Optics and Photonics Congress 2024

OSK Summer
Annual Meeting

ICC JEJU, Korea
JULY 7 SUN - 10 WED

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사단법인 한국광학회
Optical Society of Korea

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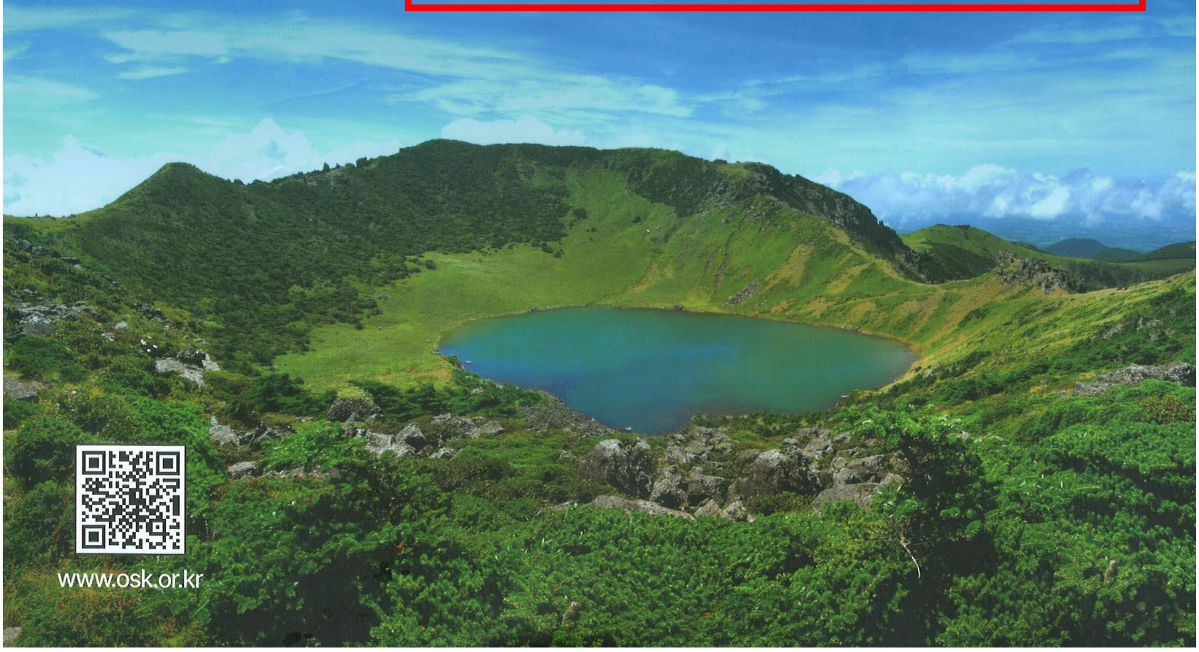

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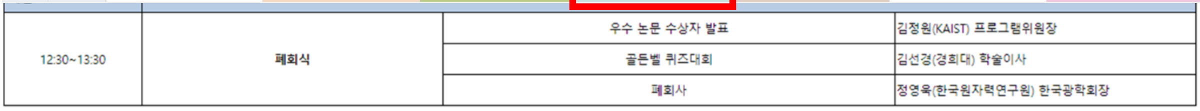
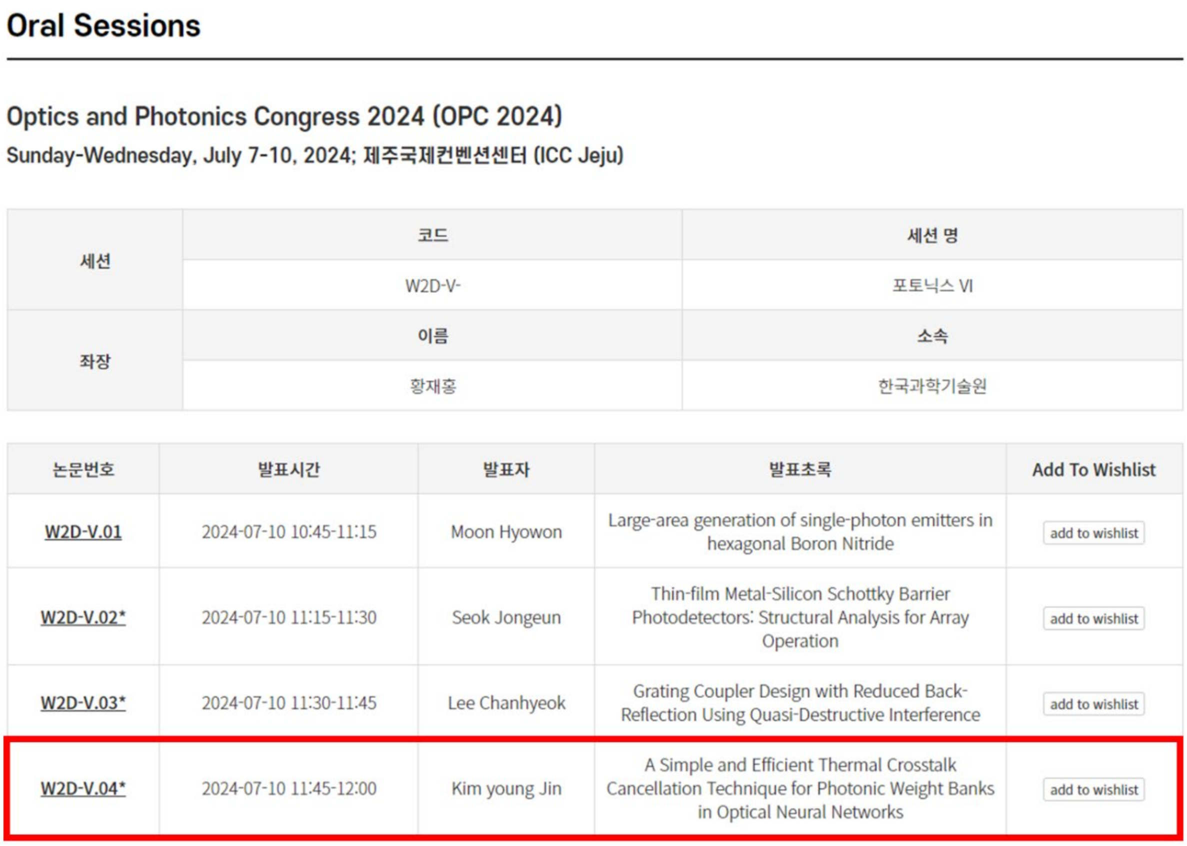
	Session / Room	삼다A홀 (A)	삼다B홀 (B)	301호 (C)	302호 (D)	303호 (E)	401호 (F)	402A호 (G)
07.07 (Sun)	**준비위원회 및 분과회의, 전시 준비** 16:00-18:00							
07.08 (Mon)	**구두발표 1** 10:30-12:00	**M1A-IV-** 양자전자 I	**M1B-S-** Tutorial I	**M1C-III-** 디지털홀로그래피 및 정보광학 I	**M1D-V-** 포토닉스 I	**M1E-VI-** 바이오포토닉스 I	**M1F-I-** 광과학 I	**M1G-II-** 광기술 I
	구두발표 2 13:30-15:00	**M2A-IV-** 양자전자 II	**M2B-S-** 산업체포럼 I	**M2C-III-** 디지털홀로그래피 및 정보광학 II	**M2D-V-** 포토닉스 II	**M2E-VI-** 바이오포토닉스 II	**M2F-I-** 광과학 II	**M2G-II-** 광기술 II
	구두발표 3 15:15-16:45	**M3A-IV-** 양자전자 III	**M3B-S-** 산업체포럼 II (레이저 안전 세션)	**M3C-III-** 디지털홀로그래피 및 정보광학 III	**M3D-V-** 포토닉스 III	**M3E-VIII-** 양자광학 및 양자정보 I	**M3F-I-** 광과학 III	**M3G-II-** 광기술 III
07.09 (Tue)	**구두발표 4** 13:30-15:00	**T1A-IV-** 양자전자 IV	**T1B-VII-** 디스플레이 I	**T1C-III-** 디지털홀로그래피 및 정보광학 IV	**T1D-S-** 한국표준과학연구원 특별세션	**T1E-VI-** 바이오포토닉스 III	**T1F-S-** Topological Photonics I	**T1G-II-** 광기술 IV
	구두발표 5 15:15-16:45	**T2A-IV-** 양자전자 V	**T2B-VII-** 디스플레이 II	**T2C-III-** 디지털홀로그래피 및 정보광학 V	**T2D-V-** 포토닉스 IV	**T2E-S-** 양자이득	**T2F-S-** Topological Photonics II	**T2G-II-** 광기술 V
07.10 (Wed)	**구두발표 6** 09:00-10:30	**W1A-IV-** 양자전자 VI	**W1B-VII-** 디스플레이 III	**W1C-III-** 디지털홀로그래피 및 정보광학 VI	**W1D-V-** 포토닉스 V	**W1E-VIII-** 양자광학 및 양자정보 II	**W1F-S-** Tutorial II	**W1G-IX-** 리소그래피 I
	구두발표 7 10:45-12:15		**W2B-VII-** 디스플레이 IV	**W2C-S-** 분과 우수논문 특별세션	**W2D-V-** 포토닉스 VI	**W2E-VIII-** 양자광학 및 양자정보 III		**W2G-II-** 광기술 VI



12:30~13:30	**폐회식**	우수 논문 수상자 발표	김정원(KAIST) 프로그램위원장
		골든벨 퀴즈대회	김선경(경희대) 학술이사
		폐회사	정영욱(한국원자력연구원) 한국광학회장



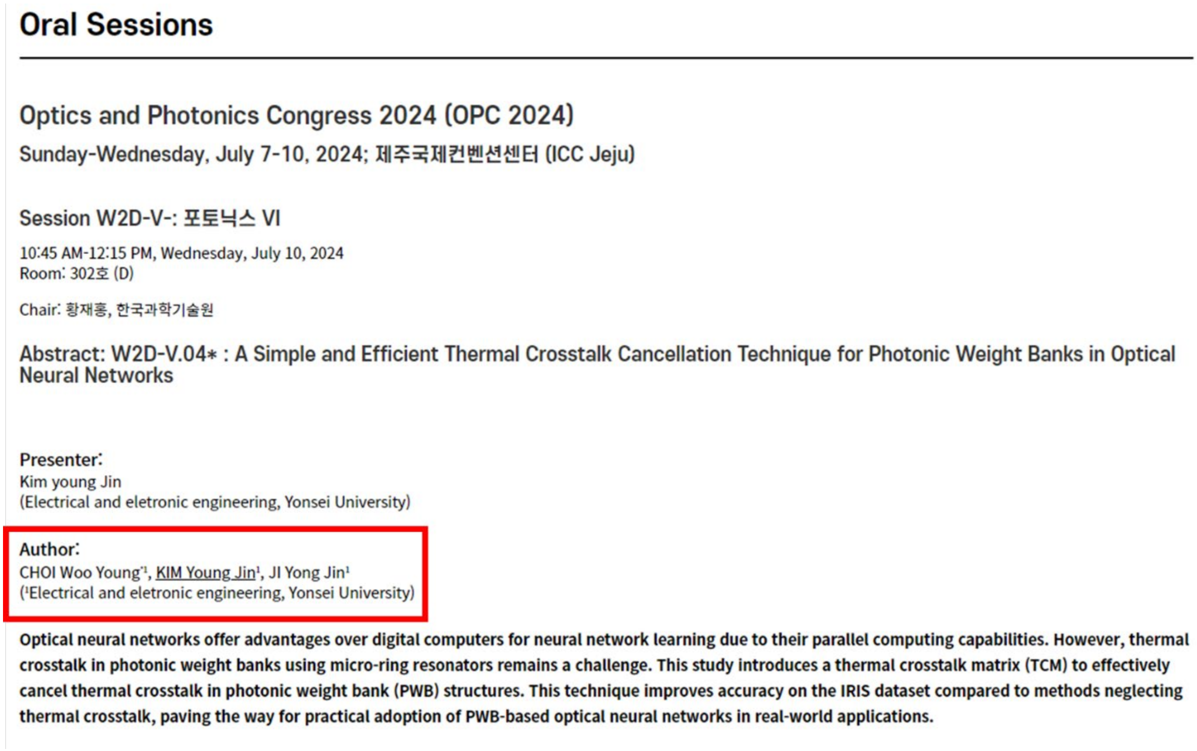
Oral Sessions

Optics and Photonics Congress 2024 (OPC 2024)

Sunday-Wednesday, July 7-10, 2024; 제주국제컨벤션센터 (ICC Jeju)

세션	**코드**	**세션 명**
	W2D-V-	포토닉스 VI
좌장	**이름**	**소속**
	황재홍	한국과학기술원

논문번호	발표시간	발표자	발표초록	Add To Wishlist
W2D-V.01	2024-07-10 10:45-11:15	Moon Hyowon	Large-area generation of single-photon emitters in hexagonal Boron Nitride	add to wishlist
W2D-V.02*	2024-07-10 11:15-11:30	Seok Jongeun	Thin-film Metal-Silicon Schottky Barrier Photodetectors: Structural Analysis for Array Operation	add to wishlist
W2D-V.03*	2024-07-10 11:30-11:45	Lee Chanhyeok	Grating Coupler Design with Reduced Back-Reflection Using Quasi-Destructive Interference	add to wishlist
W2D-V.04*	2024-07-10 11:45-12:00	Kim young Jin	A Simple and Efficient Thermal Crosstalk Cancellation Technique for Photonic Weight Banks in Optical Neural Networks	add to wishlist



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Session W2D-V-: 포토닉스 VI

10:45 AM-12:15 PM, Wednesday, July 10, 2024
Room: 302호 (D)

Chair: 황재홍, 한국과학기술원

Abstract: W2D-V.04* : A Simple and Efficient Thermal Crosstalk Cancellation Technique for Photonic Weight Banks in Optical Neural Networks

Presenter:
Kim young Jin
(Electrical and eletronic engineering, Yonsei University)

Author:
CHOI Woo Young[*1], KIM Young Jin[1], JI Yong Jin[1]
([1]Electrical and eletronic engineering, Yonsei University)

Optical neural networks offer advantages over digital computers for neural network learning due to their parallel computing capabilities. However, thermal crosstalk in photonic weight banks using micro-ring resonators remains a challenge. This study introduces a thermal crosstalk matrix (TCM) to effectively cancel thermal crosstalk in photonic weight bank (PWB) structures. This technique improves accuracy on the IRIS dataset compared to methods neglecting thermal crosstalk, paving the way for practical adoption of PWB-based optical neural networks in real-world applications.

A Simple and Efficient Thermal Crosstalk Cancellation Technique for Photonic Weight Banks in Optical Neural Networks

YoungJin Kim[1] **, Yongjin Ji**[1] **and Woo-Young Choi**[1]
Department of Electrical and Electronic Engineering, Yonsei University, 03722, Korea
* rladudwls500@yonsei.ac.kr, yjji0314@yonsei.ac.kr, wchoi@yonsei.ac.kr

Abstract— **Optical neural networks offer advantages over digital computers for neural network learning due to their parallel computing capabilities. However, thermal crosstalk in photonic weight banks using micro-ring resonators remains a challenge. This study introduces a thermal crosstalk matrix (TCM) to effectively cancel thermal crosstalk in photonic weight bank (PWB) structures. This technique improves accuracy on the IRIS dataset compared to methods neglecting thermal crosstalk, paving the way for practical adoption of PWB-based optical neural networks in real-world applications.**

I. Introduction

Optical networks based on micro-ring resonators (MRRs) have emerged as a promising alternative to digital computers for neural network learning due to their parallel computing capabilities(1) (3). However, existing research on thermal crosstalk between MRRs(2)(4) has limitations, such as high computational complexity and the assumption of a symmetric phase coupling matrix, which restricts the design flexibility of thermal actuators and hinders the scalability of photonic weight banks (PWBs) for industrial needs.

This study aims to develop simple and efficient thermal crosstalk cancellation techniques for PWB structures, enabling the practical adoption of PWB-based optical neural networks for real-world applications, particularly in larger and more complex neural network architectures.

II. Result and Discussion

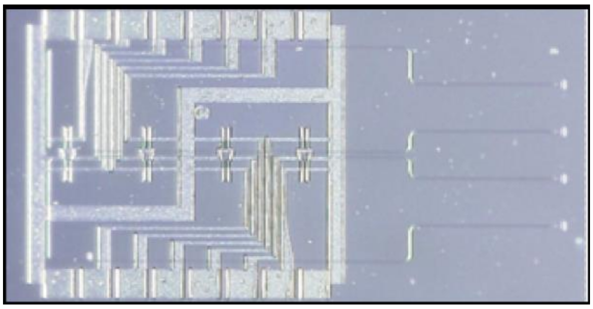
In this study, a thermal crosstalk cancellation technique for photonic weight banks (PWB) using micro-ring resonators (MRR) was developed. Simulations were performed using extracted parameters from MRMs fabricated by NanoSOI through a multi-project wafer (MPW) process. A thermal crosstalk matrix (TCM) is introduced that represents the influence of thermal crosstalk between neighboring rings. The matrix is constructed based on the size of the ring array, where each element (i, j) represents the percentage of thermal crosstalk from ring i to ring j. In N-channel weight bank, the TCM is given by:

$$\begin{bmatrix} T_A^* \\ T_B^* \\ T_C^* \\ T_D^* \end{bmatrix} = \begin{bmatrix} H_{aa} & H_{ab} & H_{ac} & H_{ad} \\ H_{ba} & H_{bb} & \cdots & H_{bd} \\ H_{ca} & \vdots & \ddots & \vdots \\ H_{da} & H_{db} & \cdots & H_{dd} \end{bmatrix} \begin{bmatrix} T_A \\ T_B \\ T_C \\ T_D \end{bmatrix} \qquad (1)$$

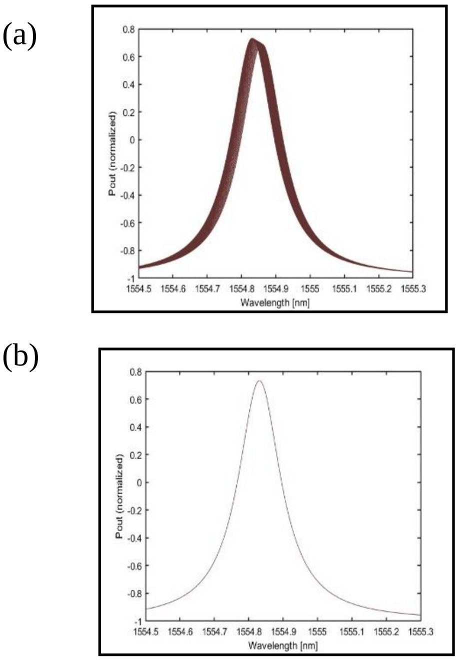
where H_{NM} represents the ratio of thermal crosstalk between ring N and ring M. The values in the same row can be defined by a function of distance. By solving this matrix, new heater values that account for thermal crosstalk were obtained.

Simulations were performed to investigate the impact of thermal crosstalk on the ring resonance by changing the nearest ring thermal actuator. The frequency response of the MRM was analyzed both with and without considering thermal crosstalk. Figure [2] presents the transmission responses of the normalized power difference between the through and drop ports. Fig.2(a) shows the responses without considering thermal crosstalk, while Fig. 2(b) demonstrates the responses after applying the TCM algorithm, which accounts for thermal crosstalk. This comparison illustrates the effectiveness of the TCM method in compensating for resonance shifts caused by thermal crosstalk. To further evaluate the effectiveness of the TCM method, it was applied to the IRIS dataset, comparing accuracy with and without considering thermal crosstalk. The method demonstrated improved accuracy, achieving over 96% on the IRIS dataset, compared to 76% without considering thermal crosstalk.

The results of the study highlight the importance of addressing thermal crosstalk in PWB structures, particularly as chip sizes increase to meet industrial needs. By developing a simple and effective thermal crosstalk cancellation technique, a meaningful step has been taken towards enabling the practical adoption of PWB-based optical neural networks for real-world applications.



[Fig.1] Photograph of the MRR chip fabricated by Nano SOI.



[Fig.2 (a)(b)] (a) Frequency response of the MRM without considering thermal cross talking (b) after the TCM-based tuning algorithm.

References

[1] Bangari, Viraj et al. “Digital Electronics and Analog Photonics for Convolutional Neural Networks (DEAP-CNNs).” IEEE Journal of Selected Topics in Quantum Electronics 26 (2019): 1-13.

[2] M. Milanizadeh, D. Aguiar, A. Melloni and F. Morichetti, "Canceling Thermal Cross-Talk Effects in Photonic Integrated Circuits," in Journal of Lightwave Technology, vol. 37, no. 4, pp. 1325-1332, 15 Feb.15, 2019

[3] Luan, E., Yu, S., Salmani, M. et al. Towards a high-density photonic tensor core enabled by intensity-modulated microrings and photonic wire bonding. Sci Rep 13, 1260 (2023).

[4] N. C. Harris et al., “Efficient, compact and low loss thermo-optic phase shifter in silicon,” Opt. Express, vol. 22, no. 9, pp. 10487–10493, 2014