

The background of the slide features a large, light blue watermark of the Yonsei University seal. The seal is circular with the text 'YONSEI UNIVERSITY' around the top and 'YONSEI' at the bottom. In the center is a shield with a book, a torch, and a central circle. Below the shield is a diamond shape containing the year '1885'.

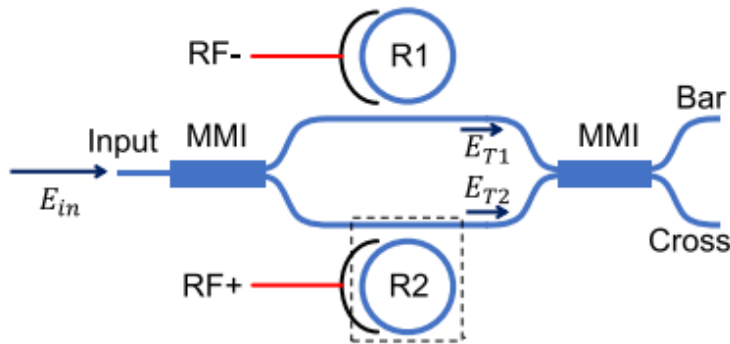
2025 Workshop

Myung-Hyun Kang

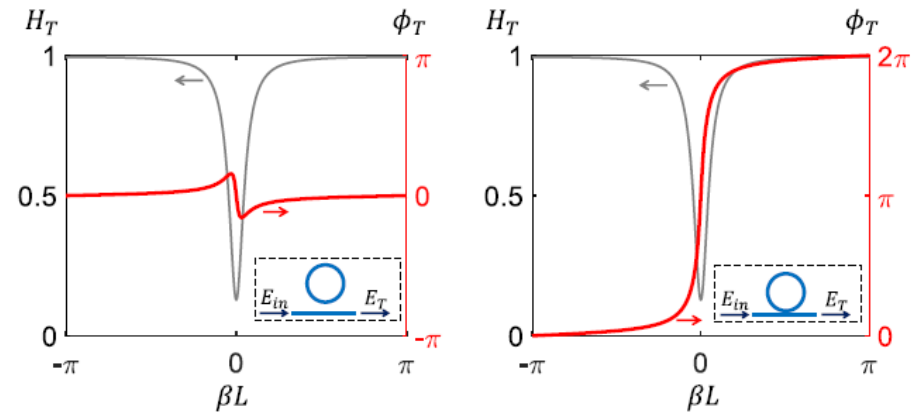
**High-Speed Circuits & Systems Lab.
Dept. of Electrical and Electronic Engineering
Yonsei University**

Ring Assisted MZM

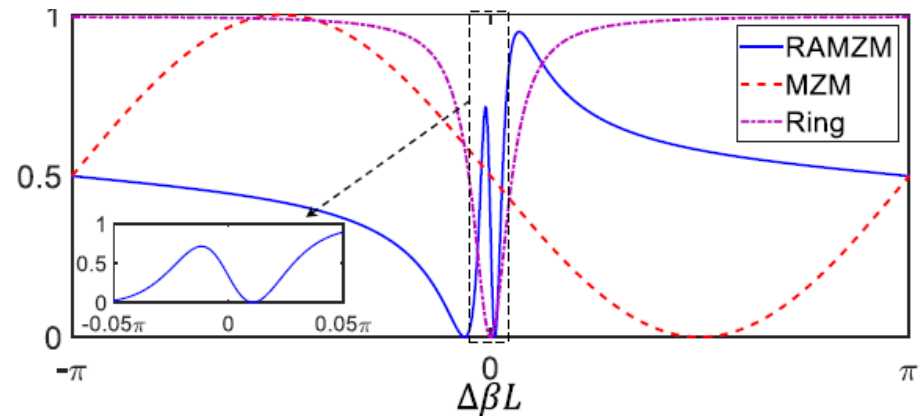
- RAMZM



- ✓ High ER
- ✓ Good linearity
- ✓ Small size

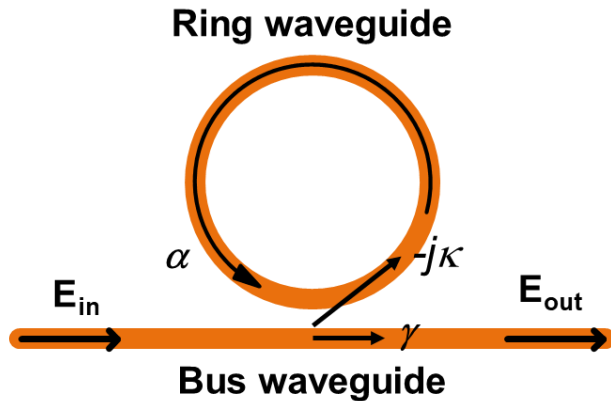


<Under & over coupled ring's phase>

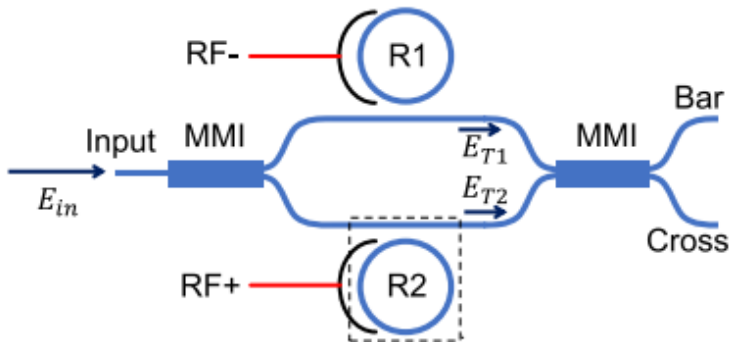


<Transfer function of RAMZM>

Difference between MRM and RAMZM



Micro Ring Modulator (MRM)



Ring Assisted Mach-Zhender Modulator (RAMZM)

- Doping $\downarrow \rightarrow$ Modulation efficiency $\downarrow \rightarrow$ BW \downarrow
- Doping $\uparrow \rightarrow$ Low Q \rightarrow Bad IL

- Low doping \rightarrow Modulation efficiency $\downarrow \rightarrow$ BW \downarrow
 \Rightarrow over-coupled ring (low Q)

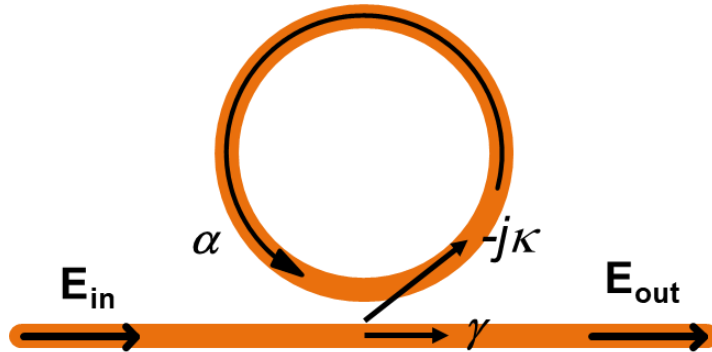
- low Q \rightarrow low ER

\Rightarrow Multiple ring (as phase shifter)

In low Q condition CMT doesn't match!

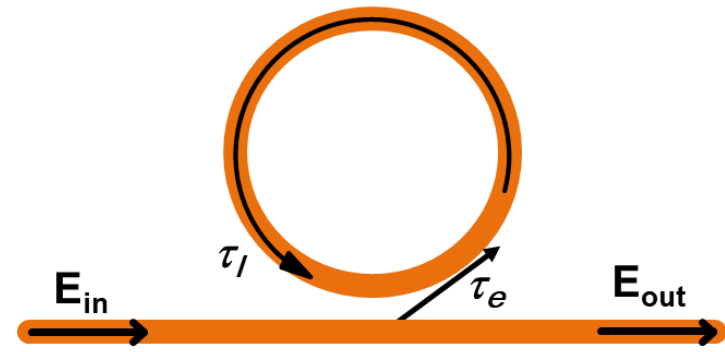
RTT & CMT Comparison

Round-Trip Theory (RTT)



$$T = \left| \frac{E_{out}}{E_{in}} \right|^2 = \frac{\alpha^2 + \gamma^2 - 2\alpha\gamma \cos(\phi)}{1 + (\alpha\gamma)^2 - 2\alpha\gamma \cos(\phi)}$$

Coupled-Mode Theory (CMT)



$$T = \left| \frac{E_{out}}{E_{in}} \right|^2 = \left| \frac{j(\omega - \omega_0) + \frac{1}{\tau_l} - \frac{1}{\tau_e}}{j(\omega - \omega_0) + \frac{1}{\tau_l} + \frac{1}{\tau_e}} \right|^2$$

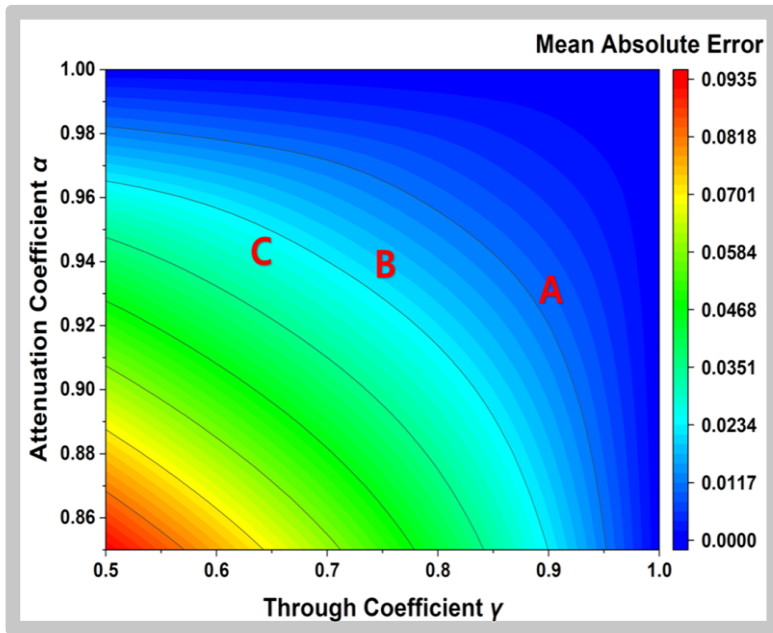
✓ **Pros** : Accurate numerical analysis

✓ **Cons** : Slow dynamic simulation time

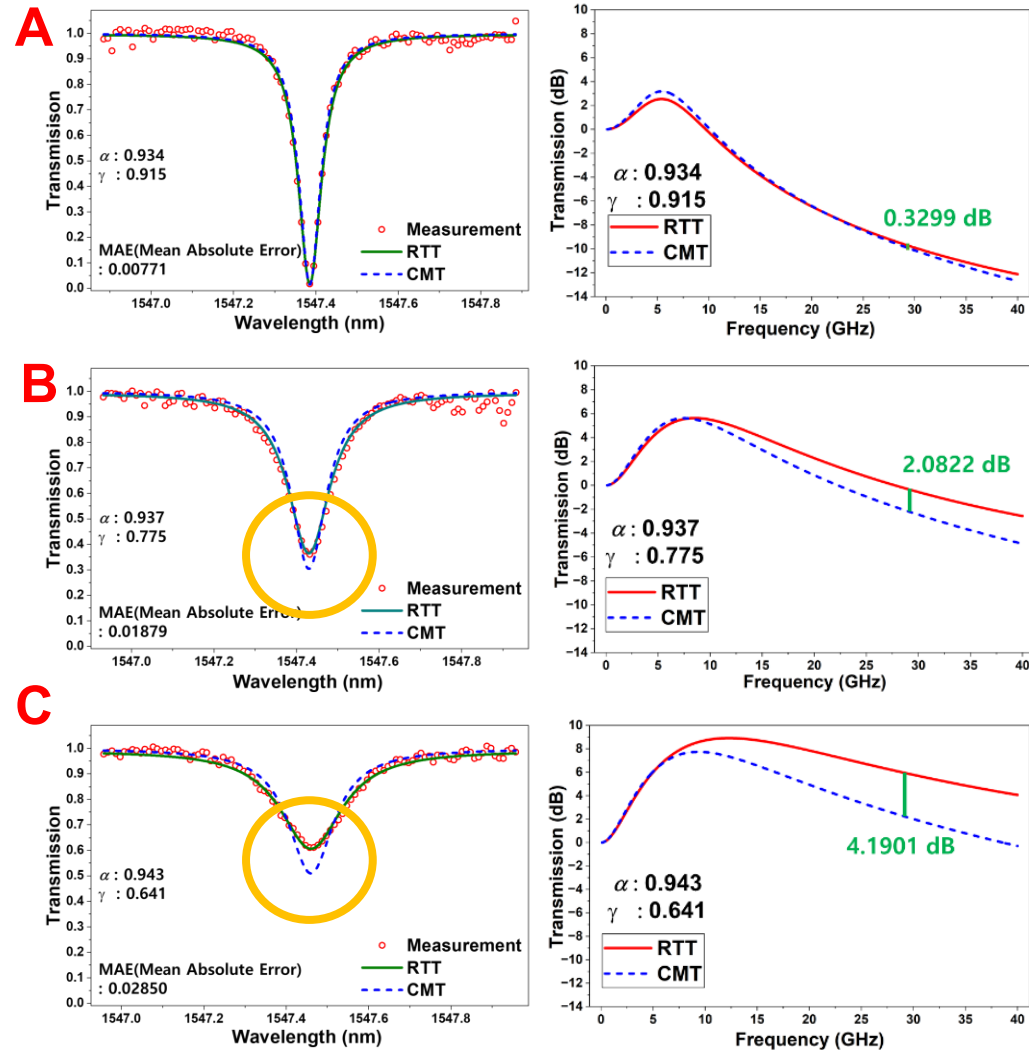
✓ **Pros** : Fast dynamic simulation time,
Co-simulation with the EIC

✓ **Cons** : Approximate model

RTT & CMT Comparison



Mean absolute error between
RTT and CMT

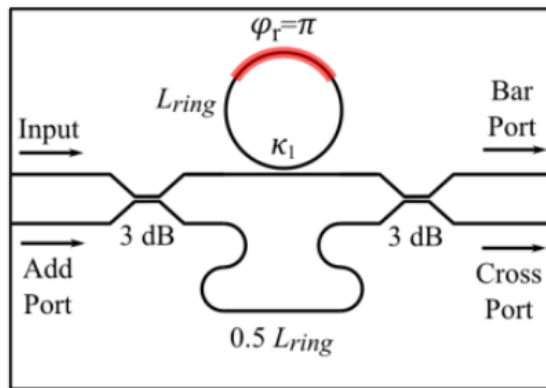


DC transmission

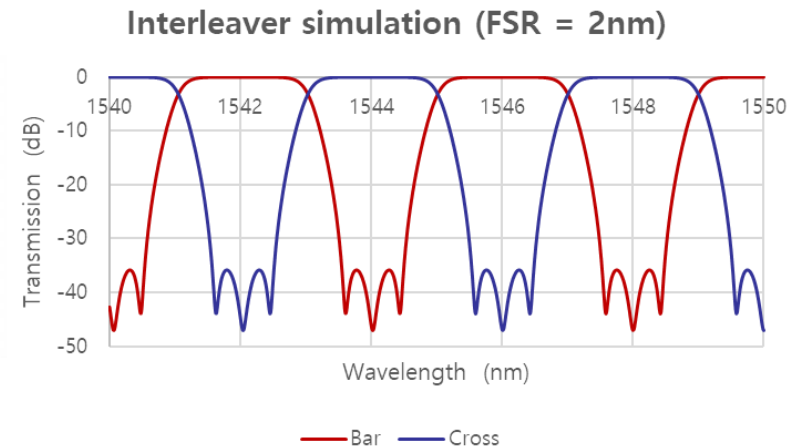
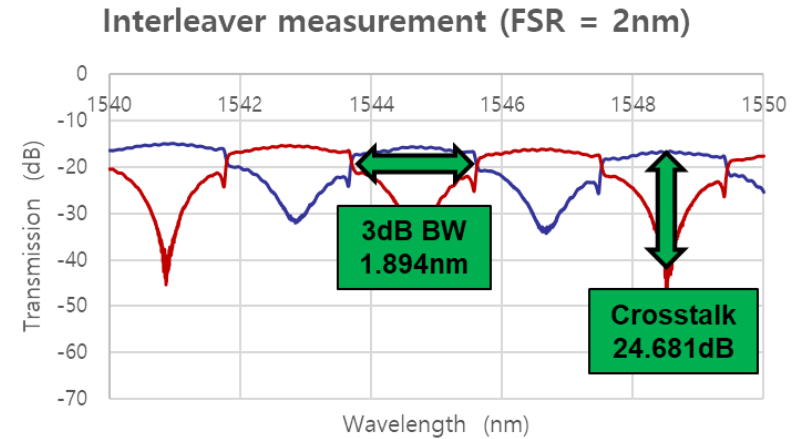
EO S21

NanoSOI Chip fabrication

- Interleaver



<2010 Optics Express, L. Luo *et al.*>



1st

2nd