Research Accomplishments of the Condensed Matter Physics Laboratory, National Institute of Physics
01 January 2021 – 31 December 2021

ARNEL A. SALVADOR, Ph. D.
CMPL Program Coordinator
December 2021

I. Executive Summary

A. Activities of the Research Group

Organization

Professor: 4	Apprentices (NIP-Students): 5
Asst. Professor: 1	Apprentices (Non-NIP): 1
REPS: 0	Undergraduate Members: 12
Adjunct Researchers: 1	

Mentoring:

PhD Physics: 6	PhD MSE: 10
MS Physics: 15	MS MSE: 20
BS Physics: 4	
BS Applied Physics: 8	

B. Research Highlights

Papers published/accepted for publications in international peer-reviewed journals: 13
Papers published in local journals: 0
International conference presentations
- With full paper: 1
- Without full paper: 12

Local conference papers
- With full paper: 15

NIP-funded projects: 4
External Grants: 7

C. Extension Work Highlights

Research Interns/OJT's (Non-NIP), for training held at NIP: none, due to COVID-19
Main Challenges Encountered and Proposed Solutions: 4

II. Technical Report

A. Activities of the Research Group

CMPL was able to publish 13 peer-reviewed Scopus-indexed manuscripts. CMPL members participated in local and international workshops and conferences conducted online. Laboratory meetings shifted to the online mode via Zoom. As some of the students moved to their home provinces, research work was partially done at home.

Due to the pandemic, internship programs were canceled. Access to CMPL rooms was restricted to NIP faculty and staff, and research staff of funded projects.

As of December 2021, CMPL has a total of 75 members: 5 PhD Faculty, 1 Adjunct Researcher, 6 PhD Physics students, 10 PhD MSE students, 15 MS Physics students, 20 MS MSE students, 4 BS Physics students, 8 BS Applied Physics students, and 6 apprentices.

1.) Organization

a.) Group Members as of December 2021

PhD Faculty (5)

1.) Dr. Estacio, Elmer
2.) Dr. Salvador, Arnel
3.) Dr. Sarmago, Roland
4.) Dr. Somintac, Armando
5.) Dr. De Los Reyes, Alexander

Adjunct Researcher (1)

Dr. Sadia-Salang, Cyril (MSEP)

PhD Physics Students (6)

1.) Cabello, Neil Irvin (P3+, Somintac)
2.) Catindig, Gerald (P3+, Salvador)
3.) De Vera, Francesca Isabel (P3+, Sarmago)
4.) Husay, Horace Andrew (P3+, Somintac)
5.) Singidas, Bess, (P3+, Sarmago)
6.) Solibet, Erick John Carlo (P3+, Somintac)

PhD MSE Students (10)

1.) Café, Arven I. (P3+, Somintac)
2.) Copa, Vernalyn (P3+, Salvador)
3.) Jagus, Rommel J. (P3+, Salvador)
4.) Loberternos, Regine (P3+, Estacio)
5.) Lopez, Lorenzo Jr. (P3+, Salvador)
6.) Montecillo, Anthony (P3+, Somintac)
7.) Publico, Jairrus (P3, Estacio)
8.) Tumanguil-Quitoras, Mae Agatha (P3+, Estacio, Salvador)
9.) Tingzon, Philippe Martin (P3+, Somintac)
10.) Tuico, Anthony (P3+, Somintac)

MS Physics Students (15)

1. Ahmad, Al-Khadeem (M2+, Somintac)
2. Andig, Roni (M2+, Salvador)
3. Armonia, Jeremias-Ibus (M2+, Somintac)
4. Dawisan, Mark Kevin (M2, Salvador)
5. Figueroa, Lourdes Nicole S. (M1, Estacio)
6. Lipardo, John Axl (M2, Sarmago)
7. Llemit, Christian Loer T. (M2, Sarmago)
8. Lopez, Rusty (M2+, Sarmago)
9. Ong, Ysabella Kassandra F. (M1, Sarmago)
10. Juguilon, Vince Paul (M1, Estacio)
11. Romero, Ezekiel Raul (M2+, Sarmago)
12. Tacneng, Jonalds (M2+, Sarmago)
13. Tan, Craig Egan Allistair (M2+, Salvador)
14. Verona, Ivan Cedrick (M2+, Estacio)
15. Vistro, Victor DC Andres (M2+, Sarmago)

MS MSE Students (20)

1.) Aves, Ron Darell A. (M2+, Somintac)
2.) Ballesteros, Laureen Ida (M2+, Somintac)
3.) Cantor, Camille Victoria (M2+, Sarmago)
4.) Cainglet, Michael Rey A. (M2+, Somintac)
5.) De Luna, Charlene (M2+, Somintac)
6.) Escaro, Archel (M2+, Somintac)
7.) Escolano, Arvin Jay (M2+, Somintac)
8.) Ferrolino, John Paul R. (M2+, Salvador)
9.) Inguito, Jonah Micah L. (M2, Sarmago)
10.) Magallanes, Bee Jay (M2+, Sarmago)
11.) Manrique, Mylenne (M2+, Somintac)
12.) Nalayog, Marvin B. (M2+, Sarmago)
13.) Pangasinan, Jamela N. (M2+, Salvador)
14.) Rola, Yuta Louie (M2+, Somintac)
15.) Salazar, Kloudene (M2+, Sarmago)
16.) Sura, Ar Jay C. (M2+, Somintac)
17.) Torremoro, Jennieva Grace E. (M2+, Sarmago)
18.) Valenzona, Marjorie (M2+, Somintac)
19.) Veloz, Raymund (M2+, Somintac)
20.) Vergara, Christopher Jude (M2+, Somintac)

BS Physics (4)

1.) Arcilla, Jose Mari Sebastian C. (B5, Estacio)
2.) Cavite, Theo Victor A. (B5+, Salvador)
3.) Nueva, Angelo Gabriel (B5+)
4.) Galarosa, Nikko F. (B5+)

BS Applied Physics (8)

1.) Alaba, Kenneth Gallano (B4, Estacio)
2.) Campano, Zsara Mari Bianca V. (B3)
3.) Flores, Patricia Frances P. (B4)

4.) Romero, Vril Jappuch P. (B3)
5.) Leonardo, Shawntel Joy (B5+, Sarmago)
6.) Llevares, Kint Ynnos B. (B5+)
7.) Magsayo, Lawrence Jay G. (B5+, Sarmago)
8.) Reyes, Giselle S. (B5, Sarmago)

Apprentices (6)

Lim, Cerx Lorenz
Belila, Alexander Paul
Celebrado, Michelle
Briones, Christian
Cruz, Lue Jeniel
Sierra, Iries-Gwyneth

Organizational Summary

Member	Category	Number
PhD Faculty		6
Student Members	PhD Physics	6
	PhD MSE	10
	MS Physics	15
	MS MSE	20
	BS	12
	Apprentices	6
	Total	75

2.) Mentoring

A.) Graduates

Degree Program	Student	Thesis Title	Defense Date	Adviser	Graduated
PhD Physics	Singidas, Bess G.	*Optoelectronics in the Graphene-GaAs Interface*	24 June 2021	Dr. Sarmago, Roland V.	2nd Sem, AY 20-21
MS Physics	Tacneng, Jonalds L.	*Reduced Time Formation of Pb-Added $Bi_{1.7}Pb_{0.3}Sr_2Ca_3Cu_4O_{12+\delta}$ Phase Via Conventional Solid State Reaction*	15 Jan 2021	Dr. Sarmago, Roland V.	pending submission of final manuscript
MS Physics	Armonia, Jeremias I.	*Effect of Silver Nanowires on the Terahertz Emission of Silicon*	16 June 2021	Dr. Somintac, Armando S.	pending submission of final manuscript

MS MSE	Maylem, Genes P.	*Cu_xO-deposited activated carbon cloth electrode for supercapacitor application*	7 May 2021	Dr. Somintac, Armando S.	2nd Sem AY 20-21
MS MSE	Madula, Rogie M.	*Strain-induced properties and sensing capability of monolayer graphene*	15 January 2021	Dr. Salvador, Arnel A.	2nd Sem AY 20-21
MS MSE	Bendal, Aldrin	*Multifunctional sensor based on piezoresistive properties of zinc oxide for strain and temperature monitoring*	30 October 2020	Dr. Somintac, Armando S.	2nd Sem AY 20-21
BS Applied Physics Instrumentation	Javar, Patricia B.	*Activation of Carbon Cloth for Supercapacitor Applications*	12 January 2021	Dr. Somintac, Armando S.	1st Sem AY 20-21
BS Applied Physics Instrumentation	Reyes, Giselle D.	*Effect of Citrate Seed Layers on Morphological and Optical Properties of Zinc Oxide Microrods Grown via Two-Step Hydrothermal Method*	23 Aug 2021	Dr. Sarmago, Roland V.	Midyear 2021
BS Applied Physics Instrumentation	Vasquez, Ardell Justin B.	*CO_2 Detection Using Thermopile-based Nondispersive Infrared Technique*	15 Dec 2020	Dr. Estacio, Elmer S.	1st Sem AY 20-21
BS Physics	Figueroa, Lourdes Nicole S.	*Investigation of the THz Emission Characteristics of an LT-GaAs Photoconductive Antenna Using Equivalent Circuit Model*	12 January 2021	Dr. Estacio, Elmer S., Dr. De Los Reyes, Alexander E.	1st Sem AY 20-21
BS Physics	Ledesma, Anselmo Jose C.	*Reflection THz - TDS of ELO GaAs on Acetate*	12 January 2021	Dr. Somintac, Armando S.	1st Sem AY 20-21

Summary of Graduates

	2nd Sem AY AY 20-21	Midyear AY 20-21	1st Sem AY 21-22	Total
PhD Physics	1	0	0	1
PhD MSE	0	0	0	0
MS Physics	2	0	0	2
MS MSE	3	0	0	3
BS Applied Physics	0	1	2	3
BS Physics	0	0	2	2

B.) **Research Highlights**

1.) Papers published/accepted for publications in international peer-reviewed journals (13)

a.) Manuel M Balmeo, John Symon C Dizon, Melvin John F Empizo, Erick John Carlo D Solibet, Verdad C Agulto, Arnel A Salvador, Nobuhiko Sarukura, Hiroshi Nakanishi, Hideaki Kasai, Allan Abraham B Padama, "Density functional theory-based investigation of hydrogen adsorption on zinc oxide (101¯ 0) surface: Revisited," *Surface Science* **703**, 121726 (2021). doi: https://doi.org/10.1016/j.susc.2020.121726

b.) Karl Cedric Gonzales, Elizabeth Ann Prieto, Gerald Angelo Catindig, Alexander De Los Reyes, Maria Angela Faustino, Mae Agatha Tumanguil-Quitoras, Horace Andrew Husay, John Daniel Vasquez, Armando Somintac, Elmer Estacio, Arnel Salvador, "Terahertz emission increase in GaAs films exhibiting structural defects grown on Si (100) substrates using a two-layered LTG-GaAs buffer system," *Journal of Materials Science: Materials in Electronics* **32**, 13825-13836 (2021). doi: https://doi.org/10.1007/s10854-021-05958-8

c.) Jessica Afalla, Elizabeth Ann Prieto, Horace Andrew Husay, Karl Cedric Gonzales, Gerald Catindig, Aizitiaili Abulikemu, Armando Somintac, Arnel Salvador, Elmer Estacio, Masahiko Tani, Muneaki Hase, "Effect of heteroepitaxial growth on LT-GaAs: ultrafast optical properties," *Journal of Physics: Condensed Matter* **33**, 315704 (2021). doi: https://doi.org/10.1088/1361-648X/ac04cc

d.) John Paul Ferrolino, Neil Irvin Cabello, Alexander De Los Reyes, Hannah Bardolaza, Ivan Cedrick Verona, Valynn Katrine Mag-usara, Jessica Pauline Afalla, Miezel Talara, Hideaki Kitahara, Wilson Garcia, Armando Somintac, Arnel Salvador, Masahiko Tani, Elmer Estacio, "Thickness dependence of the spintronic terahertz emission from Ni/Pt bilayer grown on MgO via electron beam deposition," *Applied Physics Express* **14**, 093001 (2021). doi: https://doi.org/10.35848/1882-0786/ac1b0d

e.) Verdad Agulto, Melvin John Empizo, Keito Shinohara, Jonah Micah Inguito, Bee Jay Magallanes, Marvin Nalayog, Daisuke Umeno, Kloudene Salazar, Mia Angela Judicpa, Kohei Yamanoi, Toshihiko Shimizu, Allan Christopher Yago, Roland Sarmago, Nobuhiko Sarukura, "Low-threshold amplified UV emission of optically pumped ZnO-polymer nanocomposites," *Journal of Crystal Growth* **573**, 126328 (2021). doi: https://doi.org/10.1016/j.jcrysgro.2021.126328

f.) Kloudene Salazar, Verdad Agulto, Melvin John Empizo, Keito Shinohara, Kohei Yamanoi, Toshihiko Shimizu, Nobuhiko Sarukura, Allan Christopher Yago, Pinit Kidkhunthod, Suchinda

Sattayaporn, Vallerie Ann Samson, Roland Sarmago, “Picosecond UV emissions of hydrothermal grown -doped ZnO microrods,” *Journal of Crystal Growth* **574**, 126332 (2021). doi: https://doi.org/10.1016/j.jcrysgro.2021.126332

g.) Joselito Muldera, Jessica Pauline Afalla, Takashi Furuya, Hideaki Kitahara, Elmer Estacio, Katsuhiko Saito, Qixin Guo, Masahiko Tani, “Creating terahertz pulses from titanium-doped lithium niobate-based strip waveguides with 1.55 um light,” *Journal of Materials Science: Materials in Electronics* **32**, 23164-23173 (2021). doi: https://doi.org/10.1007/s10854-021-06802-9

h.) 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, Arnel Salvador, Armando Somintac, Elmer Estacio, “Terahertz Emission Enhancement of Gallium-Arsenide-Based Photoconductive Antennas by Silicon Nanowire Coating,” *IEEE Transactions on Terahertz Science and Technology* **12**, 36-41 (2021). doi: https://doi.org/10.1109/TTHZ.2021.3115726

i.) Joselito Muldera, Jessica Pauline Afalla, Takashi Furuya, Hideaki Kitahara, Elmer Estacio, Katsuhiko Saito, Qixin Guo, Masahiko Tani, “Terahertz pulses from titanium-doped lithium niobate strip optical waveguide using a 1.55-micrometer pump beam,” *Infrared, Millimeter-Wave, and Terahertz Technologies VIII* 11906 (2021). doi: https://doi.org/10.1117/12.2601151

j.) Joseph De Mesa, Angelo Rillera, Melvin John Empizo, Nobuhiko Sarukura, Roland Sarmago, Wilson Garcia, “Low-energy femtosecond pulsed laser deposition of cerium (IV) oxide thin films on silicon substrates,” *Journal of Crystal Growth* **574**, 126323 (2021). doi: https://doi.org/10.1016/j.jcrysgro.2021.126323

k.) Hannah Bardolaza, Alexander De Los Reyes, Neil Irvin Cabello, John Paul Ferrolino, Ivan Cedrick Verona, Armando Somintac, Arnel Salvador, Elmer Estacio, “Improved terahertz emission characteristics from photoconductive antennas integrated with micron-size 1D and 2D metal line arrays,” *Infrared, Millimeter-Wave, and Terahertz Technologies VIII* 1190607 (2021). doi: https://doi.org/10.1117/12.2601521

l.) Erick John Carlo Solibet, Melvin John Empizo, Maria Cecilia Angub, Raymund Veloz, Christopher Jude Vergara, Horace Andrew Husay, Kohei Yamanoi, Toshihiko Shimizu, Elmer Estacio, Arnel Salvador, Nobuhiko Sarukura, Armando Somintac, “Interplay of Zn (OAc) 2 concentration, morphology, and emission in hydrothermal-grown ZnO nanostructures,” *Journal of Crystal Growth* **575**, 126339 (2021) doi: https://doi.org/10.1016/j.jcrysgro.2021.126339

m.) Francesca Isabel De Vera, Bess Singidas, Roland Sarmago, “Coupling behavior of $Bi_2Sr_{2-x}In_xCaCu_2O_{8+\delta}$,” *Cryogenics* **121**, 103406 (2022). doi: https://doi.org/10.1016/j.cryogenics.2021.103406

2.) International conference presentations with full paper in print proceedings (2):

a.) John Paul Ferrolino, Neil Irvin Cabello, Alexander De Los Reyes, Valynn Katrine Mag-usara, Jessica Pauline Afalla, Hannah Bardolaza, Ivan Cedrick Verona, Miezel Talara, Hideaki Kitahara, Armando Somintac, Arnel Salvador, Masahiko Tani, Elmer Estacio, "Spintronic terahertz emission from Ni/Pt bilayer grown on MgO," *Journal of Physics: Conference Series* **1943**, 012035 (2021). doi: https://doi.org/10.1088/1742-6596/1943/1/012035

3.) International conference presentations WITHOUT full paper (12):

a.) Horace Andrew Husay, Anthony Montecillo, Gerald Angelo Catindig, Erick John Carlo Solibet, Elmer Estacio, Arnel Salvador, Armando Somintac, "Coupled plasmon-LO phonon modes in epitaxially lifted-off i-GaAs/n-GaAs heterojunctions probed by Raman spectroscopy," The 8th Asian Conference on Crystal Growth and Crystal Technology, held on 2 March 2021.

b.) Mary Clare Escano, Maria Herminia Balgos, Tien Quang Nguyen, Elizabeth Ann Prieto, Elmer Estacio, Arnel Salvador, Armando Somintac, Rafael Jaculbia, Norihiko Hayazawa, Yousoo Kim, Masahiko Tani, "Revealing the true bulk As-antisite defect in GaAs (110) using DFT calculations and STM/STS measurements," APS March Meeting 2021, Session F59: Electronic Structure: Theory and Spectra, held on 16 March 2021.

c.) Elmer Estacio, Elizabeth Ann Prieto, Alexander De Los Reyes, Neil Irvin Cabello, Hannah R Bardolaza, Valynn Katrine Mag-Usara, Jessica Pauline Afalla, Armando Somintac, Arnel Salvador, Hideaki Kitahara, Masahiko Tani, "Novel GaAs-Based, MBE-Grown Materials for THz Photoconductive Antenna Emitter Research at the University of the Philippines," Japan Society of Applied Physics – The Optical Society Joint Symposia 2021, held on 26 August 2021 at Washington, DC United States.

d.) Nathaniel Hermosa, Ramon delos Santos, Elmer Estacio, "How to detect Terahertz wave via weak measurement," Japan Society of Applied Physics – The Optical Society Joint Symposia 2021, held on 26 August 2021 at Washington, DC United States.

e.) Masahiko Tani, Ramon delos Santos, Takashi Furuya, Hideaki Kitahara, Elmer Estacio, Joselito Muldera, Mary Clare Escaño, Miezel Talara, Michael Bakunov, "Terahertz wave generation and detection in GaAs crystals enhanced by using tapered parallel plate waveguides as focusing optics," Japan Society of Applied Physics – The Optical Society Joint Symposia 2021, held on 26 August 2021 at Washington, DC United States.

f.) Joselito Muldera, Jessica Pauline Afalla, Takashi Furuya, Hideaki Kitahara, Elmer Estacio, Katsuhiko Saito, Qixin Guo, Masahiko Tani, "Terahertz emission from titanium-diffused magnesium oxide-doped lithium niobate optical waveguides," Japan Society of Applied Physics – The Optical Society Joint Symposia 2021, held on 26 August 2021 at Washington, DC United States.

g.) Elmer Estacio, "GaAs terahertz photoconductive antenna emitters with integrated micron-size metamaterial", The 7th Academic Conference on Natural Science for Young Scientists, Master, and Ph.D. Students from ASEAN Countries, held on 15 October 2021 at Hanoi&Vinh City, Vietnam.

h.) Hannah Bardolaza, Neil Irvin Cabello, John Paul Ferrolino, Ivan Cedrick Verona, Miguel Bacaoco, Armando Somintac, Arnel Salvador, Alexander De Los Reyes, Elmer Estacio, "Investigation of an extraordinary terahertz transmission through a one-dimensional metal line array", The 7th Academic Conference on Natural Science for Young Scientists, Master, and Ph.D. Students from ASEAN Countries, held on 16 October 2021 at Hanoi&Vinh City, Vietnam.

i.) Ivan Cedrick Verona, Alexander De Los Reyes, Hannah Bardolaza, Neil Irvin Cabello, Armando Somintac, Arnel Salvador, Elmer Estacio, "Terahertz PCA-PCA quasi-time domain spectroscopy using commercial multimode-diode laser", The 7th Academic Conference on Natural Science for Young Scientists, Master, and Ph.D. Students from ASEAN Countries, held on 16 October 2021 at Hanoi&Vinh City, Vietnam.

j.) Jairrus Publico, Ivan Cedrick Verona, Hannah Bardolaza, Neil Irvin Cabello, Alexander De Los Reyes, Elmer Estacio, "Terahertz emission at 1.55 um below-bandgap and 780 nm above-bandgap femtosecond laser excitation of LT-GaAs photoconductive antenna device", The 7th Academic Conference on Natural Science for Young Scientists, Master, and Ph.D. Students from ASEAN Countries, held on 16 October 2021 at Hanoi&Vinh City, Vietnam.

k.) Gerald Angelo Catindig, Elizabeth Ann Prieto, Karl Cedric Gonzales, Rommel Jagus, Kerphy Liandro Patrocenio, John Daniel Vasquez, Elmer Estacio, Armando Somintac, Arnel Salvador, "Strain studies on epitaxially-lifted off gallium arsenide thin films", The 7th Southeast Asia Collaborative Symposium on Energy Materials, held on 16 November 2021 at University of Tsukuba, Japan.

l.) Rogie Madula, Vernalyn Copa, Lorenzo Lopez Jr., Horace Andrew Husay, Jamela Pangasinan, Charlene De Luna, Armando Somintac, Elmer Estacio, Arnel Salvador, "Induced strain influence on monolayer graphene on fluorinated ethylene propylene substrate for flexible gas sensor application", The 7th Southeast Asia Collaborative Symposium on Energy Materials, held on 16 November 2021 at University of Tsukuba, Japan.

4.) Local conference presentations
With full paper in print proceedings (15)

a.) J.B Publico, I.C. Verona, H.R. Bardolaza, N.I. Cabello, A. De Los Reyes, E. Estacio, “Terahertz emission of LT-GaAs and SI-GaAs photoconductive antenna devices at 1.55 um below-bandgap femtosecond laser excitation,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-1B-02 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-1B-02.

b.) N.I. Cabello, H.R. Bardolaza, I.C. Verona, J.P. Ferrolino, M. Bacaoco, A. Somintac, A. Salvador, A. De Los Reyes, E. Estacio, “Improved terahertz generation from a photoconductive antenna with metal line arrays,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-1B-04 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-1B-04.

c.) R. Madula, V. Copa, H.A. Husay, J. Pangasinan, C. De Luna, A. Somintac, and A. Salvador, “Influence of strain on monolayer graphene on flourinated ethylene propylene characterized by Rama spectroscopy,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-1E-05 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-1E-05.

d.) M.M Rosette, M.A. Zosa, R. Sarmago, “Improved film morphology after cold-bath quenching of electrophoretically deposited $Bi_2Sr_2CaCu_2O_8$ with LiCl as a supporting electrolyte,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PA-01 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PA-01.

e.) N.I. Cabello, A. De Los Reyes, V. Sarmiento, J.P. Ferrolino, V.D.A. Vistro, J.D. Vasquez, H.R. Bardolaza, H. Kitahara, M. Tani, A. Salvador, A. Somintac, E. Estacio, “Improvement of terahertz emission in gallium arsenide photoconductive antennas coated with silicon nanowires via dropcasting,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PA-02 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PA-02.

f.) M. Manrique, H.A. Husay, E. Estacio, A. Salvador, A. Somintac, “Effects of temperature on strain and lattice anharmonicity in silicon nanowires as investigated by power-dependent Raman spectroscopy,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PA-03 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PA-03.

g.) A. De Los Reyes, L.N. Dela Rosa, I.C. Verona, V.P. Juguilon, N.I. Cabello, H.R. Bardolaza, E. Estacio, “An investigation of the terahertz emission properties of low-temperature-grown gallium arsenide photoconductive antenna devices using an equivalent circuit,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PA-04 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PA-04.

h.) C.L.Llemit, R. Sarmago, “Effect of Fe doping on the structural and electronic properties of wurtzite ZnO using first principles calculations,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PA-08 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PA-08.

i.) J.A. Lipardo, E.R. Romero, D. Aquino, J. Mallillin, R. Sulit, R. Sarmago, V.A. Samson, J.P. Maulion, R. Pugal, “Simulation study of fan-beam geometry set-up for industrial gamma-ray computed tomography,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PA-09 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PA-09.

j.) J. Muldera, J.P. Afalla, T. Furuya, H. Kitahara, E. Estacio, K. Saito, Q. Guo, M. Tani, “Generating terahertz pulses from titanium-doped lithium niobate-based optical waveguides with 1.55 um excitation,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-EA-01 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-EA-01.

k.) E.R.D. Romero, R. Sarmago, V.A. Samson, “Simulation of polychromatic x-ray transmission computed tomography process with tungsten-anode source and varying source filter thickness,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PB-06 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PB-06.

l.) V.P. Juguilon, A. De Los Reyes, E. Estacio, “Design of an absolute spectral emission power distribution measurement system in the UV-Vis-NIR region using an integrating sphere head and spectrometer,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-PB-13 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-PB-13.

m.) I.C. Verona, G. Lachica, V.P. Juguilon, A. De Los Reyes, H. Bardolaza, N.I. Cabello, G. Serafica, E. Estacio, “All optical detection of T4 bacteriophage via near-infrared transmission spectroscopy,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-2B-05 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-2B-05.

n.) R. Andig, C.E.A. Tan, G.A. Catindig, E.J.C. Solibet, A. De Los Reyes, H.A. Husay, E.A. Prieto, M.J. Empizo, K.C. Gonzales, I.C. Verona, H.R. Bardolaza, V.A. Samson, G.F. Dean, N. Sarukura, A. Somintac, E. Estacio, A. Salvador, “Effect of electron irradiation on the THz emission of low temperature-grown GaAs/Si epilayers,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-2F-04 (2021). URL: https://proceedings.spp-online.org/article/view/SPP-2021-2F-04.

o.) J.P. Ferrolino, N.I. Cabello, A. De Los Reyes, H. Bardolaza, I.C. Verona, V.K. Mag-usara, J. Afalla, M. Talara, H. Kitahara, W. Garcia, A. Somintac, A. Salvador, M. Tani, E. Estacio, “Ni/Pt spintronic emitters as potential reliable THz source,” Proceedings of the Samahang Pisika ng Pilipinas 39, SPP-2021-3E-02 (2021).

URL:
https://proceedings.spp-online.org/article/view/SPP-2021-3E-02.

7.) NIP-funded Projects (4)

a.) Project Leader: Dr. Sarmago, Roland V.
Title: *Investigation of defects on doping in BSCCO, YBCO HiTc superconductors and ZnO wide bandgap semiconductors*
Duration: 01 January – 31 December 2021

b.) Project Leader: Dr. Salvador, Arnel A.
Title: *E-beam irradiation and surface modification of Gallium Arsenide (GaAs)*
Duration: 01 January – 31 December 2021

c.) Project Leader: Dr. Somintac, Armando S.
Title: *Raman spectroscopy of nanowires*
Duration: 01 January – 31 December 2021

d.) Project Leader: Dr. Estacio, Elmer S.
Title: *Simulation of the terahertz emission characteristics of an LT-GaAs photoconductive antenna in the equivalent circuit model*
Duration: 01 January – 31 December 2021

8.) External Grants (7):

a.) Project Leader: Dr. Estacio, Elmer S.
Title: *Design and fabrication of a photoconductive antenna array for terahertz application*
Duration: 01 February – 31 January 2021
Amount: PHP 300,000.00
Funding Agency: UP-OVCRD

b.) Project Leader: Dr. Salang, Cyril S.
Title: *InGaAs-based mismatched heterostructures for terahertz emission*
Duration: 01 February 2020 - 31 January 2021
Amount: Php 300,000.00
Funding Agency: UP - OVCRD

c.) Project Leader: Dr. Salvador, Arnel A.
Title: *Terahertz emission enhancement in GaAs on Si (100) utilizing two-step low-temperature GaAs system*
Duration: 13 Jan 2020 - 12 January 2021
Amount: P300,000.00
Funding Agency: UP-OVCRD

d.) Project Leader: Dr. Salvador, Arnel A.
Title: *Radiation damage investigations on functional materials: Material development, analysis, and informatics*
Duration: 1 April 2019 to 30 September 2021
Amount: P2,009,190.00
Funding Agency: DOST-JSPS

e.) Project Leader: Dr. De Los Reyes, Alexander
Title: *Spintronic terahertz emission from ferromagnetic/non-*

magnetic thin films deposited via electron beam
Duration: 15 May 2021 - 14 Nov 2022
Amount: Php 450,000.00
Funding Agency: OVPAA

f.) Project Leader: Cabello, Neil Irvin
Title: *Effects of silicon nanowire coating on the terahertz emission of gallium arsenide-based photoconductive antennas*
Duration: 15 May 2021 - 14 Nov 2022
Amount: Php 450,000.00
Funding Agency: OVPAA

g.) Project Leader: Husay, Horace Andrew
Title: *Surface modification of silicon for terahertz applications*
Duration: 09 Nov 2020 - 08 May 2022
Amount: Php 450,000.00
Funding Agency: OVPAA

C.) Extension Highlights

1.) Extension Work Activities (4)

a.) Name: Dr. Estacio, Elmer S.
Activity: Lecturer, "My Adventure in terahertz photonics: From far away and back"
Event: NCRP Achievement Awardees' Lecture Series
Date: 25 March 2021

b.) Name: Dr. Estacio, Elmer S.
Activity: Host
Event: PAASE Research Expertise Cluster 7: Electronics, Electrical Engineering, Instrumentation
Date: 13 August 2021

c.) Name: Dr. Salvador, Arnel A.
Activity: Invited Guest Speaker
Event: DOST Report Episode 69: Balik Puso, Balik Pilipinas, Balik Scientist
Date: 20 August 2021

d.) Name: Dr. Sarmago, Roland S.
Activity: Lecturer, "Studying wide bandgap oxide semiconductors"
Event: Asian Collaborative Research Lecture Series
Date: 4 December 2021

2.) Research Interns/OJT's (Non-NIP), for training held at NIP

*Cancelled due to COVID-19

D.) Main Challenges Encountered and Proposed Solutions

Main Challenges Encountered	**Proposed Solutions**
NIP Access – Due to access and quarantine restrictions brought by COVID19, it has been difficult to enter premises of NIP to perform maintenance checks and equipment	A detailed guideline for non-UP employed and undergraduate students would help in implementing NIP access restrictions. However, this is subject to the approval of the UP administration.
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	A proper document tracking system is recommended. A proper inventory of the remaining chemicals and supplies could also be performed.
Equipment – Downtime of equipment or delay in purchase affects the experiment and thesis of the student.	It is recommended to fast-track the purchase of equipment to avoid delay for both project and/or thesis-related deliverables. Budget for maintenance and upkeep of equipment should be included in research proposals.
Bad internet connectivity at times, lack of access to good internet subscriptions, and troubles with electronic devices made it difficult to reach some students. Some students also suffered from mental health issues.	Maintain constant communication with the students through several modes aside from the internet, such as SMS. Include communication expenses for work from home in LIBs of funded projects.

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

1.) Dr. Estacio, Elmer S.
First Vice-President
Samahang Pisika ng Pilipinas

2.) Dr. Salang, Cyril S.
Secretary General
Samahang Pisika ng Pilipinas

3.) Dr. Somintac, Armando S.
Director, Project Management and Research Generation Office
Office of the Vice-Chancellor for Research and Development
University of the Philippines Diliman

4.) Dr. Salvador, Arnel A.
2021 Severino & Paz Koh Lectureship Award in Science
The Philippine-American Academy of Science&Engineering

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), and Dr. Salang (Right) (From:http://nip.upd.edu.ph/people/faculty/professors/ and Dr. Salang's LinkedIn)

Abstracts of Peer-Reviewed Articles (through screen capture from the journal website or 1st page of the pdf file)

ELSEVIER

Surface Science
Volume 703, January 2021, 121726

Density functional theory-based investigation of hydrogen adsorption on zinc oxide $(10\bar{1}0)$ surface: Revisited

Manuel M. Balmeo [a], John Symon C. Dizon [a], Melvin John F. Empizo [b], Erick John Carlo D. Solibet [c], Verdad C. Agulto [b], Arnel A. Salvador [b, c], Nobuhiko Sarukura [b], Hiroshi Nakanishi [d], Hideaki Kasai [d], Allan Abraham B. Padama [a]

Show more

https://doi.org/10.1016/j.susc.2020.121726

Highlights

- H atom adsorbed on top of O atom shifts the conduction band below the Fermi level.
- H atom adsorbed on top of Zn atom shifts the valence band upward.
- There is an enhanced H adsorption energy for the full coverage system.
- Low coverages H adsorption were used to explain properties of full coverage system.

Abstract

Density functional theory based calculations with Hubbard correction (DFT + U) were performed to investigate the effects of varying coverage and different adsorption sites on hydrogen (H) adsorption on zinc oxide (ZnO) $(10\bar{1}0)$ surface. Results show that H adsorption on top of oxygen (O) at low coverage (0.25 monolayer, ML) shifts the conduction band below the Fermi level and narrows the band gap. These phenomena are attributed to the charge transfer between H and the surface zinc (Zn) and O atoms. On the other hand, the H adsorption on top of Zn at low coverage (0.25 ML) shows an overlapping of H, Zn, and O states while maintaining the semiconductor nature of the system. At high coverage (1.0 ML), a charge accumulation layer on the surface forms, and the mechanisms that govern the interactions of H atoms when adsorbed exclusively on top of Zn or top of O are found to be similar with the low coverage cases. Lastly, at full coverage (2.0 ML), the effect of H on top of Zn is more evident as the system retained its semiconducting property. The adsorption energy is enhanced due to the reinforced overlapping of the H, Zn, and O states and due to the possible attraction between the adsorbed H atoms. The properties and stability of full-coverage adsorption were explained based on the findings on high- and low- coverages adsorption. The findings of the study will aid in understanding the interaction of H with the ZnO surface toward the further development of ZnO's optoelectronic applications.

Published: 22 April 2021

Terahertz emission increase in GaAs films exhibiting structural defects grown on Si (100) substrates using a two-layered LTG-GaAs buffer system

Karl Cedric Gonzales, Elizabeth Ann Prieto, Gerald Angelo Catindig, Alexander De Los Reyes, Maria Angela Faustino, Mae Agatha Tumanguil-Quitoras, Horace Andrew Husay, John Daniel Vasquez, Armando Somintac, Elmer Estacio & Arnel Salvador

Journal of Materials Science: Materials in Electronics **32**, 13825–13836 (2021) | Cite this article

Abstract

Terahertz (THz) emission increase is observed for GaAs thin films that exhibit structural defects. The GaAs epilayers are grown by molecular beam epitaxy on exactly oriented Si (100) substrates at three different temperatures (T_S = 320 °C, 520 °C and 630 °C). The growth method involves the deposition of two low-temperature-grown (LTG)-GaAs buffers with subsequent in-situ thermal annealing at T_S = 600 °C. Reflection high energy electron diffraction confirms the layer-by-layer growth mode of the GaAs on Si. X-ray diffraction shows the improvement in crystallinity as growth temperature is increased. The THz time-domain spectroscopy is performed in reflection and transmission excitation geometries. At T_S = 320 °C, the low crystallinity of GaAs on Si makes it an inferior THz emitter in reflection geometry, over a GaAs grown at the same temperature on a semi-insulating GaAs substrate. However, in transmission geometry, the GaAs on Si exhibits less absorption losses. At higher T_S, the GaAs on Si thin films emerge as promising THz emitters despite the presence of antiphase boundaries and threading dislocations as identified from scanning electron microscopy and Raman spectroscopy. An intense THz emission in reflection and transmission excitation geometries is observed for the GaAs on Si grown at T_S = 520 °C, suggesting the existence of an optimal growth temperature for GaAs on Si at which the THz emission is most efficient in both excitation geometries. The results are significant in the growth design and fabrication of GaAs on Si material system intended for future THz photoconductive antenna emitter devices.

Journal of Physics: Condensed Matter

PAPER

Effect of heteroepitaxial growth on LT-GaAs: ultrafast optical properties

Jessica Afalla[6,1], Elizabeth Ann Prieto[2,3], Horace Andrew Husay[2], Karl Cedric Gonzales[2,4], Gerald Catindig[2], Aizitiaili Abulikemu[1], Armando Somintac[2,3], Arnel Salvador[2,3], Elmer Estacio[2,3], Masahiko Tani[5] + Show full author list

Published 16 June 2021 •

Journal of Physics: Condensed Matter, Volume 33, Number 31

Citation Jessica Afalla *et al* 2021 *J. Phys.: Condens. Matter* 33 315704

References ▾

+ Article information

Abstract

Epitaxial low temperature grown GaAs (LT-GaAs) on silicon (LT-GaAs/Si) has the potential for terahertz (THz) photoconductive antenna applications. However, crystalline, optical and electrical properties of heteroepitaxial grown LT-GaAs/Si can be very different from those grown on semi-insulating GaAs substrates ('reference'). In this study, we investigate optical properties of an epitaxial grown LT-GaAs/Si sample, compared to a reference grown under the same substrate temperature, and with the same layer thickness. Anti-phase domains and some crystal misorientation are present in the LT-GaAs/Si. From coherent phonon spectroscopy, the intrinsic carrier densities are estimated to be 10^{15} cm^{-3} for either sample. Strong plasmon damping is also observed. Carrier dynamics, measured by time-resolved THz spectroscopy at high excitation fluence, reveals markedly different responses between samples. Below saturation, both samples exhibit the desired fast response. Under optical fluences $\geqslant 54$ μJ cm^{-2}, the reference LT-GaAs layer shows saturation of electron trapping states leading to non-exponential behavior, but the LT-GaAs/Si maintains a double exponential decay. The difference is attributed to the formation of As–As and Ga–Ga bonds during the heteroepitaxial growth of LT-GaAs/Si, effectively leading to a much lower density of As-related electron traps.

Applied Physics Express

LETTER

Thickness dependence of the spintronic terahertz emission from Ni/Pt bilayer grown on MgO via electron beam deposition

John Paul Ferrolino[1], Neil Irvin Cabello[2], Alexander De Los Reyes[2], Hannah Bardolaza[2], Ivan Cedrick Verona[2], Valynn Katrine Mag-usara[3], Jessica Pauline Afalla[3], Miezel Talara[3], Hideaki Kitahara[3], Wilson Garcia[2] + Show full author list

Published 19 August 2021 •

Applied Physics Express, Volume 14, Number 9

Citation John Paul Ferrolino *et al* 2021 *Appl. Phys. Express* **14** 093001

+ Article information

Abstract

We report on the spintronic terahertz (THz) emission from a Ni/Pt bilayer on MgO grown via electron beam deposition. The films were grown with varying Ni thicknesses with a constant Pt thickness. The nominal Ni thickness values of 3, 5, 7, 9, 15, and 23 nm exhibited thickness-dependence of the THz emission intensities which was well-fitted with a model by Torosyan et al. Thickness-dependence was also observed for the peak frequencies and bandwidth characteristics. These results are consistent with previously reported MBE-grown ferromagnetic/nonmagnetic metal spintronic THz emitters utilizing the inverse spin-Hall effect.

Journal of Crystal Growth 573 (2021) 126328

Contents lists available at ScienceDirect

Journal of Crystal Growth

journal homepage: www.elsevier.com/locate/jcrysgro

Low-threshold amplified UV emission of optically pumped ZnO-polymer nanocomposites

Verdad C. Agulto [a,*], Melvin John F. Empizo [a], Keito Shinohara [a], Jonah Micah L. Inguito [b], Bee Jay Magallanes [b], Marvin B. Nalayog [b], Daisuke Umeno [a], Kloudene A. Salazar [b], Mia Angela N. Judicpa [c], Kohei Yamanoi [a], Toshihiko Shimizu [a], Allan Christopher C. Yago [c], Roland V. Sarmago [a,d], Nobuhiko Sarukura [a]

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ARTICLE INFO

Communicated by Toshinori Taishi

Keywords:
A1. Photoluminescence
A1. Characterization
B1. Nanomaterials
B1. Oxides
B1. Polymers
B2. Semiconducting II-VI materials

ABSTRACT

Metal oxide-polymer nanocomposites have the combined properties of inorganic and organic materials which can pave the way for a wide array of applications. In short-wavelength optoelectronics, zinc oxide (ZnO) is an attractive component for nanocomposites owing to its stable ultraviolet (UV) luminescence at room temperature. We present herein the observed amplification of the UV emission of oriented ZnO nanorods topped by different polymer layers. The optical emission properties are investigated under different excitation power densities. The as-grown nanorods exhibit UV emission that increases linearly with excitation. On the other hand, the ZnO-polymer nanocomposites exhibit dramatic UV emission enhancement and spectral narrowing. The results show that amplified UV emission can be achieved at a lower excitation threshold by incorporating a polymer layer on top of oriented ZnO nanorods. In this regard, the ZnO-polymer nanocomposites show potential as low-threshold UV light sources attractive for optoelectronic devices.

1. Introduction

Metal oxide-polymer nanocomposites pave the way for materials innovation owing to the rich possible combination of properties from metal oxides (e.g., rigidity, thermal stability, optical and magnetic properties) and organic materials (e.g., flexibility, processability, reactivity). The desired combination of properties is necessary for certain applications and can be achieved through careful and systematic design of nanocomposite materials. Among metal oxides, zinc oxide (ZnO) is capitalized in various fields as inorganic filler of composite materials for its biocompatibility, antimicrobial properties, and optoelectronic properties. ZnO-polymer nanocomposites thus find diverse applications in coatings, photocatalysis, and electrodes, among others [1–4]. Moreover, ZnO nanomaterials can be synthesized into various morphologies such as spheres, rods, wires, and tetrapods [5] which have different physical characteristics that can be taken advantage of. This versatility along with low cost renders ZnO a practical material for the development of nanocomposites.

For short-wavelength applications of nanocomposites, the wide direct bandgap (~3.3 eV) and high exciton binding energy (60 meV) of ZnO are useful properties. Various studies have demonstrated ZnO-polymer nanocomposites for photodetection, scintillator, and light-emitting diode applications [6–9]. We previously investigated composites made of randomly oriented ZnO microrods and polyvinylpyrrolidone (PVP) and found that the ZnO-PVP composites have an ultrafast lifetime of ~ 30 ps under UV excitation and thus could be developed as UV phosphors [10]. In the present study, the ZnO-polymer nanocomposites have oriented nanorods and exhibit amplified UV emission under a low-threshold excitation power which is attractive for lasing applications and UV light sources. Various optical applications could then be developed from different composite geometries. In addition to PVP, the high-density cationic polymer, polydiallyldimethylammonium chloride (PDDA), is also used in this study for the fabrication of oriented ZnO-polymer nanocomposites. PVP and

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Journal of Crystal Growth

journal homepage: www.elsevier.com/locate/jcrysgro

Picosecond UV emissions of hydrothermal grown Fe^{3+}-doped ZnO microrods

Kloudene A. Salazar [a,b,*], Verdad C. Agulto [c], Melvin John F. Empizo [c], Keito Shinohara [c], Kohei Yamanoi [c], Toshihiko Shimizu [c], Nobuhiko Sarukura [c], Allan Christopher C. Yago [d], Pinit Kidkhunthod [e], Suchinda Sattayaporn [e], Vallerie Ann I. Samson [f], Roland V. Sarmago [a,b,c]

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ARTICLE INFO

Communicated by Kozo Fujiwara

Keywords:
A1. Defects
A1. Doping
A. Photoluminescence
B1. Oxides
B.1. Zinc Compounds
B2. Semiconducting II-VI materials

ABSTRACT

We report the successful iron (III), Fe^{3+} doping of hydrothermal-grown zinc oxide (ZnO) microrods. The Fe^{3+}-doped ZnO microrods were synthesized at 90 °C using zinc acetate dihydrate, hexamethylenetetramine, and iron (III) chloride aqueous solutions. Compared to the undoped microrods, the Fe^{3+}-doped microrods exhibit more intense, sharper 564-nm (visible) emissions and shorter 388-nm (ultraviolet) emission lifetimes attributed to the successful incorporation of Fe^{3+} in a 6-coordinated geometry. Fe^{3+} is incorporated as an interstitial or part of a defect complex that effectively modified the defect structure while preserving the hexagonal wurtzite lattice. These results reveal the possibility of intentional transition metal doping of hydrothermal-grown ZnO micro/nanostructures with faster emission lifetimes for possible scintillator applications.

1. Introduction

Zinc oxide (ZnO) is a II-VI semiconductor considered to be a promising material for next-generation optoelectronic devices owing to its wide direct band gap of 3.37 eV and high exciton binding energy of 60 meV at room temperature. Efficient excitonic recombination in ZnO has led to studies for short-wavelength applications such as ultraviolet (UV) lasers, UV phosphors, and transparent diodes [1–5]. ZnO has been synthesized using various techniques such as electrodeposition [6,7], co-precipitation [8,9], combustion [10,11], and the hydrothermal method [12–14] producing a wide range of morphologies such as nanoparticles [15], nanoflowers [16], nanotubes [12], and micro/nanorods [2,17–21]. Fabricating ZnO via electrophoretic deposition (EPD) produces uniform, large-scale ZnO micro/nanostructures, but comes at the expense of limited substrate choice [6,7,13]. On the other hand, co-precipitation and gel combustion synthesis had issues in size controllability and impurity formation [8–10]. The hydrothermal method is a facile, versatile and scalable technique that allows the synthesis of high-quality ZnO micro/nanostructures while providing sufficient size control through changes in growth parameters such as time [14], temperature [14], precursors[13], and pH. Additionally, it allows ZnO to be deposited on flexible and foldable substrates, which is crucial for portable electronics development [13].

ZnO bulk crystals, thin films, and micro/nanostructures were reported to have fast emission lifetimes in the order of nanoseconds. Although undoped ZnO crystals exhibit a UV lifetime of ~ 1.0 ns making it viable as scintillator material [18], nanosecond lifetime is quite insufficient to probe ultrafast, short-wavelength optical pulses [18,22]. Pushing the possibility for ZnO as a scintillator with high conversion efficiency and fast emission lifetime, doping with transition metals such as gadolinium (Gd) [15], cobalt (Co) [23], aluminum (Al) [24], and iron (Fe) [8,10,25–28] have been investigated. Among the possible dopants, Fe shows an advantage due to the proximity of the ionic radii of Fe^{2+} (76 pm) and Fe^{3+} (69 pm) to that of Zn^{2+} (74 pm) [28,29], reducing the lattice strain and more likely preserving the ZnO hexagonal lattice [28]. It has been reported that charge compensation of two Fe^{3+} ions and

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Published: 17 August 2021

Creating terahertz pulses from titanium-doped lithium niobate-based strip waveguides with 1.55 μm light

Joselito E. Muldera, Jessica Pauline C. Afalla, Takashi Furuya, Hideaki Kitahara, Elmer S. Estacio, Katsuhiko Saito, Qixin Guo & Masahiko Tani

Journal of Materials Science: Materials in Electronics **32**, 23164–23173 (2021) | Cite this article

Abstract

We demonstrate that terahertz radiation can be generated from titanium-diffused magnesium oxide-doped lithium niobate optical strip waveguides when pumped by a single laser source with a wavelength of 1.55 μm. Titanium-in-diffusion was performed on a magnesium oxide-doped lithium niobate substrate by the deposition of titanium in a 40-μm wide strip pattern and then annealing in a vacuum furnace. Prism-coupled Cherenkov-phase matching was utilized to extract the terahertz emission from the waveguide. The contrast between the emission from the waveguide against the bulk crystal when the sample was moved along its crystal facet was also recorded, where an improvement of ~ 18.0% in the time-domain peak signal of the waveguide was observed. The waveguide's performance was also measured against that of a commercial terahertz emitter, a photoconductive antenna, where it was found that the time-domain signals of the two were comparable. The terahertz power spectra also revealed that the lithium niobate-based waveguides have a broader bandwidth by more than 1 THz, with a similar signal-to-noise ratio. As an effect, the waveguides gave a better signal at higher frequencies and, at times, reaching as high a difference of 20 dB. These results indicate the possibility of using titanium-in-diffusion to generate intense terahertz emission from titanium-doped lithium niobate waveguides and that these strip waveguides are viable alternatives to commercial terahertz emitters, especially at high frequencies. It is expected that much better output can be obtained from an optimized waveguide design and with more appropriate optics.

Journals & Magazines > IEEE Transactions on Terahert... > Volume: 12 Issue: 1

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

Publisher: IEEE Cite This PDF

Neil Irvin Cabello ; Alexander De Los Reyes ; Vladimir Sarmiento ; John Paul Ferrolino ; Victor DC Andres Vistro ; John Daniel Vasquez ;... All Authors

Abstract

Document Sections

I. Introduction

II. Methodology

III. Results and Discussion

IV. Conclusion

Authors

Figures

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.

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Page(s): 36 - 41

DOI: 10.1109/TTHZ.2021.3115726

Date of Publication: 27 September 2021

Publisher: IEEE

9 October 2021

Terahertz pulses from titanium-doped lithium niobate strip optical waveguides using a 1.55-micrometer pump beam

Joselito E. Muldera, Jessica Pauline C. Afalla, Takashi Furuya, Hideaki Kitahara, Elmer S. Estacio, Katsuhiko Saito, Qixin Guo, Masahiko Tani

Author Affiliations +

Proceedings Volume 11906, Infrared, Millimeter-Wave, and Terahertz Technologies VIII; 119061O (2021)
https://doi.org/10.1117/12.2601151
Event: SPIE/COS Photonics Asia, 2021, Nantong, Jiangsu, China

Abstract

We demonstrate that titanium-doped lithium niobate strip optical waveguides can act as terahertz emitters. Terahertz pulses were produced by pumping with a femtosecond laser at a wavelength of 1.55 μm via the prism-coupled Cherenkov-phase matching scheme. Near-single cycle time-domain pulses were generated and the terahertz time-domain peak signal from the 40-μm waveguide was found to be ~18% higher than that observed with bulk crystal. The THz power spectra revealed a broad bandwidth and high signal-to-noise ratio. These findings signify the feasibility of titanium-in-diffusion to produce strong terahertz radiation from titanium-doped lithium niobate waveguides.

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Low-energy femtosecond pulsed laser deposition of cerium (IV) oxide thin films on silicon substrates

Joseph A. De Mesa [a,*], Angelo P. Rillera [a], Melvin John F. Empizo [b], Nobuhiko Sarukura [b], Roland V. Sarmago [a], Wilson O. Garcia [a,b]

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ARTICLE INFO

Communicated by Toshinori Taishi

Keywords:
A1. Characterization
A1. Crystal structure
A1. Surfaces
A3. Pulsed laser deposition
B1. Oxides
B1. Rare earth compounds

ABSTRACT

Cerium (IV) oxide (CeO_2, ceria, or cerium dioxide) has been investigated for various applications due to its excellent physical and chemical properties. Since high-precision processing of such functional material can be conceived through pulsed laser deposition (PLD) with a low-energy, ultrashort pulsed laser, we report the low-energy (~ 8.0 nJ) femtosecond PLD (fs-PLD) of CeO_2 thin films on silicon (Si) substrates. The CeO_2 thin films are deposited for 2.0 to 5.0 h at room temperature with background oxygen (O_2) gas and then annealed at 1000 °C for 0.5 h in ambient air. The as-deposited CeO_2 film is amorphous and featureless due to the low-energy laser pulse and room-temperature deposition but exhibits good stoichiometry due to the background gas. The film properties likewise improve with post-deposition annealing coupled with a longer deposition time. Despite the change in stoichiometry, the annealed CeO_2 films exhibit improved reflectivity and enhanced crystallinity. Although other deposition parameters need to be optimized further and the film stoichiometry entails additional examination, our results show the viability of low-energy fs-PLD for the fabrication of CeO_2 thin films and similar functional materials.

1. Introduction

Cerium (IV) oxide (CeO_2), also known as ceria or cerium dioxide, is one of the most abundant and stable rare earth metal oxides found in the earth's crust. As a functional material, CeO_2 exhibits desirable properties such as wide bandgap (3.6 ~ 6 eV), high refractive index ($n = 2$ at 500 nm), high visible to near-infrared transparency, high melting point (2873 K), thermal stability, and good adhesion. Due to these properties, different forms of CeO_2 have been investigated for various applications. For example, CeO_2 nanoparticles on carbon cloth have been shown to exhibit high energy storage performance that is attributed to the rich redox chemistry and porous structure of CeO_2 [1]. CeO_2 nanoparticles have also been synthesized by laser ablation in water, and their anti-bacterial activity and minimal inhibition concentration have been examined [2]. On the other hand, CeO_2 thin films have been used as buffer layers for the preparation of superconducting $YBa_2Cu_3O_7$ (YBCO) films through chemical solution-based coating pyrolysis [3]. In addition, with CeO_2's high dielectric constant of up to 26 and Ce ions' variable valence states of Ce^{3+} and Ce^{4+}, CeO_2 films have been fabricated as gate dielectrics of metal–oxide semiconductor field-effect transistors (MOSFETs) and capacitors [4,5].

Given their numerous applications, CeO_2 thin films have been deposited on a variety of substrates through chemical vapor deposition (CVD) [6], electron beam evaporation [7], sputtering [8,9], molecular beam epitaxy (MBE) [10], atomic layer deposition (ALD) [11,12], and pulsed laser deposition (PLD) [13–18]. Among these techniques, PLD is considered suitable in fabricating high-quality metal oxide films due to the improvement of the layer-by-layer growth, the control of film surface morphology and stoichiometry, and the possible deposition at relatively low temperatures [18–20]. In depositing a material on a desired substrate, PLD utilizes a pulsed laser beam to ablate the target material either through vaporization, melting, or direct particle ejection, and the deposition involves four stages namely: (1) laser-target interaction, (2) plasma plume generation and expansion, (3) plasma plume-substrate interaction, and (4) film nucleation and growth [21]. The first two stages are complex phenomena wherein the complexity originates from the dependence of laser ablation and plume expansion on the laser characteristics and ambient deposition conditions

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9 October 2021

Improved terahertz emission characteristics from photoconductive antennas integrated with micron-size 1D and 2D metal line arrays

Hannah Bardolaza, Alexander De Los Reyes, Neil Irvin Cabello, John Paul Ferrolino, Ivan Cedrick Verona, Armando Somintac, Arnel Salvador, Elmer Estacio

Author Affiliations +

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Abstract

Terahertz (THz) photoconductive antennas (PCA's) from SI-GaAs substrates having one-dimensional (1D) and two-dimensional (2D) micron-size metal line arrays (MLA's) were fabricated. Photolithography and electron beam deposition of Ni/Au were used to fabricate spiral PCA's and 1D/2D MLA's on the transmission side of the PCA. Compared to a reference bare PCA, the THz time-domain signal enhanced ~6x for 1DMLA and ~11x for 2DMLA, with their corresponding bandwidths broadened. The origin of the enhancement is being investigated but is currently attributed to spoof surface plasmon phenomena. Integrating MLA's with PCA's demonstrates a more cost-effective alternative to nanostructure fabrication within the PCA gap.

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Interplay of $Zn(OAc)_2$ concentration, morphology, and emission in hydrothermal-grown ZnO nanostructures

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Highlights

- ZnO nanostructures are fabricated using different $Zn(OAc)_2$ concentrations.
- Lower $Zn(OAc)_2$ concentrations result in highly oriented ZnO nanorods.
- Higher $Zn(OAc)_2$ concentrations result in larger, randomly oriented ZnO nanocrystals.
- $Zn(OAc)_2$ concentration affects nanostructure morphology and emission.
- The UV emission properties can be attributed to a reabsorption phenomenon.

Abstract

We report the interplay of zinc acetate [$Zn(CH_3COO)_2$, $Zn(OAc)_2$] concentration, morphology, and emission in hydrothermal-grown ZnO nanostructures. Highly oriented nanorods with intense, 54 to 96 ps near-band-edge ultraviolet (UV) emissions are successfully fabricated using 25 to 75 mM concentrations. On the other hand, larger and randomly oriented nanocrystals are fabricated using 100 to 150 mM concentrations. Although all nanostructures exhibit hexagonal wurtzite crystal structures, increasing the $Zn(OAc)_2$ concentration affects their preferential orientation, morphology, and UV emission. The peculiar nanostructure emissions observed are also attributed to a reabsorption phenomenon among adjacent nanostructures. For potential scintillator applications, particularly for x-ray diagnostics, our results suggest that less than 100 mM $Zn(OAc)_2$ concentrations should be used to reduce the UV emission reabsorption in hydrothermal-grown ZnO nanostructures.

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

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ABSTRACT

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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