The 23rd Opto-Electronics and Communications Conference

OECC 2018

Conference Program & Abstracts

July 2 – 6, 2018

ICC Jeju, Korea

• Organized by
  Optical Society of Korea (OSK)

• Cosponsored by
  Korean Institute of Communications and Information Sciences (KICS)
  Institute of Electronics and Information Engineers (IEIE)

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  International Society for Optics and Photonics (SPIE)
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  The Optical Society of Japan (OSJ)
  Chinese Society for Optical Engineering (CSOE)
  Taiwan Photonics Society (TPS)

• Supported by
  Korea Tourism Organization (KTO)
  Korean Federation of Science and Technology Societies (KOFST)
  Jeju Special Self-Governing Province
  Jeju Convention & Visitors Bureau (JCVB)
# OECC 2018 Program

## July 02 (Mon.)

<table>
<thead>
<tr>
<th>Time</th>
<th>Venue</th>
<th>Event</th>
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<tbody>
<tr>
<td>14:00-17:00</td>
<td>Samda Hall A (Room A) 301</td>
<td>Workshop I: Direct Detection vs. Coherent Detection for Short- and Intermediate-Haul Applications, Silicon Photonics</td>
</tr>
<tr>
<td>17:00-18:00</td>
<td>Samda Hall B (Room B) 302</td>
<td>Workshop II: Registration (12:00-18:00)</td>
</tr>
<tr>
<td>18:00-20:00</td>
<td>Lobby (3F)</td>
<td>Get-Together Party (Ocean View, 5F)</td>
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## July 03 (Tue.)

<table>
<thead>
<tr>
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<th>Venue</th>
<th>Event</th>
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<tbody>
<tr>
<td>08:45-09:00</td>
<td>Samda Hall A (Room A) 303</td>
<td>Opening ceremony</td>
</tr>
<tr>
<td>09:00-09:45</td>
<td>Samda Hall B (Room B) 301</td>
<td>Plenary Talk I - Roel Baets (Halla Hall, 3F)</td>
</tr>
<tr>
<td>09:45-10:30</td>
<td>Samda Hall A (Room A) 303</td>
<td>Plenary Talk II - Masatoshi Suzuki (Halla Hall, 3F)</td>
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<tr>
<td>10:30-11:00</td>
<td>Samda Hall B (Room B) 301</td>
<td>Coffee Break</td>
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<tr>
<td>11:00-11:45</td>
<td>Samda Hall A (Room A) 303</td>
<td>Plenary Talk III - Sanghoon Lee (Halla Hall, 3F)</td>
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<tr>
<td>12:30-14:00</td>
<td>Samda Hall A (Room A) 303</td>
<td>Lunch</td>
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<tr>
<td>14:00-15:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk I - Roel Baets (Halla Hall, 3F)</td>
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<tr>
<td>15:30-16:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Coffee Break</td>
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<tr>
<td>16:00-17:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk II - Masatoshi Suzuki (Halla Hall, 3F)</td>
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## July 04 (Wed.)

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<tr>
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<tbody>
<tr>
<td>08:30-10:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk I - Roel Baets (Halla Hall, 3F)</td>
</tr>
<tr>
<td>10:00-10:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>10:30-12:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk II - Masatoshi Suzuki (Halla Hall, 3F)</td>
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<tr>
<td>12:00-13:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Lunch</td>
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<tr>
<td>13:00-14:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Poster Session I (Lobby, 3F)</td>
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<tr>
<td>14:00-15:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk III - Sanghoon Lee (Halla Hall, 3F)</td>
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<tr>
<td>15:30-16:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>16:00-17:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Poster Session II (Lobby, 3F)</td>
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## July 05 (Thu.)

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<tbody>
<tr>
<td>08:30-10:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk I - Roel Baets (Halla Hall, 3F)</td>
</tr>
<tr>
<td>10:00-10:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>10:30-12:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk II - Masatoshi Suzuki (Halla Hall, 3F)</td>
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<tr>
<td>12:00-13:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Lunch</td>
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<tr>
<td>13:00-14:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Poster Session III (Room A)</td>
</tr>
<tr>
<td>14:00-15:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk III - Sanghoon Lee (Halla Hall, 3F)</td>
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<tr>
<td>15:30-16:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>16:00-17:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Poster Session IV (Room A)</td>
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## July 06 (Fri.)

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<tbody>
<tr>
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<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk I - Roel Baets (Halla Hall, 3F)</td>
</tr>
<tr>
<td>10:00-10:30</td>
<td>Halla Hall A (Room A) 303</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>10:30-12:00</td>
<td>Halla Hall A (Room A) 303</td>
<td>Plenary Talk II - Masatoshi Suzuki (Halla Hall, 3F)</td>
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## Exhibitions

- **Mode Division Multiplexing**
- **Direct-Detection Systems**
- **Optical Fiber Applications**
- **Silicon Photonics**
- **Passive Devices**
- **10Giga Internet and Broadband Access**

## Workshops

- **Workshop I**
- **Workshop II**

# Banquet

- **Lunch**
- **Dinner**
- **Banquet**
### Tuesday, July 3

#### Room D (302)

- **3D2-1 16:00-17:30**
  - **Optical Transmitter 1**
  - **Session Chair:** Nicola Calabretta (TU/e)
  - **Invited**

#### Room E (Halla Hall A)

- **3E2-1 16:00-16:30**
  - **Silicon Nitride (TriPleX™) based Photonic Integrated Circuits for a Broad Range of Application Modules**
  - **Session Chair:** Benjamin J. Eggleton (The Univ. of Sydney)
  - **Invited**

- **3E2-2 16:30-17:00**
  - **Integrated Polarization Diversity Devices**
  - **Invited**

- **3E2-3 17:00-17:15**
  - **Two- and Three-Dimensional Polymer Directional Coupler for High-Density Optical Interconnects at 1550 nm**
  - **Invited**

#### Room F (303)

- **3F2-1 16:00-16:30**
  - **Symposium 1**
  - **10Giga Internet and Broadband Access**
  - **Session Chair:** Xiang Liu (Huawei), T. Nirmalathas (The Univ. of Melbourne)
  - **Invited**

- **3F2-2 16:00-17:00**
  - **State of Broadband Access and High Speed PON**
  - **Invited**

- **3F2-3 17:00-17:30**
  - **Deployment of 10G Internet and Broadband Access: Korean Story**
  - **Invited**

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**3D2-1 16:00-16:30**

**Modeling Depletion-Type Si Ring Modulators**

- **Woo-Young Choi**, Minkyu Kim, Myungjin Shin, Byung-Min Yu, Christian Mai, Stefan Lischke, and Lars Zimmermann
- **Yonsei Univ., Korea, IHP, Germany**

For achieving monolithic integration of Si electronics and photonics, accurate and convenient-to-use models for Si photonic devices are very important. We present such a model for depletion-type Si ring modulators.

**3D2-2 16:30-17:00**

**Ultra-Low-Power Microring Modulators for PAM and WDM Links**

- **Wei Shi** and **Yelong Xu**
- **Université Laval, Canada**

We review our recent results on low-power microring modulators for pulse-amplitude modulation and high-quality frequency comb generation. This single-laser WDM solution is promising for next-generation optical interconnects.

**3D2-3 17:00-17:15**

**A Wavelength Stabilization Integrated Circuit for 25-Gb/s Si Micro-Ring Modulator**

- **Min-Hyeong Kim**, Lars Zimmermann, and Woo-Young Choi
- **Yonsei Univ., Korea, IHP, Germany**

We demonstrate wavelength stabilization of Si micro-ring modulator (MRM) with an integrated circuit custom-designed in 0.25-μm BiCMOS technology. Our circuit controls the MRM temperature so that it can have the maximum optical modulation amplitude with 25-Gb/s modulation.

**3D2-4 17:15-17:30**

**An Actively Mode-Locked Laser based on a 5th Order Micro-Ring Resonator**

- **Qihong Wu**, Yuhua Li, Shaohao Wang, Qian Li, and Sai Tak Chu
- **Peking Univ., China, City Univ. of Hong Kong, China, Fuzhou Univ., China**

We present a mode locked laser configuration with an integrated 5th order micro-ring resonator, where highly stable pulse trains with single and multiple pulses per period have been achieved.

**3E2-1 16:00-16:30**

**Integrated Photonics 1**

- **Session Chair:** Benjamin J. Eggleton
- **Invited**

**3E2-2 16:30-17:00**

**Integrated Polarization Diversity Devices**

- **Kyong Han Kim**, Yudae Kim, Yoohan Kim, Dong Wook Kim, and Moon Hyoek Lee
- **Inha Univ., Korea, Heinrich Hertz Inst., Germany**

Integrated polarization diversity devices, such as polarization beam splitter, polarization rotator, and polarizer, are very important in silicon-based photonic integrated circuits. The integrated polarization diversity devices are introduced, and experimentally demonstrated results are reported.

**3E2-3 17:00-17:15**

**Analytical Investigation of Generic Form Expressing Adaptive Dispersion of Optical Fractional Fourier Transform Circuit**

- **Tomohiro Naganuma** and **Hiroyuki Uenohara**
- **Tokyo Inst. of Tech., Japan**

We clarified the regularity of the dispersion performance of an optical fractional Fourier transform circuit, realizing variable dispersion compensation in an optical OFDM system. The generic form of dispersion performance is presented.

**3F2-1 16:00-16:30**

**State of Broadband Access and High Speed PON**

- **Hyung Jin Park**
- **KT, Korea**

An overview of recent developments of the SiN based TriPleX™ Photonic-Integrated-Circuit technology is given. The unique features of the technology are explained and application examples in a variety of wavelength ranges are shown.

**3F2-2 16:30-17:00**

**Broadband Access in Japan and Flexible Optical Access**

- **Sangyeup Kim**
- **NTT Corp., Japan**

**3F2-3 17:00-17:30**

**Deployment of 10G Internet and Broadband Access: Korean Story**

- **Sung-uk Rha**
- **NIA, Korea**

We demonstrate wavelength stabilization of Si micro-ring modulator (MRM) with an integrated circuit custom-designed in 0.25-μm BiCMOS technology. Our circuit controls the MRM temperature so that it can have the maximum optical modulation amplitude with 25-Gb/s modulation.
Modeling Depletion-Type Si Ring Modulators

Woo-Young Choi, Minkyu Kim, Myungjin Shin, Byung-Min Yu,
Christian Mai*, Stefan Lischke*, and Lars Zimmermann*.
Department of Electrical and Electronic Engineering, Yonsei University, Seoul Korea.
* IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Abstract

For achieving monolithic integration of Si electronics and photonics, accurate and convenient-to-use models for Si photonic devices are very important. We present such a model for depletion-type Si ring modulators.

Depletion-type Si ring modulators (RMs) have a very large potential for applications in high-performance optical interconnect systems, since they have the large modulation bandwidth and the small size [1, 2]. For optimal design of electronic-photonic ICs containing both Si RMs and electronic circuits, such Si RM models are required that are easy to use and compatible with standard IC design tools. In addition, the extraction of model parameters should be simple and straightforward.

Various models for Si RM have been reported [3-5]. However, they either require a substantial amount of computation time or not very compatible with the standard IC design tools. A new approach that overcomes these problems has been proposed [6].

Fig. 1(a) shows the structure of a Si RM used for the present investigation. It is fabricated by IHP Si photonics foundry service. Its characteristics can be accurately modeled by the coupled-mode equations [7]:

\[
\frac{d}{dt}a(t) = \left( j\omega - \frac{1}{\tau} \right) a(t) - j \frac{2}{\tau_e} E_e(t),
\]

(1)

\[
E_e(t) = E_i(t) - j \frac{2}{\tau_e} a(t).
\]

(2)

In the above equations, \(a(t)\) is the optical energy amplitude stored in the ring resonator, \(E_i(t)\) and \(E_e(t)\) are the input and the output optical field, respectively. \(\omega\) is the ring resonance angular frequency given as \(\omega_r = 2\pi mc/n_{res}L\), where \(m\) is an integer representing the resonance mode number, \(c\) is the velocity of light in vacuum, \(L\) is the ring circumference, and \(n_{res}\) is the effective index of the ring waveguide at the resonance. \(\tau\) is the decay time constant for \(a(t)\), given as \(1/\tau = 1/\tau_e + 1/\tau_i\) where \(\tau_e\) and \(\tau_i\) represent the decay time constant in \(a(t)\) due to the coupling loss and input optical field, respectively.

If numerical values of three parameters \((n_{eff}\, \tau_e\, \text{and}\, \tau_i)\) are known, the RM characteristics can be well modeled. For the extraction of these values, the minimum mean square error method is used for fitting the steady-state equation to the measured transmission characteristics. Fig. 1(b) shows the measured normalized transmission characteristics at three different bias voltages. Dots are measured results and solid lines are fitted results with extracted values.

Fig. 2. Measured and simulated E/O frequency responses for different detuning values. [8]

With these parameters, the Si RM small-signal modulation frequency response in the s-domain can be derived from the coupled-mode equations as [8]

\[
G = \frac{s + 2/\tau_e}{D^2 + (2/\tau_e)D + 1/\tau_i^2}
\]

(3)

where \(D\) represents how much the input light angular frequency is detuned from the resonance angular frequency, \(G\) is the response gain given in terms of \(n_{eff}\, \tau_e\, \text{and}\, \tau_i\), and \(D\). Fig. 2 confirms the accuracy of this small-signal model with the measured results.

In order to implement the large-signal RM model which can provide the RM transient modulation characteristics, the coupled-mode equations can be
numerically solved in Verilog-A [5]. However, this approach has limitation in that its simulation takes quite a long time for achieving high accuracy. A piece-wise linear model based on the equivalent circuit representing Eq. 3 can provide much fast computation in SPICE environment [6].

![Diagram](image1.png)

**Fig. 3(a)** A large-signal equivalent circuit model of Si RM and (b) Simulated (upper) and measured (lower) eye-diagrams for 2-Vpp, 25-Gbps, 2^11-1 PRBS input signal. [6]

This new model can be very easily used for co-simulation of electronic circuits and Si RMs. **Fig. 4(a)** shows a schematic diagram for an integrated 25-Gbps Si photonic transmitter (Si RM and driver). Such an electronic-photonic integrated circuit can be fabricated monolithically with IHP’s Photonic BiCMOS technology, which provides high-performance 0.25-µm SiGe BiCMOS circuits and Si photonic components on the same Si platform [9]. **Fig. 4(b)** shows the simulated vertical eye opening normalized to input optical power at different values of Itail and RL, two key parameters in the driver design that determine eye-opening, power consumption, and bandwidth. **Fig. 4(c)** shows simulated eye-diagrams at three different conditions represented by point A, B, C in **Fig. 4(b)**. Clearly, the optimal combination of Itail and RL can be easily determined.

**REFERENCES**


