Low-power Si-photonic Multi-channel Filter Controller for High-capacity Programmable Optical Switching Network

Thesis Proposal

김 현 규

Contents

- Introduction
- Motivation
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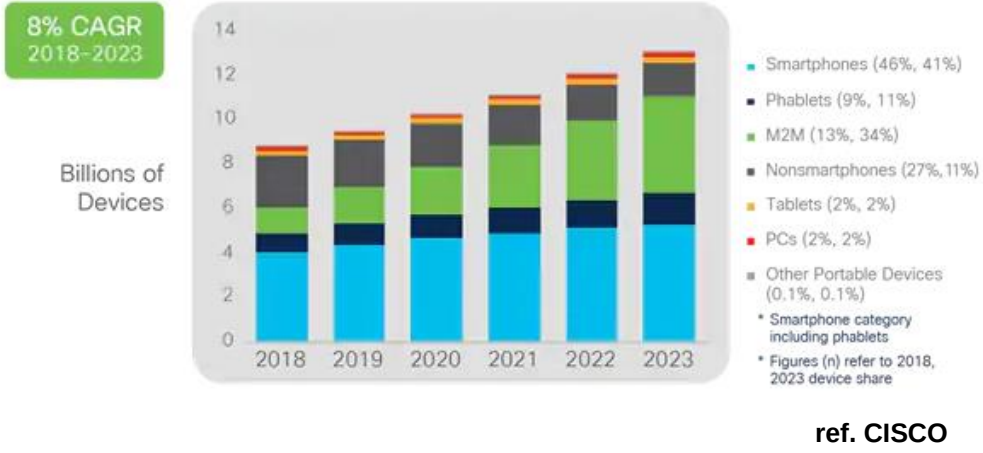
Data-center Nowadays

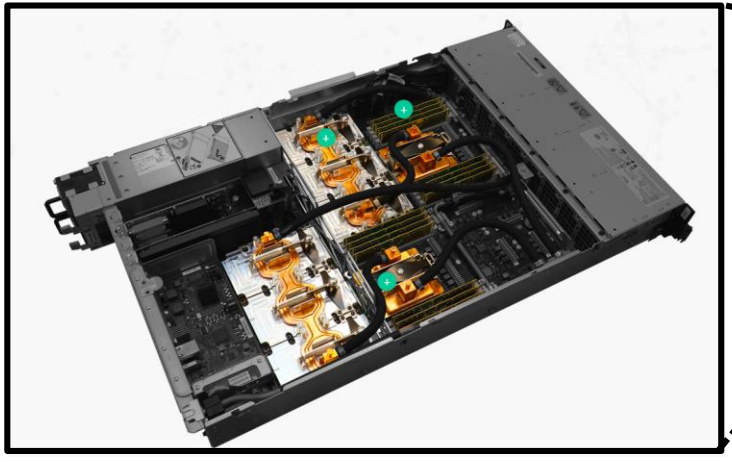


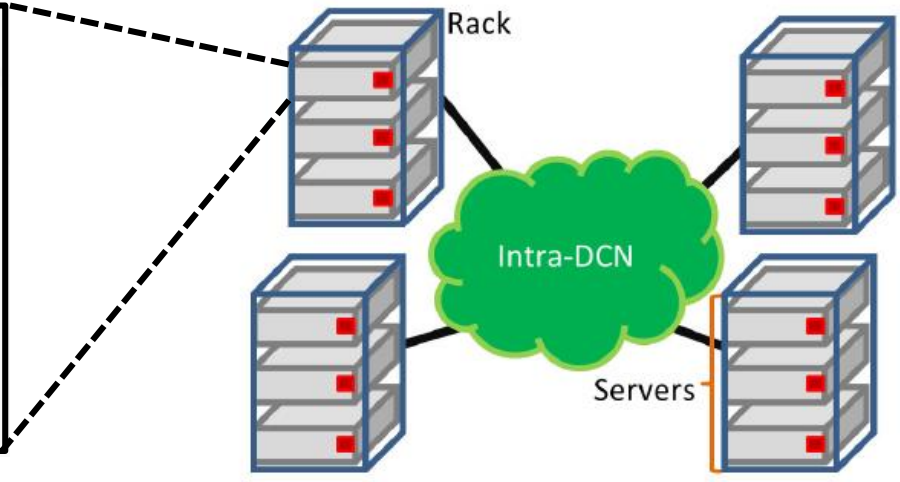
ref. CISCO

Why the data center industry continues to grow?

- **Rapid growth of mobile / cloud / video service**
- **Machine to Machine(M2M) communication**

Growing burden to Data-center





< Nodes of IBM – ORNL SUMMIT >

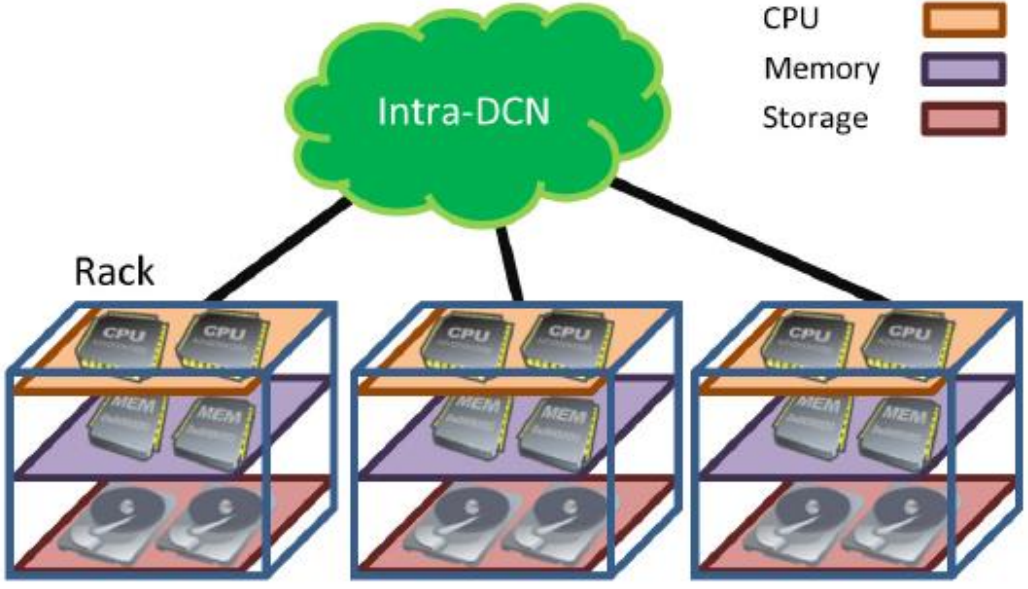
- Processing : 26.7 TFLOPS
- Efficiency : 13.9 GFLOPS/W
- Mellanox EDR 100G InfiniBand Opcial I/O

✓ **Increasing data traffic leads to inefficiency of available resources**

✓ **Delay in data processing → Worse quality of service**

➢ ***Need a new type of server and network architecture***

Next Generation of Data-center Network(DCN)



< Disaggregated Data-center Network >

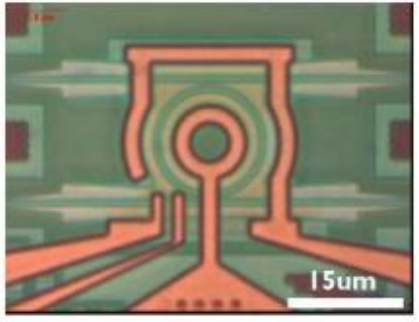
- **Optical link of data center : Between server I/O → Between hierarchy I/O**
- **Beyond the limits of electrical switches → Optical switch**

What to do?

- **Ring-resonator based switching network**

  - ✓ **Using Si wafer**
    - **Mass production**
    - **Using existing Si industry**
  - ✓ **Small footprint device**
    - **High integration density**

→ Si photonics based ring-resonator

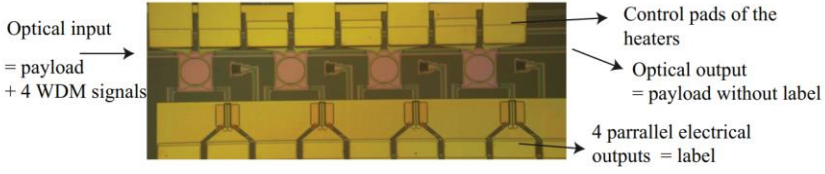


(IMEC)

Modulator

(IME)

Switch



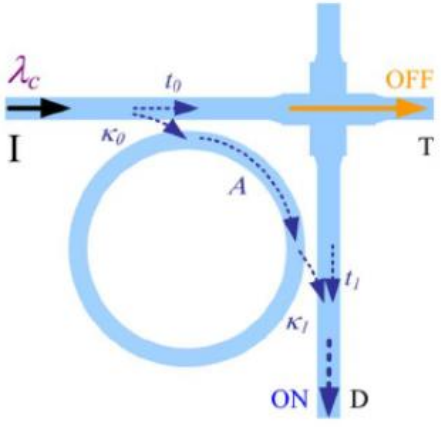
(Ghent Univ.)

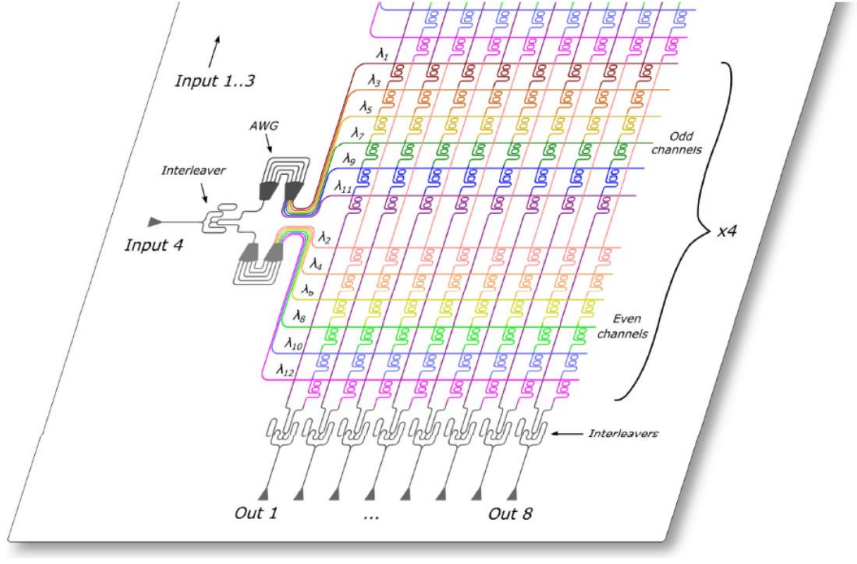
WDM Filter

< Ring-resonator based optical devices >

What to do?

- **Scalable algorithm**





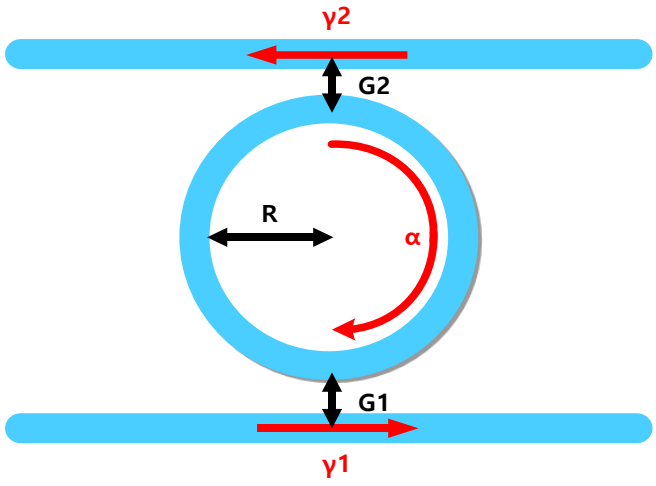
- ✓ **Series processing**

→ **Control algorithm design needs to be considered up to N matrices**

- ✓ **Parallel processing**

What to do?

- **Power consumption optimization**



$$n_{eff} L = m\lambda_{res}$$

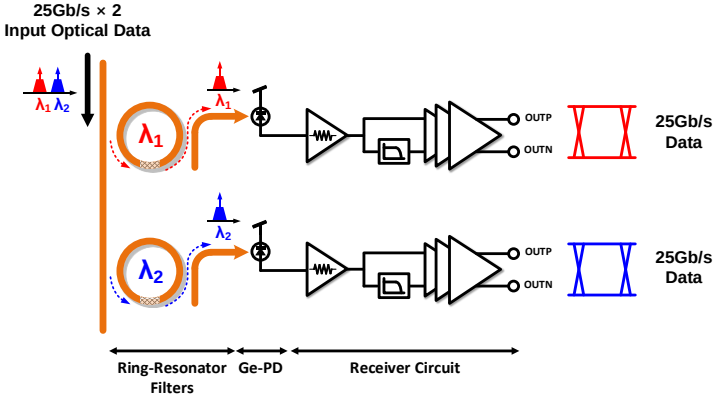
→ **Sensitive to temperature!**

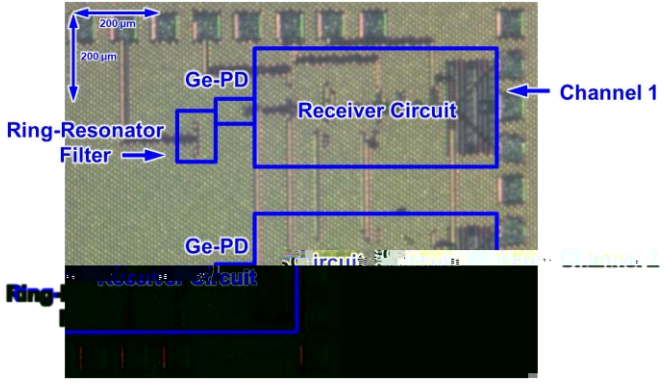
- ✓ **Unsystemized channel scanning and routing**
- ✓ **Uncertainty by process variation**
  - ➢ **High power consumption for control**

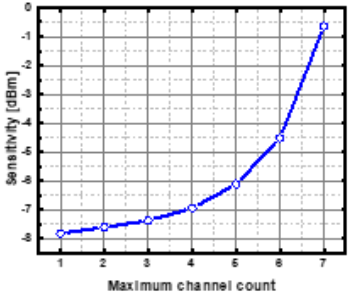
1. **Using systemized initial scanning method**
2. **Compensate the process variation**

What I did?

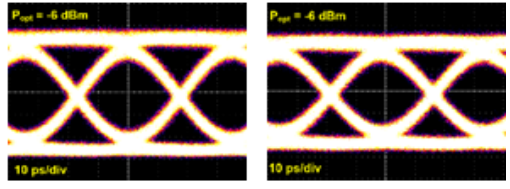
- **Co-optimization of ring-resonator and optical receiver**





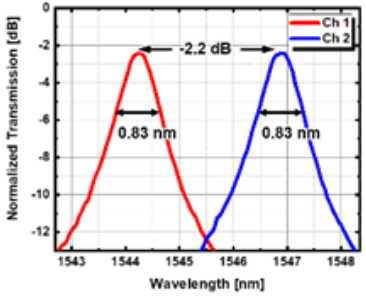


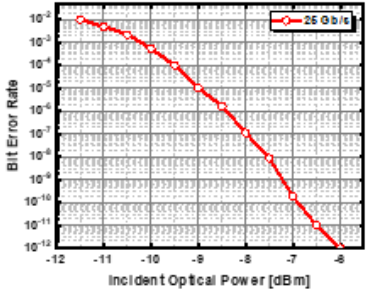
< Channel Count vs Sensitivity >



< Channel 1 > < Channel 2 >

< Eye Diagram >

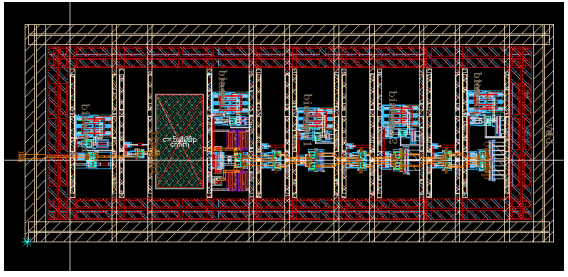




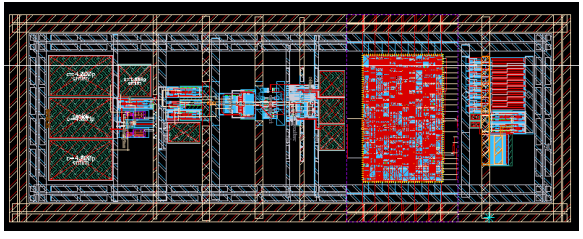
< BER Curve >

What I did?

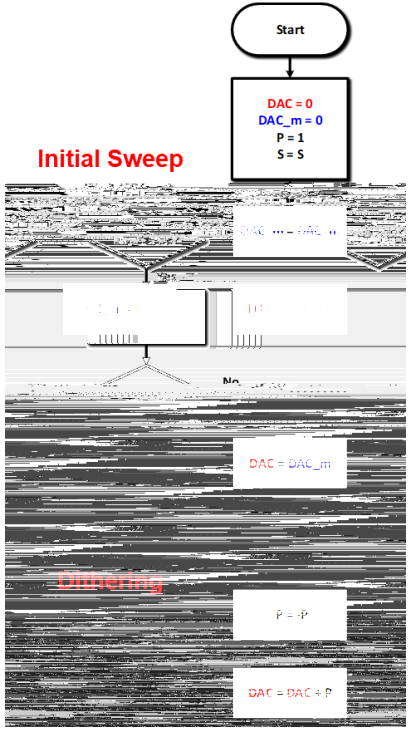
- **FSR-scanning filter controller**



< Receiver block >

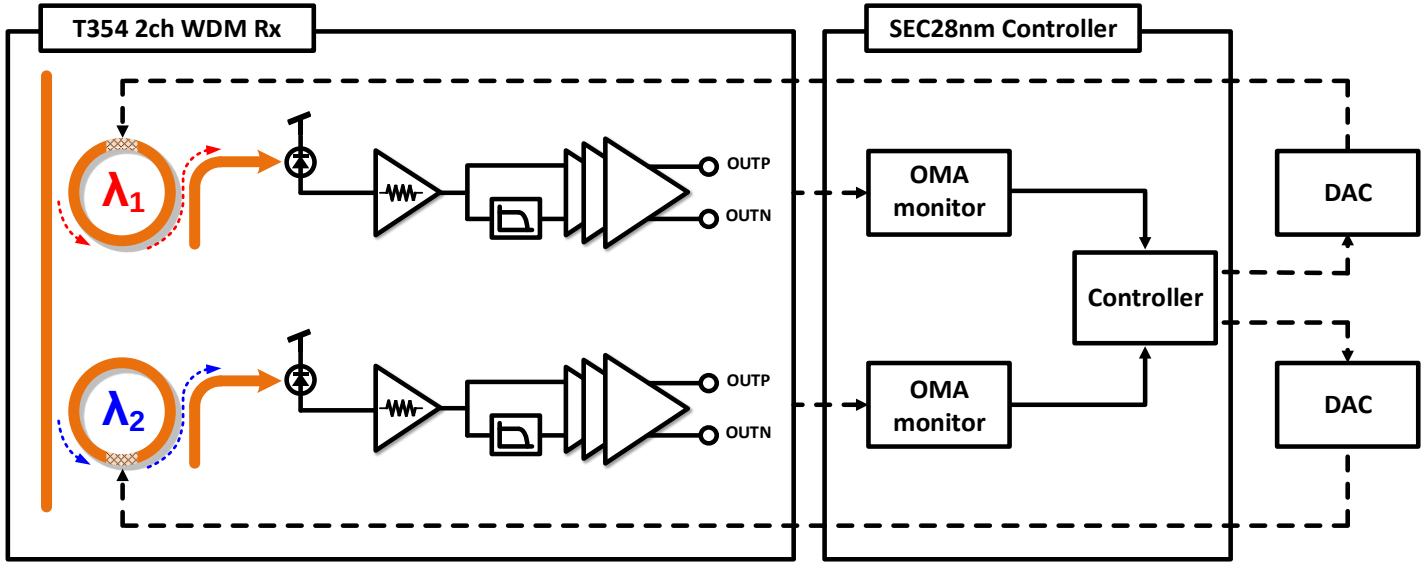


< Controller block >



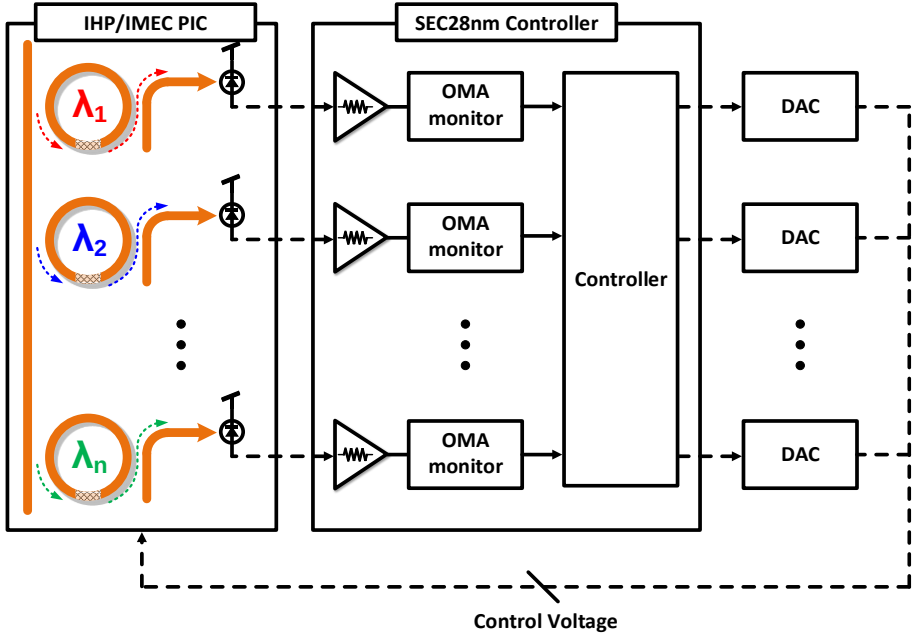
현재 실험 진행중!

연구 목표 – 1차 (2020. 08. ~ 2020. 12.)



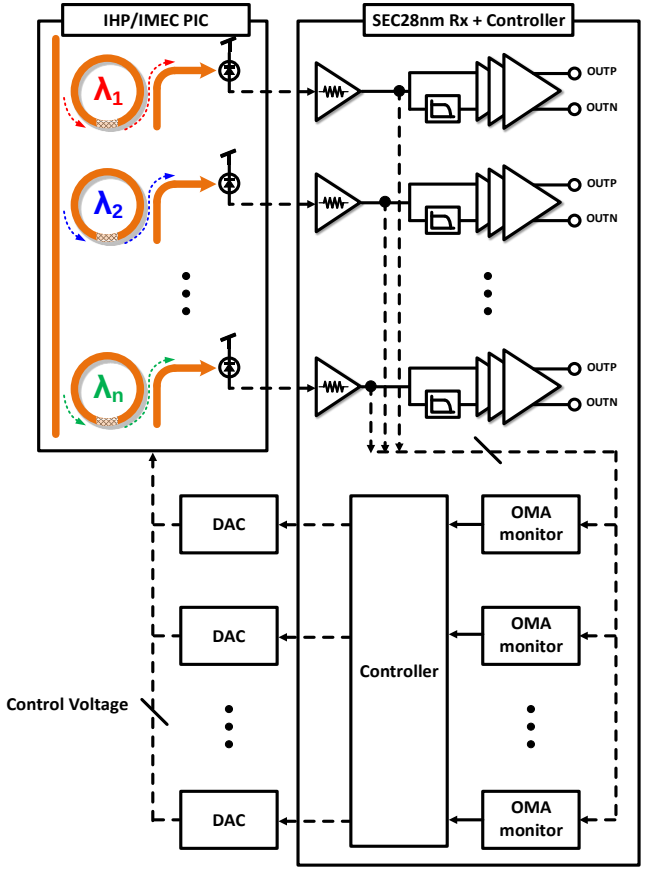
- **2채널 WDM receiver**를 이용한 **calibration + scanning algorithm** 검증
  - Initial calibration 알고리즘 + 채널 1개 스캔 기능이 2채널에서 제대로 동작하는지 검증하는 것이 목표
  - T354 EPIC 칩 + S2003 칩 (9~10월 중 chip out)

연구 목표 – 2차 (2021. 01. ~ 2020. 12.)



- **1차에서 검증된 controller를 확장해 4채널 filter controller 설계**
  - Filter+PD+TIA를 활용, 4채널 filter controller 설계 (채널 라우팅 기능 추가)
  - IHP(T354, T448) or IMEC PIC + CMOS 공정 활용 (필요하다면 IDEC을 통해서도 진행할 예정)

연구 목표 – 3차 (2022. 01. ~ 2022. 12.)



- **2차에서 검증된 controller algorithm이 탑재된 4채널 100-Gb/s 급 receiver system**

  - 2차에서 검증된 다채널 filter controller를 활용해 4 x 25 Gb/s receiver와 integration
  - 위와 마찬가지로 IHP(T354, T448) or IMEC PIC + CMOS 공정 활용 (or EPIC)

요약

- 논문 제목

  국문 : 대용량 프로그래머블 광 스위치 네트워크를 위한 저전력 실리콘 포토닉스 기반 다중 필터 제어기

  영문 : **Low-power Si-photonic Multi-channel Filter Controller for High-capacity Programmable Optical Switching Network**

- 최종 연구 목표

  - 확장성 있는 **Reconfigurable control algorithm**을 탑재한 **2(4)**채널 **ring-filter** 기반 **receiver system** 구현
    - ✓ **2(4)** 채널 링 필터 **+ 4 x 25-Gb/s**급 **Optical Receiver (Hybrid Integration)**
    - ✓ 링 필터의 **process variation**을 **initial calibration**
    - ✓ 필터 **1**개 스캔으로 전체 채널 할당 가능
    - ✓ 채널 재구성 가능