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$*$-Ricci-Yamabe soliton on Kenmotsu manifold with torse forming potential vector field

Soumendu Roy[a], Santu Dey[b], Ali. H. Alkhaldi[c], Akram Ali[c,*], Arindam Bhattacharyya[d]

[a] *Division of Mathematics, School of Advanced Sciences, Vellore Institute of Technology, Chennai-600127, India*
[b] *Department of Mathematics, Bidhan Chandra College, Asansol - 4, West Bengal-713304, India*
[c] *Department of Mathematics, College of Science, King Khalid University, 61421 Abha, Saudi Arabia*
[d] *Department of Mathematics, Jadavpur University, Kolkata-700032, India*

Abstract. The goal of the present paper is to deliberate $*$-Ricci-Yamabe soliton, whose potential vector field is torse-forming on the Kenmotsu manifold. Here, we have shown the nature of the soliton and found the scalar curvature when the manifold admitting $*$-Ricci-Yamabe soliton on the Kenmotsu manifold. Next, we have evolved the characterization of the vector field when the manifold satisfies $*$-Ricci-Yamabe soliton. Also, we have embellished some applications of a vector field as torse-forming in terms of $*$-Ricci-Yamabe soliton on the Kenmotsu manifold. We have developed an example of $*$-Ricci-Yamabe soliton on 3-dimensional Kenmotsu manifold to prove our findings.

1. Introduction

In 1972, K. Kenmotsu [20] obtained some tensor equations to characterize the manifolds of the third class. Since then the manifolds of the third class have been called Kenmotsu manifolds. In 1982, R. S. Hamilton [17] introduced the concept of Ricci flow, which is an evolution equation for metrics on a Riemannian manifold. The Ricci flow equation is given by:

$$\frac{\partial g}{\partial t} = -2S, \tag{1.1}$$

on a compact Riemannian manifold M with Riemannian metric g. A self-similar solution to the Ricci flow ([17], [32]) is called a Ricci soliton [18] if it moves only by a one-parameter family of diffeomorphism and scaling. The Ricci soliton equation is given by:

$$\pounds_V g + 2S + 2\Lambda g = 0, \tag{1.2}$$

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Keywords. Ricci-Yamabe soliton, $*$-Ricci-Yamabe soliton, torse forming vector field, conformal Killing vector field, Kenmotsu manifold.
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* Corresponding author: Akram Ali
Email addresses: soumendu1103mtma@gmail.com (Soumendu Roy), santu.mathju@gmail.com (Santu Dey), ahalkhaldi@kku.edu.sa (Ali. H. Alkhaldi), akali@kku.edu.sa (Akram Ali), bhattachar1968@yahoo.co.in (Arindam Bhattacharyya)

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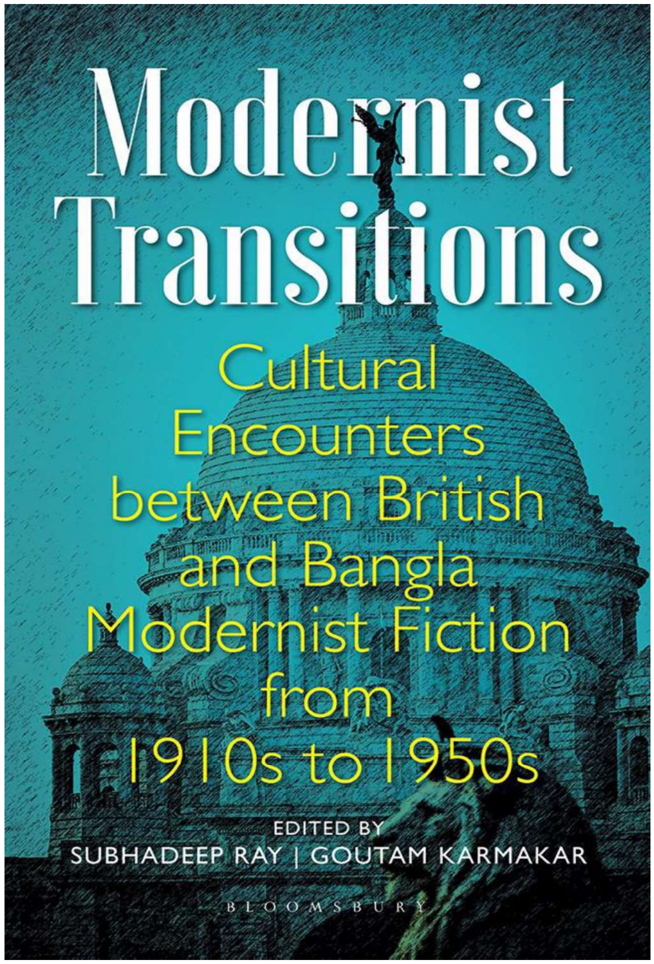

Modernism has always been a contested term, and the most energetic debates about the reach of the term have recently been associated with an emerging interest in global modernism, or planetary modernism. However, horizons of multiple modernisms remain fuzzy, and conflicts and compromises between their range of practices and ideological networks mostly depend on how they were shaped by the history of imperial modernity. In this respect, Indian and British modernism of the first half of the twentieth century shared a

Design and analysis of MIMO antenna array for TeraHertz communication

| Research Article | Published: 04 April 2024

| (2024) Cite this article

Amit Banerjee

View ORCID ID profile

Microsystem Design-Integration Lab, Physics Department, Bidhan Chandra College, Asansol, India

Pia Sarkar, Arijit Saha, Amit Banerjee & Vedatrayee Chakraborty

Abstract

Antenna array of two dipole antennas made of copper has been designed and analyzed for 0.1 THz frequency in this work for element spacing of $d = \frac{3\lambda}{4}$ and $d = \lambda$, where λ is the wavelength. Antenna length is $\frac{\lambda}{2}$ and width is $\frac{\lambda}{200}$. Range of azimuth angle is [- 180°–180°] and elevation angle is [- 90°–90°]. Variation in correlation of power transmitted from first port to second port (S_{21}) has been analyzed changing tilt variation of second dipole, inter element spacing and frequency. optimization of results antenna gain has been achieved as 5.41dBi and 6.35dBi for element spacing of $d = \frac{3\lambda}{4}$ and $d = \lambda$ respectively. Favorable values of diversity gain, total active reflection coefficient and mean effective gain have been achieved in this design as 10 dB, 0.5 dB and - 9.6 dB respectively. This design gives good results of envelope correlation coefficient as 0.02 and 0.098 for element spacing of $d = \frac{3\lambda}{4}$ and $d = \lambda$ respectively. This antenna is capable of exhibiting isolation of - 17.6702 dB and - 20.0044 dB for $d = \frac{3\lambda}{4}$ and $d = \lambda$ element spacing respectively. Antenna efficiency is of high value as 96.48% and 97.67% for element spacing of $d = \frac{3\lambda}{4}$ and $d = \lambda$ respectively. A communication system has been studied implementing the proposed design. Encoding, precoding, orthogonal frequency division multiplexing and beam steering techniques have been applied to maintain signal quality. A compact array of small size (1.5 × 0.015 mm^2), low

nanomaterials

Article

Edge-Terminated AlGaN/GaN/AlGaN Multi-Quantum Well Impact Avalanche Transit Time Sources for Terahertz Wave Generation

Monisha Ghosh [1,2], Shilpi Bhattacharya Deb [3], Aritra Acharyya [4], Arindam Biswas [2,5], Hiroshi Inokawa [6], Hiroaki Satoh [6,*], Amit Banerjee [7,*], Alexey Y. Seteikin [8,9] and Ilia G. Samusev [9,*]

1 Department of Electronics and Communication Engineering, Supreme Knowledge Foundation Group of Institutions, Mankundu, Chandannagar 712139, India; monisha.ghosh@skf.edu.in
2 Department of Mining Engineering, Kazi Nazrul University, Asansol 713340, India; arindam.biswas@knu.ac.in
3 Department of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal Road, Beliaghata, Kolkata 700015, India; shilpi.bhattacharya@rcciit.org.in
4 Department of Electronics and Communication Engineering, Cooch Behar Government Engineering College, Harinchawra, Ghughumari, Cooch Behar 736170, India; aritra.acharyya@cgec.org.in
5 Centre for IoT and AI Integration with Education-Industry-Agriculture, Kazi Nazrul University, Asansol 713340, India
6 Research Institute of Electronics, Shizuoka University, Hamamatsu 4328011, Japan; inokawa.hiroshi@shizuoka.ac.jp
7 Microsystem Design-Integration Lab, Physics Department, Bidhan Chandra College, Asansol 713303, India
8 Computation Biophysics Group, Amur State University, Blagoveshchensk 675027, Russia; seteikin@mail.ru
9 Research and Education Center for Fundamental and Applied Photonics & Nanophotonics, Immanuel Kant Baltic Federal University, Kaliningrad 236000, Russia
* Correspondence: satoh.hiroaki@shizuoka.ac.jp (H.S.); amitbanerjee.nus@gmail.com (A.B.); is.cranz@gmail.com (I.G.S.)

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Abstract: In our pursuit of high-power terahertz (THz) wave generation, we propose innovative edge-terminated single-drift region (SDR) multi-quantum well (MQW) impact avalanche transit time (IMPATT) structures based on the $Al_xGa_{1-x}N/GaN/Al_xGa_{1-x}N$ material system, with a fixed aluminum mole fraction of $x = 0.3$. Two distinct MQW diode configurations, namely p^+-n junction-based and Schottky barrier diode structures, were investigated for their THz potential. To enhance reverse breakdown characteristics, we propose employing mesa etching and nitrogen ion implantation for edge termination, mitigating issues related to premature and soft breakdown. The THz performance is comprehensively evaluated through steady-state and high-frequency characterizations using a self-consistent quantum drift-diffusion (SCQDD) model. Our proposed $Al_{0.3}Ga_{0.7}N/GaN/Al_{0.3}Ga_{0.7}N$ MQW diodes, as well as GaN-based single-drift region (SDR) and 3C-SiC/Si/3C-SiC MQW-based double-drift region (DDR) IMPATT diodes, are simulated. The Schottky barrier in the proposed diodes significantly reduces device series resistance, enhancing peak continuous wave power output to approximately 300 mW and DC to THz conversion efficiency to nearly 13% at 1.0 THz. Noise performance analysis reveals that MQW structures within the avalanche zone mitigate noise and improve overall performance. Benchmarking against state-of-the-art THz sources establishes the superiority of our proposed THz sources, highlighting their potential for advancing THz technology and its applications.

Keywords: AlGaN; edge-termination; GaN; IMPATT; multi-quantum well; Schottky barrier; SDR; terahertz

1. Introduction

The terahertz (THz) frequency range, often referred to as the “terahertz-gap”, has become a focal point of research and innovation due to its immense potential for a wide

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RESEARCH ARTICLE

Multiple Quantum Barrier Avalanche Photodiode Based on GaN/AlGaN Heterostructures for Long Wavelength Infrared Detection

SOMRITA GHOSH[1], ARITRA ACHARYYA[2], ARINDAM BISWAS[1,3], AMIT BANERJEE[4], HIROSHI INOKAWA[5], (Member, IEEE), HIROAKI SATOH[5], (Member, IEEE), ALEXEY Y. SETEIKIN[6,7], AND I. G. SAMUSEV[6]

[1]Department of Mining Engineering, Kazi Nazrul University, Burdwan, Asansol, West Bengal 713340, India
[2]Department of Electronics and Communication Engineering, Cooch Behar Government Engineering College, Harinchawra, Ghughumari, Cooch Behar, West Bengal 736170, India
[3]Centre for IoT and AI Integration with Education-Industry-Agriculture, Kazi Nazrul University, Burdwan, Asansol, West Bengal 713340, India
[4]Microsystem Design-Integration Laboratory, Department of Physics, Bidhan Chandra College, Asansol, West Bengal 713303, India
[5]Research Institute of Electronics, Shizuoka University, Hamamatsu 4328011, Japan
[6]Research and Education Center for Laser Nanotechnology and Information Biophysics, Immanuel Kant Baltic Federal University, 236000 Kaliningrad, Russia
[7]Computation Biophysics Group, Amur State University, 675027 Blagoveshchensk, Russia

Corresponding authors: Arindam Biswas (mailarindambiswas@yahoo.co.in), Aritra Acharyya (ari_besu@yahoo.co.in), and I. G. Samusev (is.cranz@gmail.com)

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ABSTRACT A multiple quantum barrier (MQB) avalanche photodiode (APD) structure based on GaN/$Al_xGa_{1-x}N$ material system has been proposed in this paper which is capable of detecting infrared (IR) signal up to 6.0 μm wavelength. A self-consistent quantum drift-diffusion (SCQDD) model developed by the authors, has been used to determine the current-voltage characteristics under dark and illuminated conditions, spectral response, excess noise properties, signal-to-noise ratio, time and frequency responses. Results show that the proposed MQB APD attains peak responsivity of 60 AW^{-1} at 3.0 μm wavelength. Incorporation of a dedicated thin *n*-type GaN layer for avalanche multiplication in between the p^+-GaN contact layer and MQB constant-field drift-layer ensures significantly low noise equivalent power under normal operating conditions at room temperature (300 K). Optical pulse response of the device reveals that special restriction over the charge multiplication able to supress the minor peaks of the current response and consequently significantly narrow pulse response can be achieved. Narrow pulse response leads to broad bandwidth of 274.5 GHz, which is significantly broader than the existing IR photo-detectors.

INDEX TERMS Avalanche photodiodes, multiple quantum barrier, self-consistent quantum drift-diffusion model, infrared, heterojunction, responsivity, pulse response, bandwidth.

I. INTRODUCTION

Avalanche photodiodes (APDs) are most suitable optical detector for the optical receivers in long-haul optical communication systems [1]. The APDs are preferred as optical signal detector over other photo-detectors in both free space and fibre-optic communication systems, except the applications in which the signal-to-noise ratio (SNR)-budget is low. In those cases, low noise *p-i-n* detector, in combination with the trans-impedance amplifier are preferred. However, high internal gain mechanism of APDs eliminates the burden of trans-impedance amplifiers in case of the applications where SNR-budget is not a major concern. Moreover, high sensitivity and ultra-high speed of APD are

The associate editor coordinating the review of this manuscript and approving it for publication was Shuo Sun.

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Open Access Article

On-Chip Modification of Titanium Electrothermal Characteristics by Joule Heating: Application to Terahertz Microbolometer

by Durgadevi Elamaran [1,*,†] (mailto:durgaelamaran@gmail.com), Ko Akiba [2] (mailto:akiba.ko.17@shizuoka.ac.jp), Hiroaki Satoh [2,3] (mailto:satoh.hiroaki@shizuoka.ac.jp) (https://orcid.org/0000-0002-5868-0219), Amit Banerjee [3,*,‡] (mailto:amitbanerjee.nus@gmail.com) (https://orcid.org/0000-0001-9612-4523), Norihisa Hiromoto [1,2] (mailto:hiromoto.norihisa@shizuoka.ac.jp) and Hiroshi Inokawa [1,2,3,*] (mailto:inokawa.hiroshi@shizuoka.ac.jp) (https://orcid.org/0000-0002-8647-3524)

[1] Graduate School of Science and Technology, Shizuoka University, Hamamatsu 432-8011, Japan
[2] Graduate School of Integrated Science and Technology, Shizuoka University, Hamamatsu 432-8561, Japan
[3] Research Institute of Electronics, Shizuoka University, Hamamatsu 432-8011, Japan
[*] Authors to whom correspondence should be addressed.
[†] Current address: Graduate School of Arts and Science, The University of Tokyo, Komaba, Tokyo 153-8902, Japan.
[‡] Current address: Microsystem Design-Integration Lab, Physics Department, Bidhan Chandra College, Asansol 713303, India.

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Article

Terahertz Radiation from High Electron Mobility Avalanche Transit Time Sources Prospective for Biomedical Spectroscopy

Sahanowaj Khan [1], Aritra Acharyya [2], Hiroshi Inokawa [3], Hiroaki Satoh [3], Arindam Biswas [4,*], Rudra Sankar Dhar [1], Amit Banerjee [5] and Alexey Y. Seteikin [6,7,*]

[1] Department of Electronics & Communication Engineering, National Institute of Technology Mizoram, Chaltlang, Aizawl 796012, Mizoram, India; khannowda@yahoo.co.in (S.K.); rudra.ece@nitmz.ac.in (R.S.D.)
[2] Department of Electronics and Communication Engineering, Cooch Behar Government Engineering College, Harinchawra, Ghughumari, Cooch Behar 736170, West Bengal, India; ari_besu@yahoo.co.in
[3] Research Institute of Electronics, Shizuoka University, Hamamatsu 4328011, Japan; inokawa.hiroshi@shizuoka.ac.jp (H.I.); satoh.hiroaki@shizuoka.ac.jp (H.S.)
[4] Centre for IoT and AI Integration with Education-Industry-Agriculture, Department of Mining Engineering, Kazi Nazrul University, Asansol 713340, West Bengal, India
[5] Microsystem Design-Integration Lab, Physics Department, Bidhan Chandra College, Asansol 713303, West Bengal, India; amitbanerjee.nus@gmail.com
[6] Immanuel Kant Baltic Federal University, 236000 Kaliningrad, Russia
[7] Amur State University, 675027 Blagoveshchensk, Russia
* Correspondence: mailarindambiswas@yahoo.co.in (A.B.); seteikin@mail.ru (A.Y.S.)

Abstract: A Schottky barrier high-electron-mobility avalanche transit time (HEM-ATT) structure is proposed for terahertz (THz) wave generation. The structure is laterally oriented and based on AlGaN/GaN two-dimensional electron gas (2-DEG). Trenches are introduced at different positions of the top AlGaN barrier layer for realizing different sheet carrier density profiles at the 2-DEG channel; the resulting devices are equivalent to high–low, low–high and low-high–low quasi-Read structures. The DC, large-signal and noise simulations of the HEM-ATTs were carried out using the Silvaco ATLAS platform, non-sinusoidal-voltage-excited large-signal and double-iterative field-maximum small-signal simulation models, respectively. The breakdown voltages of the devices estimated via simulation were validated by using experimental measurements; they were found to be around 17–18 V. Under large-signal conditions, the series resistance of the device is estimated to be around 20 Ω. The large-signal simulation shows that the HEM-ATT source is capable of delivering nearly 300 mW of continuous-wave peak power with 11% conversion efficiency at 1.0 THz, which is a significant improvement over the achievable THz power output and efficiency from the conventional vertical GaN double-drift region (DDR) IMPATT THz source. The noise performance of the THz source was found to be significantly improved by using the quasi-Read HEM-ATT structures compared to the conventional vertical Schottky barrier IMPATT structure. These devices are compatible with the state-of-the-art medium-scale semiconductor device fabrication processes, with scope for further miniaturization, and may have significant potential for application in compact biomedical spectroscopy systems as THz solid-state sources.

Keywords: avalanche transit time; high electron mobility; 2-DEG; monolithic integration; noise measure; noise spectral density; terahertz biomedical

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1. Introduction

Recently, the frequency gap between the millimeter-wave and infrared bands, known as the terahertz gap (THz-gap), is drawing the attention of researchers due to its enormous possible applications in the fields of imaging, astronomy and spectroscopy; the quality inspection of industrial, medical and pharmaceutical products; in bio-sensing; etc. [1–8]. Some solid-state devices such as high-electron-mobility transistors (HEMTs), heterojunction

LETTER OF COLLABORATION

between

Dr Saumen Chakraborty
Assistant Professor of Physics
Bidhan Chandra College, Asansol-713301, W.B. (India)

and

Dr Saumendra Sankar De Sarkar
Assistant Professor of Physics
Raniganj Girls' College, P.O.: Searsole Rajbari-713358, W.B. (India)

This letter establishes that the above mentioned academicians (parties) have agreed on their collaboration towards promotion of research in the field of Nonlinear Dynamical Systems out of their mutual interest.

Collaboration between these two academicians will be supported by mutual educational cooperation regarding use of laboratory and library oftheir parental institutions.

If anyone (or both) of the parties is (are) in receipt of Financial Grant towards their work from any source, it is the right and responsibility of that party (both the party) to utilize the fund to whom the grant is awarded.

Both the parties ensure that no other financial agreement is being made hereunder.

This collaboration (agreement) takes effect upon the date of signature and validfor a period of 5 (five) years, after which it may be renewed, considering the effectiveness and progress towards their goal.

The provisions of this collaboration (agreement) may be amended at any timeby the mutual consent in writing of both parties.

Signed By

Saumen Chakraborty
(Dr Saumen Chakraborty)
Dated: 11.07.2022

Saumendra Sankar De Sarkar
(Dr Saumendra Sankar De Sarkar)
Dated: 11 JUL 2022

Dept. of Physics
Bidhan Chandra College
Asansol-713304

Assistant Professor
Department of Physics
Raniganj Girls' College

Approved by/ In Presence of/ Countersigned by

Falguni Mukhopadhyay
(Dr Falguni Mukhopadhyay)
Dated: 11-07-2022

Chhabi De
(Dr Chhabi De)
Dated: 11.07.2022

Principal
Bidhan Chandra College
Asansol

Principal
Raniganj Girls' College
Searsole Rajbari-713358
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Certificate of Collaboration

I am pleased to write this certificate of ongoing collaboration, details of which are as follows:

- **Collaboration Between:**

Faculty of Science and Engineering,
Jharkhand Rai University, Ranchi
Principal Investigator: Dr Shraddha Prasad,
Associate Professor, Jharkhand Rai University, Ranchi
Jharkhand- 834010
and

- **Department of Physics,**

Bidhan Chandra College, Asansol
Principal Investigator: Dr Ajay Kumar Sharma,
Department of Physics, B.C. College, Asansol
West Bengal- 713304

- **Duration of Collaboration**: 2017-2023 and continuing.
- **Details of Collaboration**: Research collaboration related to Electronic, Opto-electronic, Mechanical, Electrical Properties of Ternary Chalcopyrites.
- **Output of Collaboration**:
- **Research Publications:**

Journal Publication:-

- "Optical properties of $CuInS_2$, $AgAlTe_2$, $CdSiP_2$, $ZnSiP_2$, $CdSnAs_2$- ternary chalcopyrites", Ajay Kumar Sharma, Shraddha Prasad, Sanjay Kumar Gorai, Akshar Wangmay, October 2022, Special Issue-V, 147-151.

Book Chapter Publication:

- "Di-electric Constant of Ternary Chalcopyrites", Ajay Kumar Sharma, Shraddha Prasad, Paradigmatic Research (2023), Shree Siddhivinayak Global Publication, 1st Edition, pp-29-33, ISBN-978-93-91773-43-4.

Ajay Kumar Sharma

Dr. Shraddha Prasad
Associate Professor
Faculty of Science and Engineering
Jharkhand Rai University, Ranchi

Dr. Ajay Kumar Sharma
Assistant Professor
Department of Physics
Bidhan Chandra College, Asansol

Research Institute of Electronics
SHIZUOKA UNIVERSITY
3-5-1 Johoku, Naka-ku, Hamamatsu, 432-8011 JAPAN
http://www.rie.shizuoka.ac.jp

静岡大学電子工学研究所
〒432-8011 浜松市中区城北三丁目5番1号
TEL 053-478-
FAX 053-478-

September 2, 2022

To the person in charge of International Bilateral Cooperation,
Department of Science and Technology (DST), India

I agree to participate in the following DST-JSPS Bilateral Joint Research Project as a principal investigator on the Japan side.

1. Tittle of the research
Design and Development of Photo-controlled Memristive Graphene/Diamond Heterojunction Devices for Ultralow-energy Micoelectronics and Computing

2. Principal investigators
India side:
(PI)Dr. Amit Banerjee, Assistant Professor, Microsystem Design-Integration Lab, Physics Dept., Bidhan Chandra College
Dr. Tanmoy Basu, Research Scientist, Centre for Quantum Engineering, Research and Education (CQuERE), TCG Centres for Research and Education in Science and Technology (TCG CREST)
Prof. Dr. Partha Pratim Sarkar, Professor, Department of Engineering and Technological Studies (DETS), University of Kalyani
Japan side:
(PI)Dr. Tomoaki Masuzawa, Lecturer, Research Institute of Electronics, Shizuoka University
Prof. Dr. Toru Aoki, Professor, Research Institute of Electronics, Shizuoka University

3. Research Period
From June 1, 2023 to May 31, 2025 (2 years)

4. Brief description of the work plan
In order to develop a novel photo-controlled memristive device, we shall fabricate carbon based hetero structures and characterize their structural, electronic, and optical properties. By making use of graphene/diamond structure, ultrafast switching of THz frequency and unified switching device and memory will be realized. The work will be performed by combining the experience and expertise in designing and simulation on the India side and fabrication and testing on the Japan side through the visits from both sides, i.e. 4 visits x 30 day/visit from India to Japan, and 4 visits x 7 day/visit from Japan to India.

Sincerely yours,

Tomoaki Masuzawa

Tomoaki Masuzawa, Ph.D.
Lecturer, Faculty of Infomatics / Research Institute of Electronics
Shizuoka University
3-5-1, Johoku, Naka-ku, Hamamatsu 432-8011, Japan
TEL: +81-53-478-1347
EMAIL: masuzawa.tomoaki@shizuoka.ac.jp

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15 December 2022

Dr. Amit Banerjee,
Assistant Professor,
Dept of Physics,
Principal Investigator, Microsystem Design-Integration Lab,
Bidhan Chandra College,
Dist: Paschim Bardhaman,
Asansol- 713304, INDIA

Dear Amit,

This is further to the recent discussions that Professor Bhanu Pratap Das, Director of the Centre for Quantum Engineering, Research and Education (CQuERE) of TCG CREST and a few other senior members of TCG CREST had with you. With great pleasure we are extending an invitation to you to join us as an Honorary Adjunct Faculty for a period of one year from 20 December 2022.

We will be much obliged if you could regularly find time to visit TCG CREST for interacting with our faculty members, research scholars and students for guiding and advising them in your domain of expertise and interest.

We will be looking forward to receiving a confirmatory note from you soon.

Thanking you,

Yours sincerely,

Joydeep Bhattacharya
Chief Development Officer
TCG Centres for Research and Education in Science and Technology

明志科技大學
MING CHI UNIVERSITY OF TECHNOLOGY

New Taipei city, Taiwan 24301
Phone: 886-2-29089899#4862
Fax: 886-2-29085247
biring@mail.mcut.edu.tw

Dated: 5th January, 2024

<u>To Whom It May Concern</u>

To

Dr. Amit BANERJEE, Ph.D.,

Principal Investigator, Microsystem Design-Integration Lab;

Assistant Professor, Bidhan Chandra College, West Bengal, INDIA;

Reference: Consulting Project with Organic Electronics Research Center (OERC), Ming Chi University of Technology, New Taipei City, Taiwan from 1st January, 2021- 31st December, 2023

Subject: Certificate of Completion

Dear Dr. Banerjee,

With reference to details mentioned above, we are pleased to provide you the certificate of satisfactory completion of our consulting project from 2021-2023 with Ming Chi University of Technology, New Taipei City, Taiwan.

As token of our gratitude, a consultation fee of 24000 NTD will be transferred to your institutional account, further disbursement of the same may be carried out according to your institutional and/or local tax norms.

We very much appreciate your support and opportunity to interact, guiding and advising in your domain of expertise in microelectronic technologies and devices.

With best regards,

Dr. Sajal Biring
Associate Professor, Department of Electronic Engineering
Head of research division
Organic Electronic Research Center
Ming Chi University of Technology

Certificate of Appointment

Certificate No. 001-2022

Date of Issue: 0101/2022

To

Dr. Amit Banerjee

Assistant Professor

Physics Department, Bidhan Chandra College

Kazi Nazrul University

Asansol, West Bengal, 713303, India

This certificate of appointment is hereby granted to you for the position as an adjunct research fellow in the Organic Electronics Research Center, Ming Chi University of Technology, New Taipei City, Taiwan due to your outstanding academic achievements. The appointment term is for one year starting from 1st January, 2022 till 31st December, 2023.

Director Shun-Wei Liu

Organic Electronics Research Center

Ming Chi University of Technology

明志科技大學
統一編號
35701534
有機電子
研究中心
電話：2908-9899 傳真：2908-5247