CAICISS result can be proposed that the Al atoms occupy selectively T4 site and at one end of a Si dimer as substituted a Al atom for a Si atom in a dimer. To determine the structure of the Al-induced nanoclusters definitely, classical ion trajectory simulations using scattering and recoiling imaging code (SARIC) have been performed for the recently proposed most possible four different cluster models (Bunk et al [Appl. Surf. Sci. 123-124 (1998) 104], Zotov et al [Phys. Rev. B 57 (1998) 12492], kotlyar et al [Surf. Sci. 506 (2002) 80] and mixed Al-Si nanocluster model [Surf. Sci. 504 (2002) 101]). Our CAICISS spectra and simulation results show that the Bunk model is best plausible one of the other three models. It is suggested that Al-Si dimer oriented with a bonding length (Δ z) of 1.00 $\pm$ 0.05 $\mathring{A}$ on topmost layer.

SESSION I10: Active Si Photonic Devices
Chair: Harry Atwater
Thursday Morning, April 20, 2006
Room 3007 (Moscone West)

8:30 AM *I10.1

Proposal for Mid-infrared Silicon Raman lasers. Bahram Jalali, Varun Raghunathan, Ramesh Shori and Oscar M Stafsudd; Electrical Engineering Department, University of California, Los Angeles, Los Angeles, California.

Silicon Photonics has achieved some key milestones in recent years in its quest towards realizing low cost, high speed optoelectronic components. The enormous infrastructure available for Silicon device manufacturing and the economy of scales have been the motivating factors in this direction. In particular, Raman scattering has been successfully used to demonstrate Lasers[1,2] and amplifiers[3,4] on pure Silicon chip. In these demonstrations, schemes like low duty cycle pulse pumping and reverse-biased carrier sweep out were employed to minimize the impact of nonlinear losses due to free carrier absorption processes. However, the maximum output power of the Raman laser is limited by the nonlinear losses and the presence of free carriers also increases the on-chip heat dissipation. In addition to this, the need for an external optical pump poses a question regarding the place of Silicon Raman lasers at telecom wavelengths, where the III-V laser technology has already made significant impact. The two-photon absorption effect which is responsible for creation of free carriers in Silicon is found to reduce significantly when pumped at energy less than half the band gap (~2.2μ m)[5]. This implies that Silicon Raman lasers pumped at mid infrared(MIR) wavelengths can operate without the competing nonlinear loss mechanisms. The linear absorption loss data[6] for Silicon also suggests that the low-loss window extends from 1.1-8μ m in wavelength. In addition to this, the absence of suitable semiconductor lasers at MIR wavelengths along with the high damage threshold of Silicon is expected to make it a potentially viable material for realizing MIR wavelength Raman devices. MIR wavelengths in the range of 2-5μ m is an important band for free space communications, bio-chemical detection and certain medical applications. Most gases and biological compounds have fundamental resonances at the MIR and can be detected using these sources. The strong absorption of water and skin cells at these wavelengths renders theses sources as attractive tools for dentistry, eye surgery etc. The implementation of Silicon Raman devices at these wavelengths could potentially miniaturize the devices used in these applications. Moreover, the inherent Stokes tunability with pump wavelength and the prospects of cascaded stokes emission could help achieve wavelengths not easily reachable using other schemes. This talk proposes a new technology, ie. Silicon Raman lasers that operate at MIR wavelengths, and discusses its applications. Silicon is compared with other standard material used as MIR sources. To support this vision, measurement of linear and nonlinear losses of Silicon at both telecom and MIR wavelengths will be presented. 1.O. Boyraz et. al.,Opt. Express, 12, 5269(2004) 2.H. Rong et. al.,Nature, 13,725(2005) 3.V. Raghunathan et. al.,CLEO, CMU1, Baltimore(2005) 4.R. Jones et. al. Nature,13,519(2005) 5.R.A. Soref, private communications 6.Properties of Silicon,INSPEC(1998)

9:00 AM I10.2

Thermo-electrical Analysis of an Optoelectronic Modulator Integrated in a SOI Rib Waveguide Operating in the Gb/s Regime. Mario Iodice, Giuseppe Coppola and Rocco Cristian Zaccuri; IMM-CNR, Napoli, Italy.

Silicon is the most diffused material for microelectronic industry and, in recent times, it is becoming more and more widespread in integrated optic and optoelectronic fields. The newest generation of photonic integrated circuits also provides on-chip optical waveguides for interconnection among active devices and improvement of optical coupling to mono-mode fibers, for instance, by means of tapered terminations. We present the thermo-electro-optical analysis of an integrated waveguide-vanishing-based optical modulator based on free-carrier dispersion effect, realizable on standard SOI wafer. The active region is 3x3 μ m^2 wide and the lateral confinement is guaranteed by two highly-doped As (8x 10^{19} cm^{-3}) and B (2x 10^{19} cm^{-3}) implanted regions 1-μ m-deep each. The implantation processes have been carefully tuned in order to get higher doping uniformity and sharp profile. The process-flow is defined using 2-D process simulation software ATHENA, by SILVACO International. This structure allows to obtain a planar device, fully compatible with electronic devices, avoiding structural steps which are harmful for photolithography processes. The 2-D semiconductor device simulation package ATLAS, by SILVACO International, has been employed to analyze the coupled electro-thermal behavior of our modulator, in particular with the aim to investigate the thermal impact of the internally generated heat on the optical characteristics, both in static and dynamic conditions. All optical analyses were performed by C2V complementary software, based on finite difference method. The electrical section of the modulation acts as a lateral p-i-n diode, which injects free carriers into the rib volume between the doped regions. The resulting channel waveguide shows single mode operation and propagation losses of about 0.8 dB for a 500-μ m-long active region. The optical behavior is based on the vanishing of the lateral confinement in the rib region, and consequent cut-off of the propagating mode. This phenomenon occurs at driving voltage of about 1.0 V, with electrical power consumption of 1.3 mW. It implies a rapid variation of the propagating characteristics, and, as consequence, the optical beam lateral redistribution into the structure. Results show that an optical modulation depth close to 100% can be reached with a rise time of about 10 ns. Fall time can be even faster, if a suitable reverse polarization is applied to the device. In our case, fall time is about 2 ns. Smart electrical driving, that is an injection overdrive of a few volts for a very short time, allows to reach rise time shorter than 1 ns. For that bias scheme the fall transient is then limiting the whole dynamic and the resulting bit rate is about 500 Mb/s. Finally, we analyzed the effect of active region area shrinking to a 1x1 μ m^2. For this size, we observe an improvement of the dynamic behavior, associated with a bias overdrive, that allows to obtain optical modulation in the Gb/s regime.

9:15 AM I10.3

Microstrutural, Optical and electro-optical Properties Of Ba0.5Sr0.5TiO3 Thin Film Deposited By Pulsed Laser Deposition For Active Low Loss Waveguide Applications. Mounir Gaidi[1,2], Marcello Ferrera[1,3], Fulvio Cusimano[1,3], Robin Helsten[1], Yongwoo Park[1], Jose Azana[1], Roberto Morandotti[1], Pasquale Cusumano[3] and Mohamed Chaker[1]; [1]INRS-EMT, Varennes, Quebec, Canada; [2]Adtek Photomask Inc, Monteral, Quebec, Canada; [3]Department of Electrical Engineering, University of Palermo, Palermo, Italy.

Barium Strontium Titanate (Ba0.5Sr0.5TiO3 or BST) films were grown by means of a reactive pulsed-laser-deposition technique on SiO2 /Si substrate. Microstructural and surface morphology of BST films were characterized by X-ray diffraction (XRD), Scanning electron microscopy (SEM) and atomic force microscopy (AFM). Films deposited at 400 ° C were amorphous and presented wide cracks. Crystallization was induced by annealing the films at 600 ° C. On the other hand, BST films deposited at 550 ° C present a cubic perovskite structure with a dense and smooth surface. The optical constants (n and k as a function of wavelength) of the films were obtained using variable angle spectroscopic ellipsometry (VASE) in the UV-Vis- NIR regions. Films deposited at 550 ° C present a high refractive (2.29) and low optical losses. Microfabricated BST /SiO2 /Si ridged waveguides were patterned using UV photolithography and high-density plasma etching. Propagation and loss characteristics at the telecommunication wavelength of 1.55 μ m were investigated using top-view scattering and Fabry-Perot resonance methods. For specific ridge widths, we obtained single-mode propagation with relatively low losses (~1 dB/cm). A high quadratic electro-optic coefficient, was obtained at 632.8 and 1550 nm by using single-beam (ellipsometric) and interferometric configuration. The tunability (electro-optical effect) of BST films decreases with the increase of oxygen pressure, indicating a strong correlation between optical, electro-optical and microstructural properties. The low optical losses and high electro-optical effect of the deposited BST thin film demonstrate the strong potential of this material for active guided-wave components for advanced optical integrated systems.

9:30 AM I10.4

High Sensitivity Sensor Based on Porous Silicon Waveguide. Sharon M Weiss[1], Guoguang Rong[1], Jarkko J. Saarinen[2] and John E. Sipe[2]; [1]Electrical Engineering & Computer Science, Vanderbilt University, Nashville, Tennessee; [2]Department of Physics and Institute for Optical Sciences, University of Toronto, Toronto, Ontario, Canada.

We report on a new sensor design for ultra-sensitive detection of chemical and biological species. The sensor combines the advantages of the large internal surface area of porous silicon and the high electromagnetic field strength localized in a waveguide mode. Light of