK, University of Denver — High resolution γ-ray spectroscopy is an important tool for non-destructive analysis of nuclear materials and is often used by safeguards inspectors to help verify the inventories of nuclear materials held around the world. The energy spectrum of photons emitted from isotopes of uranium or plutonium in the 40 – 1000 keV energy range give unique signatures that, if accurately measured, give inspectors important information about the age and enrichment of the material and therefore its intended purpose. In this talk I will describe recent work by a team of researchers from the University of Denver, the National Institute of Standards and Technology, and Los Alamos National Laboratory on γ-ray spectrometers with more than an order of magnitude improvement in energy resolution over standard techniques. The heart of this improved tool for non-proliferation is a microcalorimeter γ-ray detector that combines a micromachined thermal isolation structure with a bulk absorber and a highly sensitive superconducting transition-edge thermometer optimized for operation well below 1 K. In the last several months, we have assembled and tested arrays of these microcalorimeters, with many detector pixels on a single chip. When read out with SQUID multiplexers, these arrays dramatically increase the speed of data collection, allowing ultra-high resolution γ-ray spectra to be acquired in roughly the same time needed for traditional detector technologies. In addition to presenting high-resolution γ-ray spectra of nuclear materials such as plutonium, I will describe the physics of the microcalorimeter, which ranges from the lifetime of quasiparticles in bulk superconductors to the thermal properties of glue.

1We thank DOE-NNSA and NIST-EEEL for support of this work