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ARTICLE

Growth of ZnO Nanorods on Different Seed Layer Thickness Using the Hydrothermal Method for UV Detection

Basavaraj S. Sannakashappanavar[1], C. R. Byrareddy[2], Nandini A. Pattanshetti[3], Kunal Singh[4], and Aniruddh Bahadur Yadav[5,*]

Seed layer thickness effect on the growth of zinc oxide nanorods was investigated in the present work. The Zinc oxide seed layer for nanorods growth was deposited using RF sputtering on a SiO_2/Si substrate. The surface morphology of the zinc oxide thin films was studied by Atomic force microscopy and X-ray diffraction. Zinc oxide nanorods were then grown on two types of seed layer (50 nm and 100 nm) by hydrothermal method. Density, dimension, surface morphology, elemental composition of zinc oxide nanorods was found to be varied with zinc oxide seed layer, as observed using Scanning electron microscopy, X-ray diffraction and X-ray photoelectron spectroscopy. To identify the application of zinc oxide nanorods and effect of seed layer on their photodetection capability, a metal-semiconductor-metal photoconductor was fabricated using shadow mask and thermal evaporation methods. Ultraviolet light of different wavelengths were exposed to the device and current–voltage characteristics was observed using semiconductor parameter analyzer. It was found that seed layer over which nanorods grown affected the light detection capacity of the device.

Keywords: Seed Layers, ZnO Nanorods, Hydrothermal Method, Metal-Semiconductor-Metal, UV Detection.

1. INTRODUCTION

Ultraviolet (UV) photodetectors are widely used in different fields like in space communications, pollution monitoring, water sterilization, military applications and also in various commercial applications [1]. In view of this, highly photosensitive devices which show efficient detection properties are in high demand. Varieties of UV detectors are available which are reliable and exhibit sensitivity towards UV spectrum with low noise and quick response. Wide band gap semiconductors, specifically metal oxides are one among such materials which are chemically and thermally stable for the above mentioned applications in all sorts of environments. Zinc oxide is one among many wide band gap (3.37 eV) materials like GaN, ZnO, TiO_2, GaP etc. which are extensively used for the detection of UV radiation [2–4]. It is an *n*-type semiconductor material with wide direct band gap and large excitation binding energy of 60 meV. ZnO is an inexpensive material that can be synthesised through diverse processing technologies. Further, Mollow was the first person to use ZnO thin film in the year 1940 for UV detection property [5]. Since then many devices bottomed on ZnO were fabricated and tested for this specific application. These devices are still in their developing stages and thus possess some limitations. ZnO for its photodetection property is widely applied in various fields, such as, solar cells, gas sensors, optoelectronic devices, biological applications, etc. [6–9].

ZnO thin films can be fabricated using various physical and chemical methods such as, sol-gel [10–12], spray pyrolysis, electrodeposition, pulsed laser deposition, metal organic chemical vapor deposition (MOCVD), thermal evaporation method [13–17], chemical vapor deposition (CVD) and hydrothermal method [18]. Effects of seed layer on the structural and optical properties of ZnO

[1]Department of Electronics and Telecommunication, AIACTT, Ashta 416301, Maharashtra, India
[2]Department of Electronics and Communication, BIT, Bangalore 560004, Karnataka, India
[3]Department of Chemistry, Karnatak University, Dharwad 580003, Karnataka, India
[4]Department of Electronics and Communication Engineering, NIT Jamshedpur, 831014, India
[5]Department of Electronics and Communication, Sree Vidyanikethan Engineering College, Tirupati 517102, Andhra Pradesh, India
*Author whom correspondence should be addressed.
Email: aniruddh.bahadur.yadav@vidyanikethan.edu, an04am@gmail.com
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Development of novel 3D scaffolds using BioExtruder by the incorporation of silica into polycaprolactone matrix for bone tissue engineering

Nandini A. Pattanashetti[a], Sara Biscaia[b], Carla Moura[b], Geoffrey R. Mitchell[b], Mahadevappa Y. Kariduraganavar[a,*]

[a] Department of Chemistry, Karnatak University, Dharwad, 580003, India

[b] Centre for Rapid & Sustainable Product Development, Polytechnic Institute of Leiria, Marinha Grande, 2430-028, Portugal

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ABSTRACT

Development of three-dimensional (3D) scaffolds has acquired a great importance for bone repair and tissue reconstruction. Thus, this paper addresses the development of 3D scaffolds by varying the content of silicon dioxide (SiO_2) in polycaprolactone (PCL) matrix. The scaffolds were fabricated by employing a novel fused deposition modelling technique (BioExtruder). The physicochemical properties of the developed 3D scaffolds were systematically studied using various techniques. The thermal properties and stability of the PCL and its composites were assessed using differential scanning calorimetry and thermogravimetric analysis. The morphology of the developed scaffolds was evaluated using scanning electron microscopy and optical microscopy, and found that the pore size was increased from 270 to 320 µm with increasing the SiO_2 content in the PCL matrix. The wettability of the developed scaffolds was assessed using contact angle meter. The scaffold incorporating 15 wt% of SiO_2 exhibited the highest hydrophilic property as well as thermal stability. The Young's modulus value determined using universal testing machine indicated that the scaffold developed with 15 wt% of SiO_2 exhibits 101.59 MPa. To assess the performance of the scaffolds for tissue engineering applications, the *in-vitro* cytotoxicity and cell proliferation were systematically carried out using L929 Mouse Fibroblasts and MG63 Osteoblasts, respectively. It was found that the scaffolds did not show any toxic effects towards the cell growth, and the cell proliferation was greatly increased > 90% during 7 days of cell culture. Based on the results, it is concluded that the scaffold containing 15 wt% of SiO_2 is of potential candidate for bone tissue engineering application.

1. Introduction

Bone repair and tissue reconstruction are the challenging topics in the fields of tissue engineering and regenerative medicine. Though bone is known for its self-healing property, the large scale bone defects, such as bone infections, trauma and bone tumours, hinder the healing process [1–3]. Thus, external intervention or bone substitute is often required to repair or replace the defect tissues. As an alternative option for conventional autografts and allografts, bone tissue engineering has been proved as more advantageous and effective in terms of bone repair and reconstruction [4,5]. To address this, a biodegradable and biocompatible scaffold serves as a temporary skeletal frame which can mimic the properties of extracellular matrix (ECM), such as mechanical support, cell adhesion, proliferation and differentiation [illegible]. These biodegradable and biocompatible scaffolds induce bone tissue regeneration and undergo gradual degradation, and thereby replacing a new bone tissue [5]. In particular, scaffolds for bone regeneration should provide a highly interconnected porous structure. These pores allow the transportation of nutrients, light and oxygen molecules to the inner parts of a scaffold and facilitate the cell growth, vascularisation and removal of waste material, and thereby maintaining a sufficient mechanical strength to provide the structural requirements of the substituted tissue [5,9,10]. Such porous bone scaffolds can be developed by various techniques, like solvent casting/particulate leaching [11,12], gas foaming [13], freeze drying [14], thermally induced phase separation [7], electrospinning [9,[illegible]] etc. However, the scaffolds with required interconnected porous structure for specific defects are difficult to manufacture with these techniques [illegible]. In recent years, the manufacturing of three dimensional scaffolds increased the hope for the production of scaffolds with closer similarities to bone matrix [illegible]. Among the manufacturing processes, 3D printing is a unique and rapid prototyping (RP) process which was developed in early 1990's at

* Corresponding author.
E-mail address: [illegible] (M.Y. Kariduraganavar).

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Synthesis, structural characterization and computational study of NLO-responsive chromophores and second-order coefficients of thermally crosslinked polymers

Radha V. Doddamani, Padmeshwary S. Rachipudi, Nandini A. Pattanashetti and Mahadevappa Y. Kariduraganavar *

This paper emphasizes the preparation of nonlinear optical (NLO) responsive chromophores and their corresponding polymers. Initially, the carboxyl acid group-based precursors of the chromophores containing strong acceptors such as nitro-substituted thiazole and thiadiazole groups were prepared and subjected to condensation reactions with a monomer to yield a series of polymers. Prior to the synthesis of the polymers, a thermally crosslinkable monomer, 2,6-di-(octy-1-nyl)-*p*-phenylenediamine, was synthesized by a Sonogashira coupling reaction. All the synthesized precursors, the monomer and their corresponding polymers were characterized using FTIR, ^{1}H NMR, and CHN analyses and UV-Vis spectrophotometry. Simultaneously, the molecular structures of the precursors were designed and optimized using the Gaussian 16 (Revision A.03) program. The dipole moments, energy band gaps between the HOMO and LUMO, polarizabilities and first order hyperpolarizabilities of the precursors were calculated theoretically using the DFT approach; the values were in the ranges of 9.4321–15.3354 D, 1.3709–1.4146 eV, 53.40–64.80 × 10^{-24} esu and 3703.35–5254.90 × 10^{-32} esu, respectively. The inherent viscosities (η inh) of the polymers were measured by an Ubbelohde viscometer and were in the range of 0.2453–0.2860 dl g^{-1}. The thermal behavior of the polymers was investigated using DSC and TGA. The glass transition temperatures of the polymers were in the range of 190–218 °C. The thicknesses and refractive indices of the thin films were determined by ellipsometry, and the values were in the range of 0.100–0.127 μm and 1.211–1.426, respectively. The molecular orientations in the thin polymer films were induced by corona poling and were ascertained using both a UV-Vis spectrophotometer and an atomic force microscope. The second harmonic generations (SHGs) of the poled polymers were determined using an Nd-YAG laser. The SHG coefficients (d_{33}) ranged between 98.30 and 106.04 pm V^{-1} at 532 nm. Among the synthesized polymers, the polymer containing dinitro-substituted thiazole demonstrated an excellent SHG coefficient as high as 106.04 pm V^{-1}. Furthermore, none of the polymers showed SHG decay below 100 °C, and they retained 95% of their SHG values even up to 600 h. Based on its enhanced NLO efficiency and long temporal stability, the polymer containing dinitro-substituted thiazole can be a particularly promising candidate for photonic devices.

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1. Introduction

Nonlinear optical materials have created tremendous interest among the scientific community in view of their wide range of applications in telecommunications, optical switching, sensor protection, information storage, *etc.*[1–5] Thus, there is a huge demand to design and develop novel nonlinear optical materials with large second-order coefficients.[6–8] To date, a wide range of NLO-responsive materials have been investigated; among these, organic materials have received much focus due to their excellent optical and electronic properties, which can be further tailored through structural modification to achieve better characteristics to improve the nonlinear optical activity of the materials for industrial processing.[9–12]

The synthesis of organic materials that contain electron-donor (D) and electron-acceptor (A) units linked through a π-conjugated bridge (D–π–A molecules as push–pull systems) has been a subject of considerable interest.[13–16] In these materials, the first-order hyperpolarizability depends on the conjugated-electronic structure, *viz.*, its length and shape and on the specific character of the donor and acceptor groups.

Department of Chemistry, Karnatak University, Dharwad 580003, India. E-mail: mahadevappa@gmail.com

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Extraction and Characterization of Cellulose from Natural Areca Fiber

RAGHU PATEL G. RANGANAGOWDA, SAKSHI SHANTHARAM KAMATH and BASAVARAJU BENNEHALLI*

Department of Chemistry, Alva's Institute of Engineering and Technology, Visvesvaraya Technological University, Mijar-574225, Karnataka, India.

Abstract

In areca empty fruit bunch, fibers are packed strongly with hemicelluloses, lignin and with slight deposition of wax and inorganic elements. In the work reported, for the extraction of cellulose from the raw areca fibers, formic acid (20% v/v) and hydrogen peroxide (10% v/v) were used and the yield of 65% cellulose was attained. To know α-cellulose content with crystallinity, XRD diffractions studies were carried and the values were found to be 93% and 71% respectively. FTIR spectral studies confirms the absence of hemicellulose, lignin and wax in the cellulose extracted from areca fibers. The morphological studies provided the evidence for isolated fibers and removal of deposits in the extracted cellulose.

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Fiber Cellulose;
Formic Acid;
Hydrogen Peroxide.

Introduction

The cellulose is commonly used in paper, film, textiles, building material and for the production of food additives. Recent researches are also focusing on solving environmental problems such as, designing a cellulose-based absorbent for oil spills and heavy metal pollution on water or land[1] and for making filters for industrial[2] and municipal wastewater treatment.[3]

Natural plant fibers are made up of polymers namely cellulose, hemicelluloses and lignin and small number of extractives. Hydrophilic cellulose is the main substance that makes up plant cell wall and contributes to the physical stability of the cells.[4] Hence, cellulose is the most abundantly available organic compound on earth. Cellulose does not dissolve in water and has high crystallinity and high molecular weight.[5]

Cellulose is a linear polymer consisting of glucose monomer units connected through 1-4 β-linkages. The terminal reducing and non-reducing sugar units stabilized the cellulose polymer chain.[6] The reactive

CONTACT Basavaraju Bennehalli basavaraju@aiet.org.in Department of Chemistry, Alva's Institute of Engineering and Technology, Visvesvaraya Technological University, Mijar-574225, Karnataka, India.

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Influence of Surface Modification on Physical, Mechanical, and Morphological Properties of Natural Single *Areca catechu* Fiber

RAGHU PATEL G. RANGANAGOWDA, SAKSHI SHANTHARAM KAMATH, RAVI KUMAR CHANDRAPPA and BASAVARAJU BENNEHALLI*

Department of Chemistry, Alva's Institute of Engineering and Technology, Mijar-574225, Karnataka, India.
*Corresponding author E-mail: basavaraju@aiet.org.in

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ABSTRACT

In the present study, fibers extracted from empty areca fruit were surface modified by giving chemical treatment with 2% NaOH solution at laboratory temperature to investigate the effect of alkali treatment on physical, mechanical, and morphological properties of *Areca catechu* fiber. Tensile strength and Young's modulus of areca fiber found to decrease with alkali treatment, but improvement in elongation at break of the fiber was observed for alkali treated fiber due to elimination of lignin and hemicelluloses from the fiber surface upon alkali treatment. The results proved that the natural *Areca catechu* fiber is a potential alternative source for strengthening the polymer composite industries.

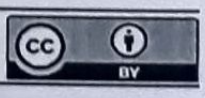
Keywords: *Areca catechu* fiber, Alkali treatment, Tensile strength, Morphology.

INTRODUCTION

Synthetic, non-biodegradable and expensive glass, carbon and kevlar fibers are commonly used in the fabrication of polymer composites because of their outstanding physical and mechanical properties. Many researchers attracted towards environmental friendly natural fibers, as a promising alternative for synthetic fibers due to their abundance, renewability, biodegradability, low cost, good specific strength, good reinforcing properties, low density and non-abrasive nature[1]. Also, natural fibers are less hazardous compared to synthetic fibers.

Agricultural crop byproducts, wheat stalks, corn stalk, rice husk, sugar cane, bagasse, fruit peels, and pineapple leaves are some of the potential source of natural fibers. Utilization of these agricultural residues as a reinforcement material in polymer composites may help in management, development of light weight, strong, eco-friendly and lucrative products with diverse applications[2-3].

The utilization of agricultural byproducts as reinforcement in composites has been reported by several researchers[4-8]. Pothana *et al.*, reported the optimum percentages of banana fibre as 40 wt%[9]. Luo and Netravali have studied the mechanical properties of pineapple fibre based polymer composites[10]. Pavithran *et al.*, studied the rupture energies of



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Low frequency piezoelectric P(VDF-TrFE) micro-cantilevers with a novel MEMS process for vibration sensor and energy harvester applications

Rashmi K.R.[a] , Rao A.S.[b] , Jayarama A.[a] , Pinto R.[b]

Save all to author list

[a] Department of Physics, Alva's Institute of Engineering and Technology, Moodbidri, Karnataka, India
[b] Department of Electronics and Communication Engineering, Alva's Institute of Engineering and Technology, Moodbidri, Karnataka, India

Abstract

Low frequency piezoelectric P(VDF-TrFE) micro-cantilever vibration sensors have been developed for the first time with a novel MEMS process. Design and simulation of micro-cantilevers were carried out using COMSOL Multiphysics based on finite element method. Frequencies and device dimensions were determined based on simulation results. The design was implemented on 110 Si wafer using a specially developed bulk micromachining process. Micro-cantilevers were fabricated with 2.5 μm thick P(VDF-TrFE) co-polymer film deposited by spin coating technique; electrodes for power output were formed by sequential thermal evaporation of Cr-Au thin films. The two critical process steps used for the suspension of P(VDF-TrFE) micro-cantilevers are: (1) bulk micromachining of silicon from the backside using anisotropic wet etchant TMAH to define the micro-cantilever suspension regions, and (2) CHF_3/O_2 based plasma etching of SiO_2 from backside for the final release of P(VDF-TrFE) micro-cantilevers. These devices were operated in longitudinal mode with Cr-Au interdigitated electrodes on

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Piezoelectric P(VDF-TrFE) micro cantilevers and beams for low frequency vibration sensors and energy harvesters

Rashmi K.R.[a], Rao A.S.[b], Jayarama A.[a], Pinto R.[b]

Save all to author list

[a] Department of Physics, Alva's Institute of Engineering and Technology, Moodbidri, Karnataka, India
[b] Department of Electronics and Communication Engineering, Alva's Institute of Engineering and Technology, Moodbidri, Karnataka, India

Abstract

Piezoelectric P(VDF-TrFE) micro-cantilevers and beams have been developed with a novel micro-electromechanical systems process very useful for low frequency vibration sensors and energy harvesters. The devices were designed and simulated using COMSOL Multiphysics simulation software to determine the resonant frequency, voltage and power output for various dimensions with length in the range 200 μm to 2000 μm, width in the range 100 μm to 400 μm and thickness 2.5 μm in all cases. Devices were fabricated on [removed] silicon wafers using a novel bulk micromachining process by suspending them using critical process steps which include: micromachining of silicon substrate from the backside using anisotropic wet etchant TMAH to define the device suspension regions with thin SiO_2 diaphragm, and release of micro-cantilevers and beams by etching the SiO_2 diaphragm from backside with CHF_3/O_2 based plasma etching. All the devices were fabricated with 2.5 μm P(VDF-TrFE) spin coated on SiO_2. Laser Doppler Vibrometer was used to measure resonant frequency, voltage and

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Novel benzofuran based chalcone material for potential nonlinear optical application

Satheeshchandra S.[a], Haleshappa D.[b], Rohith S.[c], Jayarama A.[d,e], Shetty N.[a]

Save all to author list

[a] Department of Physics, S.D.M College (Autonomous), Ujire, 574240, India
[b] Department of Physics, Yenepoya Institute of Technology, Moodbidri, 574225, India
[c] Department of Chemistry, Sahyadri College of Engineering & Management, Mangaluru, 575007, India
[d] Department of Physics, Alva's Institute of Engineering, and Technology, Moodbidri, 574227, India

View additional affiliations

Abstract

A novel nonlinear optical material, (2E)-1-(1-benzofuran-2-yl)-3-(2-bromophenyl) prop-2-en-1-one monohydrate; is synthesized and crystals are grown at ambient temperature using solution growth method. Spectroscopy techniques such as FT-IR, FT-Raman and ^{1}H NMR are used to confirm the presence of functional groups in the grown crystals. These crystals are crystallized in non-centrosymmetric orthorhombic structure with a space group $P2_12_12_1$ and the powder second harmonic generation (SHG) test shows that the SHG efficiency of these crystals are 2.03 times that of KDP. UV–Vis–NIR studies of these crystal shows maximum optical transparency in the complete visible and near infrared spectral region. The TGA/DTA analysis reveals that the material manifests good thermal stability (280.8 °C) as well. The nature of molecular interactions and their quantitative role towards the crystal packing is being studied using Hirshfeld surface and 2-D fingerprint analysis. The

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Effect of Aluminium doping on photoluminescence and third-order nonlinear optical properties of nanostructured CdS thin films for photonic device applications

Raghavendra Bairy[a,*], Jayarama A.[b,c], G.K. Shivakumar[a], Suresh D. Kulkarni[d], Shivaraj R. Maidur[c], Parutagouda Shankaragouda Patil[e]

[a] Department of Physics, NMAM Institute of Technology, Nitte, Karkala, 574110, India
[b] Department of Physics, Alva's Institute of Engineering and Technology, Moodabidri, 574227, India
[c] Department of PG Physics, Alva's College, Moodabidri, 574227, India
[d] Department of Atomic and Molecular Physics, MIT, Manipal Academy of Higher Education, Manipal, 576104, India
[e] Department of Physics, K.L.E. Institute of Technology, Hubballi, 580030, India

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ABSTRACT

The work presented here reports the influence of Aluminium (Al) doping on CdS thin films for the structural, morphological, optical and third-order nonlinear optical (NLO) properties. Thin films of Pure CdS and Al-doped CdS ($Cd_{1-x}Al_xS$) with x = 0, 0.01, 0.05 and 0.1 are prepared on the glass substrate at 350 °C using the spray pyrolysis technique. The observed X-Ray Diffraction (XRD) patterns of CdS films are found to a polycrystalline hexagonal structure and are not much affected by Al doping. Also the films have been examined by Field Emission Scanning Electron Microscopy (FESEM) images. The transmittance of the CdS films is observed to be 50–60% in the visible region and that decreased at higher doping concentrations and with higher Al doping the direct optical band gap is decreased from 2.52 to 2.38 eV. To understand the defect states characteristics, the corresponding room-temperature photoluminescence (RTPL) spectra have also been taken and found the nonlinear behavior in a band to band-edge emission in the prepared samples upon Al incorporation. The sign and the magnitude of the third-order NLO properties were determined using the Z-scan technique with a continuous wave laser as the excitation source. It is observed that the material exhibit strong two-photon absorption (2PA) with the nonlinear absorption (NLA) coefficient (β) in the range of 10^{-4} cmW^{-1} and nonlinear refractive index (NRI) $n_2 \sim 10^{-9}$ cm^2W^{-1}. The third-order NLO susceptibility has found to be enhanced from 3.12×10^{-5} esu to 6.36×10^{-5} esu upon Al incorporation. Optical limiting characteristics of the prepared films are studied at the experimental wavelength. The results suggest that the $Cd_{1-x}Al_xS$ is a promising material for nonlinear optical devices at 532 nm and optical power limiting applications.

1. Introduction

In the visible region, the semiconductor materials with high optical transmittance, large nonlinear optical properties and ultrafast time response are the critical issue for optoelectronics control and communication applications [1]. The NLO properties of CdS nanostructured semiconductor materials have fascinated more consideration in recent years [2]. It is due to their size decreased from bulk to a few nanometres, wide direct band gap energy and more stability [3]. It has been widely used in applications including optoelectronics and photonics, lasers, LED's, transistors [4]. It has also been investigated as sensors for ultraviolet radiation [5]. The two-photon absorption (2PA) observed in CdS semiconductor nanostructure [6]. The desired properties and usefulness of CdS for futuristic devices reside on the extent of doping different impurities [7]. High transparency, homogeneity and low electrical resistivity in the visible region are essential characteristics for the materials to be used as window layers for solar cell applications [8]. In order to reduce the electrical resistance, a large grain size is a prerequisite in the buffer layer for solar cells applications [9]. With a thermal treatment after the deposition, larger grain size can be achieved. Furthermore, during chemical bath deposition process doping of CdS films with other chemical elements affects the resulting physicochemical properties such as the electrical resistivity, band gap energy and crystalline structure. Till date, to decrease the band gap energy of

* Corresponding author. Department of Physics, NMAM Institute of Technology, Nitte, 574110, Karkala Tq and Udupi District, Karnataka, India.
E-mail address: rbairy@gmail.com (R. Bairy).

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Dept. Of Physics
Alva's Institute of Engg. & Technology
Mijar, MOODBIDRI - 574 225

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Second and third order nonlinear optical studies of a novel thiophene substituted chalcone derivative

D. Haleshappa[a,b,*], A. Jayarama[c,d], Raghavendra Bairy[e], Santhosha Acharya[a], Parutagouda Shankaragouda Patil[f]

[a] Department of Physics, Yenepoya institute of technology, Moodbidri 574225, India
[b] Department of Physics, Mangalore institute of technology and engineering, Moodbidri 574225, India
[c] Department of Physics, Alva's institute of engineering and technology, Moodbidri 574225, India
[d] Department of PG Physics, Alva's college, Moodbidri 574225, India
[e] Department of Physics NMAM institute of technology, Nitte, karkala 574110,India
[f] Department of Physics, KLE Institute of Technology, Opposite Airport, Gokul, Hubballi 580030, India

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ABSTRACT

A noncentrosymmetric chalcone derivative (*E*)-1-(thiophen-2-yl)-3-(3, 4, 5-trimethoxyphenyl) prop-2-en-1-one (TTMP) was synthesized using Claisen Schmidt condensation approach and single crystals were grown using slow evaporation method. The grown TTMP crystals crystallizes in orthorhombic structure with $Pna2_1$ space group. The intermolecular interactions of the TTMP crystals were envisioned by Hirshfeld surface analysis (HSA). Further, the structural conformations of the crystal were carried out by using 1H NMR, FTIR, and FT-Raman spectral analysis. The UV–Vis–NIR spectrum of the sample clearly shows the prime transparency in the entire visible and near infrared region. Thermal studies (TG/DTA/DSC) of the TTMP sample shows excellent thermal stability and phase transition and also noticed that crystal was most stable up to 152.65 °C. The second harmonic generation efficiency was obtained for the crystals using Nd:YAG laser and is to be 1.93 times that of urea. The third order nonlinear absorption coefficient (β), nonlinear refractive index (n_2), third-order nonlinear susceptibilities ($\chi^{(3)}$), second order hyper polarizability (γ_h) and optical limiting thresholds were determined by Z-scan technique using the Diode-Pumped Solid State (DPSS) Continuous Wave (CW) laser. The results suggest that the TTMP molecules are promising materials for optoelectronic device applications.

1. Introduction

The chalcone derivatives have a high amount of scope in photonics and optoelectronic applications, such as frequency doubling, optical switching and optical limiting [1,2]. Nonlinear optical phenomenon is the most significant property among all other properties which promises an innovative change in the field of photonics and optoelectronic applications [3]. Among a large number of nonlinear optical materials, the organic chalcone derivatives show better stability, relatively short cut off wavelengths of transmittance, and outstanding blue light transmittance [4–7]. Compared to inorganic materials, organic materials are more flexible to optimize the required nonlinear optical property by possessing the donor and acceptor groups in the same molecule by altering the substituent and functional groups on the initial reactants. It has been generally understood that the second-order molecular nonlinearity in chalcone materials can be enhanced by large delocalized π-electron systems with strong donor and acceptor groups [8,9]. The significant nonlinearity has appeared as a consequence of molecular configuration with two planar rings connected by conjugated double bonds [10]. Hence, the search for the novel chalcone material by altering the substituent and functional groups resulting in better NLO properties is never ceased. The organic Chalcone derivatives are motivating kind of NLO materials which can be modified to match the desires. In these structures, two aromatic rings have to be substituted with suitable electron donor or acceptor groups like −OCH3, −SCH3, −Cl, −Br, etc. To increase the asymmetric charge distribution in either or both ground state and excited states, giving rise to an advanced optical nonlinearity [11,12]. The substitution of electron acceptors/donors on either end of the phenyl rings of chalcone greatly influences the formation of noncentrosymmetric crystal packing, which is a primary criterion for the exhibition of second harmonic generation (SHG) in a crystal [13]. Many of the methoxy substituted chalcones show

* Corresponding author.Department of Physics, Yenepoya Institute of technology, Moodbidri 574225, India.
E-mail address: halesh.phy@gmail.com (D. Haleshappa).

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H.O.D.
Dept. Of Physics
Alva's Institute of Engg. & Technology
Mijar, MOODBIDRI - 574 225

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Role of Zn in tuning the band gap, surface morphology, photoluminescence and optical nonlinearities of CdO nanostructures for photonic device applications

Bairy R.[a], Jayarama A.[b,c] ✉, Kulkarni S.D.[d], Murari M.S.[e], Vijeth H.[f]

Save all to author list

[a] Department of Physics, N.M.A.M. Institute of Technology, Nitte, Karkala, 574110, India
[b] Department of Physics, Alva's Institute of Engineering and Technology, Moodbidri, 574227, India
[c] Department of PG Physics, Alva's College, Moodbidri, 574227, India
[d] Department of Atomic and Molecular Physics, MIT, Manipal Academy of Higher Education, Manipal, 576104, India

View additional affiliations

Abstract

We report the role of Zn doping on third-order nonlinear optical properties (NLO) of CdO thin films. Thin $Cd_{1-x}Zn_xO$ films' was prepared using the spray pyrolysis (SP) technique [with x = 0, 0.01, 0.05 and 0.1 at. %] to study the morphological, surface morphology, linear optical, photoluminescence and NLO properties. The study of x-ray diffraction (XRD) revealed the crystalline nature of the prepared thin films, and the Zn-doping improves the crystallite size. The' films morphology is mainly influenced by the'doping'shown by the images of FESEM (field emission scanning electron microscopy). As the doping concentration of Zn increases, the direct energy band-gap (Eg) value increased from 2.51 eV to 2.60 eV for undoped CdO to 10% of Zn doped CdO. Room temperature photoluminescence spectra (RTPL) of the prepared samples are investigated for an in-depth understanding of the conduction band

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Enhancement of power output in passive micro-direct methanol fuel cells with optimized methanol concentration and trapezoidal flow channels

Rao A.S.[a], Rashmi K.R.[b], Manjunatha D.V.[a], Jayarama A.[b], Pinto R.[a]

Save all to author list

[a] Department of Electronics and Communication Engineering, Alva's Institute of Engineering and Technology, Moodbidri, D. K., Karnataka, India

[b] Department of Physics, Alva's Institute of Engineering and Technology, Moodbidri, D. K., Karnataka, India

Abstract

This work presents design, fabrication and optimization of methanol concentration and flow channel cross-sectional geometry for enhanced power output in passive micro-direct methanol fuel cells. Passive micro-direct methanol fuel cells are fabricated with flow channels in silicon having both rectangular and trapezoidal cross-sectional geometry for flow of methanol at anode and air at cathode using microelectromechanical systems (MEMS) fabrication technique. The experiments are conducted at 25 °C by feeding methanol with a flow rate of 25 μl min^{-1} and supply of air at cathode by air-breathing method. Results show a peak in open circuit voltage and power density at 7 M methanol concentration for passive micro-direct methanol fuel cells having both rectangular and trapezoidal cross-sectional geometry. A study of influence of silicon flow channel cross-sectional geometry on passive micro-direct methanol fuel cell performance shows for the first time that the flow channels with trapezoidal cross-section enhance the power density (6.64 mW cm^{-2}) nearly by a factor of two compared to that of flow channels with rectangular cross-section (3.9 mW cm^{-2}) at 7 M methanol concentration. We believe that, though our results of significant enhancement of power density with trapezoidal fuel flow channels are obtained with micro-direct methanol fuel cells as a platform, they should also be applicable to other proton exchange membrane fuel cells with ethanol or humidified hydrogen as fuel. © 2019 IOP Publishing Ltd.

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MOODBIDRI - 574 225, D.K.

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Investigation of third-order nonlinear optical properties of nanostructured Ni-doped CdS thin films under continuous wave laser illumination

Bairy R.[a] ✉, Jayarama A.[b,c], Shivakumar G.K.[a], Radhakrishnan K.[d], Bhat U.K.[e]

Save all to author list

[a] Department of Physics, N.M.A.M. Institute of Technology, Nitte, Karkala, 574110, India
[b] Department of Physics, Alva's Institute of Engineering and Technology, Moodabidri, 574227, India
[c] Department of PG Physics, Alva's College, Moodabidri, 574227, India
[d] Department of Civil Engineering, N.M.A.M. Institute of Technology, Nitte, Karkala, 574110, India
View additional affiliations

Abstract

We report the third-order nonlinear optical (NLO) properties and optical limiting (OL) thresholds of pure CdS and Ni-doped CdS thin films have been investigated with the Z-scan technique under continuous wave laser excitation. Nanocrystalline CdS thin films with various doping concentrations of Ni (0%, 1%, 3%, 5% and 10at.%) are prepared by spray-pyrolysis technique. XRD patterns reveal that all the prepared films are polycrystalline and the incorporation of Ni does not lead to major changes in the crystalline phase of $Cd_{1-x}Ni_xS$ thin films. The surface morphology of the prepared films is impacted by the Ni-doping and is indicated by Field Emission Scanning Electron Microscopy (FESEM) images. With an increase in Ni-doping concentration, the energy band-gap value decreased from 2.48eV to 2.23eV. From the Z-scan data, it is observed that the material show strong two-photon absorption (2PA) and with an increase in Ni-doping concentrations from 0 to 10at.%, the nonlinear absorption coefficient (β) are enhanced from 0.92×10^{-5} to 4.46×10^{-5} (cm W^{-1}), nonlinear refractive index (n_2) from 0.2967×10^{-9} to 0.1297×10^{-8} (cm^2 W^{-1}) and thereby the third-order NLO susceptibility ($\chi^{(3)}$) values also increased from 1.7075×10^{-6} to 7.4743×10^{-6} (esu). OL characteristics of the prepared films are studied at the experimental wavelength. The results propose that the $Cd_{1-x}Ni_xS$ film is a capable material for nonlinear optical devices at 532nm and optical power limiting applications. © 2019, Springer Science+Business Media, LLC, part of Springer Nature.

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01

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Power enhancement of passive micro-direct methanol fuel cells with self-sulfonation of P(VDF-TrFE) copolymer during lamination on Nafion membrane

Rao A.S.[a], Manjunatha D.V.[a], Jayarama A.[b], Achanta V.G.[c], Duttagupta S.P.[d], Pinto R.[a]

Save all to author list

[a] Department of Electronics and Communication Engineering, Alva's Institute of Engineering & Technology, Moodbidri, India

[b] Department of Physics, Alva's Institute of Engineering & Technology, Moodbidri, India

[c] Department of Condensed Matter Physics and Materials Science, Tata Institute of Fundamental Research, Mumbai, India

[d] Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India

Abstract

Among the various advances that have taken place in fuel cells, efforts to reduce the methanol crossover and thereby increase fuel cell performance are important. One method by which crossover can be reduced is through introduction of hydrophobic surface on membrane which reduces the entry of methanol into the membrane. Here we show that coating of poly(vinylidenefluoride-trifluoroethylene) on Nafion results in reduction in crossover due to the introduction of hydrophobicity on the surface of the composite membrane which, in turn, improves the fuel cell performance. Further, FTIR results have shown that sulfonic-acid groups diffuse from Nafion into the poly(vinylidenefluoride-trifluoroethylene) during the dip-coating process which introduces proton conductivity in the lamination without the sulfonation process of polymer. Passive micro-direct methanol fuel cells are used as a platform for our experiments. Results show for the first time that 10 μm thick coating of poly(vinylidenefluoride-trifluoroethylene) on Nafion results in enhancement of power density. © 2019 Hydrogen Energy Publications LLC

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Pore size tuning of Nafion membranes by UV irradiation for enhanced proton conductivity for fuel cell applications

Rao A.S.[a], Rashmi K.R.[b], Manjunatha D.V.[a], Jayarama A.[b], Prabhu S.[c], Pinto R.[a]

Save all to author list

[a] Department of Electronics and Communication Engineering, Alva's Institute of Engineering and Technology, Mijar, Moodbidri, D.K., 574225, Karnataka, India

[b] Department of Physics, Alva's Institute of Engineering and Technology, Mijar, Moodbidri, D.K, 574225, Karnataka, India

[c] Department of Condensed Matter Physics and Materials Science, Tata Institute of Fundamental Research, Mumbai, 400005, India

Abstract

The influence of optimal ultraviolet irradiation of Nafion membranes in enhancing proton conductivity and performance of passive micro-direct methanol fuel cells with silicon micro-flow channels is investigated for the first time. Initially, Nafion membranes are irradiated with different doses of ultraviolet radiation ranging within 0–400 mJ cm^{-2} and their water uptake, swelling-ratios, porosity, and proton conductivities are measured using standard procedure. Results show that there is an enhancement in proton conductivity with an optimal dose of 198 mJ cm^{-2} ultraviolet radiation. This

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The structural and third-order nonlinear optical studies of a novel nitro group-substituted chalcone derivative for nonlinear optical applications

Davanagere H.[a], Jayarama A.[b,c], Patil P.S.G.[d], Maidur S.R.[d], Quah C.K.[e], Kwong H.C.[f]

Save all to author list

[a] Department of Physics, Yenepoya Institute of Technology, Moodbidri, 574225, India
[b] Department of Physics, Alva's Institute of Engineering and Technology, Moodbidri, 574225, India
[c] Department of PG Physics, Alva's College, Moodbidri, 574225, India
[d] Department of Physics, KLE Institute of Technology, Opposite Airport, Gokul, 580030, Hubballi, India
View additional affiliations

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Alva's Institute of Engg. & Technology
MOODBIDRI - 574 225, D.K

Abstract

A novel optically high-transparent chalcone derivative (E)-3-(3-nitrophenyl)-1-(thiophene-2-yl)prop-2-en-1-one (2AT3N) has been synthesized and crystallized using slow evaporation solution method. The grown single crystals were characterized by FT-IR and FT-RAMAN vibrational technique. The spectroscopic investigations confirmed the presence of various functional groups in the grown single crystals. The single crystal X-ray diffraction analysis revealed that the harvested single crystals possess triclinic crystal structure under centrosymmetric space group P-1. In addition, the intermolecular interactions in the molecule were figured out by Hirshfeld surface analysis. The 2AT3N crystal possesses high optical transmittance beyond cutoff wavelength (358 nm) in the entire visible region. The thermal stability of the crystals has been examined by TG/DTA/DSC measurements. The 2AT3N crystals are thermally stable up to 148.3 °C. The third-order nonlinear optical properties have been studied using Z-scan experiment (532 nm and 200 mW). The Z-scan Experimental results reveal that the 2AT3N single crystals show high-order nonlinear absorption coefficient ($\beta \sim 10^{-5}$ cm W^{-1}) and nonlinear refractive index ($n_2 \sim 10^{-9}$ cm^{2}W^{-1}). The optical limiting study on 2AT3N was carried out using open aperture Z-scan data. The grown single crystals possess reverse saturation absorption (RSA) due to excited state absorption. The structural and nonlinear optical property relationship of the molecule along with the role of nitro group substitution in the enhancement of nonlinear optical property has been discussed in detail. Nonlinear optical studies show that, the synthesized novel

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Combined Effect of Piezoviscous Dependency and Non-Newtonian Couple Stress on Squeeze-Film Porous Annular Plate

K RVasanth[1,2], B N Hanumagowda [3] and J Santhosh Kumar[3]

[1]Research Scholar, REVA University, Bangalore-560064, India
[2]Alva's Institute of Engineering & Technology,
Department of Mathematics,Mijar, Moodbidre, Mangalore. India
[3] REVA University, Bangalore-560064, India

Corresponding Author: vasanthkr129@gmail.com

Abstract: Squeeze film investigations focus upon film pressure, load bearing quantity and the minimum thickness of film. The combined effect of pressure viscous dependent and non-Newtonian couple stress in porous annular plate is studied. The modified equations of one dimensional pressure, load bearing quantity, non dimensional squeeze time are obtained. The conclusions obtained in the study are found to be in very good agreement compared to the previous results which are published. The load carrying capacity is increased due to the variation in the pressure dependent viscosity and also due to the couple stress effect. Finally this results in change in the squeeze film timings.

1. Introduction

In the field of hydrodynamic lubrication, the couple stress thin film characteristics of several bearings have studied for some decades [1-6] by considering the viscosity of the lubricant as constant, although it depends on both pressure and temperature. In recent years, the viscosity of variation of non-Newtonian couple stress with temperature and pressure has been given thoughtful study in many practical applications to engineering. Hanumagowda [7] investigated the characteristics of thin film for circular step bearing and considered the viscosity variation of couplestress fluid. Naduvinamani et al [8] discussed for parallel stepped plates,Lin et.al[9] investigated behaviour of Squeeze film for long partial journal bearings , Bartz and Ehlert [10] discussed the influence of pressure viscosity oils on pressure, temperature and film thickness for elastohydrodynamic rolling contacts. In all these studies, the pressure dependent viscosity variation of couplestress lubricant on the squeeze film behaviour is discussed and found to be more important. All of the previous investigations were concerned with impermeable surfaces. Wu[12,13] studied theoretically, the squeeze-Film behaviour for annular Disks and rectangular plates by considering the porous facing. He found the importance of porous facing on the squeeze film behaviour. In this paper, therefore, the influence of piezo-viscous dependency on porous annular plates lubricating with non-Newtonian couplestress fluid is investigated.

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Combined Effect of Piezo-Viscous Dependency and Non-Newtonian Couple Stresses in Porous Squeeze-Film Circular Plate

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Vasanth Karigowdar Rajendrappa[1,2,*], Hanumagowda Bannihalli Naganagowda[1], Jogyalla Santhosh Kumar[1], Raju Buchanahalli Thimmaiah[1]

[1] School of Applied Sciences, REVA University, Bangalore, 560064, India
[2] Alva's Institute of Engineering & Technology, Mijar, Moodbidre, Dakshina Kannada, 574225, India

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ABSTRACT

On the basis of Morgan and Cameron approach and the Barus experimental research, a mathematical model is considered for the combined effect of piezo-viscous dependency and non-Newtonian couple stresses on the squeeze-film characteristics of porous circular plates. An analytical solution for the mathematical model using the small perturbation technique is obtained. The results are presented graphically for selected parameter values. Results put forward to show that the effect of pressure dependent viscosity is to enhance the load carrying capacity significantly and lengthen the squeeze film time and the effect of permeability is to decrease the pressure, load carrying capacity and squeeze film time. It is seen that the present results are in good agreement with the earlier works in the limiting conditions of conventional circular bearing.

1. Introduction

An excellent review has been given on squeeze film lubrication of various porous bearings in the field of Tribology. For example, Morgan and Cameron [1], Rouleau [2], Wu [3], Cusano [4], Prakash and Vij [5], and Tian [6]. They have confined their investigations to Newtonian fluid as a lubricant and described that the bearing performance of various disks would be increased with use of porous bearings of different permeabilities. The generalised micro-continuum theory which permits the presence of couple stress, body couples and non-symmetric stress tensors proposed by Stokes [7]. Many researchers have made an attempt to study the effect of couple stress characteristics of distinct thin film bearing such as finite journal bearing, externally pressurized circular step Thrust bearing, rotor bearing system, and sphere and a flat plate by Lin [8-11]. Recently, Elsharkawy [12] studied the effect of misalignment on the performance of finite journal bearings lubricated with couple stress

* *Corresponding author.*
E-mail address: Vasanthkr129@gmail.com (Vasanth Kumar)

Effect of pressure dependent viscosity on couple stress squeeze film lubrication between porous circular stepped plates

B N Hanumagowda [1], B T Raju [1], J Santhosh Kumar [1] and K R Vasanth [2]

[1] REVA University, Bangalore-560064, India.
[2] Alva's Institute of Engineering & Technology,
Department of Mathematics, Mijar, Moodbidre, Mangalore-575006. India.

hanumagowda123@rediffmail.com,ratnamsanthosh83@gmail.com,vasanthkr129@gmail.com

Abstract: In this paper, the effect of PDV on the couple stress squeeze film lubrication between porous circular stepped plates is presented. Keeping the base of Christensen's stochastic theory modified Reynolds equation is derived. Reynolds equation, fluid film pressure, squeeze film time and load carrying capacity are solved using standard perturbation technique. The results are tabulated and presented graphically for selected physical parameters and found that the squeeze effect is depleted in a porous bearing compared to its nonporous and increasing permeability has an adverse effect on the pressure, load carrying capacity and time of approach.

1. Introduction:

From past two decades study on porous squeeze film bearings attracted by many researchers because of wide applications in engineering namely lubrication of film elements, artificial joints, automatic transmissions and internal combustion engines etc. Porous bearings are useful because of self lubricant characteristics and low cost. Initially Morgan and Cameron [1] analyzed under steady conditions on narrow porous journal bearing. Later Prakash and Vij [2] studied on non rotating porous journal bearing. Researchers [3-8] studied on anisotropic porous rectangular plates with lubricants containing polar additives in squeeze film lubrication. Hanumagowda et al.[9] extended the work on MHD and surface roughness on circular stepped plates.

Available literature shows that not much work has been carried out on the effect of viscosity on porous circular stepped plates. We can see some of the studies on bio-lubricated joints and squeeze film

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A radial basis function method for fractional Darboux problems

Chandhini G.[a,*], Prashanthi K.S.[a], V. Antony Vijesh[b]

[a] Department of Mathematical and Computational Sciences, National Institute of Technology Karnataka, Surathkal 575025, India
[b] School of Basic Sciences, Indian Institute of Technology Indore, Indore 452017, India

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ABSTRACT

In this paper, a radial basis function (RBF) collocation known as Kansa's method has been extended to solve fractional Darboux problems. The fractional derivatives are described in the Caputo sense. Integration of radial functions that appears due to fractional derivatives have been dealt using Gauss–Jacobi quadrature method. The equation has been linearized using successive approximation. A few test problems have been solved and compared with available solutions. The effect of RBF shape parameter on accuracy and convergence has also been discussed.

1. Introduction

Darboux problems, where the governing equation is of hyperbolic in nature, in general arises in wave phenomena. Consider,

$$\begin{aligned} D_{xy} = \frac{\partial^2 u}{\partial x \partial y} &= f(x, y, u(x, y)), \quad (x, y) \in J \\ u(x, 0) &= g(x); \quad x \in [0, a] \\ u(0, y) &= h(y); \quad y \in [0, b] \end{aligned} \tag{1.1}$$

where $a, b > 0$, $J := [0, a] \times [0, b]$ and g and h are continuously differentiable functions.

Sometimes the Darboux problem is also referred as the Goursat problem. Certain classical problems of mathematical physics and rigid body dynamics are expressed in terms of Darboux problems. They can also be considered as a limiting case of tricomi problem. Efforts to solve (1.1) numerically is dated back to 1960s. These attempts are made by Day [1,2], Jain and Sharma [3] and Gourlay [4]. They are based on Trapezoidal or other quadrature formulae and Runge–Kutta type methods. Later a nonlinear trapezoidal formula based on geometric means [5] and harmonic means [6] are also considered in solving Goursat problems. In [7], a general class of difference schemes for this problem have been attempted. In 2011, the problem has been solved in a triangular domain with mixed Dirichlet and impedance boundary conditions [8], based on Runge–Kutta method and trapezoidal formula.

In recent years, fractional order differential equations (FDEs) are attracting not only mathematicians but also engineers and scientists from various fields. It is found that these equations can be used to model many natural phenomena and physical problems more accurately than their classical counterparts. To name a few, some of the problems where numerical schemes have been useful are: plasma transport problem with anomalous diffusion [9], fractional order Bloch equation that provides basis for nuclear magnetic resonance spectroscopy and magnetic resonance imaging [10] (NMR and MRI, respectively), description of the dynamic events that occur in biological tissues [11], fractional model for the shafting system of the water jet mixed-flow pump during the startup process [12], fractional neutron point kinetic model to analyse the dynamic behaviour of neutrons [13], etc.

In the present article, we have considered the fractional Darboux problem in the following form:

$$\begin{aligned} {}^{c}D^{\bar{\alpha}} u(x, y) = \frac{\partial^{\alpha_1+\alpha_2} u}{\partial x^{\alpha_1} \partial y^{\alpha_2}} &= f(x, y, u(x, y)), \quad (x, y) \in J, \\ u(x, 0) &= g(x) \quad x \in [0, a]; \\ u(0, y) &= h(y); \quad y \in [0, b], \end{aligned} \tag{1.2}$$

where $a, b > 0$, $J := (0, a] \times (0, b]$, $\bar{\alpha} = (\alpha_1, \alpha_2) \in (0, 1] \times (0, 1]$ and g and h are continuously differentiable functions with $g(0) = h(0)$. The function $f : J \times \mathbb{R} \to \mathbb{R}$ is a continuous function and satisfies Lipschitz condition with respect to the third variable u with Lipschitz constant L.

Researchers, namely, Abbas, Benchohra and Vityuk have worked extensively on the existence and uniqueness of various classes of fractional Darboux problem for hyperbolic type; see [14] and the references therein. The problems considered were fractional equations or inclusions with and without delay terms in various forms. Results are also established for equations that involves impulsive effect. Vityuk and Mykhailenko [15] have obtained the sufficient conditions of the existence and uniqueness of the solution of implicit fractional Darboux problem and also provided some numerical solutions.

Past two decades have witnessed an extensive development of RBF based schemes for solving PDEs. The reasons for such an interest towards

* Corresponding author.
E-mail addresses: chandhini@nitk.edu.in (C. G.), ksprashanthi@gmail.com (P. K.S.), vijesh@iiti.ac.in (V.A. Vijesh).

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