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Chairs

Jeremy Theil
Lumileds, LLC
MS 91UJ
370 W. Trimble Rd.
San Jose, CA 95131
408 435-6233

Travis Blalock
Dept. of Electrical & Computer Engr
University of Virginia
C215 Thornton Hall
351 McCormick Rd.
Charlottesville, VA 22904-4743
434-924-1331

Markus Boehm
Institut Mikrosystemtechnik
Universität Siegen
Hoelderlinstr. 3
Siegen, D-57068 Germany
49-271-740-3293

Donald S. Gardner
Intel Corporation
MS SC1-03
2200 Mission College Blvd
Santa Clara, CA 95054
408-765-2025

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* Invited paper
8:30 AM *DL.4
Vertical Integration of Hydrogenated Amorphous Silicon on CMOS Circuits. Nicolas Wyrsch1, C. Miazza1, C. Ballif1, A. Shah1, N. Blanc2, R. Kaufmann3 and P. Jarren3; 1IMT, University of Neuchâtel, Neuchâtel, Switzerland; 2CSEM SA, Zurich, Switzerland; 3CERN Meyrin, CERN, Geneva, Switzerland.

Active pixel sensors (APS) in CMOS technology have recently gained a lot of interest. However, the fact that the pixel read-out electronics shares the die area with the sensor element is an important factor limiting the smallest possible “pixel area” which are unacceptable for certain applications. The implementation of additional functionalities (at the pixel level) and the introduction of more advanced technologies (with smaller feature sizes) renders the problem more acute. Vertical integration of hydrogenated amorphous silicon (a-Si:H) sensors on top of the readout electronics is a promising solution to this problem. It has been introduced successfully for several applications, especially for vision sensors with high sensitivity [1] or high dynamic [2], infrared light vision [3] and for particle detection [4]. a-Si:H offers two significant advantages: (a) low deposition temperature (≤ 200°C) posing, thus, no problem for the direct deposition on CMOS chips, and (b) a larger band gap (larger than that of GaAs) that has beneficial aspects for the applications mentioned above. This paper will review some of the main examples of this thin-film on ASIC (TFA) technology (also called thin-film on CMOS (TFC) technology). The integration of a-Si:H sensors on the CMOS chip will be discussed in detail and especially the issues regarding the a-Si:H design and the influence of the CMOS chip design (i.e. its surface morphology) on the a-Si:H sensor performance. [1] S. Benthen et al., IEEE Journal of Solid State Circuits, vol. 35, no. 7, pp. 928-945, 2000; [2] B. Schneider et al., in B. Jahne, H. Haussecker, P. Geissler, Handbook on Computer Vision, and Applications, Academic Press, Boston, pp. 237-270, 1999. [3] A. J. Syllais et al., MRS Proc. Vol. 609 (2001) A14.4.1.1 [4] N. Wyrsch et al., MRS Proc. Vol. 808 (2004) in print.

9:00 AM *DL.1
Influence of Design Parameters on Dark Current of Vertically Integrated a-Si:H Diodes. Clement Miazza1, Nicolas Wyrsch1, Gregory Choong1, Sylvain Dunand1, Arvind Shah1, Christophe Ballif2, Rolf Kaufmann2, Nicolas Blanc2, Mathieu Despeisse3 and Pierre Jarren3; 1Institute of Microtechnology, University of Neuchâtel, Neuchâtel, Switzerland; 2Photons Division, CSEM SA, Zurich, Switzerland; 3EP Division, CERN, Geneva, Switzerland.

The development of image and particle sensors based on thin-film on CMOS (TFC) technology, where the a-Si:H detectors are vertically integrated on top of a CMOS chip, has led to promising preliminary performances [1]. A high sensitivity (50 to 195 V/μA/cm²) was proven [2]. However, difficulties in reaching very low dark currents (Idark<10−13A/cm²) were encountered [2]. Therefore, to understand the correlation between the diode architecture and the substrate topology with the observed behaviour of the dark current, some special test structures were developed and fabricated both by photolithography and on a dedicated CMOS chip designed by CERN. Thanks to these structures we could gain in testing flexibility compared to the conventional TFC sensors and investigate the influence of various design parameters on dark current. In the present paper the results of this study will be presented and the crucial parameters influencing the dark current will be evidenced and discussed in detail. This will lead to a better understanding of dark current mechanisms and give design rules with actual a-Si:H technology and material.

9:15 AM *DL.3
Reduction of Residual Transient Photocurrents in a Si:H Elevated Photodiode Array Based CMOS Image Sensors. Jeremy Theil, Lunieds, LLC, San Jose, California.

While a-Si:H based elevated photodiode arrays hold the promise of superior performance and lower cost, CMOS-based image sensors relative to those based upon crystalline silicon photodiodes, one area where a-Si:H based sensor performance has not been as good is in image lag. This problem is only exacerbated by Stiehler-Wronski Effect induced charge degradation. Image lag caused by residual charge from photocurrents trapped within the junction once the light source is removed and can be measured for several seconds, even under continuous applied reverse bias. It is seen both in constant and variable bias pixel architectures. However, by carefully controlling n-Si:H junction bias conditions, it is possible to significantly reduce the transient photocurrents. This article will describe how the photocurrent decay time constants can be reduced by almost an order of magnitude. Finally the physical causes behind image lag in a-Si:H based photodiode arrays will be discussed.
Conventional color imagers using color filter arrays to separate the three fundamental components of the visible light. This approach for color imaging or color sensing, if silicon is to dominate these limitations color sensor arrays were realized using vertically integrated thin film sensors. The complete color information can be detected at the same spatial position of the sensor array without the optical cross-talk. The color separation the terminal nipili structures prepared by a low temperature CVD process. The spectral sensitivity of the sensors can be controlled by the optical and optoelectronic properties of the materials on one hand and the design of the devices on the other. The sensors were grown on top of a 512 x 512 pixel active matrix readout electronic pixel with a pitch of 100μm. Amorphous silicon TFTs were used as pixel switches. The operating principle of the all amorphous silicon color imagers presented here is the interplay of the illumination conditions and the applied bias voltages on color separation, the lines spread function and modulation transfer function will be discussed. The p-layer of the nipili sensor is patterned so that the top diode is more sensitive to crosstalk.

Integrated Zinc Oxide Thin Films and Nanostructures in Polymer-Based Devices; Atsushi Matsumura1, Zvonimir Z. Bandic2 and Renato P. Camata3, 1Dept. of Physics, Univ. of Alabama at Birmingham, Birmingham, Alabama; 2Hiltachi San Jose Research Center, San Jose, California.

Zinc oxide (ZnO) exhibits a suite of properties that are desirable for monolithic integration. Its wide direct band gap (3.37 eV) and large exciton binding energy (50 meV) at 300K make it an attractive compound for UV light emitting diodes, lasers, and sensors. ZnO nanostructures with high aspect ratios that have been recently demonstrated display strong piezoelectricity and potential applications in biosensors and nanoelectronics. ZnO is biologically safe and good quality polycrystalline films with moderate Hall mobilities (>1 cm²/Vs) that can be grown at room temperature are compatible with polymeric materials. Because it is transparent in the visible, ZnO-based thin film transistors may also be used in drivers and, through doping, as magnetic storage media. If incorporated into other nanoelectronic systems, these ZnO nanowires could enable new devices with intelligent semiconductor films featuring multiple embedded sensors, data processing arrays, and distributed memory elements. In this study we have targeted the integration of ZnO thin films onto free-standing flexible polyimide films and on polyimide/Au/SiO₂ substrates with various device topologies. ZnO layers with thickness between 100 nm and several microns were deposited by pulsed laser deposition (PLD) while structural and optical properties were evaluated with x-ray diffraction and photoluminescence (PL). Room temperature PL of ZnO films deposited between 100°C and 300°C using a laser energy density of 3.0-5.6 J/cm² showed broad spectral feature centered at 370 nm from excitonic emission in ZnO. Broad PL bands are observed between 400 nm and 500 nm due to bound exciton/complex recombinations. This PL behavior is indistinguishable from that observed for ZnO thin films grown on sapphire substrates (e.g., by MBE) showing that the essential optical properties of these films are not affected by their integration into polymeric-based devices. In this work we also address the challenge of spatially resolved device integration of nanocrystals and nanostructures. For this purpose we used a novel PLD-based technique known as Nanoparticle Beam Pulsed Laser Deposition to produce ZnO nanocrystals that are delivered in the form of a nanoparticle beam to the polyimide substrate. This method achieves the co-deposition of the deposition of nanoparticles and gas phase constituents that are often present simultaneously in conventional PLD. These processes are manipulated independently by operating two separate PLD-based sources, such that one source delivers a broad nanoparticles while the other is configured for the production of a gas-phase dominated plume. We will describe how we are exploring the focused nanoparticle beam capability of this method to deposit ZnO nanocrystals of specific sizes at selected locations on our polyimide surface. This approach may allow the integration of new functionalities to polymer-based devices with lateral spatial resolution of tens of microns.

Infra-Red Photo- Detectors Monolithically Integrated with Silicon-based Photonic Circuits; J. D. Bradley, P. E. Jessop and Andy Peter Knights; Engineering Physics, McMaster University, Hamilton, Ontario, Canada.

The development of monolithic silicon photonic systems has been the subject of intense research over the last decade. In addition to passive waveguiding and photonic devices, applications of electrical and optical functionality have yielded devices with the ability to dynamically attenuate, switch and modulate optical signals. Despite this significant progress, much higher levels of integration and increased functionality are required if silicon is to dominate as a substrate for photonic circuit fabrication as it does in the microelectronic industry. In particular, there exists a requirement for efficient silicon-based optical sources and detectors which are compatible with CMOS fabrication technologies. In this talk we will review the development of and integrated silicon-based detectors and optical interconnections for high-speed telecommunication and quiet fiber optic links. The focus will be on recent developments that have led to the integration of photodetectors and modulators with silicon integrated circuits. We will begin with a review of the basic optical properties of silicon and the ways in which these can be engineered to support high-speed photonic communication applications.

Direct Growth of Ge on Si by Molecular Beam Epitaxy for CMOS Integrated Long Wavelength Devices; Yu-Hsuan Kuo1, Xiaojun Yu1, Junxian Fu1, Theodore I. Kamins2, Glenn S. Solomon1 and James S. Harris1; 1Solid State and Photonics Lab, Stanford University, Stanford, California; 2Hewlett-Packard Laboratories, Palo Alto, California.

The delay and power consumption of metal wires have become a bottleneck in the inter- and intra-chip communications of future high speed ICs. One approach to this problem is optical interconnections for high-speed signaling and clock distribution with low attenuation and crosstalk. Germanium is not only useful for near infrared (NIR) photodetection but also compatible with silicon fabrication. Ge grown on silicon will enable the low-cost monolithic integration of optical sensing and electronic processing components into the same chip. The main issue in the growth of Ge on Si is the 4% lattice mismatch, causing severe problems, like 3-D islanding and dislocations. In this presentation we use solid-source molecular beam epitaxy (MBE) are used a novel PLD-based technique known as Nanoparticle Beam Pulsed Laser Deposition to produce ZnO nanocrystals that are delivered in the form of a nanoparticle beam to the polyimide substrate. This method achieves the co-deposition of the deposition of nanoparticles and gas phase constituents that are often present simultaneously in conventional PLD. These processes are manipulated independently by operating two separate PLD-based sources, such that one source delivers a broad nanoparticles while the other is configured for the production of a gas-phase dominated plume. We will describe how we are exploring the focused nanoparticle beam capability of this method to deposit ZnO nanocrystals of specific sizes at selected locations on our polyimide surface. This approach may allow the integration of new functionalities to polymer-based devices with lateral spatial resolution of tens of microns.

CMOS Integrated Long Wavelength Devices; J. D. Bradley, P. E. Jessop and Andy Peter Knights; Engineering Physics, McMaster University, Hamilton, Ontario, Canada.

The development of monolithic silicon photonic systems has been the subject of intense research over the last decade. In addition to passive waveguiding and photonic devices, applications of electrical and optical functionality have yielded devices with the ability to dynamically attenuate, switch and modulate optical signals. Despite this significant progress, much higher levels of integration and increased functionality are required if silicon is to dominate as a substrate for photonic circuit fabrication as it does in the microelectronic industry. In particular, there exists a requirement for efficient silicon-based optical sources and detectors which are compatible with CMOS fabrication technologies. In this talk we will review the development of and integrated silicon-based detectors and optical interconnections for high-speed telecommunication and quiet fiber optic links. The focus will be on recent developments that have led to the integration of photodetectors and modulators with silicon integrated circuits. We will begin with a review of the basic optical properties of silicon and the ways in which these can be engineered to support high-speed photonic communication applications.

In a wide-spread area of biotech and medical applications tools are required for the parallel detection of presence or quantitative amount of specific DNA sequences in a given sample. Commercially available state-of-the-art DNA microarray chip systems use optical detection techniques for that purpose. By avoiding the relatively expensive and complicated optical set-ups, electronic readout techniques in principle
allow more robust and easier operation, but their status of development is lower. Medium and high density (approx. > 50 resp. > 1,000 sites) electronic chips require on-chip circuitry. Standard CMOS extended by the requests transducer materials allows signal amplification, signal processing, and multiplexing directly beneath the sensors. This feature translates into superior signal integrity, optimum robustness against crosstalk related signal distortions, and consequently highest possible signal-to-noise ratio and dynamic range. In [1-4], the development of fully-electronic medium-density CMOS sensor arrays is reported. A redox-cycling based electrochemical sensor principle is applied. Single sensor consists of interdigitated gold electrodes (width = spacing = 1 μm, diameter = 100 ... 250 μm). After immobilization of single-stranded DNA probe molecules on the Au surface, a sample containing target molecules is applied to the whole chip. Hybridization of matching DNA strands translates into increasing sensor currents [5]. The required Au sensor electrodes are provided in a post CMOS extra process. A Ti/Pt/Au stack is deposited using the lift-off process. The basic CMOS technology is a 0.5 μm 5 V, 6 V, n-well standard process. To allow operation of these chips within a wide field of application scenarios, the specified electronic dynamic range per sensor equals 10^12 A ... 10^−2 A. Specifically adapted ADCs are operated within each sensor site, using a sawtooth generator concept where an integrating capacitor is charged by the sensor current, and reset again by a switch transistor when the switching level of a comparator is reached. The number of reset pulses is encoded by a digital counter whose output provides a digital word representing the sensor signal. Based on this sensor site circuit approach, a user-friendly prototype array is derived with 8 x 16 positions, peripheral blocks such as bandgap reference, auto-calibration, and serial digital electronic interface and total amount of 8 pins for power supply and data transmission. [1] R. Thewes et al., Tech. Dig. ESSC, p. 350, 2002 [2] F. Hofmann et al., Tech. Dig. EEDM, p. 488, 2002 [3] M. Schienle et al., accepted for publication in EEDM, 2004 [4] A. Frey et al., submitted for publication at ISCAS 2005 [5] R. Hintsche et al., in 'Frontiers in Biosensors I', F. Scheller et al. ed., Birkauser Verlag Basel/Switzerland, 1997.

2:00 PM D2.2

Blue Phosphorescent Cyclometalated Iridium Complexes derived from Phenylpyrazole Derivatives: Synthesis, Density Functional Theory (DFT) Calculations and Organic Light-Emitting Diodes Study. Hyuk Kwon1, Myoung-Chul Um1, Myoung Ki Kim1, Hye Soon Choi1, Su-young Choi1, Kwan Hee Lee2, Su Jin Park2 and Jong-In Hong1; 1School of Chemistry, Seoul National University, Seoul, South Korea; 2Corporate R&D Center, Samsung SDI, Seoul, South Korea.

There have been increasing interest and research activity in organic light-emitting diodes (OLEDs), and enormous progress has been made in the improvement of efficiency, luminance, and reliability. In OLED displays, blue phosphorescent materials still remain elusive because their color index and efficiency have not been fully optimized. This study shows how color tuning and emission intensity control are possible through the main ligand on iridium (III) complexes. Herein, we report on the design, synthesis, spectroscopic study and EL data of new blue phosphorescent cyclometalated iridium complexes derived from phenylpyrazole derivatives, where the magnitude of the rf power, gas flow rate, and nozzle composition were deposited onto silicon substrates which were coated with platinum/TiO2/SiO2 and on bare Si. The magnitude of the rf power was varied in the range of 50 to 150 W. Chemical composition of the films was measured by electron probe analysis. The stoichiometric ratio of the Ba and Sr was controlled with the deposition parameters of rf power, gas flow rate, and nozzle composition. We will show that in the single hybrid nozzle system, the film composition can be controlled by adjusting the ratio of BaTiO3/SrTiO3 in the nozzle, while in the dual nozzle system the film composition can be controlled by adjusting the power supplied to each nozzle. Post deposition annealing in oxygen at temperatures in the range of 650 to 750 C is necessary to form homogeneous BaSr1−x Tio2 thin films.

2:45 PM D2.5

Optimization of the Metal/Silicon Ratio on Nickel Assisted Crystallization of Amorphous Silicon. Luis Pereira, Francisco Bulos-Porto and Elvira Fortunato; 1Department of Material Science, CENIMAT/CEMOP, Caparica, Portugal.

The aim of this work is to optimize the metal/silicon ratio on nickel metal induced crystallization of silicon layers. For this purpose amorphous silicon layers with 90, 135 and 180 nm were used on the top of which Ni layers with 0.5 nm were deposited and annealed the required time to crystallize the a-Si with different thicknesses. The data show that the a-Si layer with 90 nm reaches a 79% crystalline fraction (as detected by spectroscopic ellipsometry) after only 2 hours annealing. No significant structural improvement is detected by ellipsometry neither by XRD when annealing for longer times. However, on samples with 135 nm after annealing for 2 hours the crystalline fraction is only 47% reaching a similar value to the one with 90 nm only after 5h, with a crystalline fraction of 82%. Here again no significant improvements were achieved through longer annealing times. Finally, the a-Si sample 180 nm thick does not show any significant crystallization after 10h of annealing. Indeed, only after 20 h was possible to detect some crystalline fraction, that do not overcome 52%. However when using 5 nm of Ni the a-Si was crystallized after 5h. These data clear suggest that the crystallization of thicker a-Si layers requires thicker Ni films to be effective for short annealing times.

3:15 PM D2.8

Integrated Optical Sensing for Biological Analysis. Evren Turhan1, Ofer Levi1, Jonathan Ziebarth2, James S. Harris2, Stephen J. Smith1 and Mike McGeehe; 1Agilent Technologies, Palo Alto, California; 2Department of Electrical Engineering, Stanford University, Stanford, California; 3Department of Molecular and Cellular Physiology, Stanford University, Stanford, California; 4Department of Material Science, Stanford University, Stanford, California.
Optical sensing remains one of the most widely used methods to study and analyze biological systems. Integrated optical systems hold much potential for portable diagnostics, high throughput experimentation and medical implants. The realization of integrated optical sensors is now possible due to developments in optoelectronics over the past decades. The focus of this research has been the development of integrated fluorescence sensors. Vertical cavity surface emitting lasers (VCSELs), PIN photodetectors and optical emission filters have been monolithically integrated to form a fluorescence sensor. The advantages of this approach are drastically reduced costs, increased parallelism and near-infrared (NIR) sensing. A theoretical limit of detection of 40 nM of IRDye 800 has been achieved on a microfluidic format. Large increases in sensitivity are possible through the systematic reduction of laser background. Another area of research that has been the development of implantable optical systems within the body. Researchers at Stanford have particularly focused on imaging systems to study brain activity in-vivo. A novel imaging modality has been invented that capitalizes on organic-LED technology combined with micro-optics. This approach allows for wide-field imaging while reducing the dimension along the optical axis, creating a flat system for implantable systems.

3:45 PM D2.7
Co-Firing of Low- and High-Permittivity Dielectric Tapes for Multilayer Ceramic Capacitors
Jae-Hwan Park, Young-Jin Choi and Jae-Geun Park; Korea Institute of Science and Technology, Seoul, South Korea.

Based on a same glass composition, the compatibilities in cofiring between low-K and high-K hybrid LTCC material systems were studied. By designing a lithium borosilicate glass frit system carefully, we developed an optimum glass frit system for both low-K and high-K dielectric systems. Films of glass frit and low-K dielectric materials were examined. By adjusting glass compositions and contents, we tried to match low-K and high-K tapes physically and chemically.

4:00 PM D2.8
Making Wafer Bonding viable for Mass Production.
Cher-Ming Tan1, Weibo Yu1 and Jun Wei2; 1School of EEE, Nanyang Technological University, Singapore, Singapore; 2Singapore Institute of Manufacturing Technology, Singapore, Singapore.

Wafer bonding is an attractive wafer fabrication technology for SoC, SIP, MEMS, SOI devices etc. However, traditional wafer bonding requires high temperature annealing above 800°C, and the time required for complete bonding is usually more than 100 hours. Recently, we have developed a medium vacuum wafer bonding (MVWB) for Si-SiO2. High bonding strength (larger than 20 MPa) is achievable in the bonding temperature of only 400°C, and the annealing time for complete bonding is only several hours (less than 5 hours). Table 1 shows the comparison of the bonding strength in MPa between traditional air wafer bonding and MVWB. The bonding efficiency (percentage of the bonded area over entire wafer area) of the MVWB is also compared with the traditional wafer bonding. It is found that at 400°C and 2 hours annealing, the bonding efficiency of MVWB is 99.4% whilst for traditional wafer bonding under the same conditions it is only 96%. One can see that the bonding efficiency is improved by MVWB. Qualitative description of the mechanism of MVWB is proposed in present work: Medium vacuum can enhance the out-diffusion of the water molecules and other trapped impurities at the initial porous interface, hence speed up the following reaction and the formation of Si-O-Si, Si-OH+HO-Si ↔ Si-O-Si + HOH and thus more bonding sites can be achieved before the interface close-up. This results in an increase in bonding strength and bonding efficiency as well as the bonding speed. Based on this, mathematical model for the MVWB has been derived, and the predicted bonding strength with time from the model agrees well with the experimental results. With the high bonding strength achievable in short time and low temperature, it is also observed that the required vacuum level is only 10-4 mbar, the cost of wafer bonding production is becoming feasible at an economical scale.

4:15 PM D2.9
Low Temperature Deposition of Indium Tin Oxide(ITO) Films on Plastic Substrates.
Vaudana Singh, B. Saswat and Satyendra Kumar; SCDT, HT Kanpur, HT Kanpur, Kanpur, Uttar Pradesh, India.

Organic light emitting diodes (OLED) require a transparent conducting electrode for injection of charge carriers and the emitted light to come out. Indium tin oxide (ITO) is a popular electrode material. The requirement of ITO is similar for solar cells and electronic papers. In order to exploit the full flexibility of organic semiconductor based large area electronic devices, the deposition of transparent conducting oxides on plastic substrates is essential.

Further, processing of organic devices on plastics prohibits high temperature processing. Therefore, low temperature deposition of ITO films is very important for flexible panel display and solar cells. In this work, we have carried out a systematic study of ITO deposition on polycarbonate substrates using rf magnetron deposition. For the optimization of structure, electrical conductivity and optical transparency of ITO coated films a variety of characterization tools such as X-ray diffraction, transmission measurements, sheet resistance, atomic force microscopy and spectroscopic ellipsometry were employed. The structural, electrical and optical properties of these films were investigated as a function of substrate temperature, deposition time, rf powers and different gas pressures. From these experiments, we obtained a reasonably low sheet resistance (14 W/ ?) and high transmittance (73%) in the visible region on plastic substrates. The uncoated plastic substrates had a transparency of ~85%. These properties were obtained at a substrate temperature below 100°C. These experiments used Argon gas and low temperature vacuum annealing during the deposition. It is also found that these films are not much affected by atmosphere and does not degrade with time. These films show good conductivity even after long time ageing (two to three months). From the observations it is clear that sheet resistance decreases with increase in deposition time at the same temperature. The ITO film thickness increases as expected. If deposition temperature is increased transmittance of ITO coated plastic improves. We also observe that ITO film is amorphous in nature at the temperature up to 100°C. AFM shows low surface roughness. Finally we have employed these ITO coated substrate in polymer LED structures using PPV. We conclude that these ITO coated substrates can be used successfully for the fabrication of organic light emitting displays.

4:30 PM D2.10
In-situ Spectroscopic Impedance of Different Transparent Conductive Oxides Preparing and After Sustained Plasma Exposure.
I. Ferreira, L. Raniero, R. Igeira, A. Pimentel, A. Goncalves, E. Fortunato and R. Martins; Department of Materials Science, New University of Lisbon and CEMOUP-UNINOVA, Caparica, Portugal.

In this work we studied the properties of transparent conductive oxides - TCOs (ZnO:Ga, ITO and ZnO:In) after being exposed to different hydrogen plasma conditions. The in-situ impedance spectroscopy was used to evaluate the effect of hydrogen plasma or heat treatment in vacuum conditions on the electrical properties of the TCOs. The eventual modification of the optical transmittance was determined by UV-VIS-NIR after exposing the TCOs to the initial steps of the solar cell process. The overall results indicate the pre-heating treatment in vacuum, enhances the TCOs resistivity. Nevertheless the hydrogen plasma conditions have a great and distinct influence on the transmittance and resistivity of the different TCOs studied. The ZnO:Ga is supporting extreme plasma condition without significant degradation, while the electrical an optical transmittance of ITO and ZnO:In are reduced in more than 50%. This result is consistent with the electrical characteristics of the solar cell produced using different TCOs where the ones produced with a ZnO:Ga TCO have the lowest series resistance.

4:45 PM D2.11
Preparation of ITO Thin Films for OLED Application with O2 Gas by FTS (Facing Targets Sputtering) System.
HyouWoong Kim, GeoHi Kim, MinJong Keum and KyungHwan Kim; Kyungwon Univ., KyungGi-Do, South Korea.

In this work the ITO thin films were prepared by FTS (Facing Targets Sputtering) system under different sputtering conditions which were varying O2 gas, input current and working gas pressure at room temperature. As a function of sputtering conditions, electrical and optical properties of prepared ITO thin films were measured. The FTS system consists of facing the two targets and the substrate located apart from the center of facing the two targets. Also the energetic particles are restricted by magnetic force in plasma. Therefore the FTS system contributes to suppression of high energy particles bombardment to the substrate. In the results the FTS system can deposit high quality thin films at low temperature. In the result, as increasing O2 gas [sccm] to 0.2[sccm], resistivity of ITO thin film was rapidly decreased with increasing the carrier mobility. Over O2 gas 0.2[sccm], resistivity of ITO thin film was increased with a little decreasing carrier concentration, in this section, O2 gas over 0.2[sccm] the carrier mobility have a similarly value. Transmittance of prepared ITO thin film was improved about 10% to 70% at increasing O2 gas [sccm] to 0.1[sccm]. And at O2 gas over 0.2[sccm], transmittance of prepared ITO thin films were over 80%.
Minimization and integration of all elements necessary for, e.g., a chemical analysis or a biochemical assay, is at the heart of the idea of micro-total Analysis Systems (μ-TAS) or Lab-on-a-Chip systems. However, while handling such micro-scale systems is one of the challenges, chemical devices, such as compactness, ruggedness and portability. In our lab, we work on the integration of optical elements to improve the performance and enhance the versatility of lab-on-a-chip systems. We have used silicon-on-insulator technology to realize waveguides, which can be employed for UV absorption detection in connection with, e.g., separation techniques. A typical waveguide sandwich consists of three layers (buffer, core and cladding). The doping of the core material ensures a higher refractive index, which is a prerequisite for waveguiding. The nature of the core dopant determines the optical transmission properties. We have successfully worked with a nitrogen-doping realizing UV transparent waveguides. In an effort to constantly improve the performance of waveguides, the latest generation features pure silica waveguides, which have a better transparency in the lower wavelengths and less propagation losses. Furthermore, we have fabricated arrays of up to 128 waveguides. Such waveguide arrays can be used to couple light to the waveguides for UV detection. Ensembles of beads or cells passing by will give off flashes of fluorescent or scattered light, which can be registered by a detector. The frequency associated with this flashing is related to the velocity of the particular sample. The velocity determination of particle velocities even though many hundreds of cells can be in the detection area at the same time, and it is also possible to get information about velocities changing over time. A number of waveguides for bead-based biochemical assays can be envisioned. While silica-on-silicon technology gives excellent results, it is typically also costly and time-consuming. We have also investigated to integrate waveguides with fluidic channels using cheaper materials and simple fabrication techniques, e.g., for a microdevice, where all functional elements (channels, waveguides and fiber couplers) are defined in SU-8. Only a single mask step is necessary and turnaround times for device production are around two days. Of course, the optical properties of SU-8 waveguides are quite different than those of glass waveguides. Finally, silicon-based on-chip photodiodes and SU-8-based fluidic dye lasers (developed by our colleagues at MIC), waveguides and fluidic channels were integrated to arrive at a higher functional microdevice for biochemical applications.

8:30 AM D3.1
Integration of Microporous Silicon Sensor Arrays for Chemical and Biological Detection. Karl D. Hirschmann1, Vinodh Rajalingam1, Jeffrey Clarkson1, Wei Sun2 and Philippe M. Fauchet2; 1Microelectronic Engineering, Rochester Institute of Technology, Rochester, New York; 2Electrical and Computer Engineering, University of Rochester, Rochester, New York.

A new class of silicon-based chemical and biological sensors that offer an electrical response to a variety of substances is described. The device utilizes silicon flow-through sensing membranes with deep trench structures formed to depths up to 100μm, fabricated by electrochemical etching which transforms the silicon into macroporous silicon (M-PSi). The sensors have demonstrated the ability to detect the presence of certain chemical and biological materials. Although the principle of operation of the devices is fairly complex, the transduction mechanisms can be compared to chemiresistors and chemically sensitive field-effect transistors (chemFETs). The electrical responses that are obtained are AC conductivity and capacitance. Previous work has demonstrated that upon exposure to organic solvents (i.e. ethanol, acetone, benzene) the devices exhibit responses that have shown the most sensitivity are AC conductance and capacitance. Previous work has demonstrated that upon exposure to organic solvents (i.e. ethanol, acetone, benzene) the devices exhibit responses that have shown the most sensitivity are AC conductance and capacitance. The incorporation of other materials that have demonstrated sensitivity to low ambient levels of contaminants is also under investigation. The sensors have been developed and fabricated in these array configurations; a microfluidic transport chip/package co-design is currently in progress. A configurable network interface has been developed to accommodate the use of the sensors for a variety of applications. The detection reduction in fabrication and integration of microelectronics into lab-on-a-chip microsystems will mark significant steps toward the realization of lab-on-a-chip microsystems.

9:45 AM D3.5
Study of Sputtered Hafnium Oxide Films for Sensor Applications. Christian Kunath1, Heinrich Gruege1, Eberhard Kurth1, Stephan Sorge1, Wolfram Pfe1 and Torsten Pechstein1; 1Fraunhofer IPMS, Dresden, Germany; 2E+H Conducta, Waldheim, Germany.

Transition metal oxides apply to a variety of purposes, such as surface enhancement or as dielectric layer in semiconductor applications. Some of the metal oxide properties for instance high dielectric permittivities, temperature stability, mechanical and chemical strength make them suitable for ion concentration or gas detection sensors. As the layer thicknesses may vary widely the deposition methods need to be adopted. Atomic layer chemical vapour deposition (ALCVD) and metal organic chemical vapour deposition (MOCVD) are used for thin layers whereas physical vapour deposition (PVD) is used for thicker layers. In this paper hafnium dioxide is considered that has been deposited using r.f. sputtering of a HfO2 target in a nitrogen/oxygen plasma on 150mm silicon wafers. The target impurity meets 30 ppm and is sufficient for the electrical and chemical layers properties for the application in mind. During layer deposition the equipment constitution has large influence on the final layer parameters. The influence of the main parameters plasma power, pressure, gas flow and gas mix was studied. During deposition the wafer and target were kept at room temperature. According to the development focus on sensor applications layer thicknesses in a range from 30 to 150nm were achieved forming a single layer. The layers obtained from multiple deposition steps are compared. Rapid thermal processing (RTP) with temperature ramps of about 50K/s has been used as well as oven processing with temperature slopes of about 3K/min to form the final state of the layer properties. Special research interest was focused on the comparison between annealing in inert and oxidizing atmospheres. Especially the absolute gas pressure and oxygen partial pressure during sputter deposition determine the final mechanical and sensor quality. Also the chemical inertness increases
with higher annealing temperature. Using X-ray diffraction the layers crystallinity has been studied. Using AFM and SEM the surface condition under different deposition processes have been characterized for detecting as deposited show generally amorphous state with only small amounts of crystallites below 20nm in size. The crystallographic appearance can be controlled by the annealing processing. Stress measurements by laser deflection of the wafer bow revealed, that annealing converts the original pressure layer stress into tensile stress. In order to investigate the impact on electrical properties in electronic devices dot structures and field effect transistors from these layers have been prepared and their characteristics and transistor function recorded. So transfer and drain characteristics, hysteresis and dielectric properties under various environments has been obtained.

10:30 AM *D3.5
An Electronic Nose from Arrays of Polymer Composite Vapor Sensors, Nathan S. Lewis. Division of Chemistry and Chemical Engineering, California Institute of Technology, Pasadena, California.

A method is described for generating a variety of chemically diverse, broadly responsive, low power vapor sensors. A key to our ability to fabricate chemically diverse sensing elements is the preparation of processable, air stable films of electrically conducting organic composites. An array of such sensing elements produces a chemically reversible, diagnostic pattern of electrical resistance changes upon exposure to different odors. Such conducting composite elements are simply prepared and are readily modified chemically to respond to a broad range of analytes. In addition, these sensors yield a fairly rapid, low power, dc electrical signal in response to the vapor of interest, and signals are readily integrated with software or hardware-based neural networks for purposes of analyte identification. Principle component analysis has demonstrated that these sensors can identify and quantify different airborne organic solvents, and can yield information on the components of gas mixtures.

11:00 AM D3.6
External Coupling of Molecular Dye Emission to High-Q Microdisk Resonators, David R. Bink1,2, Michael H. Bartl1,2, Lidong Zhang3, Galen D. Stucky3 and Evelyn L. Hu1,3,4. 1Electrical and Computer Engineering, UC Santa Barbara, Santa Barbara, California; 2Chemistry and Biochemistry, UC Santa Barbara, Santa Barbara, California; 3Materials, UC Santa Barbara, Santa Barbara, California; 4California NanoSystems Institute, UC Santa Barbara, Santa Barbara, California.

Semiconductor microdisk resonators have proven to be excellent high-Q microcavities with the ability to efficiently modify emission from embedded self-assembled semiconductor quantum dots. For emerging applications in, for example ultralow threshold lasing, quantum computing, and bio-sensing, however, it would be desirable to separate emitter/resonator fabrication and incorporation. This would not only greatly expand the choice of the emitting species including colloidal nanocrystal quantum dots, organo-metallic complexes and organic dyes, but would also greatly simplify and fine-tuning and optimization of both emitter and microresonator. It would be desirable to independently fabricate the emitter and resonator such that the emitter is not incorporated within the microdisk but rests on the surface. In order to couple to the microdisk, an emitter must coincide in frequency and spatially overlap the mode. Theoretical simulations show that the mode leaks out tens of nanometers in the vertical direction of the disk. We demonstrate here the proof-of-principle coupling of external emission from dye molecules to the cavity modes provided by a microdisk resonator. Coupling is achieved by bringing the dye molecules - embedded in a low refractive index SBA-15 type nanostructured hybrid silica matrix - in close proximity to the microdisk utilizing a fast and simple fabrication method that combines semiconductor microprocessing with sol-gel supramolecular self-assembly chemistry. We found that emission from dye molecules located at the rim of the microdisk is stronger and more modulated than several beams emitted from the center. In contrast, much poorer coupling was observed to emission of dye molecules in the center of the microdisk, and no mode structure was observed in the emission of dye molecules distant from the microdisk. We will discuss the external coupling behavior and efficiency in terms of spatial position of the emitter, properties of the silica host matrix, and microdisk dimensions.

11:15 AM D3.7

Array based vapor sensing has emerged as a powerful approach toward the detection of chemically diverse analytes. We have developed a unique chemical detection technology [1-4] in which colorimetric changes in an array of dyes constitute a signal much like that generated by the mammalian olfaction system; each dye is a cross-responsive sensor. This technology uses a disposable two-dimensional array of chemosensitive dyes as the primary sensor elements, making it particularly suitable for detecting a wide range of VOC's. Striking visual identification of a wide range of VOC's are easily made at parts per billion (ppb) levels, for example to aldehydes, ketones, and halo-organic compounds. Nearly all prior sensors rely exclusively on van der Waals interactions (e.g., physical adsorption on surfaces, absorption into polymers) between the analytes and the sensors. Unfortunately, vdW interactions are the weakest and least specific of all intermolecular interactions and are not effective for any process involving molecular recognition. In contrast, our design of colorimetric sensor arrays is based chemo-responsive dyes that must contain a center to interact strongly with analytes, through reversible bond formation, strong acid-base interactions, or strong dipolar interactions. The consequent dye classes from these requirements are aromatic dyes that are (1) Lewis acid dyes (i.e., metal ion containing dyes), (2) Bronsted acidic or basic dyes, and (3) dyes with large permanent dipoles (solvatochromic dyes). By using hydrophobic hydrophobic substrates, we have avoided essentially any resistance to changes in humidity, which is a very serious problem for other electronic nose technology. A variety of recent applications will be discussed. [1] Rakow, N. A.; Suslick, K. S. "A Colorimetric Sensor Array for Odor Visionalization" Nature, 2000, 406, 710-714. [2] Suslick, K. S.; Rakow, N. A. "Colorimetric Artificial Nose Having an Array of Dyes & Method for Artificial Olfaction" U.S. Patent 6, 568, 558; April 9, 2002. [3] Suslick, K. S.; Rakow, N. A.; Sen, A. "Colorimetric Artificial Nose Having an Array of Dyes and Method for Artificial Olfaction: Shape Selective Sensors" U.S. Patent 6, 495, 102; Dec. 17, 2002. [4] Suslick, K. S., Rakow, N. A.; Sen, A. "Chemsesing: A Colorimetric Array Detector" Proc.ISOEN02 (ed. A. D’Amico and C. DiNatale; IEEE: Baltimore, 2003), pp. 46-52. [5] Suslick, K. S. "An Optoelectronic Nose: Colorimetric Sensor Arrays" MRS Bulletin, 2004, 29, 720-725. Suslick, K. S.; Rakow, N. A.; Sen, A. "Colorimetric Sensor Arrays For Molecular Recognition" Tetrahedron 2004, in press; 11:45 AM D3.8

For micro total analysis systems methods for micropatterning, scaling, and manufacturability, as well as techniques for connecting the microstructures to the macroworld are of particular significance. Monolithic instruments consists of an assembly of three-dimensional integrated modules (e.g. fluidic networks, electrical and optical sensors, microelectronic circuits) to support the efficient interconnections. To demonstrate the feasibility of a specific lab-on-microchip, results on a fabricated micro fluid flow system with monolithically integrated optical detectors based on amorphous silicon and an electroosmosic micropump without moving parts and a mass flow sensor using the thermal anemometric principle are reported. Further developments and potential applications for microanalysis are outlined. The fluidic channel network is built into a polymer layer SU-8 which sandwiched between two plates (e.g. glass-glass, ASIC waffer-glass). In case of the cytometer the excitation light, $\lambda_{exc}=380\text{nm}$, enters through the glass plate and irradiates the chromosome in the channel. Lab-on-chip test results with antitactile-cocaine (Ox) demonstrate a significant difference in the normalized intensity spectrum of Ox and Ox-H+ according to 200nm amount of substance. Experimental test parameters are bias voltage $V_{bias}=-2.5\text{V}$, detection volume $\Delta V=26\text{nl}$, fluid concentration $c=10^{-5}\text{M}$, diode area $A_{D}=0.12\text{mm}^2$ and a constant flow of 1ul/min. The micropump consists of several stages of narrow channel structures (channel cross section $4\mu m \times 15\mu m$) to enhance electroosmosic flow. The pump operates at voltage around 4.6V, it is capable of pumping against the hydrostatic pressure that arises from differences in the liquid level of the reservoirs. Typical pumping speeds are on the order of $100\text{ul}/\text{sec}$ corresponding to the flow rate of 5nl/min. The present pump design uses a PDMS cover to allow electroosmotic gases to escape the pumping channels. The mass flow sensor consists of a heater sandwiched between two temperature sensors, all made of platinum and placed on the substrate on the channel's bottom. The flow rate measurements for DI water were performed using a syringe pump. The sensitivity is about 1pA/(nl/min) at the amplifier input for flow rates ranging from 10nl/min to 2ul/min. It can be improved by thermal isolation of the sensor elements from the substrate.

SESSION D4: Photonic Systems
Chair: Don Gardner
Wednesday Afternoon, March 30, 2005
Room 8008 (Moscone West)
As the degree of integration in ICs continues to increase, electrical interconnects are facing severe limitations such as speed, power dissipation, and cross-talk. On-chip optical interconnects are promising solutions to these problems associated with large multi-GHz Si ICs particularly in global signaling and clocking. In such applications, monolithic integration of photodetectors (PD) with the advanced Si CMOS is essential to accommodate a high density of detectors on the chip in a cost-effective manner. MSM-PDs are attractive for their integration simplicity for low-cost realization of Si-based optoelectronics. Efficient distribution of optical signal to PDs is of utmost importance in optical transceivers. Waveguides play a key role in optical systems due to their ease of integration. Moreover, being mechanically compliant, polymer waveguides can tolerate thermal expansion mismatches and maintain optical alignment. In this work, Si MSM-PDs are integrated with Si of Polymer Pillars, interconnection technology that enables high density and mechanically compliant electrical and optical I/O interconnects at the wafer level. Intergenerated Si-MSMs were fabricated by liftoff of 15nm Ti and 35nm Au. A thin (<1µm) SiO2 layer for adhesion was then deposited at 150°C on the prefabricated Si MSM-PDs. Avaratel 2000P polymer was spin-coated followed by UV irradiation, hard bake, and spray development. Finally, wafers were cured for 1 hour at 200°C. Pillars with varying aspect ratio were fabricated on identical MSM-PDs. Some pillars were intentionally removed to assess the effects of polymer processing on detector performance. Current-voltage (I-V) characteristics for PDs with different measured waveguide thicknesses were measured using a picoammeter and a voltage source. Photo-to-dark current ratio normalized to input optical power (NPDR) was measured to evaluate overall device performance. NPDR was higher for PDs with better surface passivation coverage. A consequence of low NPDR was the effect of changes in light-emitting devices. We demonstrated the possibility of controlling the electroluminescence signal by means of SAW. In the present work, PDs were systematically characterized by current-voltage, light-voltage, photoconductivity, and lifetime measurements at cryogenic temperature. The traveling electric field associated with SAWs was found to drive electrons into the p-side of the junction where both electrons and holes are present and allow detailed studies of the effects of the acoustic modulation in light-emitting devices. We demonstrated the possibility of controlling the electroluminescence efficiency by means of SAWs. In the present work, PDs were systematically characterized by current-voltage, light-voltage, photoconductivity, and lifetime measurements at cryogenic temperature. 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theoretical simulations. The results obtained demonstrate effective indices in a range from $\eta_{eff} = 0.994$ to 0.6, good to very good focusing performance under sufficient transverse band conditions. For example, at 7.59 GHz and for the TM mode, $\eta_{eff} = 0.0042$, increasing to 0.53 if the frequency is increased to 12 GHz. The maximum intensity in the focus spot increases from 3 to 40 (in terms of a transmission coefficient and gain) under these conditions. If the TE mode is chosen, an effective index cannot be defined and the lens behaves as if a beam splitter. The experimental results compare favourably or, even quite well with theoretical predictions, albeit some trade-off may be needed in more complex conditions. This device is easily scaled to other frequency bands and may find uses not only in the microwave regime, but also in the THz and optical part of the spectrum.

2:45 PM D4.5 MBE Growth of High Quality GaAs on Si through Direct Ge Buffers. Xiaojun Yu, Yu-Hsuan Kuo, Junxian Fu and James S. Harris; Solid State and Photonics Laboratory, Stanford University, Stanford, California.

The realization of low defect density GaAs on Si heteroepitaxy would enable monolithic integration of III-V materials and devices with conventional Si integrated-circuit (IC) technology. However, GaAs/Si heteroepitaxy has been hampered by the existence of threading dislocations, which are induced during GaAs growth on Si substrates. The threading dislocations propagate from the Si/GaAs interface into the GaAs layer, leading to a decrease in electronic performance. Various techniques, such as high temperature growth, Ge buffer layers, and high pressure growth, have been attempted in order to reduce the threading dislocation density in the GaAs layer. The threading dislocations mostly originate from the Si/GaAs interface and propagate into GaAs, instead of starting from GaAs/Ge interface. The anti-phase domains are negligible which are mainly confined near the GaAs/Ge interface. The structural properties of the films were characterized by measuring structural, optical and compositional and annealing limits for the observation of luminescence have been determined. Refractive indices of these films have been analyzed using transmission ellipsometry of the films. For example, at 7.59 GHz and for the TM mode, $\eta_{eff} = 0.0042$, increasing to 0.53 if the frequency is increased to 12 GHz. The maximum intensity in the focus spot increases from 3 to 40 (in terms of a transmission coefficient and gain) under these conditions. If the TE mode is chosen, an effective index cannot be defined and the lens behaves as if a beam splitter. The experimental results compare favourably or, even quite well with theoretical predictions, albeit some trade-off may be needed in more complex conditions. This device is easily scaled to other frequency bands and may find uses not only in the microwave regime, but also in the THz and optical part of the spectrum.

2:45 PM D4.6 Characterization of Undoped ZnO Thin Films Prepared by O3-Assisted Pulsed Laser Deposition. Tamiko Oehshima1, Shouta Nakashima1, Yuki Matsunaga1, Hiroharu Kawasaki1, Yoshiaki Suda1 and Kenji Eibohara2; 1Sasebo National College of Technology, Sasebo, Japan; 2Kumamoto University, Kumamoto, Japan.

Zinc oxide (ZnO) is a II-VI wide direct band gap semiconductor and is an important material in various fields of applications such as transparent conductive electrodes, surface acoustic wave devices and optoelectronic devices. ZnO is suitable for an ultraviolet light-emitting devices due to its wide direct band gap (3.37 eV) with a large exciton binding energy of 60 meV at room temperature. Because spontaneously grown ZnO thin films form donor defects such as oxygen vacancies or zinc vacancies or interstitial zinc, they have n-type conductivity. Many researchers have synthesized p-type ZnO thin films by impurity doping or co-doping techniques have been performed. In this research, we have attempted to synthesize undoped ZnO thin films with p-type electrical conductivity by pulsed laser deposition (PLD) method using a second harmonic Nd:YAG laser. High oxidation ozone (O3) gas was used in order to compensate oxygen vacancies and suppress interstitial zinc. Undoped ZnO thin films deposited on the corning glass and silicon substrates at various conditions were characterized by measuring structural, optical and electrical properties. The structural properties of the films were analyzed by X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS). Photoluminescence (PL) measurement and a UV-visible spectrometer were used to study the optical properties. The electrical properties such as conduction type (p-type or n-type), carrier density, resistivity and mobility were investigated by Hall measurement. Undoped ZnO thin films were grown on different substrate temperature of room temperature and the O3 + O2 gas pressure of 1.3 Pa. The post-annealed ZnO thin films showed c-axis orientation having a sharp (002) diffraction peak. The ZnO thin films prepared in the O3 concentration region of 3,000-5,000 ppm showed p-type conduction.

3:30 PM D4.8 Luminescent Si Nanocrystals Formed Within Silicon Rich Silicon Oxide Thin Films. Tyler Roschuk1,2, Michael Flynn1,2, Jacek Wojcik1,2, Othman Zalloun1,2, Edward Irving1,2 and Peter Mascher1,2; 1Engineering Physics, McM aster University, Hamilton, Ontario, Canada; 2Centre for Electro photonic Materials and Devices, McMaster University, Hamilton, Ontario, Canada.

Silicon nanocrystals have been the subject of many research projects in the past few years. Quantum confinement effects resulting from their small size have been used to enhance luminescence. This has brought hope in the search for a silicon based emission device, something that is typically disregarded in photonics due to the indirect bandgap of silicon, which makes emission from Si an inefficient process. In this research, we have investigated the formation of silicon nanocrystals in silicon rich silicon oxide (SiO$_2$) thin films, with compositions from 36% to 50% Si, deposited by electron cyclotron resonance plasma enhanced chemical vapor deposition and annealing at temperatures up to 1200 °C in an Ar ambient. The resulting phase separation and nanocrystal nucleation have been analyzed as a function of the initial composition and annealing conditions through the use of transmission electron microscopy (TEM), Raman spectroscopy, and Fourier transform infrared spectroscopy experiments. TEM has also been used to examine the nanocrystal size and distribution within the films. Photoluminescence experiments for these films have been conducted with a HeCd laser emitting at 266 nm. Through these experiments compositional and annealing limits for the observation of luminescence have been determined. Refractive indices of these films have been analyzed using transmission ellipsometry of the films. For example, at 7.59 GHz and for the TM mode, $\eta_{eff} = 0.0042$, increasing to 0.53 if the frequency is increased to 12 GHz. The maximum intensity in the focus spot increases from 3 to 40 (in terms of a transmission coefficient and gain) under these conditions. If the TE mode is chosen, an effective index cannot be defined and the lens behaves as if a beam splitter. The experimental results compare favourably or, even quite well with theoretical predictions, albeit some trade-off may be needed in more complex conditions. This device is easily scaled to other frequency bands and may find uses not only in the microwave regime, but also in the THz and optical part of the spectrum.

4:15 PM D4.8 Towards CMOS Compatible Nanophotonics. Mark Brongersma, Rashid Zia, Anurantita Tewary, Anu Chandran, Rajag Pala, John Lii, John Schuler, Alex Guichard, Rohan D. Kekatpure, Andrew Carlson, Benjamin Reddy, David N. Bursic, Peter B. Catrysse and Mark D. Selker; Geballe Laboratory for Advanced Materials, Stanford University, Stanford, California.

The tremendous growth of the communication industry has increased the demand for new photonic functionality at a low cost. For this purpose, it would be highly desirable to have light sources, waveguides, amplifiers, and detectors that are monolithically fabricated on Si with CMOS technology. The materials used in current CMOS integrated circuit technologies are chosen to optimize electronic performance. However, upon closer examination these materials are also suitable for generating, manipulating, and detecting optical signals. The unique properties of Si nanostructures such as nanowires and nanotubes may be exploited to fabricate light sources, light emitters, and SPOLEs, and Si and SiO$_2$ can be used to fabricate an array of other high performance devices. For example, at 7.59 GHz and for the TM mode, $\eta_{eff} = 0.0042$, increasing to 0.53 if the frequency is increased to 12 GHz. The maximum intensity in the focus spot increases from 3 to 40 (in terms of a transmission coefficient and gain) under these conditions. If the TE mode is chosen, an effective index cannot be defined and the lens behaves as if a beam splitter. The experimental results compare favourably or, even quite well with theoretical predictions, albeit some trade-off may be needed in more complex conditions. This device is easily scaled to other frequency bands and may find uses not only in the microwave regime, but also in the THz and optical part of the spectrum.

4:30 PM D4.7 Improved Luminescent Efficiency of PDP Blue Phosphor by Microwave Irradiation. Sin-Ping Lee, Chun-Ching Lin, Kuang-Ting Kuo and San-Yuan Chen; Materials Science and Engineering, National Chiao-Tung University, Hsinchu, Taiwan.

BaMgAl1017:Eu2+ phosphor is useful and commercial blue
phosphor for plasma display panel and lamp. For the enhancement of phosphor efficiency, it is necessary to be advanced in the particle size and morphology of the phosphor materials. Highly luminescent efficiency blue-light phosphors have been successfully produced by microwave irradiation treatment. The SEM images and XRD analysis reveal that the surface morphology of the blue-light phosphors can be notably modified by microwave irradiation to become more spherical shapes and exhibit with better crystalline property. In addition, the surface of the phosphor is formed cleaner with a few surface defects, which acts as a quenching site consuming photoexcited electrons. The vacuum ultraviolet (VUV) PL spectra show that the microwave irradiation treatment can effectively enhance the luminescent efficiency by a factor of 2.5 times for intensity in comparison with that phosphor without microwave treatment. The improvement in all visible emission can be related to the modified surface morphology to induce the large internal quantum efficiency and increased crystalline properties of the blue-light phosphors. The commercial phosphors make re-treatment to reach highly luminescence by microwave irradiation. These results demonstrate that such a simple approach can provide for the fabrication of highly luminescent efficiency phosphors for the optoelectronic devices.

4:45 PM D4.10
Tungsten Oxide Nanoribbons Fabricated in Moisturized Environment. Yiu WingChing1,2, Hong HunQuan1,2, Wu HuaSheng1,2, Wei ZhiFeng1 and Xu ShiJie1,
1Department of Physics, The University of Hong Kong, Hong Kong, China; 2CAS and HKU Joint Laboratory on New Materials, Hong Kong, China.

Tungsten oxide is a very potential material for photonic and superconducting applications due to its wide bandgap and superconducting behavior. However, due to the lack of preparation methods, the reported nanostructures for this material so far are limited to nanowires and nanorods. We report in this paper the first successful synthesis of tungsten oxide nanoribbons using a novel thermal oxidation method. Also the morphologies and optical properties relationship of tungsten oxide nanoribbons, as well as that of nanowires and nanorods were investigated. By oxidizing tungsten plate under a moisturized condition at 650 °C, and using Potassium iodide as catalyst, tungsten oxide nanoribbons were obtained on a large scale; while under a dry synthesis environment, only nanowires and nanorods were realized. The morphologies and optical properties relationship of the nanostructures were examined using scanning electron microscopy (SEM), transmission electron microscopy (TEM), and low temperature photoluminescence (PL). As-grown nanoribbons, with 30nm thick and length up to 300nm, exhibit similar photoluminescence spectra with the value reported for a tungsten oxide film, whereas nanowires and nanorods have different photoluminescence spectra. Therefore, it can be concluded that the appearance of tungsten oxide nanoribbons is strongly dependent on the moisturized fabrication conditions, and that the photoluminescence properties are related to the morphologies of the nanostructures. Acknowledgement: This work is supported by the HKUGC grant HKU7054/03P.