Kyushu University – Eindhoven University of Technology

Joint Workshop on Terahertz and Semiconductor Technologies

Friday 21 November 2025, 9:00-12:30 (CET) / 16:00-19:30 (JST)

The Netherlands and Japan are important hightech players and partners in business, research and education for fields like advanced chip-design, integrated photonics, heterogeneous integration and packaging and assembly. In a step to further develop bilateral partnerships, this joint workshop brings together young scientists from Kyushu University and Eindhoven University of Technology to delve into Terahertz and Semiconductor related technologies.

Keywords: Integrated circuits, photonic device, terahertz technology, semiconductor process technologies, optoelectronics

Language: English

Venue:

Onsite (Kyushu University) 313 Large Conference Room, ISEE

Onsite (TU Eindhoven) TBD

Online (Zoom link will be sent after registration)

Registration: https://forms.gle/dBm8xT9KrHjbcmcPA

Program (CET / JST)

(8:50 /15:50	Check-in Zoom Link)
09:00 / 16:00	- Welcome by Rob STROEKS, Sr. Coordinator External Partnerships, TU Eindhoven
	- Welcome by Prof. Masaharu SHIRATANI, Vice President, Kyushu University
	- Introduction by Prof. Kazutoshi KATO, Kyushu University
	- Introduction by Prof. Shihab AL-DAFFAIE, TU Eindhoven
09:15 / 16:15	**Session 1: THz technologies**
	- (20 min) **Prof. Klaas-Jan Tielrooij**, TU Eindhoven
	- (15 min) **Yoshiki Kamiura**, Kyushu University
	- (15 min) **Bram Heijnen**, TU Eindhoven
	- (15 min) **Masato Kawano**, Kyushu University
	- (15 min) **Rohit Kapoor**, TU Eindhoven
10:35 / 17:35	Break
10:45 / 17:45	**Session 2: Semiconductor technologies**
	- (20 min) **Associate Prof. Hisashi Kino**, Kyushu University
	- (15 min) **Tsz Chung Cheng**, Kyushu University
	- (15 min) **Ali Kaan Sünnetçioğlu**, TU Eindhoven
	- (15 min) **Naqeeb Ullah**, Kyushu University
	- (15 min) **Bas van Dijck**, TU Eindhoven
12:05 / 19:05	Discussion
12:30 / 19:30	Closing Remarks by Prof. Al-Daffaie and Prof. Kato

Contact (scientific program):

- Prof. Kazutoshi Kato, Kyushu University, kato@ed.kyushu-u.ac.jp

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- Rob Stroeks, TU Eindhoven, r.e.m.stroeks@tue.nl

Presenters

- Kyushu University

"Enhancement of carrier mobility in metal-oxide semiconductor field-effect transistors using negative thermal expansion gate electrodes"
Associate Prof. Hisashi Kino. kino@ed.kyushu-u.ac.jp
Abstract: We propose using a negative thermal expansion material as a gate electrode to introduce a large tensile strain into a MOSFET channel. MOSFETs with the negative thermal expansion gate electrode were fabricated and evaluated. Compared to conventional MOSFETs, these MOSFETs with a negative thermal expansion gate electrode exhibit a 10% increase in electron mobility.

"High-power 300GHz photomixer on SiC substrate enables high-speed wireless transmission"
Yoshiki Kamiura, Ryo Doi, Shinji Iwamoto, Masato Kawano, Yuya Mikami, Kazutoshi Kato. kamiura.yoshiki.639@s.kyushu-u.ac.jp Supervisor: Kazutoshi Kato, kato@ed.kyushu-u.ac.jp
Abstract: We present a compact 300-GHz photomixer module based on a SiC-uni-traveling carrier photodiode (UTC-PD), achieving a record output power of 4 mW that enables wireless transmission beyond 10 m. A 270-GHz coherent link further demonstrates 125-Gbit/s 32QAM transmission over 0.5 m with a BER below the HD-FEC threshold. These results highlight the broadband and high-power capability of SiC-based photomixers for scalable, high-capacity terahertz wireless systems toward future B5G/6G networks.

"Terahertz Wave Beam Steering Using Chromatic Dispersion at Optical Fibers by arrayed photomixers"
Masato Kawano, Yoshiki Kamiura, Yuya Mikami, Kazutoshi Kato. kawano.masato.014@s.kyushu-u.ac.jp Supervisor: Kazutoshi Kato, kato@ed.kyushu-u.ac.jp
Abstract: We experimentally demonstrate a terahertz (THz) beam steering system using tunable lasers and chromatic dispersion of optical fibers. By tuning the optical wavelength, the relative phase difference between dispersed optical paths is controlled, enabling all-optical steering of the THz

beam without electronic phase shifters. This system offers a compact and energy-efficient solution for future 6G wireless communication systems.

"Determination of exchange stiffness in Pt/Co/Ni multilayer system"

Tsz Chung Cheng, Yuto Tomita, Lin Zhang, Yuichiro Kurokawa, Yasukazu Murakami, Hiromi Yuasa.
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Supervisor: Prof. Hiromi Yuasa, hiromi.yuasa@ed.kyushu-u.ac.jp

Abstract:
Interfacial-Dzyaloshinskii-Moriya Interaction (i-DMI) inducing magnetic multilayers can support various types of topological spin texture that can be used for next generation computing or storage devices, such as skyrmions. When characterizing such materials, researchers often omitted the exchange stiffness constant by assuming a fixed value, due to the difficulties to measuring the value. In this work, we demonstrated using electron holography to observe static magnetic domain structures to obtain both exchange stiffness and i-DMI constant vital for characterization and simulations of such magnetic systems.

"A Wideband Data Recovery Circuit (DRC) for Forward Data Communication in the Over-Coupled Inductive Mode of the SWPDT System"

Naqeeb Ullah, Mohd Khairi Bin Zulkalnain, Adel Barakat, Haruichi Kanaya.
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Supervisor: Prof. Haruichi Kanaya, Kanaya@ed.kyushu-u.ac.jp

Abstract:
In this work, a wideband data recovery circuit (DRC) is proposed for forward data communication in the over-coupled inductive mode of the SWPDT system. The conventional DRCs often fail in this mode due to varying operating frequencies. Therefore, we present a wideband DRC using ASK with on–off keying (OOK) modulation, eliminating the need for passive diodes and averaging circuits. Implemented in 0.18 µm CMOS, the circuit operates across 5–150 MHz carrier frequencies and achieves a 2 Mb/s data rate.

Eindhoven University of Technology

"Nonlinear and integrated THz photonics with graphene"

Prof. Klaas-Jan Tielrooij
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Abstract:
The massless electrons in graphene, which have a tunable carrier density and exhibit ultrafast electron-electron thermalization dynamics, offer unconventional avenues toward THz photonics. We have demonstrated the ability to exploit electronic heat in graphene and related (meta)materials for nonlinear up-conversion of (sub)THz light, creating harmonic signals with high efficiency [1,2,3] and black-body radiation into the visible [4]. Besides THz nonlinear

photonics, we have shown that electronic heat in graphene also offers exciting possibilities toward THz photodetectors that are simultaneously fast, sensitive, and broadband [5]. Most recently, we have developed an integrated detector-interferometer that enables coherent THz wave detection [6].

[1] Nature 561, 507 (2018)

[2] ACS Nano 15, 1145 (2021)

[3] Light: Sci. Appl. 11, 315 (2022)

[4] Nano Lett. 23, 3872 (2023)

[5] Nano Lett. 19, 2765 (2019)

[6] To be published

"Real-time monitoring of electrochemical reactions by THz time-domain spectroscopy"

Bram J. Heijnen, Sina Haghverdi Khamene, Mariadriana Creatore, and Jaime Gomez Rivas.

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Supervisor: Prof. Jaime Gomez Rivas, J.Gomez.Rivas@tue.nl

Abstract:

Hydrogen (H2) is a key component in the transition from fossil fuels to a sustainable energy supply. It can be a major solution for the storage of wind and solar energy on a large scale. Hydrogen is produced through the electrolysis of water which is an electrochemical reaction where water is converted into hydrogen and oxygen by applying an electrical current. The field of electrochemistry deals with the study of these reactions. In spectroelectrochemistry (SEC), the field of electrochemistry is combined with spectroscopic techniques to study the chromic changes during electrochemical reactions. A spectroscopic technique that is hardly being investigated in SEC is terahertz time-domain spectroscopy (THz-TDS), despite its extended use as a non-contact probe to study a carrier dynamics in thin films. In this contribution, the use of THz-TDS for studying the carrier dynamics during the electrolysis of water is investigated. We show that we can measure changes in carrier mobility in an electrode during electrochemical processes in parallel with cyclic voltammetry (CV) measurements. The CV analysis revealed a decrease in current density over prolonged cycling, while THz-TDS demonstrated potential for examining the carrier dynamics behind this instability mechanism.

"Enhanced Terahertz Detection Using Inverted Gate Architecture in Graphene TeraFETs"

Rohit Kapoor, Jakob Holstein, Shihab Al-Daffaie, Juan Antonio Delgado Notario, Vito Clericò, Hartmut. G. Roskos r.kapoor@tue.nl

Supervisor: Prof. Shihab Al-Daffaie, s.al-daffaie@tue.nl

Abstract:

Antenna-coupled terahertz field-effect transistors (TeraFETs) are key components for THz detection and imaging in the 0.1–10 THz range. While conventional TeraFETs rely on semiconductor materials such as Si or GaN, graphene offers new opportunities due to its exceptional carrier mobility and plasmonic effects. This work presents a comparative study of two novel graphene-based TeraFET

architectures using h-BN/graphene/h-BN stacks: a conventional structure with a gold top-gate and an inverted configuration featuring a gold back-gate. Both designs are integrated with identical broadband bow-tie antennas.

THz characterization was performed at 350 GHz. The device with the inverted gate exhibited a significantly higher optical voltage responsivity (71 V/W) compared to the non-inverted one (34 V/W). Correspondingly, the optical noise-equivalent power (NEP) was found to be lower for the inverted design (71 pW/√Hz) than for the top-gate version (151 pW/√Hz). This improvement is attributed to the enhanced screening of surface potentials at the Si/SiO_2 interface provided by the buried gate electrode.

With an optical NEP of 71 pW/√Hz, inverted-gate graphene TeraFETs approach the performance of the best broadband Si-CMOS and GaN/AlGaN-based detectors. These results demonstrate that positioning the gate beneath the graphene channel offers a promising design pathway for future high-sensitivity THz detectors. The study highlights the potential of two-dimensional materials for innovative detection architectures.

"Study and development of high efficiency, high speed electro-optic phase modulators on InP membrane technology"

Ali Kaan Sünnetçioğlu, James Arthur Hillier, Duarte Fernandes da Silva, Floris Pronk, Yi Wang and Yuqing Jiao. a.k.sunnetcioglu@tue.nl

Supervisor: Prof. Yuqing Jiao, Y.Jiao@tue.nl

Abstract:

Photonic Integrated Circuits (PICs) have emerged as a key technology for enabling scalable, energy-efficient, and high-bandwidth optical communication systems. Among the various material platforms, Indium Phosphide (InP) stands out for its ability to integrate active and passive photonic components, such as lasers, modulators, and detectors, on a single chip. This project focuses on the development of InP electro-optic phase modulators on an InP membrane-on-silicon platform. Electro-optic phase modulators are essential components in modern optical communication systems, enabling high-speed modulation, coherent signal generation, and phase control in complex integrated photonic circuits.

This study involves the design and optimization of two distinct modulator epitaxial structures and device architectures aimed at high efficiency and high-speed radio-frequency (RF) applications. The design process incorporates comprehensive optical, electrical, and electro-optic simulations to accurately model device performance. Key performance metrics such as electro-optic efficiency, small-signal electrical–electrical (EE) bandwidth, and electro–optical (EO) bandwidth will be quantified through these analyses. This work will provide insights into the trade-offs between epitaxial design, device geometry, and modulation performance, contributing to the advancement of high-speed hybrid InP membrane on silicon photonic integration technology.

"Spatiotemporal microscopy to follow heat and charge transport"

Bas van Dijck, S. Varghese, M.C. van Hemert, L. Moczko, H.O. Ramsden1, A. Block2, K.J. Tielrooij
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Abstract:

Understanding heat and charge transport is essential for a wide range of technological applications. Several techniques exist to characterize transport in devices, but all of them have their limitations. Moreover, approaches that can analyze both heat and charge transport directly with minimal modeling, are rare.

Recently we have developed a technique [1] that allows us to characterize this transport in thin films directly in space and time. Unlike conventional approaches, this technique enables direct optical access to carrier dynamics in the system by means of measuring the differential reflection. By means of integrating a high-resolution scanning mirror we enable the possibility to track these carriers with nanometer positioning precision and a time resolution limited by the pulse width of the laser used.

The integrated delay line provides insight into the dynamics happening at different time scales of the material, while the tunable wavelength of the laser allows us to tune the type of carriers we are sensitive to. To characterize the diffusion of these carriers we analyze the evolution of the broadened distribution at “pre-time-zero” obtained by changing the beam-offset using the scanning mirror.

We have employed this technique to study a range of materials, for example heat diffusion in both thin gold films [2] and transition metal dichalcogenides [1], and charge and exciton diffusion in graphene nanoribbons [3]. We characterized and quantified the diffusivity in these materials, and we observe interesting transport phenomena such negative effective thermal diffusion, hydro-thermoelastic heat transport and ultrafast charge diffusion respectively. Extending this tool to a broad wavelength regime and introducing pulse-picking allows us to use this tool for a wide range of materials and the study of longer-lived phenomena on the nano- to microsecond timescales.

[1] S. Varghese et al. A pre-time-zero spatiotemporal microscopy technique for the ultrasensitive determination of the thermal diffusivity of thin films , Rev. Sci. Inst 94 034903, 2023

[2] A. Block et al. Observation of Negative Effective Thermal Diffusion in Gold Films , ACS Photonics, 10(4) 1150-1158, 2023

[3] S. Varghese et al. Ultrafast Charge and Exciton Diffusion in Monolayer Films of 9-Armchair Graphene Nanoribbons, Adv. Mat. 36, 2407796, 2024