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The IEEE International Conference on Group IV Photonics (GFP) is one of the leading international conferences focused on Silicon Photonics and other group IV element based photonic materials and devices. The 10th IEEE International Conference on Group IV Photonics will be held at the Grand Hilton Seoul in the beautiful city of Seoul Korea from 28-30 August 2013. The conference is planned as a single track conference and will include both oral and poster sessions of contributed and invited papers comprising reviews on a number of important and timely topics. A post-deadline session will feature the most recent and exciting results. Technical results on group IV element photonic materials and devices, including integration and fabrication technologies are welcomed. The success of the GFP conference depends on a large extent on your contributions and active participation. We strongly encourage you to attend the conference and submit your most recent results.

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WEDNESDAY, 27 AUGUST 2014	THURSDAY, 28 AUGUST 2014	FRIDAY, 29 AUGUST 2014
GENERAL SESSION: SPACE ADDENAUER AND EXHIBITS/COFFEE BREAK: SALON HONNORAT		
REGISTRATION: SPACE ADDENAUER FOYER		
WA: Welcome/Introduction & Plenary Session 8:15am-10:00am	**ThA:** Integration 8:15am-10:00am	**FA:** Silicon Laser Sources 8:30am-10:00am
EXHIBITS/COFFEE BREAK 10:00am-10:30am		
WB: Silicon Modulators 10:30am-12:15pm	**ThB:** Hybrid Photonics with New Materials 10:30am-12:30pm	**FB:** Bio and Wavelength Sensing 10:30am-12:00pm
LUNCH BREAK (ON OWN) 12:15pm-1:30pm	LUNCH BREAK (ON OWN) 12:30pm-1:45pm	LUNCH BREAK (ON OWN) 12:00pm-1:30pm
WC: GeSn Photonics 1:30pm-3:00pm	**ThC:** Resonator-Based Photonics 1:45pm-3:45pm	**FC:** Emission from Germanium 1:30pm-3:00pm
EXHIBITS/COFFEE BREAK 3:00pm-3:30pm	EXHIBITS/COFFEE BREAK 3:45pm-4:15pm	EXHIBITS/COFFEE BREAK 3:00pm-3:30pm
WD: MID-IR Photonics 3:30pm-4:45pm	**ThD:** Coupling and Polarization Issues 4:15pm-5:30pm	**FD:** Modulation and Switching 3:30pm-4:45pm
WE: Passive Photonic Devices 4:45pm-6:00pm	**Poster Session II** Salon Honnorat 5:30pm-6:45pm	**Post-Deadline Session:** Space Addenauer 4:45pm-5:30pm
Welcome Reception/Poster Session I Salon Honnorat 6:00pm-8:30pm		**Registration Hours:** 27- 28 August 2014: 7:00am-5:00pm 29 August 2014: 8:00am-3:00pm

Thursday, 29 August 2013

8:30 AM – 10:30 AM
Session ThA: Silicon Modulators
Session Chair: TBD

ThA1 8:00 AM - 8:30 AM (Invited)

Integration of High Performance Silicon Optical Modulators, D. Thomson, F. Gardes, Y. Hu, G. Mashanovich, G. Reed, *University of Southampton, Southampton, UK*, L. Zimmermann, D. Knoll, S. Lischke, *IHP, Frankfurt (Oder), Germany*, H. Porte, *Photline Technologies, Besançon, France*, B. Goll, H. Zimmermann, *Vienna University of Technology, Vienna, Austria*, L. Ke, P. Wilson, *University of Southampton, Southampton, UK*, S. Chen, S. Hsu, *National Tsing Hua University, Hsinchu, Taiwan, R.O.C.*, G. Duan, A. Le Liepvre, C. Jany, A. Accard, M. Lamponi, D. Make, *III-V Lab, Palaiseau, France*, F. Lelarge, *III-V, Palaiseau, France*, S. Messaoudene, D. Bordel, J. Fedeli, *CEA LETI, Grenoble, France*, S. Keyvaninia, G. Roelkens and D. Van Thourhout, *Ghent University-IMEC, Ghent, Belgium*

We present our recent work on high speed silicon optical modulators developed within the UK silicon photonics and HELIOS projects. Examples of their integration with other photonic and electronic elements is also presented

ThA2 8:30 AM - 8:45 AM

Novel Transmission Lines for Si MZI Modulators, J. Witzens, F. Merget, M. Sharif Azadeh, B. Shen, M. P. Nezhad and J. Hauck, *RWTH Aachen University, Aachen, Germany*

We present MZI Silicon Photonics modulators with an advanced transmission line design which overcomes bandwidth limitations arising from crosstalk and improves linear losses. Push-pull optical bandwidth of 22.2 GHz with VpL=1.6 V.cm is experimentally validated.

ThA3 8:45 AM - 9:00 AM

Strong Quantum-Confined Stark Effect from Light Hole Excitonic Transition in Ge Quantum Wells for Ultra-Compact Optical Modulator, P. Chaisakul, D. Marris-Morini, M. Rouifed, *Université Paris Sud, Orsay, France*, J. Frigerio, G. Isella, D. Chrastina, *Politecnico di Milano, Como, Italy* and L. Vivien, *Université Paris Sud, Orsay, France*

New possibilities of light modulation in Ge/SiGe quantum wells are experimentally explored using asymmetric polarization dispersion of light-hole excitonic transitions. QCSE from electron-light-hole transition can significantly reduce footprint, energy dissipation over the previously-studied electron-heavy-hole transition.

ThD4 4:45 PM - 5:00 PM

Low Temperature Surface Passivation for Carrier Injection Type SiGe Optical Modulator, Y. Kim, J. Han, M. Takenaka and S. Takagi, *University of Tokyo, Tokyo, Japan*

Surface passivation using Al2O3 deposited at 200 oC is examined to suppress surface recombination for carrier injection SiGe optical modulators. The modulation efficiency is improved by 1.3 by inserting Al2O3 layer prior to SiO2 deposition.

ThD5 5:00 PM - 5:15 PM

Evaluation of Chemical Potential for Graphene Optical Modulators Based on the Semiconductor-Metal Transition, T. Kayoda, J. Han, M. Takenaka and S. Takagi, *The University of Tokyo, Bunkyo-ku, Japan*

TD-BPM simulation exhibits high modulation efficiency of 0.61 dB/um in graphene optical modulators based on the semiconductor-metal transition. Evaluation of graphene chemical potential in graphene-gate-metal MOS capacitors demonstrates feasibility of device principle for 1.55-um wavelength.

ThD6 5:15 PM - 5:30 PM

Excess Carrier Lifetimes in Ge Layers on Si, R. Geiger, *Paul Scherrer Institut, Villigen, Switzerland*, J. Frigerio, *L-Ness, Dipartimento di Fisica del Politecnico di Milano, Como, Italy*, M. J. Süess, R. A. Minamisawa, *Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, Villigen, Switzerland*, D. Chrastina, G. Isella, *L-Ness, Dipartimento di Fisica del Politecnico di Milano, Como, Italy*, R. Spolenak, *Laboratory for Nanometallurgy, ETH Zürich, Zürich, Switzerland*, J. Faist, *Institute for Quantum Electronics, ETH Zürich, Zürich, Switzerland* and H. Sigg, *Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, Villigen, Switzerland*

Electron/hole lifetimes in thermally strained Ge layers on Si are deduced from time-resolved infrared pump-probe transmission spectroscopy. A doping scheme with n-doped Ge on intrinsic Ge yields maximum lifetimes of approximately 3 ns.

5:30 PM – 7:00 PM
Session ThP: Poster Session II, Emerald Hall A
Session Chair: TBD

ThP1

Uniform Characteristics of Si-wire Waveguide Devices Fabricated on 300 mm SOI Wafers by Using ArF Immersion Lithography, Y. Tanushi, T. Kita, *Department of Communication Engineering, Tohoku University, Sendai, Japan*, M. Toyama, M. Seki, K. Koshino, N. Yokoyama, M. Ohtsuka, A. Sugiyama, E. Ishitsuka, T. Sano, T. Horikawa, *National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan* and H. Yamada, *Department of Communication Engineering, Tohoku University, Sendai, Japan*

We have investigated characteristics uniformity of Si-wire waveguide devices formed on 300 mm SOI wafers by using ArF immersion lithography process. Very low dispersion of group indices within wafers was confirmed from measurements of asymmetric Mach-Zhender interferometers.

ThP2

Dense Photonics Integration on a Micron-Scale SOI Waveguide Platform , T. Aalto, M. Cherchi, M. Harjanne, M. Kapulainen and S. Ylinen, *VTT Technical Research Centre of Finland, Espoo, Finland*

Feasibility of micron-scale SOI waveguides for dense photonics integration is demonstrated. Compact circuits are obtained by applying multiple etching steps on 3-12 µm thick SOI layers. Optoelectronics is integrated on SOI using thermo compression bonding.

ThP3

Optimization of Stress-Induced Pockels Effect in Silicon Waveguides for Optical Modulators, A. Aleali, D. Xu, J. H. Schmid, P. Cheben, *National Research Council of Canada, Ottawa, Canada* and W. N. Ye, *Carleton University, Ottawa, Canada*

A method for the optimization of strain-induced Pockels effect in silicon waveguides is proposed. We introduce a new figure of merit and show a 35% enhancement in FOM compared to most efficient reported devices.

ThP4

Ultra-Compact Hybrid Silicon Plasmonicpolarization Diversity Circuit, L. D. Sanchez, S. Mas and P. Sanchis, *Valencia Nanophotonics Technology Center, Valencia, Spain*

A polarization diversity circuit with a footprint of 21µm2 based on a hybrid silicon plasmonic polarization splitter and rotator is reported. The device features insertion losses below 6.1dB and extinction ratios above 21dB.

ThP5

Microring Stacks for Vertical Coupling between Photonic Planes, J. T. Bessette and D. Ahn, *Samsung Advanced Institute of Technology - America, Cambridge, MA, USA*

We present designs for stacked Si microring couplers for compact exchange of optical signals between photonic planes separated vertically in excess of 10 µm with wide bandwidth and flat pass-bands.

ThP6

Global Optimization of Silicon Nanowires for Efficient Parametric Processes, D. Vukovic, J. Xu, J. Moerk, L. K. Oxenloewe and C. Peucheret, *Technical University of Denmark, Kgs. Lyngby, Denmark*

We present a global optimization of silicon nanowires for parametric single-pump mixing. For the first time, the effect of surface roughness-induced loss is included in the analysis, significantly influencing the optimum waveguide dimensions.

ThP7

Slotted Silicon Microring Resonators with MultimodeInterferometer Couplers, Y. Xiong and W. N. Ye, *Carleton University, Ottawa, Canada*

We demonstrate a SOI slotted microring resonator using a multimode interferometer (MMI) coupler. We achieved high bandwidth of 0.25 nm, and a quality factor Q of ~6000 for rings with a radius of 20 µm.

ThP8

Proposed Best Practices in Silicon Photonics Layout vs. Schematic Physical Verification, J. Ferguson, *Mentor Graphics Corp., Wilsonville, OR, USA* and F. Pikus, *Mentor Graphics Corporation, Wilsonville, OR, USA*

Silicon photonics promises significant performance improvements and manageable production costs. However, photonics designers must embrace some fundamental process changes. We propose best practices for accurate extraction and layout vs. schematic comparison of silicon photonics circuits.

ThP9

Phase Matching of Degenerate Four Wave Mixing in Silicon-Chalcogenide Slot Waveguides, P. W. Nolte, C. Bohley and J. Schilling, *Martin-Luther-University Halle-Wittenberg, Halle, Germany*

We present a novel design route for silicon/chalcogenide hybrid slot waveguides, which allows waveguide geometries with FOM > 1, a maximum field concentration within the infiltrated material and a vanishing group velocity dispersion (GVD) at the same time.

ThP10

A Small-Signal Model for Modulation Response of a Silicon Ring Modulator, Y. Ban, J. Lee and W. Choi, *Yonsei University, Seoul, Korea*

We derive a small-signal model for modulation response of a Si ring modulator. Our model is based on the multiple round-trip model but it gives simple but accurate description of the ring modulator modulation dynamics.

Small-Signal Frequency Responses for Si Micro-Ring Modulators

Yoojin Ban[1], Jeong-Min Lee[1], Byung-Min Yu[1], Seong-Ho Cho[2], and Woo-Young Choi[1]
[1]Department of Electrical and Electronic Engineering, Yonsei University, Seoul, Korea
[2]High Performance Device Group, Samsung Advanced Institute of Technology, Yongin, Gyeonggi-do, Korea

Abstract: We present a new small-signal model for the modulation frequency response of a Si micro-ring modulator. The model is based on the coupled-mode theory and has the well-known second-order system characteristics. The accuracy of the model is confirmed with measured Si MRM small-signal frequency response.

Si photonics is attracting a great amount of research interest as it is the best platform for realizing high-bandwidth, low-power, and small footprint optical interconnect systems [1, 2]. One of the key components for optical interconnect systems based on Si photonics is a Si electro-optic modulator that can provide large bandwidth and high modulation efficiency with small size and power consumption [3]. A Si micro-ring modulator (Si MRM) is a very attractive device in this regard and there have been several reports of very high-speed operation [4, 5]. An accurate modeling of Si MRM characteristics is crucial for successful realization of the Si MRM. In particular, an accurate but easy-to-use model for Si MRM modulation bandwidth is of great interest for Si MRM performance optimization as well as Si MRM driver circuit design. Although there have been several reports of numerical analyses of Si MRMs [6, 7], such approaches can be time-consuming and do not provide physical insights. Previously, we reported an analytic small-signal frequency model for the Si MRM based on the round-trip analysis [8]. In this paper, we present a new small-signal model based on the coupled-mode theory (CMT) [9]. Our new model is much more convenient to use as it has the well-known second-order system characteristics. In addition, we confirm the accuracy of our model with measured results.

Fig. 1 shows dimensions of the Si MRM used for our investigation. The input light in a bus waveguide is partially coupled into the ring and, after experiencing round-trip phase shifts, coupled out to the bus waveguide. The round-trip phase shift is electrically tunable with an embedded reverse biased PN junction for high-speed modulation. The figure also includes a photograph of the Si MRM used for the present study. It is fabricated through the OpSIS-IME multi-project-wafer foundry service on 220-nm thick Si on 2-μm thick buried oxide layer. Fig. 2 shows the measured transmission characteristics of the device biased at -1 V.

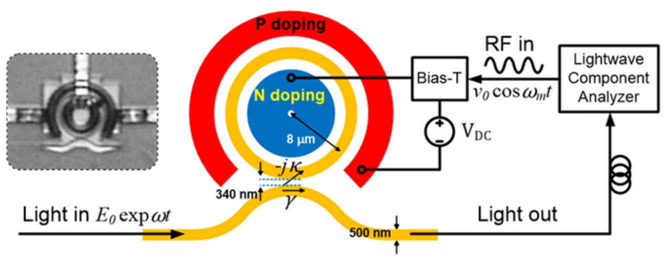

Fig. 1. Structure of a Si MRM (Photograph of the Si MRM)

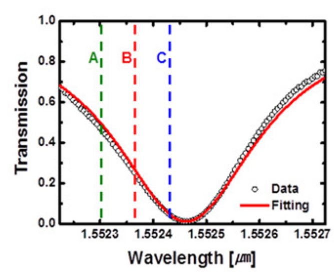

Fig. 2. Transmission at -1 V bias voltage

From the CMT, Si MRM dynamics can be modeled as [9]

$$\frac{da(t)}{dt} = \left(j\omega_0 - 1/\tau\right)a(t) - j\mu E^i(t) \text{ and } E^t(t) = E^i(t) - j\mu a(t). \quad (1)$$

In the above equation, $a(t)$ represents the total energy stored in the ring with resonance angular frequency ω_0. ω_0 is given as $2\pi mc/(\eta_0 L)$ with the mode number m, the speed of light c, the group index of the ring η_0, and the ring circumference L. $E^i(t)$ and $E^t(t)$ represent input and output light field, respectively, where $E^i = E_0\exp(\omega t)$. τ is the decay time constant satisfying $1/\tau = (1-\alpha^2+\kappa^2)c/(2\eta_0 L)$, where α represents the round-trip loss and κ is the coupling coefficient for the ring-bus coupler. μ is the mutual coupling coefficient satisfying $\mu^2 = \kappa^2 c/(\eta_0 L)$. η_0 ~4, α ~0.956 and κ ~0.262 can be determined for our MRM from the measured transmission characteristic shown in Fig. 2.

When the MRM is modulated by the applied small voltage signal, $v_0\cos(\omega_m t)$, around the bias voltage, the group index can be expressed as $\eta(t) = \eta_0 + (\partial\eta/\partial v)\, v_0\cos(\omega_m t)$. Then, Eq. (1) is modified as

$$\frac{da(t)}{dt} = \left(j\omega_0 - 1/\tau\right)\eta_0\left[1/\eta_0 - v_0/\eta_0^{\,2}(\partial\eta/\partial v)\cos(\omega_m t)\right]a(t) - j\mu E^i(t), \text{ and } E^t(t) = E^i(t) - j\mu a(t). \qquad (2)$$

Since the mutual coupling is not very much affected by the instantaneous group index change, we assume μ does not change with time [10].

After applying the usual small-signal approximation to Eq. (2), we can derive h(t), defined as $E^i(t) / E^t(t)$, as

$$h(t) = H_0 + H(\omega_m)\exp(j\omega_m t) + H\left(-\omega_m\right)\exp(-j\omega_m t),$$

$$\text{where } H_0 = \frac{j\omega - j\omega_0 + 1/\tau - \mu^2}{j\omega - j\omega_0 + 1/\tau} \text{ and } H(\omega_m) = \mu^2\frac{v_0}{2j\omega_m\eta_0}\frac{\partial\eta}{\partial v}\left[\frac{j\omega_0 - 1/\tau}{j\omega - j\omega_0 + 1/\tau} - \frac{j\omega_0 - 1/\tau}{j\omega_m + j\omega - j\omega_0 + 1/\tau}\right]. \qquad (3)$$

After taking the Laplace transform of Eq. (3), we obtain $\Delta(s)$, MRM small-signal response in the s-domain for modulation frequency ω_m relative to DC response, as

$$\Delta(s) = \left|\frac{H(\omega_m)H_0^{*} + H^{*}(-\omega_m)H_0}{H_0 H_0^{*}}\right| = G\frac{s+z}{s^2 + (2/\tau)s + D^2 + 1/\tau^2} = G\frac{s+z}{(s+1/\tau + jD)(s+1/\tau - jD)}, \qquad (4)$$

where z is roughly equal to μ^2, and detuning D that indicates how far the input light frequency is away from the resonance frequency is given as $D = |\,\omega - \omega_0\,|$. As can be seen from Eq. (4), $\Delta(s)$ has one zero and two complex poles.

Fig. 3 (a) shows measured frequency responses with the input light detuned at 4, 12, and 20 GHz from the resonance using the lightwave component analyzer. The difference in DC gain is due to the difference in the slope of the transmission curve for each detuning as can be seen in Fig. 2. To remove the frequency dependence of our measurement setup and the grating coupler, we normalized 20- and 12-GHz detuning responses with 4-GHz detuning response. Fig. 3 (b) and (c) show the resulting normalized responses as well as the calculated results obtained from Eq. (4). Measurement and calculation results are in very good agreement, confirming the accuracy of our small-signal model. .

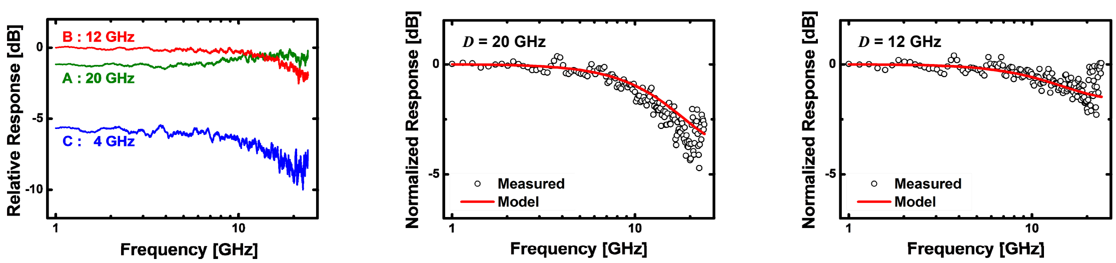

Fig. 3. (a) Frequency response at different detuning level, normalized frequency response of (b) 20 GHz detuning and (c) 12 GHz detuning

In summary, we derived and confirmed a new small-signal model of a Si MRM based on the coupled mode theory. With our small-signal model, the complicated modulation dynamics of Si MRM can be easily analyzed as the resulting model has the well-known second order system characteristics. It should be very useful for designing and analyzing Si MRMs as well as Si MRM driving circuits.

References

[1] R. Soref , "The Past, Present, and Future of Silicon Photonics," JOSA A 14, 1678 - 1687 (2006).

[2] Q. Xu, B. Schmidt, S. Pradhan, M. Lipson, "Micrometre-scale silicon electro-optic modulator" Nature 435, 325-327 (2005).

[3] P. Dong, S. Liao, D. Feng, H. Liang, D. Zheng, R. Shafiiha, C.-C. Kung, W. Qian, G. Li, X. Zheng, A. V. Krishnamoorthy, and M. Asghari, "Low Vpp, ultralow-energy, compact, high-speed silicon electro-optic modulator," Opt. Express, vol. 17, no. 25, 22484–22490 (2009).

[4] G. Li, A.V. Krishnamoorthy, I. Shubin, J. Yao, Y. Luo, H. Thacker, X. Zheng, K. Raj, J.E. Cunningham, "Ring Resonator Modulators in Silicon for Interchip Photonic Links," J. Sel. Topics Quantum Electron 19, 3401819, (2013).

[5] X. Li, H. Xu, Y. Hu, K. Xiong, Z. Li, T. Chu, J. Yu, and Y. Yu, "44-Gb/s Silicon Microring Modulators Based on Zigzag PN Junctions," *IEEE Photon. Technol. Lett.*, vol. 24, no. 19, 1712–1714 (2012).

[6] L. Zhang, Y. Li, J.-Y. Yang, M. Song, R. G. Beausoleil, and A. E. Willner, "Silicon-based microring resonator modulators for intensity modulation," IEEE Select. Topics Quant. Electron. 16, 149–158 (2010).

[7] M. Song, L. Zhang, R. G. Beausoleil, and A. E. Willner, "Nonlinear distortion in a silicon microring-based electro-optic modulator for analog optical links," J. Sel. Topics Quantum Electron 16, 149 - 158 (2010).

[8] Y. Ban, J. -M. Lee, and W. –Y. Choi , "A small-signal model for modulation response of a silicon ring modulator," 10th IEEE Int. Conf. GFP (2013)

[9] B. E. Little, S. T. Chu, H. A. Haus, J. S. Foresi, and J.-P. Laine, "Microring resonator channel dropping filter," J. Lightwave Technol., vol. 15, 998–1005 (1997).

[10] S. Akiyama and S. Nomura, "Dynamic response of modulators based on cascaded-ring-resonator," Opt. Express, vol 20, no 20, 21847–21859 (2012).