

# *Master Lectures on Photonics Integration*

## **VCSEL Photonics for Communications and 3D Sensing**

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**Venue: IB202, National Taiwan University of Science and Technology, Taipei, Taiwan**

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**Photonic Integration Center (HiSiPIC) of National Taiwan University of Science and Technology  
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The 47 years of research and development have ushered in a new era of VCSEL photonics, encompassing high-speed optical interconnects in datacenter networks and 3D sensing. Numerous unique features have already been established. The market for VCSELs has been expanding rapidly, and they are now recognized as indispensable devices underpinning the information society, from data communications to smart sensing, due to their distinctive attributes such as low power consumption, high-speed modulation, and 2D-array configuration. VCSELs have played a crucial role in advancing high-density optical interconnects for high-performance computing and datacenter networks. Recent developments in AI clusters necessitate increased interconnect bandwidths and reduced power consumption. High-speed VCSELs have been intensively developed in response to the rapid growth in network traffic, with data rates reaching 100 Gbps or higher. Additionally, 3D sensing has garnered significant attention for a wide range of applications, including face ID in mobile phones, LiDAR for autonomous vehicles, distance sensors for robots, security cameras, and motion sensors in virtual reality. In this talk, the advancements in VCSEL photonics will be reviewed. We present a lateral integration platform, including high-speed coupled cavity VCSELs for datacenter networks, along with their linear drive optics (LPO) and co-packaged optics (CPO). Furthermore, we demonstrate a VCSEL-based solid-state scanner with high resolution and a large field of view. Fumio Koyama Hirose Prize, and the 2024 IEEE Nick Holonyak, Jr. Medal for Semiconductor Optoelectronic Technologies. He is a Fellow of IEEE, Optica, IEICE, and the Japan Society of Applied Physics.



**Fumio Koyama** received his Ph.D. degree from Tokyo Institute of Technology, Japan, in 1985. For 40 years at Tokyo Institute of Technology, he has been one of the leading researchers in VCSEL photonics. He served as the Director-General (Dean) of Institute of Innovative Research at Tokyo Institute of Technology from 2018 to 2020. Since 2023, he has been Professor Emeritus, as well as Head of the VCSEL Photonics Research Unit at the Institute of Innovative Research, and a Specially Appointed Professor. His research interests include high-speed VCSEL photonics, photonic integrated devices, and 3D optical sensing. He has authored or co-authored over 1,000 journal and conference papers, including more than 100 invited talks.

He has received numerous awards, including the IEEE Student Paper Award in 1985, the IEE Electronics Letters Premium in 1985 and 1988, the 2004 Ichimura Award, the 2006 IEICE Electronics Society Award, the 2007 MEXT Prize for Science and Technology, the 2008 IEEE/LEOS William Streifer Scientific Achievement Award, the 2012 Izu Hayashi Award from the Japan Society of Applied Physics, the 2015 Tokyo Metropolitan Government Award, the 2016 Ichimura Prize in Industry for Excellent Achievement, the 2017 Kenjiro Sakurai Memorial Award, the 2018 Okawa Award, the 2019 Optica Nick Holonyak, Jr. Award, the 2024 Hirose Prize, and the 2024 IEEE Nick Holonyak, Jr. Medal for Semiconductor Optoelectronic Technologies. He is a Fellow of IEEE, Optica, IEICE, and the Japan Society of Applied Physics.