CHAPTER 16

ELECTRONIC SCIENCE

Doctoral Theses

01. BALIYAN (Anjali)
Study of Optical Fiber Biosensors for the Detection of Triacylglycerides.
Supervisor : Prof. Enakshi Khular Sharma
Th24021

Abstract
(Not Verified)

In the past decade, various types of sensors have been developed for estimation of biological, chemical and environmental elements. In this thesis, we have studied optical fiber based biosensors for the detection of triacylglycerides in human blood. In the first optical fiber bio-sensor for estimation of concentration of triacylglycerides we have prepared the sensing probe by covalent immobilization of lipase enzyme (Lip 11) for the detection of triacylglycerides on an optical fiber in which a long period grating has been fabricated and studied the performance. Measurements of shift in resonance wavelengths with concentration of triacylglycerides in phosphate buffer solution are reported along with a theoretical modelling of the experimental results. Next we have studied optical fiber Surface Plasmon Resonance based sensors. We have fabricated sensing probes by coating the fiber with silver metal and used different techniques such as gel entrapment method, covalent bonding and Electrostatic method using Zinc Oxide (ZnO) nanostructures for immobilizing the enzyme and studied the performance in terms of sensitivity, response time, repeatability, K , resolution, limit of detection etc. Although, optical fiber biosensors using long period fiber gratings or SPR as transducer for detecting of triacylglycerides showed high sensitivity towards the concentration of triacylglycerides they require extensive facilities such as writing system for LPG fabrication and vacuum coating units for metal thin film . Hence, we also fabricated a probe prepared by attaching silver nanoparticles (Ag-NPs) over a small length of optical fiber core and immobilizing lipase enzyme (bio-recognition layer) over the surface of the metal nanoparticles. This sensor operates in the wavelength modulation scheme, in which the peak absorbance wavelength is measured with respect to the changing concentration of triacylglycerides solution. The thesis concludes with a summary of the performance of the various fabricated and tested sensors and scope for future work in the area.

Contents

1. Introduction 2. Analysis of optical fiber 3. Long period grating as triacylglycerides sensor 4. Single mode fiber between concatenated long period gratings as sensor probe 5. Surface plasmon resonance based fiber optic sensor for the detection of triacylglycerides 6. Localized surface plasmon resonance based fiber optic sensor for the detection of triacylglycerides using silver nanoparticles 7. Surface plasmon resonance based fiber optic sensor for the detection of triacylglycerides with Ag/ZnOnanorods. Conclusion and bibliography

02. DAVINDER KAUR

Design and Analysis of Lossy Mode Resonance Sensors.

Supervisors : Prof. Avinashi Kapoor and Dr. Vinod Kumar Sharma

Th24018

Abstract
(Not Verified)

In the past few decades, optical sensors based on surface plasmon resonance (SPR) was dominating in the field of bio sensing. Little attention has been paid in the field of optical sensors based on the lossy mode resonance (LMR) in absorbing thin films. As LMRs has several advantages over SPRs such as the ability to generate several resonances in the same spectrum and the excitation under both TE and TM polarization, a refractive index sensor based on LMRs is proposed in this thesis. Theoretically spectral and angular analysis of Kretschmann configuration are investigated. Sensitivity as high as 4652 nm/RIU is achieved and the reason for enhanced sensitivity by introducing a low index matching layer is discussed in sufficient details. Using Fresnel reflection coefficients the reflectivity and the values of reflectance minima was calculated and the same results are obtained by solving the eigen value equation. The penetration depth of evanescent wave in the medium of proposed sensor is also increased. This has advantages where the cell/molecules are of larger size in biological/ chemical sensors. Effect of losses on the sensor parameters is discussed. In the next step the optimization of the sensor in visible wavelengths is done as most of the bio/chemical sensors are expected to operate at these wavelengths. Also the effect of prism index on the sensitivity was discussed. Next the sensitivity of the proposed sensor is improved up to three times (from 4652 nm/RIU to 17,024 nm/RIU) by considering prism of very large refractive index. It is shown that spectral sensitivity increases and angular sensitivity decrease with increase in index of matching layer. Also, since ITO is chemically stable and the sensitivity is of the order of that obtained using some of the best SPR sensors, our proposed sensor may find its application in many practical bio/chemical sensors.

Contents

1. Introduction 2. Basic theory 3. Sensor based LMR 4. Lossy mode resonance sensors operating in visible region 5. Critical evaluation of optimized parameters of sensors 6. Conclusion and future scope.

03. DHRUVASHI

Study of Zinc Oxide Based Dilute Magnetic Semiconductor Thin Films.

Supervisor : Dr. P. K. Shishodia

Th 24022

Abstract
(Verified)

The research in dilute magnetic semiconductors (DMSs) is growing rapidly and has attracted much attention due to its various practical applications in spintronic devices. DMS can be obtained by doping a small fraction of transition metal (TM) into a conventional semiconductor. ZnO is familiar among researchers since it is a n-type semiconductor with wide bandgap of 3.34 eV and high binding energy of 60 meV at room temperature. In the present work, a systematic studies on the TM doped ZnO (ZnO:TM) systems have been performed. The films were fabricated on corning glass substrates by sol-gel spin coating method. Manganese (Mn) and Cobalt (Co) dopants have been used as magnetic impurity into the ZnO. It has been observed that Mn and Co both are soluble up to 5 wt.% into the ZnO matrix which is confirmed by X-ray diffraction (XRD) and Raman measurements. The crystal structure of doped films degrade due to the formation of secondary phases with higher concentration of

dopants. In ZnO:Mn films, weak ferromagnetic signals have been observed at low field. Whereas, the magnetic measurement of the ZnO:Co films show a well-defined hysteresis loop. It has been observed that the ZnO:Co (5 wt.%) film show better ferromagnetism with saturation magnetization. It is also observed that doping of ZnO with a mixture of Manganese and Cobalt cause remarkable changes in the magnetic property of ZnO based DMSs. In this framework, the concentration of Mn was fixed to 5 wt.% by varying the Co concentration (3, 5 and 10 wt.%). No secondary phases were observed from XRD pattern of codopedZnO thin films. The transmittance of co-doped ZnO films was found very less as compared to mono-doped films. In co-doping the solubility limit has been increased up to 10 wt.%. Consequently, the magnetic properties were improved in co-doped ZnO system.

Contents

1. Introduction 2. Experimental and characterization techniques 3. Study of manganese doped Zinc Oxide (ZnO:Mn) thin films 4. Study of Cobalt doped Zinc Oxide (ZnO:Co) thin films 5. Influnce of co-doping (MN,Co) on ZnO thin films 6. Summary.

04. GAUTAM (Khyati)
Application of Graphene in ZnO Based Optoelectronic Devices.
Supervisors : Dr. Koteswara Rao Peta and Prof. P. K. Bhatnagar
Th 24250

Abstract
(Verified)

In the present work ZnO nanorords have been used to circumvent the problem of low light extraction (due to unwanted total internal reflections occurring at optically distinct layers) in MEH-PPV based polymer light emitting diode (PLED). For this purpose ZnO nanorods have been grown by hydrothermal method over ITO substrate using ZnO seed layer. The effect of growth temperature of seed layer has also been studied on the structural and optical properties of ZnO nanorods by growing seeds at five different temperatures (150-550 °C). The seed layer grown at 350 ºC was observed to be uniformly textured with c-axis orientation leading to synthesis of vertically aligned nanorods with an enhanced UV emission. The growth kinetics of ZnO seed layer have been explained for the observed behavior. These vertical ZnO nanorods (NRs) were further incorporated in the PLED structure and were found to drastically enhance the luminance by ~ 22 times as compared to basic MEH-PPV device owing to their single mode wave guiding effect. The turn-on voltage was also found to increase slightly by incorporation of ZnO nanorods. In order to circumvent this issue the emissive layer is doped with graphene which serve as conductive nanofiller. It is observed that graphene doping decreases the turn on voltage of the device structure due to the establishment of conducting pathways in the polymer matrix. At the optimized concentration of graphene (0.005 wt%) the PLED was found to be 60 times more efficient than pristine MEH-PPV based device. In addition, an effort has also been made to tune the structural and optical properties of ZnO nanorods by anionic doping of ZnO with chlorine (Cl). The significant changes in morphology (from nanorods to nanodisk to nanoflakes) and relaxation dynamics with Cl doping suggest prospective LED and laser applications of as-grown nanostructures.

Contents

1. Introduction 2. Synthesis and characterization techniques 3. Effect of growth temperature of seed layer on structural and optical properties of ZnO nanorods prepares by hydrothermal method 4. Chlorine doping : Its effects on the growth and relaxation dynamics of ZnO nanorods 5. Single mode wave guiding effect of ZnO nanorods to enjance the lininance of conjugated MEH-PPV based light emitting

diode 6. Application of graphene in improving the performance of ZnO nanorods MEH-PPV based PLED. 7. Conclusion and future scope of work.

05. GAUTAM (NAINA)

Study on Synthesis, Characterization and Modifications of Organic-Inorganic Hybrid Materials for Photovoltaic Applications.

Supervisors : Prof. Avinashi Kapoor and Dr. Fouran Singh

Th 24022

Abstract
(Verified)

Wide band gap oxide semiconductors have been explored a lot as inorganic acceptor material for hybrid solar cells leading to research in ZnO as an appropriate material. Reasons being it has higher electron mobility, low-cost, stable against photo-degradation, can be synthesized via different techniques making ZnO an attractive option for low cost solar cells. The objective of my work can be divided in three parts, firstly thin films of pure ZnO and cadmium doped ZnO were synthesized and analyzed .Ternary Cd Zn O thin films were prepared by sol-gel method and were discussed as function of doping concentration in terms of structural, compositional, morphological and optical properties. Structural study reveals that the films exhibit hexagonal wurtzite structure with no preferred orientation along with phase segregation for higher doping concentration. Also, band-gap tuning was achieved without affecting the transparency in the visible region. This was followed by modifications in lightly doped films with the help of swift heavy ion irradiation technique and study the post irradiation effects. Lightly doped Cd Zn O thin films were investigated before and after irradiation with 120MeV Ag and 80MeV O in order to understand the effect of fluence and electronic stopping energy S (KeV/nm) on various properties of the film. When irradiated with 120MeV Ag ions at various fluencies (ions/cm), the maximum change was observed at the highest dose of 3×10 ions/cm along with increase of various defect densities in the system. Band gap widening and narrowing was observed as a result of different S (KeV/nm) .Finally, pure ns- ZnO was utilized as the acceptor material in a hybrid solar cell. A device structure such as ITO/PEDOT:PSS/ns-ZnO+P3OT/BDs/Ag was developed. The developed device exhibits a very high conversion efficiency of 4.67% and fill factor 52.9% under 100mW/cm visible band illumination.

Contents

1. Introduction 2. Synthesis and modification techniques 3. Characterization techniques 4. Effect of Cd doping concentration in ZnO thin films 5. Effect of swift heavy ION irradiation on $CD_{0.05}Zn_{0.95}O$ thin films 6. Development and characterization of organic-inorganic hybrid solar cell 7. Summary and future scope.

06. GUPTA (Yashika)

Development, Characterization and Optimization of p-SnS Thin Films for Photovoltaic Applications.

Supervisor : Dr. Parun

Th 24017

Abstract
(Not Verified)

Now-a-days Tin Sulphide (SnS), a layered Chalcogenide material, is gaining popularity as a potential candidate for inorganic thin film solar cell absorber layer. However in spite of showing a huge potential, only 5% efficiency has been achieved for p-SnS solar cells till date. The main purpose of this work is to understand the relevance of p-SnS thin film properties in different regions of solar cell operation such as junction and neutral regions. In this thesis, we have extensively worked on

thickness dependent neutral region properties of p-SnS solar cells. We have shown how anisotropy (orientation of crystal planes) and defects present in the film (giving rise to Urbach tail) affect not only charge carrier generation by the thin film absorber layer but also carrier transport through the p-SnS neutral region. The experimental results have also been theoretically verified by Albanesi et al. with Density of states (DOS), band structure and optical properties calculations using Ab inito software. To investigate the effect of SnS properties on its performance, we fabricated p-SnS/CdS heterojunction solar cells. It was found that the defects present in p-SnS films not only affect the neutral region properties of the cell but also affect it's depletion region by contributing to trap- assisted recombination across the junction and hence result in low efficiency of p-SnS based solar cells along with the poor band alignment at p-SnS/CdS heterojunction.. The thesis concludes that the defect structure of p-SnS thin film, which on one hand makes it a suitable photovoltaic candidate, results in it's poor photo conversion efficiency. This study addresses the key questions related to the SnS photovoltaics and lays the foundation for material manipulation in order to achieve better photosensitive layers for solar cell applications.

Contents

1. Introduction 2. Fabrication and characterization techniques 3. p-SnS thin films for PV applications 4. Study of n-CdS/p-Sns heterojunction solar cell 5. Summary and Conclusion. Bibliography.

07. SACHIN KUMAR
Novel Attribute of Ring FET : A Modeling and Simulation Based Investigation.
Supervisors : Prof. Mridula Gupta and Dr. Sanjeev Singh
Th 24209

Contents

1. Introduction. 2. Drain current modelling and linearity behavior analysis of nanoscale RingFET 3. Investigating the impact of skin deep insulated extension on analog performance of RingFET 4. Influence of double gate engineering on linearity performance of RinghFET for RFIC application 5. Impact of gate electrode, gate oxide and channel material engineering on nanoscale Ring FET: A case study 6. Conclusion and future scope. Annexure

08. SHARMA (Swati)
Study and Fabrication of Organic-Inorganic nanocomposite Based Hybrid Solar Cells.
Supervisors : Prof. Avinashi Kapoor and Dr. Natasha
Th 24017

Abstract
(Not Verified)

Alternative energy resources are being extensively studied by the scientific community to cater to the growing energy needs of the world. Sun being the ultimate source of energy, makes solar energy the most abundant and viable of all these energy resources. Amongst various solar cell technologies, hybrid solar cell technology is currently the most extensively researched field. This work focuses on synthesis and study of P3OT- ZnS nanocomposite for photovoltaic application. The ZnS nanoparticles were synthesized using wet chemical co-precipitation technique. The particles were spherical in nature with uniform size distribution. The P3OT- ZnS nanocomposite was employed to form a hybrid solar cell structure and the device exhibited better efficiency and FF compared to that of a P3HT-ZnS hybrid solar cell structure due to better phase interaction of the active layer in the P3OT- ZnS nano composite. In the next section, effect of Al and Y doping on ZnS nanoparticles is discussed. Al and Y

Doped nanoparticles were prepared using the same chemical co-precipitation technique. Structural, morphological and optical properties of the nanoparticles were analyzed and it was observed that Al and Y doping can be used for tailoring optical band gap of the ZnS nanoparticles without altering its crystal structure significantly. Electrical conductivity of the Al doped ZnS nanoparticles was investigated and it was observed by five times with respect to undoped nanoparticles. It is proposed that due to increase in conductivity of the acceptor material, charge transport through the active layer of the hybrid solar would cell would increase which would lead to improvement in device performance. The same is exhibited by increase in efficiency of the P3OT-ZnS: Al nanocomposite based hybrid solar cell as compared to P3OT:ZnS nanocomposite based cell. Thus P3OT-ZnS nanocomposite has the potential to be exploited for photovoltaic application.

Contents

1. Introduction 2. Experimental methods and characterization techniques 3. Study and analysis of P3OT-ZnS hybrid solar cell 4. Synthesis and characterization of AI and Y doped ZnS nanoparticles 5. Enhancement in photovoltaic activity of P3OT-ZnS nanocomposite by AI doping 6. Conclusions and scope for future work.

09. SUBHASH CHANDER

Simulation, Modelling and Characterization of MMIC (Monolithic Microwave Integrated Circuit) Components.

Supervisor : Prof. Mridula Gupta

Th 24015

Abstract
(Not Verified)

There is demand for compact electronic systems for all applications. In introductory *Chapter 1*different types of electronic circuits have been explained along with advantages and disadvantages. This chapter also explained about why the new materials are needed, and components fabricated using these new materials, require characterization before using in MMICs. In *Chapter 2* the characterization of thin film nichrome resistors has been carried out. The performance of thin film resistor mainly depend upon the composition of the nichrome material and growth parameters, which are explained. The details of MMIC stack have been given. The parameter extraction of the equivalent circuit has been done which can be used for circuit design. In *Chapter 3* the characterization of planar circular inductor has been carried out. The analysis of the inductor has been carried out for figure of merit for different track width/spacing between turns for optimum small size and for different substrate thicknesses. Finally the planar circular spiral inductors were fabricated, measured and parameters were extracted for equivalent circuit which can be used in circuit design. In *Chapter 4* the study of active component normally-off GaN based high electron mobility transistor(HEMT) has been carried out for DC and breakdown voltage characteristics of the device. Field plate has been used to increase the breakdown voltage. In *Chapter 5* the study of AlGaN/GaN HEMT has been carried out. The difference in breakdown voltage has been observed by using different passivating materials. Effect of buffer thickness is also studied on breakdown voltage. Further, the DC characteristics have been investigated for different architectures of AlGaN/GaN HEMTs. In chapter 6 the conclusion of the work carried out in this dissertation has been explained.

Contents

1. Introduction 2. Characterization of thin film nichrome resistors for GaN based MMICs 3. Characterization of circular planar inductor for GaN based MMICs 4. Analysis of enhancement mode GaN HEMT 5. Analysis of breakdown voltage and DC

characteristics through modified architecture of AIGaN/GaN HEMT 6. Conclusion and future scope.

10. TOMAR (Raghbendra Singh)
Study of Optical Control of Passive Microwave Devices and its Application.
Supervisors : Prof. Enakshi Khular Sharma and Dr. Avanish Bhadauria
Th 24020

Abstract
(Not Verified)

Progress in acceptance of photonics for microwave systems or microwaves for photonic systems has given rise to the new area of research now called “Microwave Photonics”. Direct optical control of microwave semiconductor devices is an area of microwave photonics, which has been of interest over the last two decades. In this thesis we have designed and analyzed three devices fabricated on a semiconductor substrate for direct optical control using laser illumination. We first present the numerical modeling of a photo-induced charge and its effect on the dielectric constant and conductivity of a semiconductor substrate for complete simulation of an optically controlled microwave device. The effect is illustrated by study of reflections in a microstrip line terminated by an optical load. A Metal Insulator Semiconductor (MIS) microstrip line shows an increase in slowing factor with a corresponding decrease in attenuation in the presence of optical illumination. This application of optical controlled has been analyzed in detail. In the next application we present an optically variable microwave attenuator fabricated on silicon substrate. The variable attenuator is based on edge side coupled microstrip line directional coupler in which the coupled and through ports are left open for illumination by a laser spot. As a third application, a new type of reconfigurable phase shifter that uses optically switched Defected Ground Structure (DGS) unit in a micostrip line on silicon substrate is presented. A range of discrete phase shifts can be obtained by cascading two to six DGS units. The experimental verification of the concept of an optically controlled phase shifter has been carried out on single and cascaded DGS units fabricated on an FR4 substrate. For the future, the current work can be extended with fabrication of the phase shifter on a semiconducting substrate and phase shifts studied under optical illumination.

Contents

1. An overview of optical control of microwave devices 2. Carrier generation in optically illuminated semiconductors and change of substrate parameters 3. Optical control of microstrip transmission line for slow wave progagation 4. Optically variable microwave attenuator on silicon substrate 5. Optically controlled phase shifter using defected ground structure 6. Experimental verification of the concept of optically controlled phase shifter using defected ground structure 7. Conclusion and future scope of work. Bibliography.