ANNUAL REPORT 2022 (DRAFT)
CONDENSED MATTER PHYSICS LABORATORY
National Institute of Physics
01 January 2022 – 31 December 2022

I. Executive Summary

Organization

Professor 4
Asst. Professor: 2
REPS:
Adjunct Researchers: 1
Apprentices (NIP-Students): 3
Apprentices (Non-NIP): 5
Undergraduate Members:16

Mentoring

PhD Physics:4
PhD MSE:12
MS Physics:11
MS MSE:10
BS Physics:2
BS Applied Physics:6

A. Research Highlights

Papers published/accepted for publication in international peer-reviewed journals: 7
Papers published in local journals:0
International conference presentations
- with full paper:0
- without full paper:8

Local conference papers
- with full paper:10

NIP-Funded Projects:4
External Grants:1
UP Funded : 2

B. Extension Work Highlights

Research Interns/OJT's (Non-NIP), for training held at NIP: 2
Main Challenges Encountered and Proposed Solutions

II. Technical Report

CMPL was able to publish 7 peer-reviewed Scopus-indexed manuscripts. CMPL members participated in local and international workshops and conferences conducted online. Access to the laboratories were restricted in the first half of the year due to the pandemic and only a limited number of graduate students were able work on their thesis. Thus the status of majority of the students where in limbo for this period. Nevertheless four (4) PhDs- two from the Institute and another two from the Materials Science and Engineering program-were able to successfully defend their thesis The lifting of restrictions in the second half of the year allowed us to slowly have face to face meetings with the students as well as gradually bring back the experimental setups to working status. In addition, students and faculty from our collaborative projects were able to visit us near the end of the year. As of December 2022, CMPL has a total of 59 members: 6 PhD Faculty, 1 Adjunct Researcher, 4 PhD Physics students, 10 PhD MSE students, 11 MS Physics students, 12 MS MSE students, 2 BS Physics students, 6 BS Applied Physics students, and 8 apprentices.

A. Activities of the Research Group

1.) Organization

a.) Group Members as of December 2022.

Organizational Summary

Member	Category	Number
PhD Faculty		6
Graduate Students	PhD Physics	4
	PhD MSE	10
	MS Physics	11
	MS MSE	12
Undergraduate Students	BS Physics	2
	BS Applied Physics	6
	Apprentice	8

PhD Faculty (6)

1.) Dr. Salvador, Arnel - (Professor)
2.) Dr. Estacio, Elmer - (Professor)
3.) Dr. Sarmago, Roland - (Professor)
4.) Dr. Somintac, Armando - (Professor
5.) Dr. De Los Reyes, Alexander-(Asst. Professor Jan 31, 2019 - Jul 31, 2022)
6.) Dr. Cabello, Neil Irvin (Asst. Professor Jan 31, 2019 - Dec. 31, 2022)

Adjunct Researcher (1)

1.) Dr. Sadia-Salang, Cyril (MSEP Asst. Professor)

PhD Physics (5)

	NAME	YR LEVEL / YRS IN PROGRAM	ADVISER
1.)	Catindig, Gerald Angelo	3.5	Dr. Arnel Salvador
2.)	De Vera, Francesca Isabel	3	Dr. Roland Sarmago
3.)	Husay, Horace Andrew	5	Dr. Armando Somintac
4.)	Solibet, Erick John Carlo	2.5	Dr. Armando Somintac
5.)	Cabello Neil Irvin	graduated 1.21-22	Dr. Armando Somintac

PhD MSE (10)

1.)	Café, Arven I.	2.5	Dr. Armando Somintac
2.)	Copa, Vernalyn	4	Dr. Arnel Salvador
3.)	Loberternos, Regine	2.5	Dr. Armando Somintac
4.)	Lopez, Lorenzo Jr.	graduating	Dr. Arnel Salvador
5.)	Montecillo, Anthony	1.5	Dr. Armando Somintac
6.)	Narag, Dean Von Johari	1.5	Dr. Sadia-Salang, Cyril
7.)	Publico, Jairrus	1.5	Dr. Elmer Estacio
8.)	Tumanguil, Mae Agatha	2.5	Dr. Elmer Estacio, Dr. Arnel Salvador
9.)	Tingzon, Philippe Martin	graduated 2.21-22	Dr. Armando Somintac
10.)	Tuico, Anthony	3.5	Dr. Alexander DeLos Reyes, Dr. Elmer Estacio

MS Physics (11)

1.)	Andig, Roni	3	Dr. Arnel Salvador
2.)	Armonia, Jeremias-Ibus	2	Dr. Armando Somintac
3.)	Dawisan, Mark Kevin	.5	Dr. Arnel Salvador
4.)	Figueroa, Lourdes Nicole S.	1	Dr. Elmer Estacio
5.)	Juguilon, Vince Paul	.5	Dr. Elmer Estacio
6.)	Lipardo, John Axl	1	Dr. Roland Sarmago
7.)	Llemit, Christian Loer T.	graduated 2.21-22	Dr. Roland Sarmago
8.)	Romero, Ezekiel Raul	3	Dr. Roland Sarmago
9.)	Tan, Craig Egan Allistair	3	Dr. Arnel Salvador
10.)	Verona, Ivan Cedrick	.5	Dr. Elmer Estacio
11.)	Vistro, Victor DC Andres	7.5	Dr. Roland Sarmago

MS MSE (12)

1.)	Cantor, Camille Victoria	2.5	Dr. Roland Sarmago
2.)	Celebrado, Michelle	2	Dr. Roland Sarmago
3.)	De Luna, Charlene	3	Dr. Arnel Salvador
4.)	Ferrolino, John Paul R.	5.5	Dr. Arnel Salvador
5.)	Inguito, Jonah Micah L.	4.5	Dr. Roland Sarmago
6.)	Llevares, Kint Ynnos B.	1	Dr. Roland Sarmago
7.)	Magallanes, Bee Jay	4.5	Dr. Roland Sarmago
8.)	Manrique, Mylenne	graduated mid yr 2021	Dr. Armando Somintac
9.)	Nalayog, Marvin B.	3	Dr. Roland Sarmago
10.)	Pangasinan, Jamela N.	3	Dr. Arnel Salvador
11.)	Salazar, Kloudene	1	Dr. Roland Sarmago
12.)	Torremoro, Jennieva Grace	2.5	Dr. Roland Sarmago

BS Physics (2)

1.)	Arcilla, Jose Mari Sebastian	4th yr	Dr. Elmer Estacio
2.)	Batalla, Dhaniel Angelo	3rd yr	Dr. Elmer Estacio

BS Applied Physics (6)

1.)	Alaba, Kenneth	4th yr	Dr. Elmer Estacio
2.)	Campano, Zsara Marie	4th yr	Dr. Elmer Estacio
3.)	Carillo, Gian Carlo	4th yr	Dr. Arnel Salvador
4.)	Flores, Patricia Frances	3rd yr	Dr. Armando Somintac
5.)	Leonardo, Shawntel Joy	4th yr	Dr. Roland Sarmago
6.)	Magsayo, Lawrence Jay G.	4th yr	Dr. Roland Sarmago

Apprentice (8)

1.)	Briones, Christian	
2.)	Celebrado, Michelle	
3.)	Cruz, Lue Jeniel	
4.)	Dris Angelo Santos	3rd yr
5.)	Lim, Cerx Lorenz Belila	
6.)	Ponce, Francis Therese	3rd yr
7.)	Romero, Vril Jappuch P.	4th yr
8.)	Sierra, Iries-Gwyneth	

2.) Mentoring

A.) Graduates

Degree Program	Name	Thesis Title	Defense Date	Adviser	Sem Graduated
PhD Physics	Cabello, Neil Irvin F.	Terahertz Emission Characteristics of Silicon Nanostructure-coated Gallium Arsenide Photoconductive Antenna	12 January 2022	Armando Somintac	1st Sem 2021-2022
PhD MSE	Lopez Jr, Lorenzo P.	Gas sensing performance of shadow-mask-fabricated graphene field-effect-transistor using a conventional and a cap champer designs in a dynamics system	03 June 2022	Arnel Salvador,adviser Armando Somintac-co adviser	Candidate for graduation 1st Sem 2022-2023
MS MSE	Mylenne Manrique	Fluence-dependent raman scattering of vertically-alligned silicon nanowire arrays	06 August 2021	Armando Somintac	1st Sem 2021-2022

PhD MSE	Tingzon, Philippe Martin B.	Residual stress experienced by MEMS tunable VCSEL devices with a bridge-type design	21 March 2022	Armando Somintac	2nd Sem 2021-2022
PhD Physics	de Vera, Francesca Isabel N.	Superconductivity and Grain Coupling Behaviour of $Bi_2Sr_{2-x}In_xCaCu_2O_{8+D}$ (In-doped Bi-2212) Bulks and Films	30 May 2022	Roland Sarmago	2nd Sem 2021-2022
MS Physics	Llemit, Christian Loer	Structural, Electronic and Magnetic Properties of Iron-related Defects in Wurtzite ZnO: an Approach from First Principles Calculations	03 June 2022	Roland Sarmago	2nd Sem 2021-2022

Summary of Graduates

	1st sem AY 2021-2022	2nd sem AY 2021-2022	midyear AY 2022-2023	Total
PhD Physics	1	1	0	2
PhD MSE	0	1	0	1
MS Physics	0	1	0	1
MS MSE	1	0	0	1
BS Physics	0	0	0	0
BS Applied Physics	0	0	0	0

B.) Research Highlights

1.) Papers published/accepted for publications in international peer-reviewed journals (7)

1. Balgos, Maria Herminia M., Mary Clare S. Escaño, Rafael B. Jaculbia, Tien Quang Nguyen, Elizabeth Ann P. Prieto, Elmer S. Estacio, Arnel A. Salvador, et al. “Atomically Precise Delineation of As Antisite Defect States from Undoped Gallium Arsenide Host Lattice by Scanning Tunneling Microscopy and Spectroscopy Measurements and Density Functional Theory Calculations.” *Physica Status Solidi (b)* 259, no. 7 (July 2022): 2100652. https://doi.org/10.1002/pssb.202100652.

2. Bardolaza, Hannah R., Neil Irvin F. Cabello, John Paul R. Ferrolino, Ivan Cedric M. Verona, M. Y. Bacaoco, Armando S. Somintac, Arnel A. Salvador, Alexander E. De Los Reyes, and Elmer S. Estacio. “Integrated Optics Spiral Photoconductive Antennas Coupled with 1D and 2D Micron-Size Terahertz-Wavelength Plasmonic Metal Arrays.” *Optical Materials Express* 12, no. 4 (April 1, 2022): 1617. https://doi.org/10.1364/OME.455044.

3. Cabello, Neil Irvin, De Los Reyes, Alexander, Sarmiento, Vladimir, Ferrolino, John Paul, Vistro, Victor D. Andres, Vasquez, John Daniel, Bardolaza, Hannah, Kitahara, Hideaki, Tani, Misahiko, Salvador, Arnel, Somintac, Armando, & Estacio, Elmer (2022). Terahertz emission enhancement of gallium-arsenide-based photoconductive antennas by silicon nanowire coating. *IEEE Transactions on Terahertz Science and Technology*, *12*(1), 36–41. https://doi.org/10.1109/TTHZ.2021.3115726

4. Catindig, Gerald Angelo R., Bardolaza, Hannah R., Vasquez, John Daniel E., Jagus, Rommel J., Patrocenio, Kerphy Liandro M., Gonzales, Karl Cedric P., Prieto, Elizabeth Ann P., Somintac, Armando S., Estacio, Elmer S., De Los Reyes, Alexander E., & Salvador, Arnel A. (2022). Compressive and tensile strain effects on the ultrafast carrier dynamics and transport of gallium arsenide thin films on silicon and magnesium oxide substrates. *Optical Materials Express*, *12*(12), 4702. https://doi.org/10.1364/OME.474151

5. De Los Reyes, Alexander, Prieto, Elizabeth Ann, Dasallas, Lean, Bardolaza, Hannah, Tumanguil-Quitoras, Mae Agatha, Cabello, Neil Irvin, Somintac, Armando, Salvador, Arnel, & Estacio, Elmer (2022). Tunneling dynamics and transport in MBE-grown GaAs/AlGaAs asymmetric double quantum wells investigated via photoluminescence and terahertz time-domain spectroscopy. *Journal of Materials Science: Materials in Electronics*, *33*(20), 16126–16135. https://doi.org/10.1007/s10854-022-08503-3

6. De Vera, Francesca Isabel N., Singidas, Bess G., & Sarmago, Roland V. (2022). Coupling behavior of Bi2Sr2−xInxCaCu2O8+d. *Cryogenics*, *121*, 103406. https://doi.org/10.1016/j.cryogenics.2021.103406

7. Tingzon, Philippe Martin, Husay, Horace Andrew, Cabello, Neil Irvin, Eslit, John Jairus, Cook, Kevin, Kapraun, Jonas, Somintac, Armando, De Leon, Maria Theresa, Rosales, Marc, Salvador, Arnel, Chang-Hasnain, Constance, & Estacio, Elmer (2022). Indirect stress and air-cavity displacement measurement of MEMS tunable VCSELs via micro-Raman and micro-photoluminescence spectroscopy. *Semiconductor Science and Technology*, *37*(3), 035013. https://doi.org/10.1088/1361-6641/ac4abc

2.) International Conference Presentations without full paper:

1. A. De Los Reyes, E. A. Prieto, L. Dasallas, H. Bardolaza, M.A. Tumanguil-Quitoras, N.I. Cabello, A. Somintac, A. Salvador, and E. Estacio, "Terahertz emission from GaAs/AlGaAs asymmetric double quantum wells," in Proceedings of the 12th International Conference on Photonics and Applications (ICPA-12) held in Con Dao, Vietnam, September 28 - October 01, 2022.

2. E. Estacio, "Collaborative research efforts between NIP-UPD and IOP-VAST on the development of nanostructured silicon for terahertz applications, " in Proceedings of the 12th International Conference on Photonics and Applications (ICPA-12) held in Con Dao, Vietnam , September 28 - October 01, 2022.

3. H.A. Husay, A. Cafe, L. Lopez, M.H. Balgos, E. Estacio, A. Salvador, and A. Somintac, "Enhanced terahertz emission from p-CuxO/n-Si heterostructures grown through thermal oxidation," in Proceedings of the 12th International Conference on Photonics and Applications (ICPA-12) held in Con Dao, Vietnam, September 28 - October 01, 2022.

4. V.P. Juguilon, D.A. Lumantas-Colades, N.I. Cabello, A. De Los Reyes, I. Maeng, C. Kang, C.S. Lee, and E. Estacio, "Carrier capture dynamics in InAs/GaAs single-layer quantum dots observed using time-resolved terahertz spectroscopy," in Proceedings of the 12th International Conference on Photonics and Applications (ICPA-12) held in Con Dao, Vietnam, September 28 - October 01, 2022.

5. E. Estacio, "Overview of the academic and research profiles of the National Institute of Physics, University of the Philippines and its work on Terahertz optoelectronics," in The 8th Southeast Asia Collaborative Symposium on Energy Materials (SACSEM) held in Tsukuba University, Tsukuba, Japan, November 28029 2022.

6. V.P. Juguilon, D.A. Lumantas-Colades, N.I. Cabello, A. De Los Reyes, I. Maeng, C. Kang, C.S. Lee, and E. Estacio, "Carrier capture in InAs/GaAs self-assembled quantum dots investigated using time-resolved terahertz spectroscopy," in The 8th Southeast Asia Collaborative Symposium on Energy Materials (SACSEM) held in Tsukuba University, Tsukuba, Japan, November 28-29 2022.

7. A. De Los Reyes, J. Publico, I.C. Verona, J.P. Ferrolino, V.P. Juguilon, L. N. Dela Rosa, H. Bardolaza, N.I. Cabello, and E. Estacio, "Carrier dynamics in semi-insulating and low-temperature-grown gallium arsenide photoconductive antenna devices under above-bandgap and below-bandgap photoexcitation" in The 83rd JSAP-OSA-SPP Joint Symposia held in Tohoku University, September 20-23 2022.

8. A. De Los Reyes, J. Publico, I.C. Verona, J.P. Ferrolino, V.P. Juguilon, L. N. Dela Rosa, H. Bardolaza, N.I. Cabello, and E. Estacio, "Terahertz time-domain emission spectroscopy of semi-insulating and low-temperature-grown gallium arsenide photoconductive antenna at below and above bandgap excitation conditions" in The 13th International Conference on Information Optics and Photonics (CIOP2022) held in Xian, China, August 7-10, 2022.

3.) Local conference presentations with full paper in print proceedings

1. AE De Los Reyes, AM Aquino, LNF Dela Rosa, VPP Juguilon, ICM Verona, JPR Ferrolino, NIF Cabello, HR Bardolaza, AS Somintac, AA Salvador, and ES Estacio, Investigating the terahertz emission properties of low-temperature-grown gallium arsenide (LTG-GaAs) photoconductive antenna (PCA) devices via Drude-Lorentz model, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-1F-04 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-1F-04.

2. ALC Jusi, MA Castrosanto, AML Magistrado, MAC Tumanguil-Quitoras, ES Estacio, and AKG Tapia, Commissioning of a terahertz system for spectroscopy and imaging in the University of the Philippines Los Baños for chemical, biological, and engineering applications, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-1E-05 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-1E-05.

3. ERD Romero, RV Sarmago, and VAI Samson, Beam hardening artifact correction in x-ray computed tomography of homogeneous objects using Residual U-Net, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-PA-13 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-PA-13.

4. FC Hila, AC Doño, SC Buenviaje, ES Estacio, AS Somintac, AA Salvador, and CS Salang, Morphological characterization and space radiation effect simulations of epitaxially grown GaAs/GaSb heterostructures, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-PA-01 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-PA-01.

5. FIN de Vera and RV Sarmago, Enhancement of TC and JC by indium doping in Bi2Sr2CaCu2O8 films, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-PA-03 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-PA-03.

6. HAF Husay, AI Cafe, JM Lopez, ES Estacio, AA Salvador, and AS Somintac, Effect of porosity on the thermal properties of porous silicon as investigated by spatially-resolved Raman spectroscopy, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-2E-02 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-2E-02.

7. JA De Mesa, MJF Empizo, K Shinohara, AP Rillera, VAI Samson, N Sarukura, RV Sarmago, and WO Garcia, Femtosecond pulsed laser deposition of highly oriented cerium (IV) oxide thin films with background oxygen gas, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-PA-14 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-PA-14.

8. LNF Dela Rosa, VPP Juguilon, ICM Verona, NIF Cabello, HR Bardolaza, ES Estacio, and AE De Los Reyes, An equivalent circuit analysis of the temperature dependence of the terahertz emission from a photoconductive antenna device, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-PA-18 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-PA-18.

9. NIF Cabello, MAC Tumanguil-Quitoras, HR Bardolaza, LL Dasallas, EAP Prieto, AS Somintac, AA Salvador, ES Estacio, and AE De Los Reyes, Terahertz time-domain spectroscopy of MBE-grown GaAs/AlGaAs asymmetric double quantum wells, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-1E-06 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-1E-06.

10. VP Juguilon, DA Lumantas-Colades, NI Cabello, A De Los Reyes, I Maeng, C Kang, C-S Kee, and E Estacio, Investigation of carrier capture dynamics in InAs/GaAs single-layer quantum dots using terahertz time-resolved spectroscopy, Proceedings of the Samahang Pisika ng Pilipinas 40, SPP-2022-1F-05 (2022). URL: https://proceedings.spp-online.org/article/view/SPP-2022-1F-05.

4.) PROJECTS

NIP-funded Projects

Project Leader: Dr. Elmer S. Estacio

Project Title: Investigation of the terahertz emission characteristics of low-temperature-grown gallium arsenide (LTG-GaAs) photoconductive antenna devices via Drude-Lorentz Model

Duration: 01 January 2022 - 31 December 2022

Funding Agency: NIP-UPD

Funding Amount: PHP 105,600.00

Project Leader: Dr. Armando S. Somintac

Project Title: Spatially-resolved Raman spectroscopy of porous Silicon

Duration: 01 January 2022 - 31 December 2022

Funding Agency: NIP-UPD

Funding Amount: PHP 105,600.00

Project Leader: Dr. Arnel A. Salvador

Project Title: Structural characterization of low-temperature-grown Gallium Arsenide (GaAs) on Silicon

Duration: 01 January 2022 - 31 December 2022

Funding Agency: NIP-UPD

Funding Amount: PHP 105,600.00

Project Leader: Dr. Sarmago, Roland

Project Title: Optical and DFT Studies of Some Doped Wide Bandgap Semiconductors, Insulators, and HiTc Superconductors Related Materials

Duration: 01 January 2022 - 31 December 2022

Funding Agency: NIP-UPD

Funding Amount: PHP 105,600.00

UP FUNDED

Project Leader: Dr. Arnel Salvador

Project Title: Tunneling in MBE-grown GaAs/AlGaAs based triple quantum wells probed via terahertz time-domain spectroscopy

Duration: 01 April 2022 - 30 September 2023

Funding Agency: OVPAA-ECWRG

Funding Amount: PHP 650,000.00

Project Leader: Dr. Estacio, Elmer

Project Title: Effects of nanoparticle deposition on the performance of photoconductive antenna devices for terahertz applications

Duration: 01 April 2022 - 30 September 2023

Funding Agency: OVPAA-ECWRG

Funding Amount: PHP 650,000.00

External Grants

Project Leader: Dr. Arnel Salvador

Project Title: Chemical and Environment - Portable Sensors and Transducers: Phase 2 (CE-PoST 2)

Duration: 01 July 2022 - 30 June 2024

Funding Agency: CHED-LAKAS (Leading Advancement in Knowledge in Agriculture and Science

Funding Amount: 169,795,594.54

Project Description : This is a collaborative program with UC Berkeley, MSU-Marawi and University of San Carlos. The program is intended to upgrade the device fabrication , characterization and modelling capabilities of the Institutes based in the Philippines. With the assistance of UC Berkeley AlN piezoelectric micromachined ultrasonic transducers will be fabricated and tested at the Institute . MSU -Marawi will be involved in thin film growth while USC will do device simulations.

C.) Extension Highlights

1.) Research Interns/OJTs (Non-NIP) for training held at NIP

a.) University of Fukui (24 November - 23 December) (pics needed & description)

NIP HOSTS UNIVERSITY OF FUKUI STUDENTS OVERSEAS EDUCATION PROGRAM 2022

UNIVERSITY OF FUKUI STUDENTS WITH CONDENSED MATTER PHYSICS LABORATORY MEMBERS

Project: Memorandum of Agreement on Academic and Research Cooperation between the University of Fukui and the University of the Philippines

Host Professor: Dr. Elmer S. Estacio (CMPL)

Visiting Students from the University of Fukui:
- Tominaga, Keita
- Takaichi, Seiwa
- Shimono, Nozomi
- Atsuya, Sakamoto
- Izumi, Akihiro

Students from the Research Center for Development of Far-Infrared Region of the University of Fukui (FIR-UF) visited NIP, in line with the Memorandum of Agreement between the University of Fukui and the University of the Philippines Diliman. The FIR-UF students were trained by members of the Condensed Matter Physics Laboratory in device fabrication processes, such as photolithography and metal deposition, along with terahertz time-domain spectroscopy. In addition, they also underwent English lessons and cultural immersion.

b.) Mindanao State University - Marawi (28 November - 16 December 2022)

MINDANAO STATE UNIVERSITY - MARAWI FACULTY AND STUDENTS VISIT NIP

MINDANAO STATE UNIVERSITY MARAWI FACULTY, RESEARCH FELLOW, AND STUDENTS WITH CONDENSED MATTER PHYSICS LABORATORY MEMBERS

Project: CHED-LAKAS-2021-010 “Chemical and Environment: Portable Sensors and Transducers Phase 2 (CE-PoST2)”

Host Professor: Dr. Arnel A. Salvador (CMPL)

Visiting Faculty and Students from MSU Marawi:

- Dr. Johnny Jim S. Ouano (Project coordinator)
- Clarisse Jade T. Estrada (Research fellow, MS Physics student)
- Sunny John A. Lood (MS Physics student)
- Zharah M. Zapanta (MS Physics student)
- Jose Andrian P. Saspa (MS Physics student)

Students and faculty from the Mindanao State University visited NIP, in line with the CHED LAKAS project entitled “Chemical and Environment: Portable Sensors and Transducers Phase 2” or CE-PoST2. The MSU students were trained by members of the Condensed Matter Physics Laboratory in device fabrication processes, such as photolithography and metal deposition, and in x-ray diffractometry characterization. Their training will be vital when they establish their respective device fabrication laboratory in their home institute.

D.) Main Challenges Encountered and Proposed Solutions

Main Challenges Encountered	Proposed Solutions
NIP Access – Due to access and quarantine restrictions brought by COVID-19, it has been difficult to enter the premises of NIP to perform maintenance checks and equipment	Lifting of the restrictions enabled the students access to the laboratories. Perhaps a better understanding of the science involved in the transmission of disease and the role of vaccines will help since other institutions did not impose a total lockdown.
Supplies – Due to payment delay of previous orders, new supplies were withheld. These resulted in the delay in the experiment and thesis of the student	Review of policies where advance purchase for small items is directly administered by the principal investigator . The ceiling for what is classified as equipment purchase has been raised to P50,000 to enable researchers to react quickly to needed repairs and supplies. There should also be a corresponding decrease in the paperwork needed.
Equipment – Maintenance and proper upkeep of experimental setups.	In times of extended shutdowns having de-humidifiers will be a useful way of extending the lifetimes of the equipment.

E.) Awards or Accreditations Received / Positions of Responsibility Held and Other Accomplishments

1.) Name: Dr. Estacio, Elmer

Position: President

Office: Samahang Pisika ng Pilipinas

Date: Jan 1, 2022 - Dec 31, 2022

2.) Name: Dr. De Los Reyes, Alexander

Position: Councilor

Office: Samahang Pisika ng Pilipinas

Date: Jan 1, 2022 - Dec 31, 2022

3.) Name: Dr. Sarmago, Roland

Position: Member, Committee on Finance

Office: University Council, University of the Philippines Diliman

Date: 2022-2023

4.) Name: Dr. Somintac, Armando

Position: Project Development Associate

Office: Office of the Vice Chancellor for Research and Development, University of the Philippines Diliman

Date: Jan 11, 2022 - present

5.) Name: Dr. Salvador, Arnel

Position: Technical Panel Member Program and Standards Mathematical Physical Science Division)

Office: CHED

Date: Jan. 2, 2021 - present

III. Photos, ISI/ SCI Publications, and Other Appendices

Figure 1. CMPL Ph.D. Researchers (From Left to Right, Top: Dr. Salvador, Dr. Sarmago, Dr. Estacio, and Dr. Somintac; Bottom, Dr. De Los Reyes (Left), Dr. Salang (Middle) and Dr. Cabello (Right) (From:http://nip.upd.edu.ph/people/faculty/professors/ and Dr. Salang and Dr. Cabello's LinkedIn)

Abstract of Peer-Revied Articles (through screen capture from the journal website or first page of the pdf file)

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RESEARCH ARTICLE

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15213951, 2022, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/pssb.202100652 by University Of The Philippines Diliman Main Library, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Atomically Precise Delineation of As Antisite Defect States from Undoped Gallium Arsenide Host Lattice by Scanning Tunneling Microscopy and Spectroscopy Measurements and Density Functional Theory Calculations

Maria Herminia M. Balgos, Mary Clare S. Escaño, Rafael B. Jaculbia, Tien Quang Nguyen, Elizabeth Ann P. Prieto, Elmer S. Estacio, Arnel A. Salvador, Armando S. Somintac, Masahiko Tani, Norihiko Hayazawa,* and Yousoo Kim**

Using a combination of scanning tunneling microscopy (STM) and spectroscopy with density functional theory calculations, the electronic properties of the subsurface arsenic antisite defect (As_{Ga}) are unambiguously delineated from those of the surrounding As atoms in undoped gallium arsenide (GaAs) lattice with atomic precision. In the GaAs(110) surface with As_{Ga} located at the second layer (2-As_{Ga}), it is found that the midgap state induced by 2-As_{Ga} manifests as a bright contrast at the As_{Ga}—As bond site. Furthermore, it is shown that STM images taken at large magnitudes of negative sample bias are dominated by the local density of states of neighboring surface As atoms. These states lead to a four-lobe symmetric contrast in the filled-state STM image around the 2-As_{Ga} defect. These results provide insights for surface/subsurface defect engineering at the atomic scale.

1. Introduction

Owing to its more efficient luminescence and superior mobility compared with silicon, gallium arsenide (GaAs) is used in several optoelectronic devices such as light-emitting diodes, lasers, transistors, and solar cells. Albeit with lower luminescence and mobility caused by a high density of point defects, GaAs grown at temperatures less than 400 °C (low-temperature [LT]-GaAs) is used as an active layer in photoconductive antenna (PCA) devices to generate and detect terahertz (THz) radiation. Careful control of the density and the electronic property of the point defects can tune the response of the PCA.[1,2] For instance, changing the density of the point defects resulted in tuning of the carrier lifetime[2–4] and conductivity[5–7] in LT-GaAs, which affect the bandwidth and the maximum bias applied to the PCA, respectively. Moreover, the midgap state induced by the As antisite defect (As_{Ga})[8] is exploited for below-bandgap absorption and allows the use of cost-effective and robust fiber lasers at telecom wavelengths (1–1.6 μm) as pumps for LT-GaAs-based PCAs.[9] A prerequisite to effective device optimization via defect engineering is to delineate the local electronic structure of the point defect with that of the host lattice and correlate it with midgap states originating from the defect.

Experimentally, scanning tunneling microscopy (STM) can probe the topography and electronic structures of various point defects. The GaAs (110) surface (**Figure 1**), in which the equal number and alternating Ga and As atoms in a zigzag line in each layer result in a nonpolar surface, is one of the typical surfaces studied via STM. Several investigations of GaAs (110) via STM have focused on the different types of dopants[10–13] and the

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Integrated optics spiral photoconductive antennas coupled with 1D and 2D micron-size terahertz-wavelength plasmonic metal arrays

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Abstract: Terahertz (THz) photoconductive antenna (PCA) emitters having one-dimensional (1D) and two-dimensional (2D) micron-size metal line arrays (MLA's) at the transmission side of the semi-insulating GaAs substrate were fabricated via UV photolithography and electron beam deposition. At a fluence of ~1.2 mJ/cm^2 and 20 V_{PP} bias, the enhancement in the THz signal peak-to-peak amplitudes are ~6 times for 1D MLA and ~11 times for 2D MLA, compared to the reference PCA, respectively. An all-optical effect via THz extraordinary transmission is conjectured for the enhancement mechanism. This metamaterial PCA design presents a feasible, yet more cost-effective alternative to photo-conducting gap nanostructure fabrication using e-beam lithography.

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1. Introduction

The terahertz (THz) photoconductive antenna (PCA) is a widely-used device for the generation and detection of THz radiation intended for spectroscopy and imaging applications [1–3]. It has the advantage of being compact; requiring relatively low optical power to generate sub-picosecond THz pulses [1–3]. A PCA consists of a semiconductor substrate with short carrier lifetime, high carrier mobility, and high breakdown voltage characteristics [2,4,5]. In a PCA THz emitter, femtosecond optical pulses generate electron-hole pairs in the micron-size gap between the electrodes, which are accelerated by a bias field. The transient current due to the acceleration and decay of photogenerated carriers in the PCA is the origin of the THz frequency pulses [2,4–7].

Diverse approaches to improve the THz performance of PCA emitters are actively being explored. Aside from developments on the photoconductive material itself, large aperture dipoles and interdigitated electrodes have been fabricated mainly to curb the saturation at high optical pump power [2,3,8–11]. Increasing the THz radiation power of PCA's with the aid of surface plasmon effect have also been investigated [12–18]. Plasmonically-enhanced PCA's have been demonstrated by fabricating metallic nanostructures such as gratings [12–14], islands [15,16], and nano-patterned arrays [17,18]. Metallic nanostructures are fabricated within the PCA gap with the aim of increasing the optical-to-THz conversion efficiency via mechanisms of local field enhancement to increase photocarrier generation [16], reduction of heat generation to increase the bias field and carrier density [18], and reduction of the carrier transport distance to the contact electrodes to increase the number of collected photocarriers [12,14].

In this work, a technique to increase the THz generation efficiency of a PCA emitter is proposed by integrating micron-sized metal structures at the PCA's emission side, in contrast to the more popular approaches involving fabrication of metallic nanostructures in the PCA gap area. The

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Terahertz Emission Enhancement of Gallium-Arsenide-Based Photoconductive Antennas by Silicon Nanowire Coating

Neil Irvin Cabello, Alexander De Los Reyes, Vladimir Sarmiento, John Paul Ferrolino, Victor DC Andres Vistro, John Daniel Vasquez, Hannah Bardolaza, Hideaki Kitahara, Masahiko Tani, *Member, IEEE*, Arnel Salvador, Armando Somintac, and Elmer Estacio

***Abstract*—In this article, we report on the enhancement of the terahertz (THz) emission characteristics of gallium arsenide-based photoconductive antennas (PCAs) upon coating with silicon nanowires (SiNWs). The SiNWs were fabricated using metal-assisted chemical etching and were dropcasted onto PCAs with dipole antenna patterns. The THz emission of the SiNW-coated PCA was observed to increase up to three times with respect to the uncoated sample. Possible mechanisms leading to the emission enhancement are proposed in the context of increased photoabsorption and capacitance induced by the SiNWs. The results demonstrate the proof of a low-cost method of enhancing the PCA performance by utilizing nanostructures.**

***Index Terms*—Nanostructures, terahertz (THz) antenna, ultrafast.**

I. Introduction

The terahertz (THz) frequency range refers to the range of the electromagnetic spectrum between 0.1 and 10 THz, or between 3 mm and 30 microns in terms of wavelength [1]. The THz range has numerous promising applications [2]–[7] due to its novel properties. The development of intense THz radiation sources is an important research thrust in order to fully take advantage of this frequency band. Generation of THz radiation is done through various materials, such as quantum cascade lasers, semiconductor surfaces illuminated with ultrafast laser pulses, nonlinear crystals, and photoconductive antennas (PCAs). Among these, the PCA is widely used in THz time-domain spectroscopy (THz-TDS) systems due to its relatively compact form factor and capability to generate broadband THz pulses [8].

Improvement of the intensity and bandwidth of the THz emission from PCAs is usually done by the variation of the PCA substrate properties [9] or the antenna structure [10], or through application of an antireflection coating [11]. Parameterizing the substrate properties is usually an expensive process, since the substrate used, which is typically low temperature-grown gallium arsenide (GaAs), is grown through ultrahigh vacuum methods, such as molecular beam epitaxy. This is true for the application of the conventional antireflection coating on PCAs as well. On the other hand, the antenna structures may be varied through incorporation of nanostructures in the PCA gap [12]–[16]. Most recently, semiconductor nanostructures such as zinc oxide [17] have also been effectively utilized as both a concentrator and an antireflection coating for the PCA.

One of the nanostructures that can be used are silicon nanowires (SiNWs), particularly SiNWs produced using metal-assisted chemical etching (MACE). MACE is an economical and convenient process to produce SiNWs in a large fabrication area [18]. The process to produce SiNWs via MACE involves immersion of Si wafers in a hydrofluoric acid (HF) and silver nitrate ($AgNO_3$) solution. SiNWs display novel properties compared to its bulk counterpart. SiNWs have demonstrated antireflection and light-trapping capabilities [19]–[21]. Additionally, the increased surface-to-volume ratio of the SiNWs lends to possible applications for supercapacitors [22].

In this study, we demonstrate enhancement in the THz emission of GaAs-based PCAs upon coating with SiNWs. The PCAs were fabricated using standard photolithography processes, while the SiNWs fabricated using MACE were harvested and were dropcasted onto the active area of the fabricated PCA. The THz emission of bare and SiNW-coated PCAs are compared. We then compared the optical and electric properties of the bare and SiNW-coated PCAs, and propose the possible causes of the enhancement in the THz emission of the SiNW-coated sample. The low-cost and convenience of both the SiNW formation and

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Compressive and tensile strain effects on the ultrafast carrier dynamics and transport of gallium arsenide thin films on silicon and magnesium oxide substrates

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Abstract: We investigate strain effects on the ultrafast carrier dynamics and transport of gallium arsenide films on silicon (GaAs/Si) and magnesium oxide (GaAs/MgO) substrates using temperature-dependent photoluminescence (PL) and terahertz time-domain spectroscopy (THz-TDS) from 11 K - 300 K. The PL shows that GaAs/Si and GaAs/MgO samples are under tensile and compressive strain at low temperature, respectively. The temperature-dependent THz emission from GaAs/Si does not show significant differences with the emission from bulk GaAs, while the THz emission from GaAs/MgO shows an order-of-magnitude decrease at low temperature. The THz emission from the samples exhibits an interplay between strain-induced effective mass changes and temperature-dependent electric field effects.

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1. Introduction

Strain engineering is an effective way to modify semiconductor device characteristics. Strain has been utilized to enhance channel currents in silicon germanium p-type metal-oxide-semiconductor field-effect-transistors (SiGe p-MOSFETs) [1], to lower threshold currents in III-V semiconductor-based lasers [2], and to increase electron mobilities in gallium arsenide (GaAs) core/shell nanowires [3]. The impact of strain on the performance of semiconductor structures originates from its effects on semiconductor properties like carrier effective mass [4], phonon scattering rates [5], and band degeneracy [6]. Strain-induced effects on crystals can also vary depending on the type and magnitude of the applied strain. Thus, strain analysis entails a wide variety of research on semiconductors.

Two common ways to induce strain on semiconductor thin films are (1) lattice-mismatched epitaxial growth and (2) external application through the diamond anvil cell (DAC) method [7]. Lattice-mismatched epitaxial growth consists of growing a semiconductor thin film on a substrate with a different lattice constant, resulting in heterostructures like p-doped indium arsenide on gallium antimonide (p-InAs/GaSb) [8] and gallium arsenide on silicon (GaAs/Si) [9]. The type of strain applied to the film depends on how the lattice constant of the film compares with its substrate. On the other hand, the DAC method is applied using mechanical

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Tunneling dynamics and transport in MBE-grown GaAs/AlGaAs asymmetric double quantum wells investigated via photoluminescence and terahertz time-domain spectroscopy

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Abstract

We study the transport of photogenerated carriers in molecular beam epitaxy (MBE)-grown gallium arsenide/aluminum gallium arsenide (GaAs/AlGaAs) coupled (CDQW) and uncoupled (UDQW) double quantum wells. Photoluminescence (PL) spectroscopy was used to investigate the optical properties and establish differences in the tunneling properties between the CDQW and UDQW. Terahertz time-domain spectroscopy (THz-TDS) measurements have shown that the emissions from the CDQW and UDQW were 57% and 31% of the THz emission of p-InAs, 800nm excitation wavelength. The higher THz emission from the CDQW is attributed to the tunneling of electrons from the NW to the WW leading to a larger dipole moment. Furthermore, excitation wavelength-dependent THz-TDS measurements have shown that when the NW is not photoexcited, high-frequency components appear in the frequency spectra. These results provide insights on the possible development of DQWs as THz optoelectronic devices. It also demonstrates the application of THz-TDS in investigating tunneling dynamics in DQWs in conjunction with established optical characterization techniques, such as PL spectroscopy.

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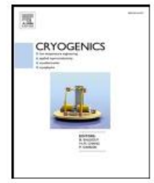

Coupling behavior of $Bi_2Sr_{2-x}In_xCaCu_2O_{8+d}$

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A R T I C L E I N F O

Keywords:
Bi-2212
Doping
AC susceptibility
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A B S T R A C T

The interplay between intrinsic grain and inter-grain effects at the superconducting state defines the behavior of bulk high-temperature superconductors. In this work, we use DC resistivity and AC magnetic susceptibility measurements to show how the intrinsic and inter-grain properties influence the intergrain phase coherence and flux dynamics of $Bi_2Sr_{2-x}In_xCaCu_2O_{8+d}$. High In-doped samples, $x \geq 0.4$, have broad resistive and diamagnetic superconducting transitions due to weak intergrain coupling caused by segregated impurities. Low doping levels, $x \leq 0.3$, have sharp superconducting resistive and diamagnetic transitions, with higher transition temperature T_C attributed to an increase superconducting pair density. This results to enhanced intergrain coupling and strong diamagnetic screening of intergrain void networks. An applied AC field of 0.77 mT amplitude deteriorates the intergrain diamagnetic screening at $x = 0.2$ through AC flux slip between grains.

1. Introduction

For the past few decades, remarkable progress in field of polycrystalline high temperature superconductors (HTS) was achieved paving the way for the production of large grain bulks, wires, tapes, films and coated conductors with promising electrical transport and magnetic properties [1–4]. However, elucidating the complex and dynamic interaction among superconducting grains as well as the grain-boundary systems remains an intriguing problem [5–7]. Bulk properties of HTS are superposition of intrinsic characteristics associated with the Ginzburg-Laundau order parameter or density of Cooper pairs and inter-granular properties strongly correlated to grain structure [8–10]. Analysis of magnetic properties and magnetoresistive experiments demonstrates consistency of upper boundary of field regime with complete field penetration into HTS grains. This indicates strong interrelation between subsystem of HTS grains and intergrain boundaries - a crucial factor in the intricate picture of magnetotransport phenomena [11,12]. Studies of excess conductivities also showed that the relationship between inhomogeneities such as mean grain size and grain boundary junctions with intrinsic properties such as carrier concentration governs thermodynamic dimensionality fluctuations. Susceptibility and magnetization measurements confirm that the interplay affects the global transport and magnetic properties of layered cuprate superconductors [13–16]. These suggest the interaction between intrinsic grain and structural parameters could be key to further understand the coupling behavior of HTS grains in the presence of an applied field.

Chemical doping and addition alter the physical, electronic and crystal properties which may affect both intrinsic and inter-grain properties of granular superconductors. Chemical doping can modify lattice structure reducing anisotropy and strengthening coupling of CuO_2 planes [17–20]. Doping also affects polycrystalline charge density waves and change carrier concentration thereby impacting the superconducting transition temperature ($T_{C\ onset}$) [4,21]. Doping and addition can also change melting properties resulting to formation of larger grains, higher texture, bulk density and stronger inter-grain connection [22–30]. Nanoparticle, nanorods and nanowire addition can improve the electrical conductivity in between grains or introduce pinning centers to prevent flux flow which improves bulk transport and magnetic properties [27,31–36].

Indium doping in Bi-2212 showed limited solubility, decreased melting temperature and enhanced Bi-2212 phase stability [37–39]. Optimal indium doping enhances T_C and grain connectivity, while higher indium content produces large weakly-connected grains and persisting superconductivity [39,40]. Hence, indium has a significant effect on the physical (structural, electrical transport and sintering) and superconducting properties of Bi-2212, and may be used to explore the evolution of superconducting volume fraction between network of grains and onset of flux flow. The diversity of coupling behavior while maintaining superconductivity makes In-doped Bi-2212 a good material for studying the role of intrinsic grain and inter-grain properties on

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Indirect stress and air-cavity displacement measurement of MEMS tunable VCSELs via micro-Raman and micro-photoluminescence spectroscopy

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Abstract

We employ micro-Raman spectroscopy to optically infer the stress experienced by the legs of a bridge-type microelectromechanical systems (MEMS) used in high contrast gratings tunable vertical cavity surface emitting lasers (VCSELs). We then employ micro-photoluminescence (PL) spectroscopy to indirectly measure the air cavity displacement of the same MEMS structure. Results from micro-Raman showed that electrostatically actuating the MEMS with a DC bias configuration yields increasing residual stress on the endpoints of the MEMS with values reaching up to 0.8 GPa. We simulated a finite element model via Comsol Multiphysics which agrees with the trend we observed based on our micro-Raman data. Our micro-PL spectroscopy showed that change in the air cavity of the VCSEL structure resulted in a change in the full width of the PL peak emitted by the layer consisting of four pairs of distributed Bragg reflectors. The change in the full width of the PL peak was due to the change in the optical cavity induced by displacing the MEMS via externally applied bias and agrees with our transfer matrix convolution simulation. These optical characterization tools can be used for failure analysis, MEMS design improvements, and monitoring of MEMS tunable VCSEL devices for mass production and manufacturing.

Keywords: laser tuning, micro-Raman spectroscopy, micro-photoluminescence spectroscopy

(Some figures may appear in colour only in the online journal)

1. Introduction

The demand for tunable vertical cavity surface emitting lasers (VCSELs) utilizing microelectromechanical systems (MEMS) has been growing in recent years [1–3]. Characterizing residual stress in MEMS enables improvement in product design and reliability. Several research groups have reported residual stress in MEMS via destructive techniques such as x-ray diffraction [4], surface profiling [5], and micromachining [6]. The nature of these destructive characterization

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