CHAPTER 43

PHYSICS AND ASTROPHYSICS

Doctoral Theses

01. ANIL KUMAR
Investigations on Biomineralization Behavior of Mesoporous Bioactive Glass and Glass Ceramics.
Supervisor : Prof. S. Murugavel
Th 24051

Abstract
(Not Verified)

Mesoporous bioactive glass (MBG) with different compositions has been synthesized through sol-gel route with the help of supramolecular chemistry approach to investigate apatite formation followed by biominerlization process. Firstly, we have discussed in-vitro dissolution and biominerlization behavior of 45S5 MBG having composition 46.1SiO2- 26.9CaO- 24.4Na2O- 2.6P2O5 (mol %). An obtained glass possesses superior textural properties and accelerated apatite formation in simulated body fluid (SBF). The pristine mesoporous 45S5 bioactive glass has been characterized by various methods before and after soaking in SBF. Cell culture studies exhibited the good cytocompatibility, which simulated the effect on proliferation of osteoblast cells up to 50 µg/mL concentration of 45S5 MBG. Secondly, we have synthesized quaternary glass having composition, 67.4SiO2- 5CaO- 25Na2O- 2.6P2O5 (in mol %) to study the in-vitro bioactivity behavior by conventional method of calcination and microwave-mediated calcination process. The microwave calcined sol-gel glass sample show superior textural characteristics and distinct biomineralization behavior than the conventional calcined glass sample. Additionally, we have synthesized Na2O-CaO-SiO2-P2O5 glass composition with different amount surfactant concentrations (weight %). The cell culture studies showed the good biocompatibility for both 2.1S and 5.4S samples and stimulated the effect on the proliferation of osteoblast cells for up to a 100 µg/ml concentration of 5.4S sample. In the last part of thesis, MBG samples of ternary SiO2-P2O5-CaO (58SiO2- 36CaO- 6P2O5; 70SiO2- 26CaO- 4P2O5; 82SiO2- 16CaO- 2P2O5- in mole %) system were successfully synthesized by modified sol-gel method. The as derived glass and glass-ceramic samples have shown superior textural characteristics followed by fast dissolution rate and high bioactivity. Based on the obtained results, it is concluded that the increase in CaO content > 30 mol %, leads to the formation of glass-ceramics. Furthermore, cell culture activities like cell viability and cell proliferation show good cytocompatibility behavior at different concentrations and time intervals.

Contents

1. Introduction. 2. Experimental and characterization techniques 3. Mesoporous 45S5 bioactive glass: synthesis in vitro dissolution and biomineralization behaviour

4. Effect of surfactant concentration on textural characteristics and biomineralization behaviour of mesoporus bioactive glasses 5. Influence of textual characteristics on biomineralization behaviour of mesoporous ternary SiO_2-P_2O_5-CaO bioactive galss and glass ceramics 6. Summary and future perspective.

02. CHAUDHARY (Vishal)
Study of Polyaniline and its Nanocomposites for Gas Sensing Applications.
Supervisor : Prof. Amarjeet Kaur
Th 24038

Abstract
(Not Verified)

Conducting polymers (CPs) are playing key role in research and development of the present era sensors due to their numerous advantages over their counterpart inorganic materials, including room temperature operation, light weights, low cost, ease of processing, environmental friendly nature, and tunable optical and electric conductivity band gap. The ability of conducting polymers to switch their conduction state with change in surrounding environment has made them potential candidate for gas/vapor sensing applications. Though the metal oxides based gas sensors are used for commercial purposes, their high temperature operation increases energy requirement, manufacturing and operation cost, and complexity. Contrary to these, conducting polymer sensors operates at room temperature and possesses reasonable sensitivity. Recently, the use of nanostructured material due to their lager surface to volume ratio as gas sensors has gained ordinate interest of researchers. With this motivation, the present thesis presents controlled growth of polyaniline nanostructures for gas sensing applications. The variation in morphology, dc charge transport and gas sensing characteristics of PAN nanostructures with varying reaction parameters (type and concentration of oxidant, surfactant, dopant) during synthesis process have been explored. The dc charge transport study is interconnected to gas sensing response to gain the insight of charge carrier dynamics for sensing phenomena. To further increase their sensitivity polyaniline nanocomposites (polypyrrole, tungsten oxide, silver nanoparticles) has been fabricated. The fabricated PAN nanostructures and nanocomposites were analyzed for morphological, structural, optical, electrical, and gas sensing characteristics. Further, all the synthesized samples were evaluated for 3 S's (selectivity, sensitivity and stability) and 5 R's (room temperature operation, reversibility, repeatability, range and response) of gas sensing studies. The samples possessing low conductivity showed best response towards oxidizing analyte (sulfur dioxide) and that with high conductivity to reducing analyte (ammonia). The analyte sensing mechanisms of fabricated samples are further explored using in-situ FTIR spectroscopy.

Contents

1. Introduction and literature review 2. Sample preparation and characterization 3. Structural, morphological and electrical properties of polyaniline nanostructures and nanocomposites. 4. Study of dc conduction mechanism in polyaniline nanostructures and nanocomposites 5. Investigations of oxidizing analyte sensing characterstics of polyaniline nanostructures and nanocomposites: electrical and optical sensing 6. Investigation of reducing analyte sensing characterstics of

polyaniline nanostructures & nanocomposites and vapor recognition. 7. Summary and future prospects.

03. DEWAN (Sheetal)
Fabrication of Semiconducting (ZnO,NiO and GaN) Heterostructures and Quantum Wells for Short Wavelength Photonic Devices.
Supervisors : Prof. Vinay Gupta and Prof. R.P. Tandon
Th 24050

Abstract
(Verified)

Short wavelength (250-450 nm) radiations are known to exhibit harmful as well as useful properties. Mild exposure to these radiations is essential for the synthesis of Vitamin D, killing of germs and medical therapies, however long exposure of the same leads to DNA mutation and skin cancer. Thus, Short wavelength LEDs are essential for harnessing the positive aspects of these radiations, whereas photodetectors are a must to overcome the harmful effects. The present thesis work is focused on the development of ZnO, NiO and GaN based short wavelength photodetectors and LEDs. A conductivity transformation from p-type to n-type was observed in RF sputtering grown NiO thin films at 2% Zn doping and were utilized to fabricated NiO p-n homojunction diodes, which exhibited good photoconduction properties (Photo-responsivity: 1.11 × 102 A/W), but poor PL emission. Alternatively, PLD grown ZnO/NiO thin films and nanostructure-based p-n junctions exhibited rectifying diode like characteristics and significant PL emission. Quantum well (QW) integrated p-n junction UV photodetectors demonstrated a high sensitivity of 7.21 × 102 and responsivity of the order of 2.38 × 102. Room temperature electroluminescence (EL) studies conducted on NiZnO/ZnO MQW based LED devices showed feeble emission, which was weak to practically realize UV LEDs. To overcome the issues encountered in oxide based photonic devices, a customized Laser MBE system was indigenously developed. GaN thin film based P-I-N junction LEDs exhibited EL emission in the wavelength range of 360-380 nm for varying injection current (5-15 mA). On the other hand, InGaN/GaN MQW integrated LED devices exhibited EL emission around 370 nm in UV region and 415-440 nm in visible region with a luminous efficacy of 0.52 lm/W at an injection current of 10 mA. The results pave a way for the realization of commercial LEDs using Laser MBE technique.

Contents

1. Introduction to short wavelength photonic devices 2. NiO thin film based UV emitters and detectors 3. PLD grown ZnO thin films and nanostructures for the realization of p-n heterojunction diodes 4. ZnO based quantum well (QW) structures 5. Design and development of laser MBE system for the growth of nitride thin films 6. Growth and optimization of doped and undoped GaN films 7. Fabrication of InGaN/GaN quantum well based LED. Summary and future work and references.

04. GUMBER (Sukirti)
Transport and Non-Linear Optical Properties of 2-Dimesional Nanostructures.
Supervisors: Dr. Pradip K. Jha and Prof. Man Mohan
Th 24045

Abstract
(Verified)

In this age of information technology, optics has emerged as a preferred method for communicating information. The processing of this information requires interaction either between different photons or photons and electrons. Several other applications of optics, from medicine to spectroscopy, are dependent on strong light-matter interaction and thus on nonlinearity of an optical medium. In semiconductor nanostructures, optical nonlinearities associated with intersubband transition are observed to be much higher in magnitude as compared to their bulk counterpart due to the large oscillator strength and therefore these nanostructures demonstrate a multitude of nonlinear optical phenomena. In our research work, we have explored the different mechanisms for controlling the non-linear optical properties of 2-dimensional nanostructures in the presence of Rashba spin-orbit interaction (RSOI) and external magnetic field. First analysing the multiphoton process in a spin-split 2-dimensional electron gas (2DEG), we have focussed our research more on 2-dimensional rings fabricated out of a 2DEG formed between heterojunctions of III-V semiconductors. It has been observed that we can have a substantial shift in the resonance frequency of multiphoton transition as well as in magnitude of nonlinear absorption and refraction in a quantum system with the simple alteration in RSOI, magnetic field and laser intensity. Also, in a four-wave mixing process, the sum frequency generation, which is directly proportional to third order nonlinear susceptibility, is found to be strongly dependent on strength of coupling field, hydrostatic pressure and magnetic field. Simultaneously, we have explored some aspects of spin-resolved transmission of charge carriers through the quantum ring in presence of RSOI and magnetic field. Since, RSOI resulting from inversion asymmetry of structures induces a momentum-dependent effective magnetic field, a geometric phase and a spin-dependent velocity correction for the charge carriers, these features can be exploited for the manipulation of spin in device applications.

Contents

1. Introduction and literature review 2. Multiphoton excitation in Spin split two dimensional electron gas 3. Effect of hydrostatic pressure and magnetic field on electro-magnetically induced transparency based nonlinear frequency conversion in quantum ring 4. Optical response of a two dimensional quantum ring in presence of rashba spin orbit coupling 5. Spin-transport in rashba coupled 2D quantum ring: an analytical model 6. Summary and future prospects. Bibliography.

05. HARENDRA KUMAR
Dissociation Dynamics of Tri- Atomic Molecular Ions.
Supervisor : Dr. Jyoti Rajput
Th 24040

Abstract
(Not Verified)

This thesis is concerned with the experimental exploration of the dissociation dynamics of multiply charged tri-atomic molecular ions. These ions can be in their stable, metastable or unstable electronic states. If molecular ions are in the unstable state, a question arises how to understand their exhibited dissociation into a set of

fragment ions. The dissociation dynamics would be helpful to understanding and be controlling reactions involving multiple product species. Upon coulomb explosion of molecular ions, the momenta of the charged recoil fragments have been measured by employing a time of flight mass spectrometer and position sensitive detector in unison. In this thesis, various two and three-body dissociation channels are identified for dissociation of OCSq+, CO2q+, and SO2 q+, (q ≥ 2), generated in ion-molecules collision. This thesis presents the relative branching ratios and kinetic energy release (KER), which are measured for each dissociation channel to know the probability of its formation and nature of electronic states of parent molecular ions. The angular distributions of the fragments momentum vectors with respect to beam direction are observed. An anisotropy is deviation of angular distribution from sine distribution. The variation of anisotropy in angular distribution of fragment is described with KER. The three-body dissociation mechanisms (as sequential and concerted) of OCS3+, CO23+ and SO23+molecular ions are presented. Dalitz plot and Newton diagram are used to separate events of these dissociation mechanisms. Further, these mechanisms are identified by employing the newly proposed method as γ -KER2 representation. This representation identifies the electronic states of intermediate molecular ions involve in sequential mechanisms with help of data reported in previous studies. It also estimates the relative branching ratios of events coming from different mechanisms. The simulation has been done to compare its results with experimental results for concerted and sequential mechanisms of molecular ions.

Contents

1.Introduction. 2. Experimental methodology 3. Data analysis 4. Two body dissociation dynamics 5. Three body dissociation dynamics 6. Simulation for dissociation dynamics 7. Summary and future outlook. Bibliography.

06. JITEN (Chongtham)
Study of Lead Free Perovskite- Based Piezoelectric Ceramics.
Supervisor : Dr. K. Chandramani Singh
Th 24044

Abstract
(Verified)

In the quest for finding a suitable alternative to the superior but toxic lead-based piezoelectric materials like PZT (lead zirconate titanate) based piezoceramics, extensive research has been going on all over the world. Some of the aspects and nature of the research work are: a) Finding new compositions that can match PZT-like properties and b) Enhancing the properties of known compositions by finding new and innovative ways of their synthesis. The work reported in this thesis are combination of both these aspects. At the same time, commercial viability of the techniques used for synthesis of compounds and fabrication of corresponding ceramics in terms of process cost and mass productivity has been given utmost importance in the work presented here. In one study, (Na0.5K0.5)NbO3 nanoscale powders of average particle size of about 35 nm were obtained by high energy ball milling and sintered at 1050°C, 1080°C and 1110°C for 1h. A crossing over in the values of internal strains η011 and η100, as well as in the values of lattice parameters 'b' and 'c' was observed as the sintering temperature increases from 1080 to 1110°C, indicating the occurrence of some structural transformation of the crystal within this temperature range. The ceramic sample sintered at 1080°C was

found to possess the highest values of lattice strain, crystallite size, grain size, room temperature dielectric constant εRT, remnant polarization Pr, piezoelectric charge constant d33 and electromechanical coupling factor kp . The dielectric response to frequency for this sample remains almost unchanged over a wide frequency range. d33 and kp values as high as 126 pC/N and 0.47 respectively were obtained for the same sample. This work reveals the sensitivity of various properties of (Na0.5K0.5)NbO3 ceramics prepared from nanoscale powders on sintering temperature.

Contents

1. Introduction 2. Experimental techniques 3. Effect of different sintering conditions on Pure KNN Piezoceramics 4. Structure and electrical properties of Li and Ta substituted $K_{0.5}$ $Na_{0.5}NbO_3$ lead free piezoelectric ceramics prepared from nanopowders 5. Effect of vanadium substitution on electrical and piezoelectric properties of lead free $(K_{0.5}Na_{0.5})NbO_3$ ceramics 6. $(Na_{0.5}K_{0.5})NbO_3$ Nanocrystalline powders produced by high energy ball milling and corresponding ceramics 7. Size effect on piezoelectric properties of barium stannate titanate ceramics prepared from Nanoparticles 8. Lead free Piezoelectric ceramics manufactured from tantalum substituted potassium sodium niobate nanopowders 9. Conclusion and future scope.

07. JOSHI (Arti)
Multi-Wavelength Study of Magnetic Cataclysmic Variables.
Supervisors: Dr. Jeewan Ch. Pandey and Prof. H.P. Singh
Th 24043

Abstract
(Not Verified)

Magnetic Cataclysmic Variables (MCVs) are binaries in which a primary magnetized white dwarf (WD) accretes material from Roche lobe-filling red dwarf companion. This thesis provides a detailed multi-wavelength study of MCVs in order to understand the accretion flow geometry at their different evolutionary states. A sample of candidate MCVs was also taken to classify them into their proper classes. In order to accomplish the aim, we have used several ground-based observatories and space-based observatories for observations in optical, X-ray, and UV band. A detailed optical and X-ray timing and spectral analyses were performed for nine MCVs. The presence of synodic and spin frequencies in the X-ray light curves and the detailed computation of magnetic accretion flow geometry of an IP V2400 Oph with spin-to-orbital period ratio (Pω/PΩ) of 0.07 indicates that it is a disc-overflow system. Three newly identified candidates IPHAS J013032+622132, IPHAS J025828+635235, and IPHAS J051814.33+294113.0 are classified for the first time as eclipsing intermediate polars with Pω /PΩ ~ 0.1. The presence of strong short period variations in these systems provides the rotational periods of the WD of 1660 s, 1203 s, and 3277 s, respectively. The source Paloma was found to be a unique IP, which is nearly synchronous and bridges the gap between the polars and intermediate polars. The asynchronicity of the Paloma was found to be ~ 17 %, which is slightly away from the line of synchronization. X-ray and UV variations of the source CD Ind show that it has similar characteristics to that of Polar but shows average asynchronicity of ~ 3 %. Among three (RXJ0859.1+0537, RXJ0749.1-0549, RXJ0649.8-0737) newly confirmed polars, RX J0749.1-0549 and RXJ0649.8-0737 are found to be 6th and

7th eclipsing long period polars, whereas RX J0859.1+0537 is found to be 12th eclipsing polar in the period gap.

Contents

1. Introduction 2. Telescopes/instruments, observations, software, data reduction and analysis techniques 3. Intermediate polars: characterization and accretion geometry 4. Paloma: an evolutionary link between polars and intermediate polars 5. CD Ind: an asynchronously rotating polar 6. Probing the optical and X ray properties of eclipsing polars 7. Summary, conclusion and future prospects. Bibliography.

08. KHUSHBOO
Investigation of Fusion and Transfer Reactions in Medium Mass Nuclei at and Near the Coulomb Barrier.
Supervisor : Prof. Samit Kr. Mandal
Th 24046

Abstract
(Not Verified)

Fusion and transfer reactions have been investigated to understand some unresolved facts such as sub-barrier fusion enhancement, role of multi-nucleon transfer and pairing correlations between nucleons. These reaction mechanisms have been explored around the Coulomb barrier with 28Si + 92,96Zr and 40Ca + 70Zn systems. The experiments have been carried out at Inter University Accelerator Centre (IUAC), New Delhi. Theoretical models have been utilized to analyze the experimental results. Fusion cross-section measurements have been performed at energies near and below the Coulomb barrier using the Heavy Ion Reaction Analyzer (HIRA). A 28Si pulsed beam from pelletron has been used to bombard the enriched targets of 92Zr and 96ZrO2 . The experimentally obtained fusion cross-sections were found to be comparatively larger for 28Si + 96Zr than 28Si + 92Zr system. Theoretical analysis revealed the importance of colliding nuclei structure on sub-barrier fusion enhancement. Positive Q-value neutron transfer channels were also observed to be essential for fusion, contributing significantly where participating nuclei are less deformed. The fusion cross-sections of 40Ca + 70Zn system have been examined theoretically for which the influence of up to two neutrons transfer was predicted to be significant with a negligible impact of multi-neutron transfer. Apart from fusion, an additional experimental investigation has been carried out for transfer reaction with 28Si + 92,96Zr systems. The experiment has been performed close to and below the Coulomb barrier using the same experimental facility as in fusion experiment. The results showed the importance of pairing correlations which enhances the probability of pair neutron transfer. Further, an enhancement was noticed for even number of neutron transfer which indicated the existence of nucleons correlation. Excited state transfer strength was also observed to be relatively higher for 96Zr than 92Zr.

Contents

1. Introduction 2. Theoretical details 3. Experimental details 4. Results and data analysis of fusion experiment 5. Results and data analysis of transfer reaction experiment 6. Summary, conclusion and research publication.

09. KSHETRIMAYUM ROJEETA DEVI

High Spain Features of Nuclear Structure in Mass A=130 Religion.

Supervisors: Prof. Suresh Kumar and Rudrajyoti Devi

Th 24248

Abstract

(Not Verified)

One of the main focus of nuclear physics is to study the atomic nucleus at the most fundamental level of how the strong nuclear force hold the nucleons (proton and neutron) together inside a nucleus. In this thesis, the important high spin phenomenon of nuclear structure was investigated. A model was developed by extending the existing Semi-classical model to interpret the nucleon alignment in the band-crossing phenomenon of Magnetic Rotational (MR) bands. The high spin states of the 133Ba and 129La nuclei were re-investigated to study the nuclear structure in mass A = 130 region. Two experiments have been performed by using the Indian National Gamma Array (INGA) spectrometer to populate the high spin states in the 133Ba and 129La nuclei by using the fusion evaporation reactions. The γ −γ and γ −γ −γ coincidence spectra were analyzed to confirm the nuclear excited energy levels and band structure of these nuclei. Directional Correlation of Oriented State ratio (RDCO) and polarization asymmetry (Δ) measurements were performed to assign the spin and parity of the excited states and established new high spin phenomenon. The polarization asymmetry measurements were done first time to confirmed the multipole character of the γ-ray transitions. The TAC calculations were done to understand the band structure. The configuration assignment have been done by comparing the TAC results with the obtained experimental B(M1)/B(E2) values and the level energies. In 133Ba the low-lying states were explore to search for wobbling excitation in this nucleus. In 129La nucleus, we focus on the re-investigation of the two dipole bands which were suggested as bands built by the coupling of the protons and the neutrons high- j orbitals.

Contents

1. Introduction 2. Theoretical frame work 3.Experiemental methodology and data analysis techniques 4. Geometry of band crossing in magnetic rotational band 5. Polarization measurement and search for wobbling excitation in ^{133} Ba nucleus 6. Re-investing of dipole bands in the ^{129} nucleus 7. Conclusion and future aspect.

10. NISHA RANI

Statistical Studies of Accelerated Cosmic Expansion.

Supervisors: Prof. Amitabh Mukherjee and Dr. Deepak Jain

Th 24041

Abstract

(Not Verified)

The year 1998 witnessed the celebrated discovery of the accelerated expansion of the universe. However, even after two decades, we do not know the physics behind this. Observations converge at flat ΛCDM model. According to this model, the universe is dominated by dark energy which is a hypothetical form of energy assumed to be distributed homogeneously throughout space and is the cause of accelerated cosmic expansion. The term Λ in this model stands for the cosmological constant, form of dark energy for ω=-1 always. While most of the observations agree with this model but it has some limitations. One usually considers time evolving ω as alternative dark energy models. But such models too have limitations. Hence the root cause behind the accelerated cosmic expansion is still a

mystery. For this reason, we focus on studying the accelerated cosmic expansion. Chapter 1 includes the basics of cosmology. Chapter 2 discuss the various observational evidence and theoretical models of dark energy. The statistical methods used in this work are explained in Chapter 3. The various parametrizations of the deceleration parameter along with the cosmological constraints are discussed in Chapter 4. In Chapter 5, we described various dark energy models which can explain the accelerated expansion of the universe. We also discuss a non-parametric smoothing method and use the reconstructed result obtained from this technique to compare some popular dark energy models. Finally, we summarise the results and conclusions in Chapter 6. Our results support the ΛCDM model and indicate that the accelerated expansion of the universe is a recent phenomenon that has occurred when $z \leq 1$. We also come to the conclusion that the differential age of galaxies may differentiate various dark energy models with the availability of better quality data in the future.

Contents

1. Introduction 2. Cosmic acceleration 3. Statistical methods in cosmology 4. Transition redshift: a new cosmological number 5. Revisiting dark energy models using differential ages of galaxies 6. Conclusion. Appendix and references.

11. RAMESH KUMAR

Study of Charge Transport Mechanism in Graphene Oxide and Reduced Graphene Oxide for Gas Sensing and EMI Shielding Applications.

Supervisor : Prof. Amarjeet Kaur

Th 24048

Abstract
(Not Verified)

Reduced graphene oxide is most fascinating derivative of graphene, since after the discovery of graphene due to their large number of possible applications such as gas sensing, EMI shielding, transparent electrodes, super capacitors and non-volatile memory devices. It has unique properties of light weight, charge transport, optical transparency and high specific surface area. These properties make reduced graphene oxide an interesting candidate for gas sensing application at room temperature. The room temperature operation of reduced graphene oxide based sensors has several advantages over inorganic metal oxides based sensors, which requires complex circuitry and high power consumption. The conducting polymers based sensors have their own limitation due to stability under ambient condition and low specific surface area. Contrary to these, reduced graphene oxide based sensors operate at room temperature and have high sensing response with stability under ambient conditions. With this motivation, the present work shows the various routes for the reduction of graphene oxide for gas sensing applications. The structural and surface morphological changes, charge transport, applications like EMI shielding and gas sensing characteristics of reduced graphene oxide sample with varying reduction routes are explored. The charge transport properties of the prepared samples have been thoroughly investigated by dc conductivity, low and high frequency ac conductivity measurements. The highly conductive nature of these reduced graphene oxide samples have made useful for high frequency EMI shielding applications. The prepared reduced graphene oxide samples were tested in the presence of various analytes for the gas sensing applications. The samples exhibit a selective response towards sulphur dioxide gas. The analytes interactions with the samples were further explained on the basis of electron transfer process.

Contents

1. Introduction and literature review 2. Sample preparation and characterization 3. Structural and morphological properties of Graphene oxide and reduced graphene oxide 4. Study of dc conduction mechanism in reduced grapheme oxide samples 5. Study of ac conduction mechanism in graphene oxide and EMI shielding applications of reduced graphene oxide samples 6. Investigations of Gas sensing properties of redued graphene oxide 7. Summary and future prospects.

12. RANA (Lokesh)
Development of Rayleigh Wave, Love Wave and Lamb Wave based Acoustic Devices for Gas/Bio Sensors.
Supervisor : Prof. Vinay Gupta
Th 24049

Abstract
(Verified)

Amongst different toxic and harmful gases, NO2 is air pollutant which causes acid rain and photochemical smog risking to the human health. Besides, abnormal level of uric acid and meningitis in human beings causes various diseases. Development of chemical sensors demands high sensitivity, fast response and good selectivity, besides the room temperature and wireless detection. Hence focus in the present work is to develop surface acoustic wave (SAW) devices as sensing platform for detection of gaseous and biological moieties (NO2, Uric acid and Meningitis). Good quality ZnO thin films were grown at 30 mTorr pressure and O2:Ar ratio 60:40 using RF sputtering for fabrication of Rayleigh SAW devices on different substrates. ZnO thin film utilized as sensing layer for detection of NO2 gas on ST-cut Quartz SAW resonator. The SAW resonator sensor exhibited enhanced sensitivity over wide concentration of NO2 gas (400 ppb to 16 ppm). A hand-held electronic module is developed for wireless gas sensing by integrating a compact frequency counter module and antenna. Variation in loss of SAW oscillator module signal was studied as a function of the distance between the oscillator module and antenna. Uric acid biosensor utilizing a Love wave acoustic (LoWA) device is fabricated on ZnO/36°YX LiTaO3. A selective bioreceptor, uricase, was immobilized on propagation path of LoWA device by physical adsorption technique (Uricase/ZnO/36°YXLiTaO3) for detecting wide concentration of uric acid (0.002 mM to 1.2 mM) with a high sensitivity (766 Hz/mM) and low detection limit of 5 µM. Lamb Wave Acoustic (LaWA) devices on SiO2/Si membrane were demonstrated successfully both as gas sensor and biosensor for detection of NO2 and Meningitis respectively. LaWA gas sensor resulted in a frequency shift of 110 kHz for 400 ppb NO2 gas, which is about 20 times higher compared to Rayleigh wave SAW sensor (6 kHz).

Contents

1. Introduction and aim of the present work 2. ZnO thin film based Rayleigh surface acoustics wave (SAW) devices 3. SAW resonator for detection of NO_2 gas 4. Fabrication of SAW oscillator for sensing applications 5. Love wave based biosensors 6. Lamb wave acoustic device: efficient chemical sensing platform. Scope and suggestions for future work and references.

13. SHARMA (Pooja)
Mathematical Models of Bacterial Growth : Cost and Benefit of Proteome Regulations.
Supervisor : Prof. Sanjay Jain
Th 24039

Abstract
(Not Verified)

Escherichia coli cells differentially regulate the production of metabolic and ribosomal proteins in order to stay close to an optimal growth rate in different environments, and exhibit the bacterial growth laws as a consequence. We present a simple mathematical model of a growing-dividing cell in which an internal dynamical mechanism regulates the allocation of proteomic resources between different protein sectors. The model allows an endogenous determination of the growth rate of the cell as a function of cellular and environmental parameters, and reproduces the bacterial growth laws. We use the model and its variants to study the balance between the cost and benefit of regulation. A cost is incurred because cellular resources are diverted to produce the regulatory apparatus. We show that there is a window of environments or a 'niche' in which the unregulated cell has a higher fitness than the regulated cell. Outside this niche there is a large space of constant and time varying environments in which regulation is an advantage. A knowledge of the 'niche boundaries' allows one to gain an intuitive understanding of the class of environments in which regulation is an advantage for the organism and which would therefore favour the evolution of regulation. The model allows us to determine the 'niche boundaries' as a function of cellular parameters such as the size of the burden of the regulatory apparatus. This class of models may be useful in elucidating various tradeoffs in cells and in making in-silico predictions relevant for synthetic biology.

Contents

1. Introduction 2. Mathematical models of bacterial growth 3. Cost benefit analysis of regulation for constant environments 4. Cost benefit analysis for time varying environments 5. Discussion.

14. SHARMA (Ram Krishna)
Search for Anomalous Gauge Coupling Through Vector Boson Scattering and Development of the GEM Detectors at the CMS Experiment.
Supervisor : Dr. Md. Naimuddin
Th 24247

Abstract
(Verified)

For physics analysis, this thesis presents the anomalous quartic gauge coupling (aQGC) measurement in the framework of dimension-eight effective field theory operators. It was performed using two channels: WV and ZV (where, V could be either a W or a Z boson) in association with the two jets produced in the forward pseudo-rapidity regions. For the WV (ZV) channels, only leptonic decay of W (Z) bosons are considered, while the V decays hadronically into a merged jet having large radii, with radius parameter 0.8. The constrains are imposed on the aQGC operators at 95% confidence level (CL). Furthermore, a theoretical interpretation of the observed results is given using the Georgi-Machacek model. The exclusion limits on the production cross-section for the charged Higgs bosons times the branching fraction at 95% CL as

a function of the mass of the charged Higgs boson are reported in this thesis. On the hardware front, work performed for the upgrade studies of the CMS detector's muon endcaps is reported. For the CMS muon endcap detector system upgrade, the Gas Electron Multiplier (GEM) detectors are proposed to be installed during the Long Shutdown-2 (2019-2020) period. To test the functionality of these GEM detectors, several beam tests were carried out in 2014, to measure their properties and evaluate their performance in terms of spatial and timing resolution, cluster size and efficiency measurements. The outcome from these beam test campaigns and the data analysis for the GEM detectors are presented here. Also, the characterisation studies for the GEM foils developed in India for the first time are also described in terms of its electrical and optical properties.

Contents

1. Introduction 2. The LCH and CMS detector 3. Gas electron multiplier 4. Anomalous quartic gouge coupling measurement 5. Summary and outlook.

15. SINGH (Avneet)
Development of Thin Film Based Packaged Gas Sensor for the Detection of Toxic and Inflammable Gases.
Supervisor : Prof. Vinay Gupta
Th 24047

Abstract
(Verified)

In the present work, packaged gas sensor for CO and CNG/PNG has been successfully developed using nanostructured SnO2 and ZnO thin films. SnO2 and ZnO have been deposited via RF magnetron sputtering in glancing angle deposition (GLAD) mode and suitable nano-catalyst has been integrated. Pd incorporated ZnO thin film (Pd-ZnO) showed sensing response of 1.02 × 103 towards 500 ppm of CO gas at 150 °C with a fast response time and recovery time of 17s and 23s respectively. LTA zeolite has been incorporated over Pd-ZnO sensor and the enhanced selectivity towards CO has been observed. The rGO-SnO2 nanocomposites and Pd-SnO2 heterostructures have been exploited. Enhanced sensing response of 93.2% has been obtained at 130 °C towards 1000 ppm of CNG/PNG, for the Pd-SnO2 sensor having SnO2 film grown at 18 mTorr. For the packaged CNG/PNG sensor, a M-shaped Pt microheater with coplanar IDEs has been patterned using photolithography technique, and integrated with Pd-SnO2 sensing element. The Pt microheater consumes 377 mW power at 130 °C. Response of 89% has been obtained for the packaged sensor having Pd-SnO2 sensing element towards 1000 ppm of CNG/PNG. The packaged sensor has been interfaced with various electronic circuits for on-field detection. A novel electric field assisted platform containing coplanar L-shaped and interdigital electrodes has also been designed. On application of 40 V between electrodes, the gas sensor exhibits a response of 78% at room temperature towards 500 ppm of H2. However, same sensing element was giving a response of 98% at 110 °C towards 500 ppm H2 gas. The power consumption of gas sensor is significantly reduced to 24 × 10-6 W using the novel electric field assisted approach..

Contents

1. Introduction and aim of the present work 2. Growth of GLAD assisted SnO_2 nanostructured thin film sensing element for detection of CO gas 3. Influence of

metal modifiers on the gas sensing characteristics of SnO_2 thin film 4. GLAD assisted ZnO nanostructured thin film for selective CO detection 5. rGO-SnO_2 nanocomposites and Pd-SnO_2 heterostructure sensors for CNG/PNG 6. Low power consumption packaged gas sensor 7. Electrical field assisted gas sensor. Scope and suggestions for the future work and references.

16. VYAS (Mukesh Kumar)
Astrophysical Jets in Relativistic Regime: Thermal and Radiative Driving.
Supervisor : Prof. Indranil Chattopadhyay
Th 24042

Abstract
(Verified)

Detailed study of relativistic jets around black hole sources, microquasars and active galactic nuclei (AGNs) is carried out and the impact of radiation and thermal driving is investigated. Across the chapters, the analysis is done in various regimes, flat space-time to curved space-time, fixed to variable adiabatic index relativistic equation of state, radial to non-radial cross section of the jet, Thomson (elastic) scattering to Compton scattering regime etc. Assumed accretion disc plays auxiliary role for generating radiation field as well as geometrically shaping the jet near its base. The disc radiates through thermal, Bremsstrahlung, Synchrotron and inverse Comptonization processes. Jets are taken to be non-rotating and axis-symmetric. Further, relativistic equation of state is used that takes care of variable adiabatic index at relativistic temperatures as well as composition of the flow. We found that special relativistic study of jets along with pseudo Newtonian potential is inadequate. Such flows are hotter by one or two orders of magnitude compared to that considered in exact curved space. The family of solutions having sonic point close to the jet base are missing in absence of general relativistic analysis. Including general relativity, we also show that the radiation field depends upon gravitational field in nonlinear manner making general relativistic analysis more significant. In relativistic analysis, the radiative moments are calculated using full relativistic transformations. Bending of photon path is also considered. We obtained internal shocks in jets close to the base as a result of non-conical cross section and nature of radiation field on jet dynamics. Theoretical evidence of internal shocks is significant as these are required to explain high energy tail of the spectra of radio sources.

Contents

1. Introduction 2. Mathematical structure 3. Methods of analysis 4. Special relativistic study of radiatively driven relativistic jets 5. General relavistic version of de laval nozzle and non radical jets with internal shocks 6. Radiatively driven relativistic jets in curved space time 7. Radiatively driven jets under Compton scattering 8. Conclusion 9. Accretion disc and associated radiation parameters. Bibliography.

17. VERMA (Manoj)
Morphology and Composition Controlled Synthesis of Plasmonic Metal Nanoparticles for Surface Enhanced Applications.
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Abstract
(Not Verified)

Plasmonic Nanoparticles has received great attention in the last decade owing to their fascinating optical properties with reference to tunable shape, size, and composition of the nanoparticles over a wide spectral range along with their wide range of applications in surface enhanced spectroscopies, nanocatalysis, bioimaging etc. In this thesis, the polymer, Poly-Vinyl Pyrrolidone (PVP), was utilized for shape and composition-controlled synthesis of plasmonic nanoparticles under ambient conditions. Conformational change in the chemical structure of PVP due to interaction with bromide ions drastically increases its ability to passivate low energy crystallographic facets of the nanoparticles during crystallization, which results in the evolution of anisotropic nanotriangles. Moreover, the dynamic solvent-solute interaction (PVP-DMF) dominates the nucleation/growth regime of metal nanoparticles and also plays an important role in defining the polymer chemisorption onto the various facets of the tiny metal seed particles, thus manipulating them to evolve into different anisotropic shapes such as nanotriangels, multi-branched 3D star shaped nanoparticles etc. On the other hand, composition controlled synthesis was achieved after simultaneous reduction of Au and Ag metal precursors by PVP, specifically in the alcohol medium, which leads to the efficient formation of alloy nanoparticles by drastically reducing their activation energy of diffusion as well as their compromised reduction potential. Differential physical parameters of these various shapes and compositions were calculated from different spectroscopic techniques such as x-ray diffraction, optical absorption, infra-red absorption and were well correlated with the observed results of Surface Enhanced Raman Scattering (SERS), Surface Enhanced Infra-Red Absorption (SEIRA), and Surface enhanced Fluorescence (SEF). Metal nanoparticles synthesized with different size/shape and compositions show dramatic variation in their catalysis capabilities in relation with variation in their catalysis rate constants.

Contents

1. Introduction 2. Material and methods 3. Shape controlled synthesis of gold nanotriangles and nanostars by poly (vinyl pyrrolidone) 4. Poly (vinyl pyrrolidone) induced formation of homogeneous nanoalloys 5. Role of shape and composition of nanoparticles in surface enhanced spectroscopy 6. Effect of morphology and composition of nanoparticles on catalysis 7. Summary and future prospects.