



## Table of Contents

|                                                                                                               |   |
|---------------------------------------------------------------------------------------------------------------|---|
| 1. Integrated Sensor–Memory Photonics for Edge Intelligence System .....                                      | 2 |
| 2. Single-Photon Source Integration to Silicon Photonics for Scalable Quantum Processing .....                | 3 |
| 3. Ferroelectric-integrated silicon photonics for non-volatile reconfigurable optical computing .....         | 4 |
| 4. Integrating Micro-LEDs into Si Photonics for Frontier Optical Interconnect Networks.                       | 5 |
| 5. Nonvolatile Integrated Photonics for Edge Neuromorphic Computing .....                                     | 6 |
| 6. Development of 2D/3D heterointerface on nanostructured Si to exceed quantum efficiency beyond limits ..... | 7 |



## 1. Integrated Sensor–Memory Photonics for Edge Intelligence System

|                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                     |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Date Posted                                                  | 22 June 2026                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                     |
| Home University                                              | Nanyang Technological University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                     |
| Partner University                                           | Sungkyunkwan University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                     |
| <b>Supervisors</b>                                           | <b>Home</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Partner</b>                                                      |
| Name                                                         | Chae Sanghoon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Sunkook Kim                                                         |
| School                                                       | School of Electrical and Electronic Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Department of Advanced Materials Science & Engineering              |
| Email                                                        | <a href="mailto:sanghoon.chae@ntu.edu.sg">sanghoon.chae@ntu.edu.sg</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <a href="mailto:seonkuk@skku.edu">seonkuk@skku.edu</a>              |
| Website                                                      | <a href="https://sites.google.com/view/sanghoonchae/home">https://sites.google.com/view/sanghoonchae/home</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <a href="https://www.aisl-skku.com/">https://www.aisl-skku.com/</a> |
| Project Description<br>(200-300 words)                       | <p>Edge artificial intelligence requires hardware that can sense, store, and process information locally with minimal power consumption. Conventional systems separate sensing, memory, and computing functions, leading to increased energy consumption and latency due to frequent data transfer.</p> <p>This project aims to develop an integrated sensor–memory photonic platform by combining high-performance photodetectors with nonvolatile photonic memory based on phase modulators. The photodetectors will directly acquire optical information, while the nonvolatile photonic devices will provide programmable memory and processing functions without continuous power consumption.</p> <p>By integrating sensing and memory within a common silicon photonic architecture, the system will enable in-sensor processing and real-time information extraction at the edge. Device and system-level demonstrations will evaluate sensing performance, memory retention, energy efficiency, and intelligent signal processing capabilities.</p> <p>This research will establish a compact and energy-efficient photonic platform for next-generation edge intelligence systems, with potential applications in autonomous sensing, communications, and artificial intelligence.</p> |                                                                     |
| Program/Center Website(s)                                    | Centre for Micro- & Nano-Electronics (CMNE)<br><a href="https://www.ntu.edu.sg/cmne">https://www.ntu.edu.sg/cmne</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                     |
| Additional Information<br>(e.g., files with project details) | N.A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                     |



## 2. Single-Photon Source Integration to Silicon Photonics for Scalable Quantum Processing

|                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                       |
|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| Date Posted                                                  | 22 Dec 2025                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                       |
| Home University                                              | Nanyang Technological University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                       |
| Partner University                                           | Sungkyunkwan University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                       |
| <b>Supervisors</b>                                           | <b>Home</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Partner</b>                                                        |
| Name                                                         | Chae Sanghoon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Hyeon Suk Shin                                                        |
| School                                                       | School of Electrical and Electronic Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Department of Energy & Department of Chemistry, SKKU                  |
| Email                                                        | <a href="mailto:sanghoon.chae@ntu.edu.sg">sanghoon.chae@ntu.edu.sg</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <a href="mailto:shin0902@skku.edu">shin0902@skku.edu</a>              |
| Website                                                      | <a href="https://sites.google.com/view/sanghoonchae/home">https://sites.google.com/view/sanghoonchae/home</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <a href="https://www.ibs.re.kr/2dgh/">https://www.ibs.re.kr/2dgh/</a> |
| Project Description<br>(200-300 words)                       | <p>Deterministic single-photon sources are essential for photonic quantum technologies, including quantum computing, secure communications, and quantum sensing. Silicon photonics offers a scalable and CMOS-compatible platform for large-scale quantum photonic integration, yet the on-chip realization of high-quality single-photon emitters remains a critical challenge.</p> <p>This project focuses on the integration of van der Waals (vdW) quantum emitters, particularly defect-based single-photon sources in hexagonal boron nitride (hBN), into silicon and silicon nitride photonic circuits. hBN hosts optically stable quantum emitters that operate at room temperature and can be deterministically positioned, making it an attractive platform for scalable quantum photonics. The project will explore hybrid integration approaches, including vdW material transfer, nanophotonic cavity coupling, and waveguide-embedded architectures, to enhance emission efficiency and on-chip photon collection.</p> <p>Comprehensive optical characterization will be performed using photon correlation measurements, lifetime analysis, and on-chip interference experiments to evaluate single-photon purity, brightness, and coherence. By combining vdW quantum materials with mature silicon photonics, this research aims to establish a practical pathway toward scalable, integrated quantum photonic processors based on deterministic single-photon sources.</p> |                                                                       |
| Program/Center Website(s)                                    | Centre for Micro- & Nano-Electronics (CMNE)<br><a href="https://www.ntu.edu.sg/cmne">https://www.ntu.edu.sg/cmne</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                       |
| Additional Information<br>(e.g., files with project details) | N.A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                       |



### 3. Ferroelectric-integrated silicon photonics for non-volatile reconfigurable optical computing

|                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                 |
|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Date Posted                                                  | 3 Nov 2025                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                 |
| Home University                                              | Nanyang Technological University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                 |
| Partner University                                           | Sungkyunkwan University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                 |
| <b>Supervisors</b>                                           | <b>Home</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Partner</b>                                                                                  |
| Name                                                         | Chae Sanghoon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Kim Yunseok                                                                                     |
| School                                                       | School of Electrical and Electronic Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | School of Advanced Materials Science and Engineering                                            |
| Email                                                        | <a href="mailto:sanghoon.chae@ntu.edu.sg">sanghoon.chae@ntu.edu.sg</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <a href="mailto:yunseokkim@skku.edu">yunseokkim@skku.edu</a>                                    |
| Website                                                      | <a href="https://sites.google.com/view/sanghoonchae/home">https://sites.google.com/view/sanghoonchae/home</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <a href="https://sites.google.com/view/yunseokkim">https://sites.google.com/view/yunseokkim</a> |
| Project Description<br>(200-300 words)                       | <p>The rapid growth of artificial intelligence and data-intensive computing has driven the need for energy-efficient hardware capable of performing computation and memory functions directly in the optical domain. Conventional silicon photonic circuits, while mature and CMOS-compatible, lack intrinsic non-volatility and reconfigurability, limiting their potential for in-memory and adaptive optical computing. This PhD project aims to develop a new class of non-volatile, reconfigurable photonic platforms by integrating ferroelectric materials with silicon photonics. The research will focus on incorporating ferroelectric materials into silicon nitride and silicon photonic devices. Leveraging their spontaneous polarization and electric-field tunability, these materials will enable persistent refractive index modulation without static power consumption. The project will investigate the underlying ferroelectric switching mechanisms, interface engineering for low-loss optical coupling, and scalable fabrication processes compatible with wafer-scale integration.</p> <p>Through this program, the candidate will implement dynamically reconfigurable optical neural networks and logic circuits by designing and demonstrating ferroelectric-based phase modulators, modulators, and photonic memory devices. This research combines NTU's cutting-edge photonic device technology with SKKU's ferroelectric materials and measurement techniques. By merging materials science, nanofabrication, and integrated optics to establish ferroelectric-integrated silicon photonics as a key component of next-generation energy-efficient optical computing systems, this research will advance the state-of-the-art in photonic in-memory computing.</p> |                                                                                                 |
| Program/Center Website(s)                                    | Centre for OptoElectronics and Biophotonics (COEB):<br><a href="https://www.ntu.edu.sg/coeb">https://www.ntu.edu.sg/coeb</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                 |
| Additional Information<br>(e.g., files with project details) | N.A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                 |



#### 4. Integrating Micro-LEDs into Si Photonics for Frontier Optical Interconnect Networks

|                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                       |
|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Date Posted                                                  | 16 Sep 2025                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                       |
| Home University                                              | Nanyang Technological University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                       |
| Partner University                                           | Sungkyunkwan University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                       |
| <b>Supervisors</b>                                           | <b>Home</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Partner</b>                                                                                        |
| Name                                                         | Chae Sanghoon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Young Joon Hong                                                                                       |
| School                                                       | School of Electrical and Electronic Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | SAINT (SKKU Advanced Institute of Nano Technology)                                                    |
| Email                                                        | <a href="mailto:sanghoon.chae@ntu.edu.sg">sanghoon.chae@ntu.edu.sg</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <a href="mailto:yjhong78@skku.edu">yjhong78@skku.edu</a>                                              |
| Website                                                      | <a href="https://sites.google.com/view/sanghoonchae/home">https://sites.google.com/view/sanghoonchae/home</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <a href="https://sites.google.com/view/snad-atsejong">https://sites.google.com/view/snad-atsejong</a> |
| Project Description<br>(200-300 words)                       | <p>The growth of artificial intelligence (AI) and data-intensive computing industries has pushed electronic interconnects to their limits related to bandwidth, energy efficiency, and latency. For sustainable high-performance computing, new optical interconnect solutions are needed. This project presents an innovative approach to build cutting-edge optical interconnect networks by integrating micro-LEDs into silicon photonic platforms. Unlike conventional laser-based systems, micro-LEDs have exceptional advantages including miniaturization, wavelength diversity, active electrical control, and seamless CMOS compatibility. This integration enables massive parallel processing through simultaneous multi-wavelength operation. It also provides cost-efficient scalability via wafer-level manufacturing processes.</p> <p>Our research aims to systematically address key technical challenges. First, we implement optimized optical pathways through advanced on-chip silicon photonic waveguide design based on simulation. Additionally, we develop active modulation systems with enhanced bandwidth by utilizing external electro-optic control. Furthermore, we strategically utilize photonic cavities such as microring resonators and photonic crystal structures to dramatically enhance signal strength through Purcell effect and resonance. Consequently, this technology will facilitate a paradigm shift toward photonic-electronic co-design architectures and establish new industry standards. This breakthrough technology will fundamentally transform how future systems communicate information and enable next-generation computing platforms spanning autonomous systems, edge computing, and quantum interconnects.</p> |                                                                                                       |
| Program/Center Website(s)                                    | Centre for Micro- & Nano-Electronics (CMNE)<br><a href="https://www.ntu.edu.sg/cmne">https://www.ntu.edu.sg/cmne</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| Additional Information<br>(e.g., files with project details) | N.A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                       |



## 5. Nonvolatile Integrated Photonics for Edge Neuromorphic Computing

|                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                         |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Date Posted                                                  | 04 Aug 2025                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                         |
| Home University                                              | Nanyang Technological University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |
| Partner University                                           | Sungkyunkwan University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                         |
| <b>Supervisors</b>                                           | <b>Home</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Partner</b>                                                                                          |
| Name                                                         | Chae Sanghoon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Lee Sungjoo                                                                                             |
| School                                                       | School of Electrical and Electronic Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | SAINT (SKKU Advanced Institute of Nano Technology)                                                      |
| Email                                                        | <a href="mailto:sanghoon.chae@ntu.edu.sg">sanghoon.chae@ntu.edu.sg</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <a href="mailto:leesj@skku.edu">leesj@skku.edu</a>                                                      |
| Website                                                      | <a href="https://sites.google.com/view/sanghoonchae/home">https://sites.google.com/view/sanghoonchae/home</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <a href="https://sites.google.com/view/skku-ndtl/home">https://sites.google.com/view/skku-ndtl/home</a> |
| Project Description<br>(200-300 words)                       | <p>Advancements in nonvolatile photonic memory are critical for next-generation edge AI and neuromorphic computing, enabling real-time inference in applications such as IoT, biosignal decoding, and time-series forecasting. This project explores the integration of ferroelectric materials into photonic neuromorphic architectures to develop ultra-fast, energy-efficient, light-based neural networks. By leveraging analog in-memory photonic computing, our approach overcomes the limitations of electronic AI accelerators, offering unmatched scalability, low latency, and power efficiency for intelligent edge devices in robotics, autonomous systems, and distributed sensing. A key innovation of this work is the fusion of emerging materials science with applied neuromorphic photonics. We propose integrating ferroelectric materials and tunable 2D nonlinear optics into silicon photonic platforms, creating a reconfigurable framework for high-speed, parallel, and adaptive processing. This hybrid architecture addresses critical challenges in edge AI, such as dynamic learning, energy constraints, and real-time adaptability, paving the way for deployable photonic neuromorphic systems.</p> |                                                                                                         |
| Program/Center<br>Website(s)                                 | Centre for OptoElectronics and Biophotonics (COEB):<br><a href="https://www.ntu.edu.sg/coeb">https://www.ntu.edu.sg/coeb</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                         |
| Additional Information<br>(e.g., files with project details) | N.A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                         |



**6. Development of 2D/3D heterointerface on nanostructured Si to exceed quantum efficiency beyond limits**

|                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                               |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Date Posted                                   | 1 July 2024                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                               |
| Home University                               | Nanyang Technological University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                               |
| Partner University                            | Sungkyunkwan University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                               |
| <b>Supervisors</b>                            | <b>Home</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Partner</b>                                                                                |
| Name                                          | Kim Munho                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Kang Joohoon                                                                                  |
| School                                        | School of Electrical and Electronic Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Department of Advanced Materials Science & Engineering                                        |
| Email                                         | <a href="mailto:munho.kim@ntu.edu.sg">munho.kim@ntu.edu.sg</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <a href="mailto:joohoon@skku.edu">joohoon@skku.edu</a>                                        |
| Website                                       | <a href="https://ntunedl.weebly.com/">https://ntunedl.weebly.com/</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <a href="https://sites.google.com/view/mfmp/home">https://sites.google.com/view/mfmp/home</a> |
| <b>Project Description</b><br>(200-300 words) | <p>Our project represents a pioneering study on completely new hybrid-type optoelectronic devices that combine two different materials: two-dimensional (2D) thin films coated on three-dimensional (3D) nanostructured black silicon (b-Si). Further advancement in the device performance will be achieved through the investigations on the conformal coating of 2D materials onto 3D nanostructures, 2D/b-Si heterointerface, and interface passivation via plasma treatment. Unlike traditional 3D devices, the combination of 2D and 3D materials creates a unique junction with exceptional thermal and electrical conductivity and remarkable responsivity. However, 2D/3D heterostructures face challenges such as limited light absorption and high interface defect density, which affect device performance. Our project aims to overcome these hurdles by combining 2D/3D heterojunction technology, nanostructured b-Si, and novel plasma-based interface passivation into a single device. Our approach involves conformally coating a 2D monolayer onto nanostructured b-Si via direct growth method, creating nanotextured b-Si, and passivating the surface using plasma treatment. The success of our project will lay the foundation for future technologies, including biosensors and optical communication systems. Importantly, our device is compatible with current complementary metal-oxide-semiconductor (CMOS) technology, enabling integration with advanced CMOS devices and circuits like CMOS image sensors. This extends the impact of our innovation beyond Singapore to the global stage. Additionally, our research has the potential to generate new knowledge on carrier transport mechanisms, heterointerface, and photomultiplication across 2D/3D interfaces, contributing to a deeper understanding of these phenomena.</p> |                                                                                               |
| Program/Center Website(s)                     | <a href="https://www.ntu.edu.sg/coeb">https://www.ntu.edu.sg/coeb</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                               |





Additional  
Information  
(e.g., files with  
project details)

The project can be summarized into four self-contained yet interconnected work packages (WPs). WP1 is the fundamental study of the coating process for large size defect-less graphene (Gr) and hexagonal boron nitride (hBN), and the nanotexturing process of b-Si, involving plasma treatment passivation. WP2 will focus on the formation of passivated 2D/3D heterointerface on a nanostructured b-Si. This will be achieved through two key methodologies: the direct growth of 2D layers and CI-based plasma passivation. Based on the successful implementation of WP1 and WP2, WP3 will perform theoretical and experimental study of the heterointerface. Particular attention will be paid to understanding carrier recombination dynamics within our 2D/3D heterojunction nanostructures. Building on the theoretical and practical insights gained in the preceding WPs, WP4 focuses on the development of high-performance self-powered devices with superior quantum efficiency. The aim is to implement the knowledge to further enhance device performance through refinement and innovative strategies. Following figure provides a visual representation of the implementation plan across the four WPs.

