# CHAPTER 16

# ELECTRONIC SCIENCE

## Doctoral Theses

01. MADAAN (Divya)
**Theoritical Study of Plasmonic Waveguides and Devices.**
Supervisor: Dr. Vinod K. Shrma
Th24463

*Abstract*
*(Not Verified)*

Guided wave polarizer is one of the applications of integrated optics. Surface-polariton polarizer (SPP) has become the subject of various theoretical and experimental investigations. Polarizer is a device used to convert an unpolarised light to a single polarization state. The applications are in communication, photography, sunglasses and liquid crystal display technology. Waveguide polarizers have been designed which are used in integrated optical circuits. In this work we concentrate on the polarizers using surface plasmon polariton phenomenon. Surface plasmon waves are electromagnetic waves coupled to the coherent oscillations of a metal's free electron density and propagate along the interface of a dielectric and metal with negative real part of permittivity. A multilayer planar waveguide structure is designed and analysed which work as a TE pass polarizer as the TM losses obtained are so high compared to the TE losses, which allow only TE mode to pass. The structure consists of two waveguides, the dielectric waveguide and the SPP waveguide. The Polarizing action is based on the interference of modes of the two waveguides. In biosensing applications the sensors should be sensitive for the refractive index around the aqueous environment preferably operating at visible wavelength. The waveguide based refractive index sensor is also designed and analysed where the same SPP phenomenon is taken, but here instead of Short-Range Surface Plasmon Polariton (SRSPP) mode, the Long Range Surface Plasmon Polariton (LRSPP) mode interacts with the dielectric waveguide mode. The Si layer above metal film is used to bring the operating point near the aqueous environment (i.e. the reflectivity minimum appears near n=1.33). The prism based sensors are considered. A minimum or a dip is observed in the reflectivity curve. The structures are analysed for angular and spectral interrogations. Both, prism based structures and Integrated Optic waveguide structures can be used for biosensing applications.

*Contents*



02. NIRWAL (Varun Singh)
**Fabrication and Characterization of Schotkty Metal Contacts to Updoped GaN.**
Supervisor: Dr. Koteswara Rao Peta
Th24462

*Abstract*
*(Verified)*

GaN electronic properties makes it suitable for high power, high frequency and high temperature electronic device applications.The performance of these devices largely depends on the quality of Schottky and Ohmic contacts. In the first part, the effect of rapid thermal annealing on the electrical and structural properties of Pd/Au Schottky contact to Ga-polar GaN grown by MBE on p-Si is analyzed. Current-voltage (I-V), capacitance-voltage (C-V), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD) and atomic force microscopy measurements are performed for the electrical and structural characterization of Schottky contact. It has been observed that there is a significant improvement in barrier height (Φ) and ideality factor (n) with reduction in leakage current upon annealing. The formation of gallide phases at metal semiconductor (M/S) interface,confirmed by XPS and XRD results is the reason for improvement in electrical properties on annealing. The second part is to understand the nature of Schottky barrier across M/S junction. We have investigated the effect of temperature on the behavior of electrical properties of Pd/Au Schottky contact to Ga-polar GaN/Si (111) in the temperature range of 125 K to 325 K in steps of 25 K using I-V and C-V analysis. The deviation of conventional Richardson's constant from theoretical value of GaN is due to barrier height inhomogeneity. This is successfully explained by assuming the double Gaussian distribution of inhomogeneous barrier heights. We have also analyzed the current transport mechanism of Pt/Au Schottky contact on N-polar GaN. I-V characteristics are plotted in the temperature range of 120 – 300 K in steps of 20 K and the values of Φ and n were calculated at each temperature. The inhomogeneous behavior of the electrical parameters is explained by assuming the single Gaussian distribution of barrier heights at the M/S interface.

*Contents*



03. SAINI (Basant)
**Investigation of Polarization Compensation Mechanicm in InGaN/GaN Solar Cells.**
Supervisor: Prof. Avinashi Kapoor
Th 24465

*Abstract*
*(Verified)*

InGaN and GaN materials in their wurtzite structure shows strong spontaneous and piezoelectric polarization due to non-centrosymmetry and prevalent piezoelectric tensors, when grown along conventional c-plane. It is stated as one of the main challenge responsible for degrading the photovoltaic performance of InGaN/GaN solar cells. Another major challenge in achieving high efficiency InGaN/GaN solar cells is the limitation in obtaining high hole concentration along with high conductance of p-doped layer. In this dissertation, the polarization compensation mechanism is investigated numerically for InGaN/GaN solar cells, especially at low hole concentration of p-doped layers, to improve the design of InGaN/GaN solar cells

by countering the detrimental effects of polarization. In this thesis, the impact of spontaneous and piezoelectric polarizations on the InGaN/GaN solar cell photovoltaic properties is discussed in detail. The effectiveness of polarization matching layers (PMLs) for the polarization compensation in InGaN/GaN solar cells is established by numerical simulations with the aim to provide optimized structures that can be realized experimentally. Further the role of PMLs in countering the SRH recombination-induced dark current is studied, and an analytical model is used to justify the simulation results. This work contributes to improved understanding of the process of carrier extraction across the absorber region, the effect of polarization charges on this extraction process, and the role of PMLs in reducing the polarization effects by reducing the SRH recombination in case of low p-GaN doping densities. In the last section of this thesis, theoretical simulations are performed to study the use of band-gap engineering as well as quantum well structure modification to increase the carrier extraction from the InGaN/GaN multiple quantum well (MQW) region of InGaN/GaN MQW solar cells. This work establishes the importance of PMLs introduced at the InGaN (QW)/p-GaN interface in improving the photovoltaic properties of the InGaN/GaN MQW solar cells.

*Contents*



04. SHARMA (Updesh)
**Design, Simulation of W-Band and Realization of KA-Band of Mems Switch.**
Supervisor: Prof. Enakshi Khulat Sharma
Th 24939

*Abstract*
*(Not Verified)*

Switches are one of the essential components in RF circuits and systems. RF MEMS switches replaced the traditional GaAs FET and p–i–n diode switches in RF and microwave systems, because of few micro-watts consumption, low insertion loss, high isolation, much lower intermodulation distortion, low cost and light weight. Due to the number of advantages of MEMS switches, these are widely used in RF to millimeter wave frequencies. The objective of the current work is primarily focused on the design, simulation and fabrication of RF MEMS Switches. The work has been done in realization of Ka band and design and simulation of W-band switches.W-Band high isolation SPST & SPDT Switches for Broadband response is also reported in the thesis. In meander type Ka band design of the switch, the effect of fabrication process induced changes on scattering parameters of RF MEMS switch structure with meander geometry for Ka-Band has been studied. The designed structures showed a return loss better than -15 dB with a maximum isolation of -43 dB at 35 GHz. From the parametric analysis, both the return loss and isolation parameters are found to be more dependent on the meander width and dielectric thickness. The switch structure is fabricated by surface micromachining technique. In Ka band, first switch structure which was of meander geometry has been designed and simulated for high isolation but not for broadband but second structure, in which two straight shunt beams were cascaded, has been designed and simulated for high isolation and broad frequency Band. In the next part the meander type of the switch of Ka band designed, fabricated and tested. In W band, two types of switch have

been designed i.e integrated SPST (cascaded series and shunt switches) and SPDT switch for high isolation and broadband.

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1. Introduction 2. Design and modelling methodologies of rf mems switches 3. Design of straight beam switch and study of scattering parameters of rf mems shunt switch with high-K dielectrics 4. Dsign and simulation of ka band spst switch 5. Fabrication and testing of ka band spst switch structures 6. Design and simulation of w band spst switch for broadband response 7. W band single pole double through (spdt) switch for broadband response. Conclusion and future work.

05. SINGH (Joginder)
**Studies on Role of Graphene in Improving the Performance of Organic Photovoltaic Devices.**
Supervisor: Dr. Koteswara Rao Peta
Th 24436

*Abstract*
*(Not Verified)*

In the present thesis, multilayer graphene (MLG) has been explored to be used in the active layer of single layer and bulk heterojunction (BHJ) organic photovoltaic (PV) devices for improving their performance. MLG has been first characterized and then incorporated into the active layer of P3HT based PV device. The MLG acts as acceptor material in this device. The J-V characteristics reveal that at the optimized concentration (0.1 wt%) of MLG, the Jsc, Voc, and hence PCE of the device improves. Increase in Jsc is a consequence of decreases in both the series resistance and geminate recombination. Cyclic voltammetry measurements revealed that the enhancement in Voc is due to downshifting in HOMO energy level of P3HT after MLG incorporation. These factors lead to an overall increment in PCE of the single layer P3HT based PV device. In BHJ structure, incorporation of MLG leads to improve PCE as well as stability of the device. The enhancement in Jsc is due to increased exciton generation. It has been shown that PCBM acts as main acceptor material while MLG provides a 2D path for fast charge transport leading to decreased non-geminate recombination in the active layer. Thus, higher numbers of charge carrier are collected at respective electrodes after incorporation of MLG causing an increase in the Fermi level splitting resulting in higher Voc. The main cause of degradation in the active layer is the generation of trap states due to the interaction of the P3HT chain with oxygen and water present in the atmosphere. Incorporation of MLG in the active layer reduces the probability of non-geminate recombination as fewer numbers of traps are encountered by the charge carriers. Hence, MLG is concluded to be a promising material for improving the PCE as well as stability of the P3HT:PCBM based PV devices.

*Contents*

1. Introduction 2. Device fabrication and characterization techniques 3. Improved performance of P3HT based organic PV device by incorporation of multilayer graphene 4. Role of multilayer graphene in enhancement of efficiency of P3HT:PCBM based photovoltaic device 5. Role of multilayer graphene in enhancement if stability of P3HT:PCBM based photovoltaic device. Conclusion and future scope of work.

06. TRIVEDI (Nitin)
**Modeling Simulation and Characterization of Junctionless Accumulation Mode Cylinderical Surrounding Gate (CSG) Mosfet for Digital Application.**
Supervisors: Prof. Mridula Gupta and Dr. Subhasis Haldar
Th 24464

*Abstract*
*(Not Verified)*

Scaling of gate length and gate oxide thickness degrades the performance of conventional MOSFETs. Short channel effects (SCEs) and hot carrier effects (HCEs) degrade the device performance significantly. To overcome SCEs various geometry based alternative devices have been explored such as double gate (DG) FET, Omega FET, Fin FET, and cylindrical gate FETs. These devices show better performance over conventional bulk MOSFET with aggressive scaling. Cylindrical surrounding gate (CSG) MOSFET that wraps the gate over the channel to enable high short channel immunity at 15 to 20 nm regime offers better scalability because of superior controllability of gate. However, the challenging part of these devices at the nanoscale is the formation of ultra-sharp source/drain junctions, source/drain series resistance, doping techniques, and thermal budget. Therefore Junctionless and Junctionless Accumulation Mode MOSFETs are an ultimate solution to cope with the problems of ultra-sharp source/drain junction formation and source/drain series resistance. Such Novel architectures have been used in this thesis work where device modeling and simulation-based studies are pursued. Initially, a new configuration i.e. Insulated Shallow Extension Cylindrical Surrounding Gate Stack (high-k ISE-CSG) MOSFET has been proposed which highly improved the device performance by improving gate leakage current. In the next step, a new structure Junctionless Accumulation Mode Cylindrical Surrounding Gate (JAM-CSG) MOSFET has been proposed. Junctionless Accumulation Mode device has been modeled and compared with conventional Junctionless MOSFET using ATLAS device simulation software. Subsequently, a new structure i.e. Dopingless (DL) Junctionless Accumulation Mode MOSFET has been proposed using Charge Plasma (CP) concept which highly improved the device Analog/RF performance. At last, the interface traps dependent linearity analysis of Single and Dual metal gate Junctionless Accumulation MOSFET has been done.

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