High Electron Mobility Transistors for Microwave & High-Power Applications

and

Developing Child Scheduler Application for SMART TV

by

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Certificate

This is to certify that this dissertation report entitled "**High Electron Mobility Transistors for Microwave and High-Power Applications**" and "**Developing Child Scheduler Application for SMART TV**" by Challa Krishna Prasanna, has been completed under our supervision and guidance, hence approved for submission in partial fulfillment for the award of degree of Master of Technology in VLSI Design to the Department of Electronics and Communication Engineering, Malaviya National Institute of Technology, Jaipur during the academic session 2015-2017.

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5. It has acknowledged all the main sources of help.

Challa Krishna Prasanna,
(2015PEV5101).

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Abstract

The whole thesis is divided in two parts. In part A of this thesis work a high speed switching AlGaN/GaN high electron mobility transistor (HEMT) of gate length 1um with incorporation of AlN as a spacer layer of width 2nm and as a nucleation layer of width 150nm. The modelled device gives maximum ON current of 1.8A/micron with a high cut-off frequency of 99GHz and a high switching ratio Ion/Ioff = 10^6 at supply voltage of 10V. This device at a constant drain-source voltage i.e Vds=10V gives a cut-in voltage of '-7V' and maximum current i.e Imax=5A/mm and a constant drain-source voltage i.e Vds=10V and constant gate-source voltage i.e Vds=-2V gives transconductance i.e g_m=900mS/mm. Thus the device proposed gives superior characteristics in terms of switching speed, switching ration, high currents, high cut-off frequencies and high break down voltages and becomes a promising candidate for high frequency and high power applications.

In part B of thesis is about Child Scheduler app and this is Smart TV application that monitors and controls the duration of content viewing for children. The users are required to create user ID and password once. Registered users can login to the app and set time duration for the viewing TV by children. The app monitors the time duration and stops viewing content when time limit is reached on real-time. Viewing duration can be further extended by users by providing login credentials again. Date and time of watching TV by children can also be scheduled earlier by the users.

This application provides a good way to monitor children to watch content is good for them and restricting other content. TV watching date and time can be scheduler earlier, so users don't need to schedule every time their children need to watch TV.

PART A:

High Electron Mobility Transistors for Microwave & High-Power Applications

Chapter 1

Introduction

1.1Motivation:

In recent years the demand of Group III-N HEMTs for high-frequency and high-power applications are increasing specially in two of the major areas: high-frequency wireless systems and high-speed optical fiber communication systems. Low cost, high-frequency, high power and low power consumption are the major requirements in development of the wireless communication systems. Compound semiconductor devices such as GaN high electron mobility transistors (HEMTs),AlGaN/GaN HEMTs (MHEMTs), are will show high performance in high frequency applications compared to Si. InxGa1-xAs HEMT have received much attention due to its capability of being operated at very high frequency region with ultra-low power consumption. Many efforts have been made to improve the device performance. Devices with higher carrier concentration, higher electron mobility and shorter gate length by use of refined heterojunction structure and novel gate shrinkage technique have been demonstrated and have shown outstanding performances.

HEMTs have so many performances advantages over MESFETs.

- High transconductance due to higher channel mobility this follows from Shockley’s gradual channel approximation.
- Higher speed due to higher transconductance.
- Reduction of parasitic and access resistances due to higher channel mobility.
- Lower-noise performance due to reduction of access resistances.
- Higher power efficiency due to reduction of parasitic resistances.

1.2 Literature Review

The very first high electron mobility transistor was realized by Mimura et al (1980), using a Al0.7Ga0.3As/GaAs heterostructure. The Al0.7Ga0.3As layer was doped n-type (ND=6.6 × 1017cm–3) and the GaAs layer was undoped. The electron concentration in GaAs and the in-plane current could be controlled by using a conventional metal-oxide-semiconductor field-effect-transistor (MOSFET) like structure with source, drain and gate contacts.

English et al (1987) and Pfeiffer et al (1989) reported that the high mobility of the electrons in the structure gave at 77 K a transconductance, three times higher than that of a conventional Schottky-gate GaAs field-effect transistor (GaAs FET). The operation of the AlGaAs/GaAs FET depends on the capability to change the space charge by the gate voltage and quantization of the energy levels is not a necessary condition. However, the carrier concentration in the devices is such that the potential well formed by the space-charge layer is very narrow and quantization results. Electrons can have, therefore, only in-plane motion, the perpendicular motion being restricted due to quantization. The quantization, although not necessary, affects significantly the device characteristics.

AlGaN-GaN Double-Channel HEMTs was proposed by Chen et al (2003), where two carrier channels are formed in an AlGaN–GaN–AlGaN–GaN multilayer structure, which is grown on a sapphire substrate. A second carrier channel at the lower AlGaN–GaN interface is formed due to the polarization field in the lower AlGaN layer, without creating any unwanted parasitic conduction path in the AlGaN barrier layer. Both in dc and RF characteristics an explicit double channel behavior is observed. RF small signal characterization and parameter extraction were performed on the device. Gain compression at a high current level was attributed to the electron velocity degradation which is induced by interface scattering of carriers.

Most of the recent advances in antimonide-based HEMTs have involved heterostructures which are grown by molecular beam epitaxy (MBE) technique. For the first time Chang et al (1977), Ludeke (1978) and Yano et al (1978) reported the growth of antimonide by MBE technique. The growth of antimonide and mixed antimonide/arsenide structures by MBE has presented some challenges compared to growth of arsenides as suggested by Bennett et al (1999) and possible solutions have been found for most of the issues. On a whole the growth of antimonides is much simpler than nitrides and does not present the safety issues associated with phosphides.

For complementary logic technology, the high mobility p-channel transistors are equally as important as n-channel transistors. However, achieving a high hole mobility in III-V semiconductors is very challenging. Enhancing the hole mobility beyond its value in bulk material is made possible by a effective technique of controlled introduction of strain in the quantum-well material. The strain reduces the hole effective mass by splitting the heavy hole and light hole valence bands. A successful attempt to realize p-type InSb quantum well structures is discussed. A significantly higher room-temperature hole mobility and a high low-temperature hole mobility is achieved by applying the biaxial strain via a relaxed metamorphic buffer. In order to demonstrate the effectiveness of high mobility in a device structure, magnetoresistive devices were fabricated from remotely doped InSb quantum wires. These devices finds place in numerous practical applications such as position and speed sensors and as read heads in magnetic storage systems. In a magnetoresistive device composed of a series of shorted Hall bars, the magnetoresistance is proportional to the electron mobility squared for small magnetic fields. Hence, the high electron mobility in InSb QWs makes them highly preferable for geometrical magnetoresistors as they are more effective.

The electron effective mass is smaller in InSb than in any other III-V semiconductor. Since the electron mobility depends inversely on the effective mass, InSb-based devices are attractive for magnetic field sensors, field effect transistors, ballistic transport devices, and other applications where the performance depends on a high mobility or a long mean free path. In addition, electrons in InSb have a large g-factor and strong spin orbit coupling, which makes them well suited for certain spin transport devices in particular.

The first n-channel InSb high electron mobility transistor (HEMT) with a power-delay product superior to HEMTs with a channel made from any other III-V semiconductor was produced in the year 2005. The high electron mobility in the InSb quantum-well channel increases the switching speed and lowers the required supply voltage. There are several materials challenges that can further increase the appeal of InSb quantum wells for transistors and other electronic device applications.

The electron mobility in InSb quantum wells can be further increased by reducing scattering by crystal defects, despite of the fact that electron mobility in InSb quantum wells is highest for any semiconductor quantum well. Due to the lack of a lattice matched semi-insulating substrate, InSb-based heteroepitaxy is usually performed on a semi-insulating GaAs (001) substrate. The formation of structural defects such as threading dislocations and microtwins which degrade the electrical and optical properties of InSb-based devices are resultant of the 14.6% mismatch between the lattice parameters of GaAs and InSb materials.

Various methods and procedures for growing InSb-based heterostructures by molecular beam epitaxy technique are developed.

Indium Antimonide semiconductor materials are under broad investigation. Rodilla et al (2009) studied two different narrow band gap semicoductors InAs and InSb, and their associated heterostructures, AlSb/InAs and AlInSb/InSb, have been by means of Monte Carlo simulations. Narrow band gap semiconductors have become a great option to increase mobility and operation frequency in high electron mobility transistors (HEMTs). Growth and fabrication of AlGaN/GaN HEMT based on silicon substrates by MOCVD is reported by Luo et al (2008). The sapphire substrate has the bottleneck of bad thermal conduction, which limits the improvement of the power density of the device, and SiC substrate is so expensive that it hinders the application of GaN material. Therefore, Si is the best alternative substrate for its low cost, good thermal conductivity and integrating with the mature Si-based processing techniques. A two-dimensional (2-D) analytical model was proposed by Kumar et al (2008) for a Dual Material Gate (DMG) AlGaN/GaN High Electron Mobility Transistor (HEMT). The developed analytical model demonstrates the unique attributes of this device structure in suppressing short channel effects (SCEs). It predicts the channel potential, electric field variation along the channel, and subthreshold drain current. The work function difference of the two metal gates, suppresses the SCEs and hot carrier effects in DMG AlGaN/GaN HEMT, thereby screening the drain potential variations by the gate near the drain. The carrier transport efficiency also improved by a more uniform electric field along the channel.

1.3 Approach:

I Simulated the modelled structures using Silvaco TCAD tool. First I started with the simple GaN/AlGaN HEMT. I calculated the transfer characteristics, output characteristics of this model. Next I introduce a spacer layers of AlN in between the GaN and the ALGaN. It improves the current carrying capability. I compared both the results and how much percentage increment is there in the currents. Further I improved this structure by placing one more layer of AlN as nucleation layer. It decreases the dislocations in the buffer layer which is the top of the substrate layer. In between the buffer and the substrate, I introduced this layer to improve the structure performance. Finally I compared all the results and how much the new modelled structure is giving the better performance than the previous ones.

1.4 Thesis Overview:

Chapter 2: In this the details of HEMT what is HEMT and what is the historical view of this HEMT is present.

Chapter 3: This chapter is of Group III-Nitrides and their Introduction, Crystal Structure, Ternary Alloys, Dislocations in Group III-N, Polarization Fields, Thermal And Electrical Properties, The Choice Of Substrate, Sapphire(AL2O3) As Substrate, Silicon Carbide(SiC) As Substrate

Chapter 4: This tells about Physics Of High Electron Mobility Transistor, The HEMT Device And Operation Principle, The Two Dimensional Electron Gas, The AlN Exclusion Layer.

Chapter 5: This is detailed description of Device structure and description, Introduction and all the 3 modelled structures and finally operation principle.

Chapter 6: This is about Simulations and Results, Transfer Characteristics, Transconductance, Drain conductance, Cut-off frequency, Output Characteristics, Comparison of results of Model1 and Model, Transfer Characteristics, Output Characteristics.

Chapter 7: This is about Discussion and conclusions and Future perspective.

Chapter 2

Introduction to HEMT:

2.1What is HEMT:

HEMT high electron mobility transistors. HEMTs are also called as hetero structure FET or Modulation-Doped FET(MODFET). Basically, modern transistors control or amplify the currents. Transistors are of two types. Bipolar Junction Transistors (BJTs) and Field Effect Transistors. HEMTs comes under FETs with excellent high frequency characteristics. In FETs two different types of transistors are there, Enhancement and Depletion mode transistors. HEMTs usually works in depletion mode.

Two different bandgap materials comes into contact and make a junction. This is what will happen in HEMT. We will call this as heterojunction and it uses as the channel instead of a doped region. Mostly We will use GaAs as buffer layer on the top of it we will use AlGaAs. In all the combinations Indium Nitride gives better high-frequency performance, gallium nitride HEMTs gives high-power performance with this additionally high-frequency performance. We can use this HEMTs in integrated circuits as digital on-off switches. We can use these as the amplifiers. Both of these uses are made possible by the FET's unique current-voltage characteristics. Compared to ordinary transistors we can use HEMTs at high frequencies up to millimetre wave (30 GHz – 300 GHz) frequencies, and used in high-frequency products such as cell phones, satellite television receivers, voltage converters, and radar equipment. They are widely used in satellite receivers, in low power amplifiers and in the defence industry.

The High Electron Mobility Transistor (HEMT) is a commonly used transistor for microwave and high power amplifiers. Typical application areas are space radio telescopes and cellular phones. Conventional HEMTs use a Gallium Arsenide (GaAs) substrate with an Aluminium-Gallium-Arsenide (AlGaAs) top layer; but this has material limitations.

Popular material Combinations are GaAs with AlGaAs, GaN with AlGaN. In this GaN HEMTs have attracted attention due to their high power performance and high mobility. Group III nitride semiconductors consisting of Gallium-Nitride (GaN), Indium-Nitride (InN) and aluminium-nitride (AlN). However, these semiconductors are a lot harder to grow than the regular Si and GaAs semiconductors so not yet been able to compete with these. The group III-nitrides show some impressive material characteristics well suited for electronic applications. A broad range of GaN electronic-devices such as the bipolar junction transistor (BJT), heterojunction bipolar transistors (HBT) and the high electron mobility transistor (HEMT) have already been realized[1].

The group III-nitrides are classified as wide bandgap materials and become intrinsic at much higher temperatures than the regular Si, Ge and GaAs semiconductors[2]. This means that a GaN HEMT can operate at much higher temperatures with less cooling and does not need extra processing steps to maximize the heat extraction. GaN also has excellent electron transport properties with high electron saturate drift velocity. GaN also has a high breakdown field i.e. the ability of sustaining large electric fields which bodes for component downscaling[3]. Combining the features mentioned above gives a GaN based HEMT superior properties compared to GaAs one with power densities up to one order of magnitude higher.

The group III-nitrides have already established themselves as the next generation of optoelectronic materials. These wide bandgap materials enables construction of blue light emitting diodes which cannot be done with regular semiconductors such as Si, Ge or GaAs. This opens up a new possibility for manufacturing of large-scale full-colour displays and blue lasers. The blue laser has already been commercialised as the "blue ray" and has by now been implemented in the eagerly awaited Playstation[3]. However, opto-electronic components and devices are beyond the scope of this work.

Theoretical[4] and experimental[5] studies have shown that insertion of a thin AlN exclusionlayer between the GaN and AlGaN drastically changes the transport properties of the channel. Demonstrations in Ref. [6] showed that the electron mobility increased from 1308 to 2177 [cm²/Vs]. Another interesting mobility increasing modification of the AlGaN-HEMT is to introduce an AlGaN alloy into the GaN buffer layer. This version of the HEMT is known as the double heterojunction.

This Master's thesis is a study of how the AlN exclusion-layer affect the electrical properties of an AlGaN/GaN heterostructure. It contains simulations of the structures.

2.2Historical View:

The idea of world's first High electron mobility transistor was presented in the late seventies by a man called Takashi Mimura working at Fujitsu laboratories, Japan. Mimura and his colleges had problems with the growth and manufacturing of the device but could in January 1980 obtain the characteristics of the world's first HEMT transistor. The team published their results in March the same year as a transistor that could compete with the conventional GaAs MESFET in high frequency applications[7]. In 1985 the manufacturing knowledge had grown too such a level that the HEMT structure was announced as the device with the lowest noise characteristics in the world. The transistor quickly gained popularity and spread all over the world[8].

AlN nitride powder was first synthesized in the late 1920s by flowing ammonia over metallic Al at elevated temperature, and GaN powder was produced in a similar way some years later. Small crystals could be made from the powder but it was not until Maruska and Tietjen used hydride vapour epitaxy (HVPE) to produce GaN in the late 1960s that the material quality was improved[9]. Asif Kahn demonstrated the first AlGaN HEMT in 1994[3].

It is also worth mentioning that 2DEG was of big academically interest. The 2-dimensional electron gases that appeared in GaAs MOSFET's (the MOSFET is very similar to the HEMT in both appearance and operation.) lead to the discovery of the quantum hall effect by Klitzing in 1980. Klitzing got the Nobel price in 1985 for his discoveries and Laughlin, Stomer and Tsui later determined the properties of the quantum hall effect and where also rewarded with the Nobel price in 1998 for their work[8.].

Chapter 3

Group III-Nitrides:

3.1 Introduction:

The nitrides have properties that make them very suitable for high-frequency power and optoelectronic device applications. I gave the brief introduction of the Group III – Nitrides and their properties, Crystal Structure ect.

There is a research is going on the Group III – Nitrides those are of GaN, AlN and InN and their ternary compounds and their quaternary alloys. AlN and InN physical properties are not even well defined compare to the GaN one. In this chapter mostly we discuss the GaN properties.

3.2 Crystal Structure :

There are three possible crystal structures that the group III-nitrides can crystallize in, wurtzite, zincblende and rocksalt. Under thermodynamically stable growth conditions, the binary group III-nitrides and its alloys will naturally crystallize into hexagonal wurtzite structure. The wurtzite crystal structure is also thermally stable i.e. no phase or decomposition change will occur once it is formed. The zincblende and rocksalt structures are on the other hand metastable, which means that atoms do not crystallize in a stable minimum energy state. This causes the crystal structure to depose into a more stable phase during. The majority of all AlGaN HEMTs are grown with wurtzite.

The wurtzite structure has a hexagonal unit cell and consists of two sub lattices, one lattice that consists of the metal (Ga, Al, In) and one of nitrogen. The two lattices are then brought together and will therefore form the wurtzite. The offset of the two lattices is 5/8c and can be seen in Figure 2. Another way of saying this would be that the lattice consists of two altering atomic planes of Ga and N pairs in the (0001) direction stacked in an ABABAB sequence so that the atoms in the first and third layer are aligned directly on top of each other.

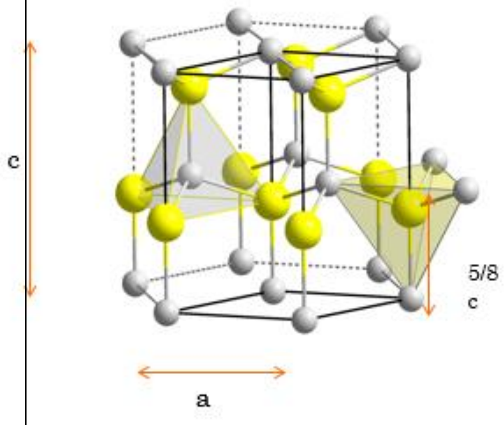


Figure3.1-Crystal Structure

Lattice Constant (A)	GaN	AlN
a	3.19	3.11
c	5.19	4.98

Table3.1-Lattice Constants

- **Yellow balls -Nitrogen**
- **Gray balls -Ga or Al**

3.3 Ternary Alloys:

Group III-nitrides consisting of GaN, InN and AlN all have unique properties. By mixing alloys of Al, In, and Ga their properties can be tailored. Ternary alloys use a notation with molar percentage x. For example $In_xGa_{1-x}N$, with x=0.7 means 70% In and 30% Ga incorporated in the lattice together with N[10].

Group III-nitrides and its ternary alloys have direct bandgaps i.e. band-to-band transitions can occur without phonon involvement. This makes the group III-nitrides with their alloys highly illuminant materials. SiC and silicon have indirect band gaps, this makes them low illuminant and not suited as an opto-electronic material[13]. The bandgap of a ternary alloy can be described with Vegard's rule

$$E\ Alloy\ (x) = xEA(x) + (1 - x)EB\ (x) - bx\ (1 - x)$$

where b is the bowing parameter of the alloy10. Often are the properties like stress, polarization and lattice constants linearly interpolated even though it is not fully correct14.

Combining Al and In would give the possibility to engineer the band-gap between 6.2 eV to 0.7 eV by simply changing the amount of Al or In in the alloy. This enables devices such as light emitting diodes (LED's) and laser diodes (LD's) working anywhere from the far infrared to deep ultraviolet spectral region[10].

3.4 Dislocations in Group III-N:

Dislocations are very common in the group III-nitrides grown today (typically ~ $10^8 - 10^{11}$ cm^{-2} in GaN) and crystal quality must be substantially improved in order to achieve better HEMT performance. Dislocations work like scattering centers for carriers in HEMTs and affect the electron mobility drastically, this phenomenon especially comes clear under high current densities.[2] It is not really fair to blame the all of the scattering of electrons only on the number of dislocations. To be a bit more specific impurity scattering by remote donors and due to interface charge, acoustic deformation potential scattering, piezoelectric scattering and polar-optical phonon scattering should be taken into count. However, the easiest way to get huge improvements in device performance would be to minimize the number of dislocations.[15]

The most common dislocations in pure GaN are screw and edge dislocations. Screws in GaN have a tendency to form small empty pipes and are usually called nanopipes (compared to SiC's bigger micropipes). However, all types of dislocations affect the device performance in the end in a negative way and scientists all over the world are trying to find techniques to get rid of them.[2] Shows how the electron mobility can increase in the 2DEG if the number of dislocations could be reduced.

Many dislocations in heterostructure are caused by the stress or strain that is built up from the differences in lattice and thermal expansion constants between epitaxial layers or substrates. A pseudomorphic epitaxial layer i.e. a non-relaxed epi-layer can be grown without misfit dislocations if the thickness of the layer is sufficiently small. However, if the layer on the other hand exceeds the critical thickness the layer will collapse and the result is a epitaxy layers built of small grains or with high values if dislocations instead of a continuous crystal. However, the stress or strain within pseudomorphic heterostructures gives rise to piezoelectric effects[11].

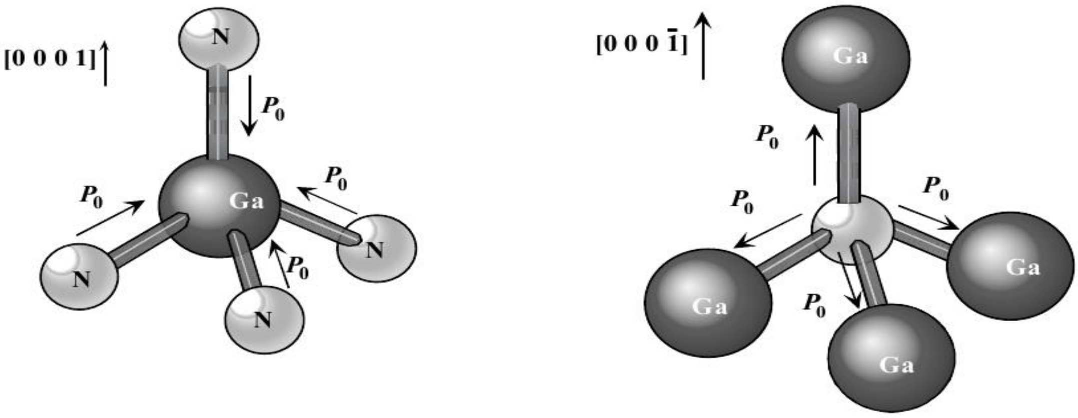
3.5 Polarization Fields:

Crystals without inversion symmetry become electrically polarized when they are elasticity strained and this phenomenon is called piezoelectricity. The strain on the solid pushes the atom out of their equilibrium position and the displacement of the atoms form a polarization field within the material. The cause of the strain in heterostructures is the misfit of lattice constants and thermal expansion coefficient like mentioned in the previous chapter. But strain can also be achieved by adding high amounts of impurities to the lattice16. The polarization can be expressed with the following tensor-equation.

$$\mathbf{P_i^{pz} = e_{ijk}\, \varepsilon_{jk}}$$

where 'e_{ijk}' are the piezoelectric coefficient tensor and 'ε_{jk}' the strain tensor. The piezoelectric coefficient tensor contains material constants and specific values for the nitrides can be found in Ref. [14] while the strain tensor is dependent on how the solid is exposed to the strain. For a biaxial (Figure 4) strained wurtzite layer all terms cancels in the tensor-equation except one component in the (0001) direction, this leaves Equation 3

Figure3.2-Polorization Fields in the Crystalline Structure

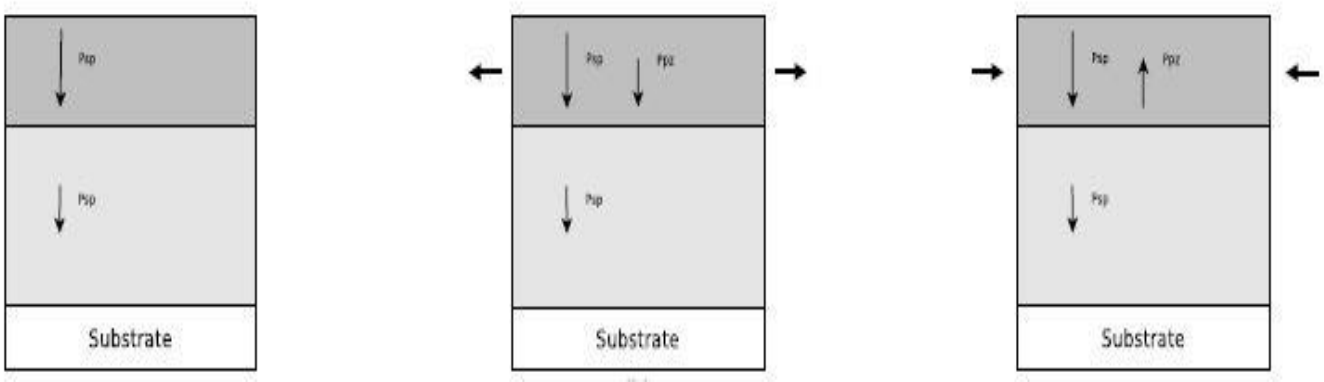


$$\mathbf{P^{pz} = 2\left(\frac{a-a_0}{a_0}\right)\left(e_{zx}-e_{zz}.\ \frac{c_{xz}}{c_{zz}}\right)}$$

where a_0 and a are the lattice constants without and with strain respectively and Cxz, Czz are the stiffness constants of the wurtzite lattice, which can be found in Ref. [14].

However, even in the absence of strain the lower symmetry of the wurtzite causes another type of polarization named spontaneous polarization. The spontaneous polarization is the result of the large difference in electronegativity between the group III metal and the nitrogen atom and this causes the III-N bond to be highly ionic. The lack of inversion symmetry in the wurtzite structure together with the highly ionic bond causes the spontaneous polarization fields[17]. Group III-nitrides posse two different polarities and the polarity of the crystal are dependent on what types of bonds there is along the (0001) direction i.e. if the cation (Ga) or anion (N) sites of the crystal planes are facing towards the sample surface. If the bonds go from cation (Ga) to anion (N), the polarity is said to be of Ga polarity and if the bonds go from the anion to cation, the polarity is said to be N polarity.[14]

Figure3.3-Pizeo electric and Spontaneous polarizations



The total polarization of the crystal is simply the sum of the spontaneous and pizoelectrical (Equation 3). In cation-face samples the spontaneous polarization field point away from the surface towards the back layer and vice verse in anion-faced.[14]

$$\mathbf{P_z^{total} = P_z^{sp} + P_z^{pz}}$$

The spontaneous polarization is larger than the pizoelectrical in AlGaN/GaN structures. But both spontaneous and pizoelectrical polarizations are very important to consider during the engineering of an AlGaN/GaN HEMT since it strongly affects the potential profile in the structure (see Chapter 4 for more details).[17]

3.6 Thermal And Electrical Properties:

The close packing with the strong bonding between atoms gives a robust, wide bandgap material with electrical and thermal properties superior to conventional Si and GaAs semiconductors. The table below compares some important electrical and thermal properties of some commonly used semiconductor materials.

Property	**Si**	**GaAs**	**GaN**
Bandgap E_g (eV)	**1.1**	**1.42**	**3.39**
Breakdown field (MV/cm)	**0.3**	**0.4**	**3.3**
Electron Mobility (cm^2/V-s)	**1350**	**8500**	**1200(Bulk),2000(2DEG)**
Maximum drift velocity(10^7cm/s)	**1.0**	**1.0**	**2.5**
Melting point temperature (^{o}C)	**1415**	**1238**	**2500**

Table3.2-Comparative Examination of Properties of Si, GaAs, and GaN

3.7 The Choice Of Substrate:

In theory would the best substrate selection for GaN epitaxy and device construction would be GaN itself. But, this is barely ever approached in practice since there are no large area, good quality, and low cost GaN wafers commercially available. Instead, it is very common to use heteroepitaxy to manufacture group III-nitride devices.[2]

It is very common that the lattice mismatch is the primarily criteria for the choice of the substrate. This does not really work out in reality for successful device manufacturing but at least gives an idea about what kind of substrates that can be used. The choice of substrate is often a balance of crystal structure, surface finish, composition, reactivity, chemical, thermal and electrical properties. All of the mentioned properties affect the epitaxy layers in some way and some common properties are summarized in (table 2). For device production process, there must be substrates available in sizes of 2 inches or larger at reasonable prices and there are not that many materials left that fit all these criteria's. There are especially two substrates left of interest, the silicon carbide (SiC) and sapphire (Al2O3).[2]

3.7.1 Sapphire(AL2O3) As Substrate:

Until 1985 GaN was deposited directly on sapphire substrates; this lead to a surface morphology as presented in with rough surfaces and crack formations. This was a huge problem and this is one of the reasons why the research on group III-nitrides is so far behind common semiconductors like Si and GaAs.

In 1986 Amano and his co-workers introduced a two-step growth process by inserting an AlN seed-layer between the substrate and the epitaxial layers grown at low temperature (~600 °C). This drastically improved the surface morphology as well as the electrical and optical properties. The insertion of the seed layer can be considered as the starting point of all modern research on group III-nitrides.[19]

Sapphire is the most extensively used substrate for growth of group III-nitrides and there is large area, good quality commercially wafers available at low cost. Sapphire has a large lattice mismatch (15%) to GaN and therefore has sapphire/GaN heterostructures generally relative high amounts of dislocation densities compared to SiC/GaN. The thermal coefficient mismatch of sapphire/GaN is smaller in the SiC/GaN case but still sufficiently large. Because of the poor thermal conductivity constant of sapphire (0.35W/cmK20), SiC is the best choice of for microwave power devices. Many groups have though demonstrated HEMT devices grown on sapphire but they usually have poor performance compared to HEMT structures grown on SiC substrates.[21]

3.7.2 Silicon Carbide(SiC) As Substrate:

SiC has some properties that are well suited for group III-nitride epitaxy. For example SiC is possible to manufacture in large quantities and there are large good quality wafers commercially available. SiC also has decently low lattice and thermal expansion coefficient mismatch with GaN (3.5 and 30% respectively). However, the mismatches are still sufficiently high to cause large densities of defects in the subsequent epilayers. Group III-nitrides grown on SiC are therefore usually under biaxial strain at room temperature and high amounts of dislocations caused by stress are very common. Even today's state of the art SiC wafers are far from free of dislocations; these dislocations may propagate into the subsequent epilayers and cause extra dislocations that degrade device performance.[2]

Growing GaN directly on SiC is problematic due to the poor wetting between these materials. This problem can be avoided with an AlN or Al1-xGaxN seed or nucleation layer just like in the sapphire case[19]. The AlN layer increases the wetting resistance between the GaN and the substrate and allows growth. The nucleation layer in the SiC case also decreases the number of dislocations because of the improved lattice match between GaN and AlN.

Pure SiC is insulating, but by inserting a controlled amount of impurities it is possible to alter the crystal's conducting properties[18]. From an electrical device design prospective the availability of conductive substrates is an advantage since contacts can be applied on the backside and thereby allow simplification of the device structure[2]. SiC is available with all kinds of impurity levels, from low-doped semi insulating to highly doped n++ and p++ substrates. The thermal conductivity is higher for SiC than for sapphire, which makes SiC better suited for high power devices such as the HEMT. SiC is rather expensive compared to sapphire.[18]

Chapter 4

Physics Of High Electron Mobility Transistor:

This Chapter is a brief introduction to the function and physics behind AlGaN and AlGaAs HEMT.

4.1 The HEMT Device And Operation Principle:

A transistor is a component for controlling and amplifying currents which is the fundamental building block for all modern electronics. Modern transistors are normally divided into two categories: the bipolar junction transistor (BJT) and the field effect transistor (FET). The HEMT, is one type of FET with excellent high frequency characteristics. A HEMT device has three contacts called drain, source and gate and the operation principle is as follows: Upon appliance of a source-drain voltage the current that passes through the device can be controlled by the gate voltage; this means in practice that the device can behave like a switch. The current that passes through the device is also amplified. An AlGaN HEMT usually works in depletion mode i.e. current flows through the device even without an external gate-voltage.[22] The voltage gate voltage necessary to stop the current flow between the source and drain is defined as the pinch-off voltage Vp.

The HEMT device consists of epi layers grown on top of each other with three contacts attached to the surface. The AlGaAs HEMT structure appearance is very similar to a GaAs MESFET. The only difference is the top layer, a MESFET has an n+ doped GaAs and a HEMT has an n+ doped AlGaAs layer (Figure 8). The operation principle of a MESFET is more or less identically to a HEMT with the use of a Schottky gate contact to deplete a channel.[23]

The appearance and the function of an AlGaN HEMT is on the other hand very similar to an AlGaAs HEMT. The AlGaN HEMT is also shown in figure and consists of a thin layer (~25nm) of $Al_{0.25}Ga_{0.75}N$ grown upon a semi insulating GaN buffer-layer (~2 µm). The high resistive or semi-insulating GaN layer is needed to avoid parallel conduction and thereby decreasing leakage currents of the device.[17] However, the AlGaN HEMT does not require an n+ doped top layer unlike the AlGaAs to operate.[23]

The operation principle of the HEMT device from a physical point of view is demonstrated in Figure 1, which demonstrates the behaviour of the conduction and valence -bands of an AlGaAs HEMT at different gate-voltages. The figure to the far left in Figure 1 is the bandstructure under zero bias (no gate voltage) and the figure to the far right in Figure 1 shows the structure biased with a gate voltage that exceeds the pinch off voltage, the picture in the middle have a gate voltage in between the other ones. When the gate voltage is zero there is a potential well or valley present at the AlGaN/GaN hetero interface. This valley is absent when the voltage exceeds the pinch off voltage and this energy valley is the reason why the device can either conduct or throttle a current.8 Inside this valley a two-dimensional electron gas will be formed, which leads to the next topic:

4.2 The Two Dimensional Electron Gas:

The 2DEG is usually a couple of nanometers thick. It is in this thin layer all electrons are gathered to minimize their energy. This thin channel is also known as a conducting channel where electrons travel from source to drain. The phenomenon of electrons gathering up in the channel originates from the bandstructure-bending in the junctions of a heterostructure.

When two or more semiconductors with different bandgaps are grown on top of each other a heterostructure is formed. Inside a heterostructure will the energybands bend because the Fermilevel, E_F, must be continuous over the entire heterostructure since the semiconductor materials are in contact.[16] ……….shows the conduction band of AlGaAs/GaAs junction, an energy valley or potential well forms at the heterointerface[1]. The low energy valley is the place with the lowest potential energy in the entire heterostructure. Since the well is very thin, electrons prefer to move sideways in two dimensions instead of up and down because otherwise they would have to move out of the well into a less preferable energy state.[16]

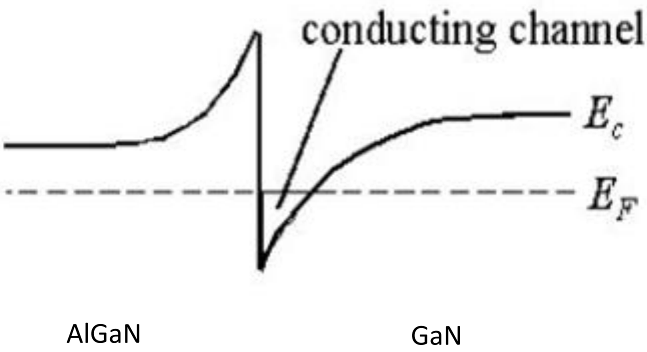


Figure4.1-Band Diagram of AlGaN and GaN

The physics behind the formation of the 2DEG described above is correct for an AlGaAs/GaAs heterojunction. The description is almost correct for an AlGaN/GaN heterojunction, but, the AlGaN-GaN heterojunction requires some special attention due to its polarization fields. The potential profile and amount of charges induced at the interface in an AlGaN/GaN interface are strongly dependent of the polarization fields that GaN and AlGaN materials pose.[14]

GaN is a strongly polar material, that is, it possesses a spontaneous polarization that leads to sheet charge accumulation on the end faces of the crystal. These sheet charges are, of course, equal in magnitude and opposite in sign to maintain overall charge neutrality. AlGaN also has a spontaneous polarization, similar to GaN but of different magnitude (in fact, a function of the aluminium content of the ternary). As a result, there is a discontinuity of the spontaneous polarization vector at the AlGaN/GaN heterointerface. Basic electrostatics states that such a discontinuity results in an interface charge proportional to the polarization difference. Furthermore, the strain resulting from growing lattice-mismatched AlGaN on GaN induces a piezoelectric charge, which supplies additional electrons to the HEMT channel.[14]

Most of the electrons in the 2DEG originate from the n+ doped AlGaAs layer in the AlGaAs HEMT. However, the AlGaN HEMT does not require an n+ doped top layer since group III-nitrides are polar materials. In fact, the polarization fields are so strong that it alone can provide high amount of electrons to the junction.[23]

4.3 The AlN Exclusion Layer:

The exclusion-layer AlGaN-HEMT is a regular AlGaN-GaN HEMT with a very thin layer (~ 1-3 nm) of AlN between the AlGaN and GaN layers. The idea behind this version of a HEMT structure is to minimize a scattering phenomenon called alloy scattering.25 The principle of the exclusion-layer AlGaN-HEMT and the alloy-scattering phenomenon is illustrated through the following scenario: In a regular AlGaN-HEMT the 2DEG is located at the junction between GaN and AlGaN, but there is not a defined border where the 2DEG starts or ends i.e. some of the 2DEG is located inside the AlGaN and some inside the GaN. The lattice of

AlGaN consists of Al and Ga atoms randomly distributed in a wurtzite lattice and when an electron travels through such a lattice some of the electrons will be scattered because of the atomic disorder, this is known as alloy scattering. AlN has a bandgap of 6.2 eV and this thin layer works as a barrier that prevents electrons from entering the AlGaN i.e. the AlN layer “pushes” all electrons of the 2DEG into to the GaN layer.26

The transport properties of the 2DEG in an AlGaN-HEMT were investigated in detailed by M. Miyoshi in 2005. Miyoshi and his co-workers modelled the electron mobility of the 2DEG through various kinds of scattering processes such as polar-optical phonons, acoustic phonons, pizoelectric fields, alloy disorder, interface roughness and dislocations. They lay down that the mobility of exclusion-layer AlGaN HEMT had similar transport properties as a regular AlGaN HEMT if alloy scattering was neglected.25

L.Shen27 and his co-workers first suggested the insertion of a thin AlN-epilayer in 2001 and they achieved electron mobility and a sheet charge density of 1522 [Vs/cm2] and 1.22*1013 [carriers/cm2] respectively as compared to a regular structure with 1200 [Vs/cm2] and 1.1*1013 [carriers/cm2] respectively. A bit more modern numbers (2004) can be found in Ref. [28] was the electron mobility was increased from 1308 to 2177 cm^2/Vs and sheet carrier density from 1.1*1013 to 1.21*1013 with and without the exclusion-layer.

Chapter 5

Device structure and description

5.1Introduction

Initially in this thesis work I designed a simple GaN/AlGaN structure. Then after introduces an additional layer called exclusion layer between GaN and AlGaN. After this I introduced one more layer between the substrate and the AlGaN this one is called nucleation layer. Both the above mentioned layers are of AlN with different thicknesses.

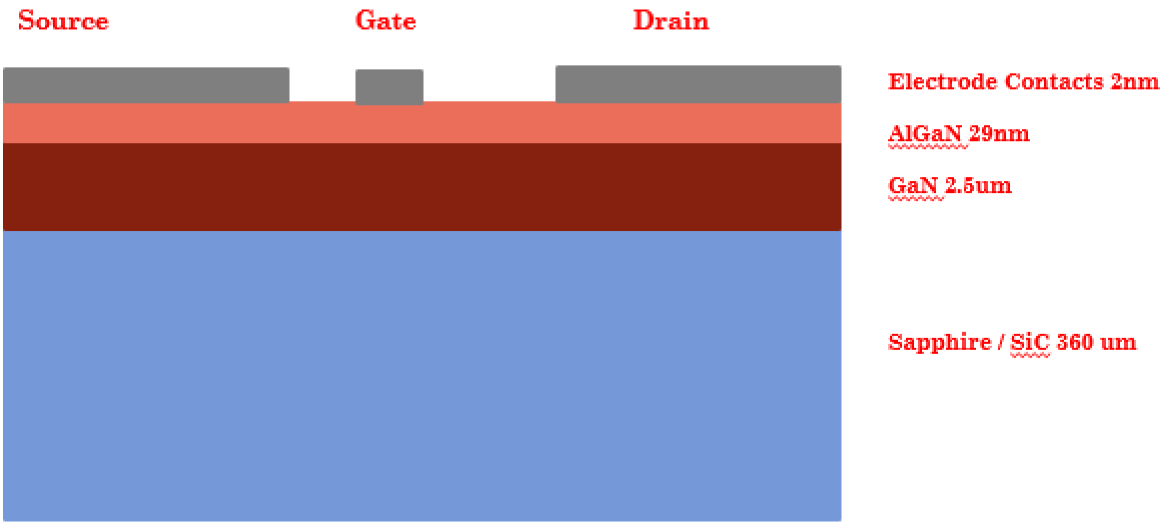


Figure5.1 : Structure 1.

5.2 Structure1 Description:

In the above structure the substrate is are of either Sapphire or SiC. It is of thickness 360 um. On the above of it GaN it is of thickness 2.5um. On the above of it AlGaN of thickness of 29nm. GaN/AlGaN is the heterojunction. Here the 2DEG will appear. The 2DEG is usually a couple of nanometers thickness. In this thin layer all electrons are gathered to minimize their energy. This thin channel is also known as a conducting channel where electrons travel from source to drain. The well is very thin, electrons prefer to move sideways in two dimensions instead of up and down, otherwise they would have to move out of the well into a less preferable energy state.

5.3 Structure2 Description:

The 2nd structure in the below figure is of spacer layer based structure of AlGaN/AlN/GaN HEMT. The layers description is from top to bottom Electrode Contacts/AlGaN/AlN/GaN, in this structure the 2DEG will form at the junction of AlN and the GaN interface. The emergy level diagram of the exclusion layer based HEMT is shown in the figure. And this is simulated using Silvaco TCAD. This is because the large bandgap between AlN and GaN.

In this structure the 2DEG is completely appear in the GaN. In the structure 1 the 2DEG is in between AlGaN and GaN. In this case there there are some obstacles for the electrons flow. In the second case the the entire 2DEG will be in the GaN buffer only so compared to the previous case in this one the electron flow will be higher. So the current is high compared to the precious one.

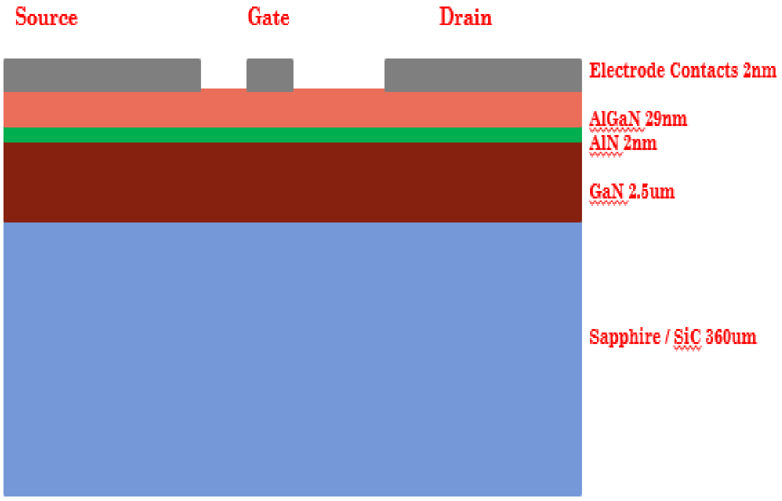


Figure5.2 : Structure 2.

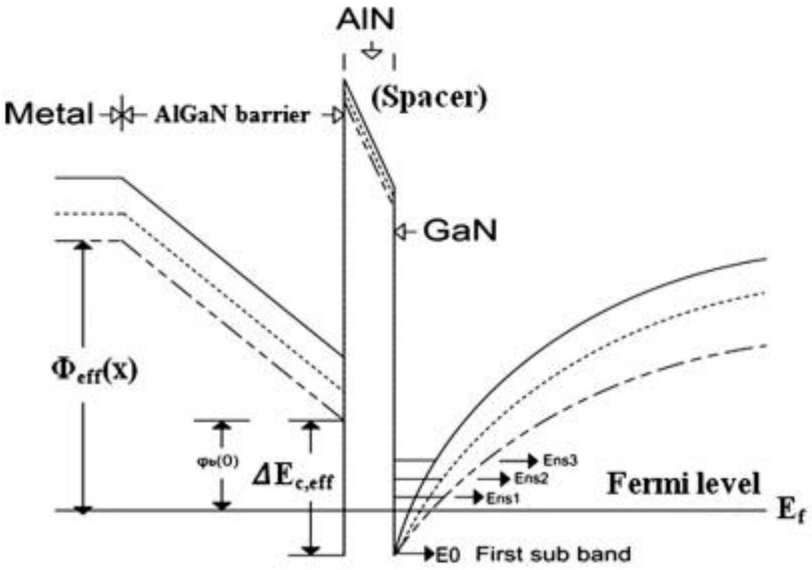


Figure5.3-Band Diagram of the above mentioned structure :

5.4 Structure 3 Description :

IN this 3rd structure it is almost similar to the structure 2 but we are including one more layer in between the

Substrate and the GaN layer to improve the structure and to decrease the dislocations. It will increases the electron flow and current flow. Compared to the above structures this one will give the better characteristics than before structures.

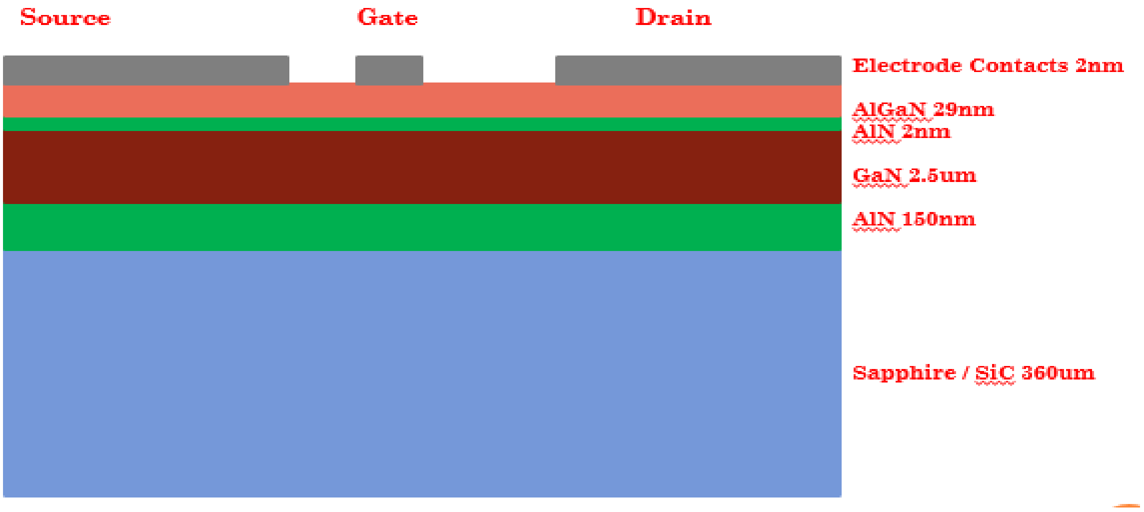


Figure5.4 : Structure 3.

5.5 Operation Principle:

This so similar to the FET. Like FET in HEMT device has three contacts called drain, source and gate. Drain and source are ohmic contacts and gate is a schottky contact. The source and drain are interchangeable and they are at constant voltage and at the same voltages. Current that passes from drain to source is controlled by gate voltage. The HEMT behaves like a switch. This will works in depletion mode i.e. current flows through the device even without an external gate-voltage pinch-off voltage Vp.

Chapter 6

Simulations and Results

6.1 Introduction:

For the simulation part we used the Silvaco TCAD tool. I already gave all the details about this in the previous chapter. In this I am giving all the simulated results with all the modelled structures. And in this I am going to show the comparisons between all the modelled structures.

6.2 Transfer Characteristics:

Transfer Characteristics is in between the gate-source voltage vs drain current. And in this I changed the gate-source voltage from -10V to 2V, and I observed the drain current change and I noticed and I recorded it. I observed all this at a constant drain-source voltage. (Constant Vds)

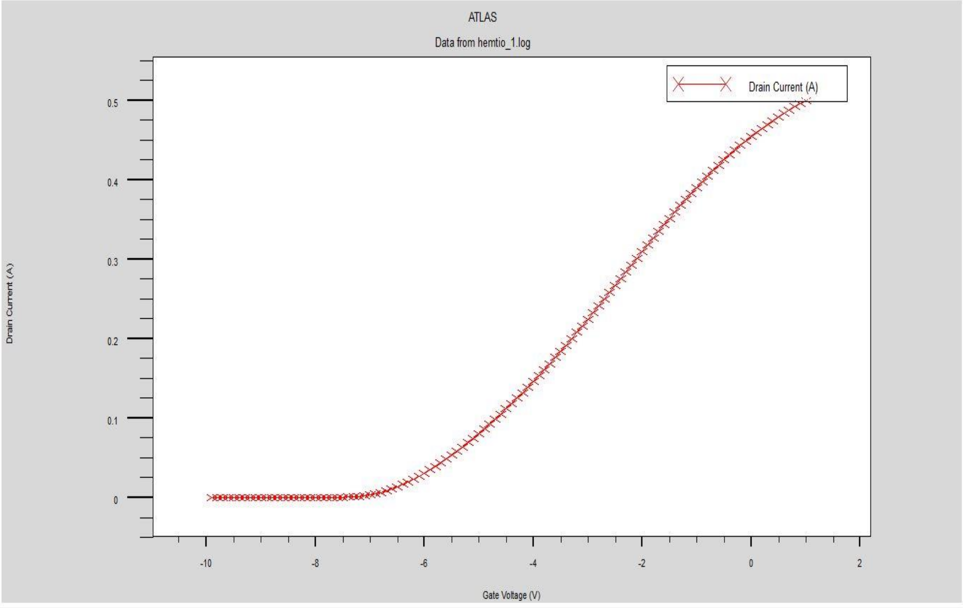


Figure6.1-Transfer Characteristics

Here is the observations and records. At constant Vds = 10V. The cutin voltage of the transfer characteristics is -7V. The Imax = 0.5A/100um that is equal to 5A/mm.

6.3 Transconductance :

By using transconductance we can analyse the microwave performance of the device. And using this we can say the current carrying capability of the device. By differentiating Id with respect to Vgs and Vd then we can get the transconductance gm and drain conductance gd. It is defined by

$$gm = \frac{dId}{dVgs}|Vd=constant$$

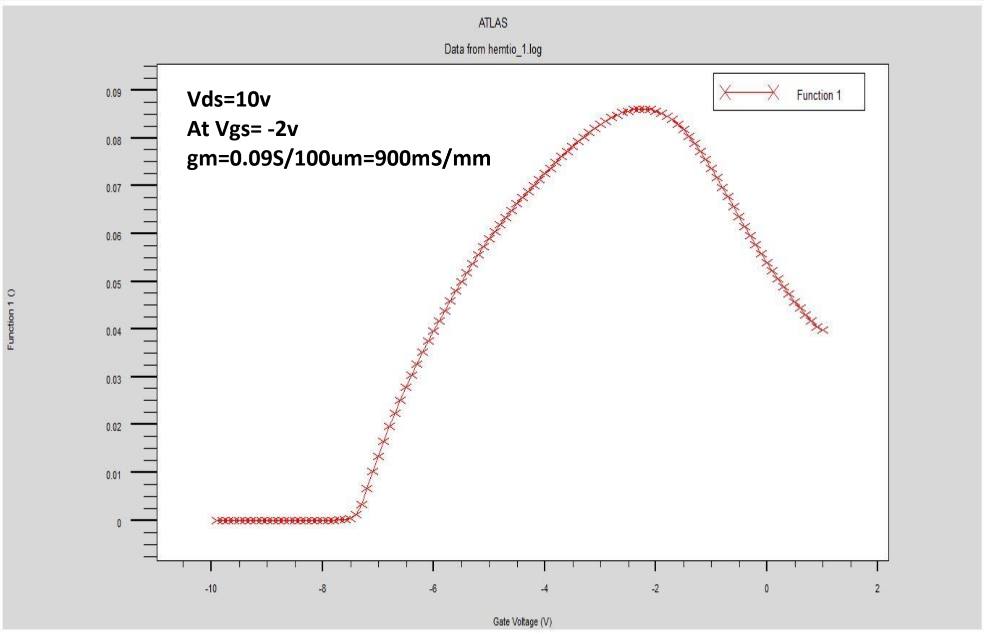


Figure6.2-Tranceconductace (gm)

This is the derivative of the previous graphs. At a constant drain-source voltage Vds = 10V.At Vgs = -2V the noted transconductance gm=0.09S/100um is equal to 900mS/mm.

6.4 Drain conductance:

The maximum voltage gain that can be achieve by the device we can get from the drain conductance.We can get the drain conductance as

$$gd = \frac{dId}{dVd}|Vgs=constant$$

6.5 Cut-off frequency:

Figure of merit for analysing HEMT performance at high frequencies like microwave frequencies the unity gain cuoff frequency (ft) will play a major role. The cutoff frequency is calculated using gm, Cgs and Cgd and the relationship is as follows.

$$ft = \frac{gm}{2*3.14*(Cgs+Cgd)}$$

We calculated cut-off frequencies at every Vgs vs Id graph calculations. In the below I am Giving the details about this. We calculated this for every Vds from 1volts to 30volts in the steps of 1V. The below figure shows this.

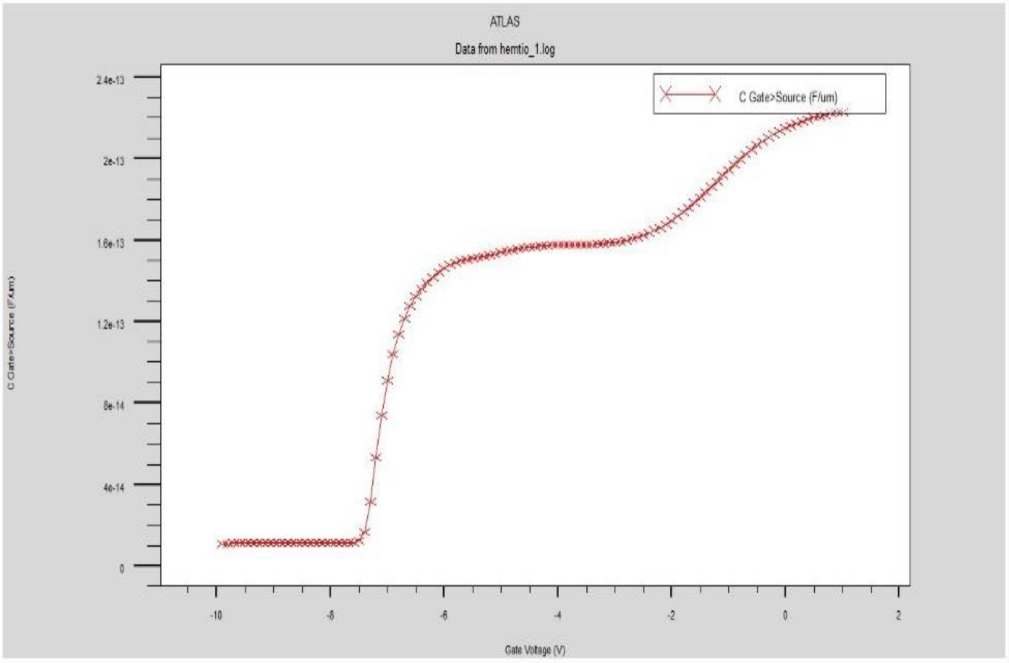


Figure 6.3-Capacitance between Gate-Source(Cgs):

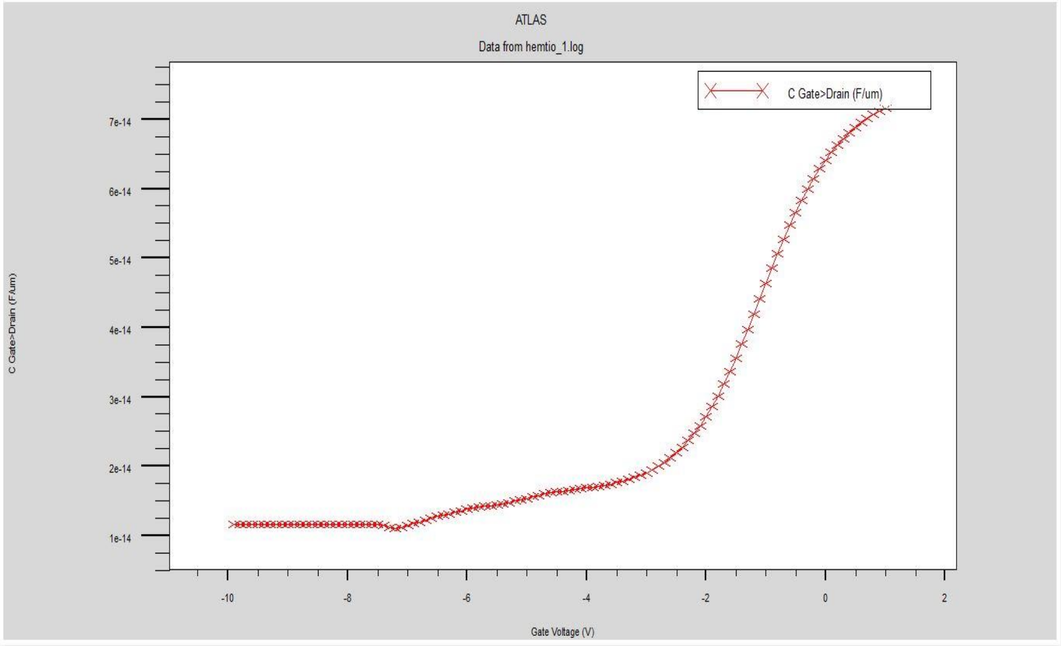


Figure 6.4-Capacitance between Gate-Source(Cgd):

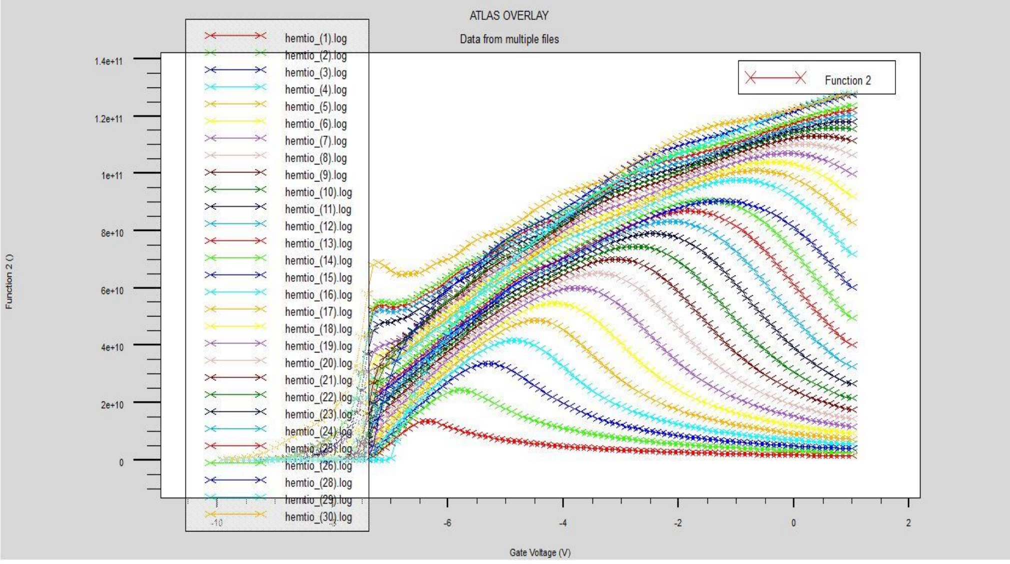


Figure6.5- Ft at different Vds ranging from 1V-30V ft at Vds=10V

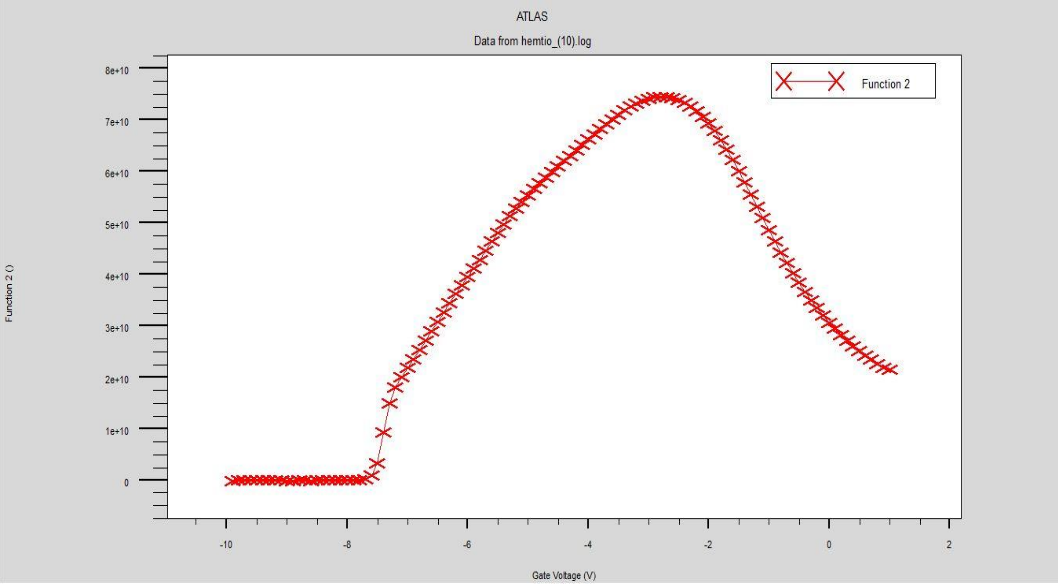


Figure6.6- Cut-off frequency at Vds=10V (ft)

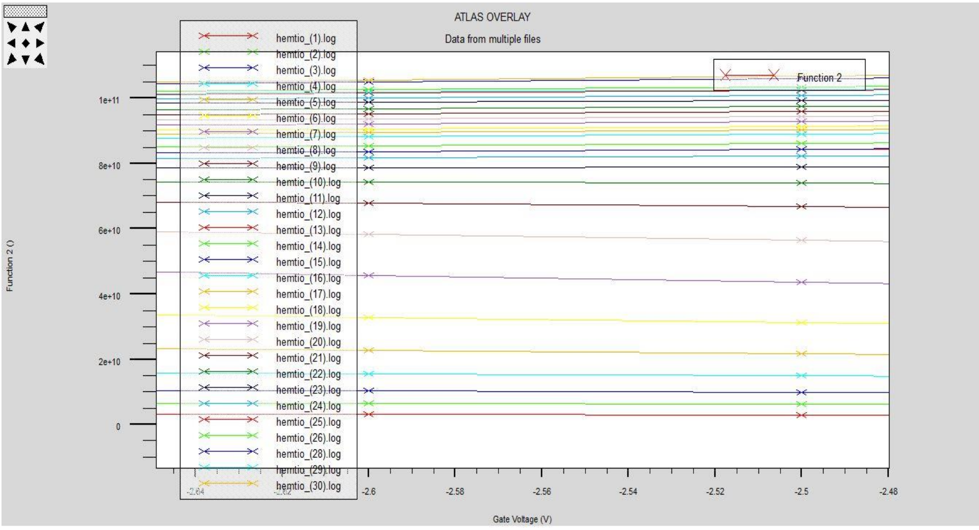


Figure6.7- Zoomed one ofFt at different Vds ranging from 1V-30V

6.6 Output Characteristics:

In this the graph is between drain voltage and the drain current at different constant gate source voltages. The Vgs is changed from -7V to 1Vs.

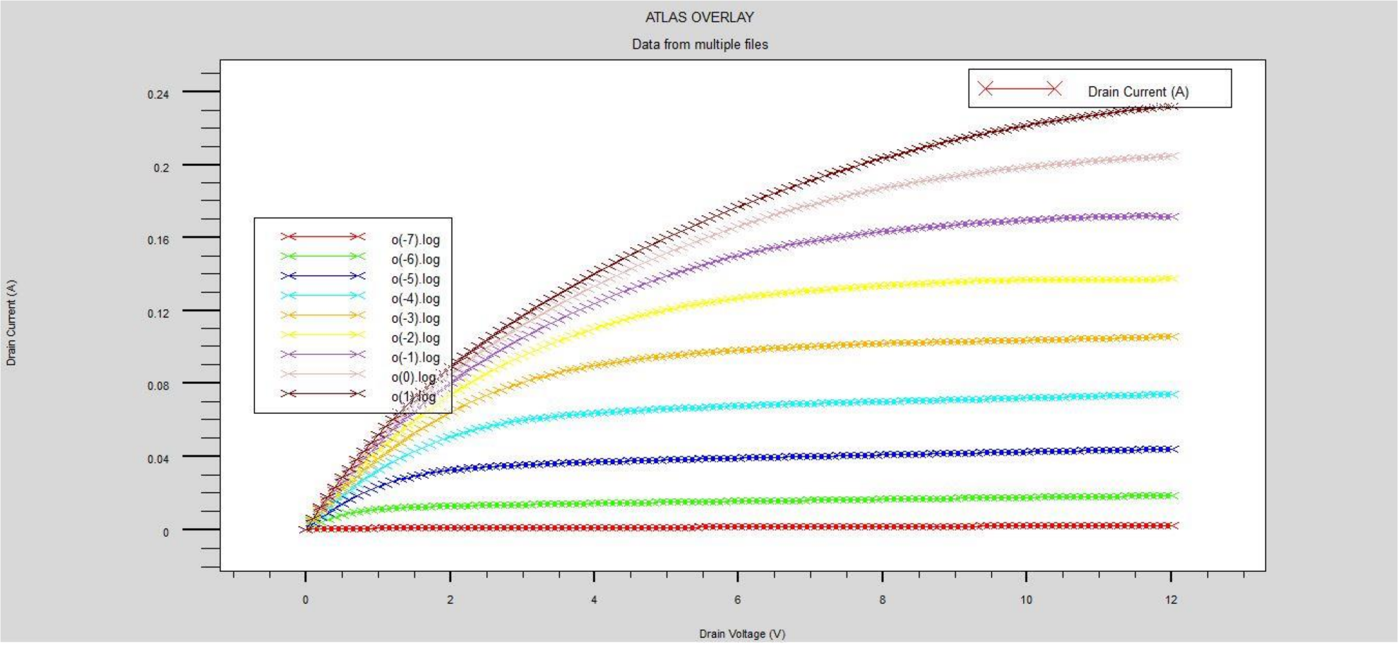


Figure6.8-OutPut Characteristics of Model3

HEMT Parameters to be controlled by silicon nitride passivation

- **Idss (DC and Pulse)**
- **Gate revrse leakage current**
- **Knee Walkout**
- **Gate-Drain Breakdown Voltage**

6.7 Comparison of results of Model1 and Model 2:

6.7.1Transfer Characteristics:

We are comparing transfer characteristics of the model1 and model2. In the model2 we introduced a layer called spacer layer or exclusion layer in between the GaN and the AlGaN. There is an increment of 11.1 % in the current.

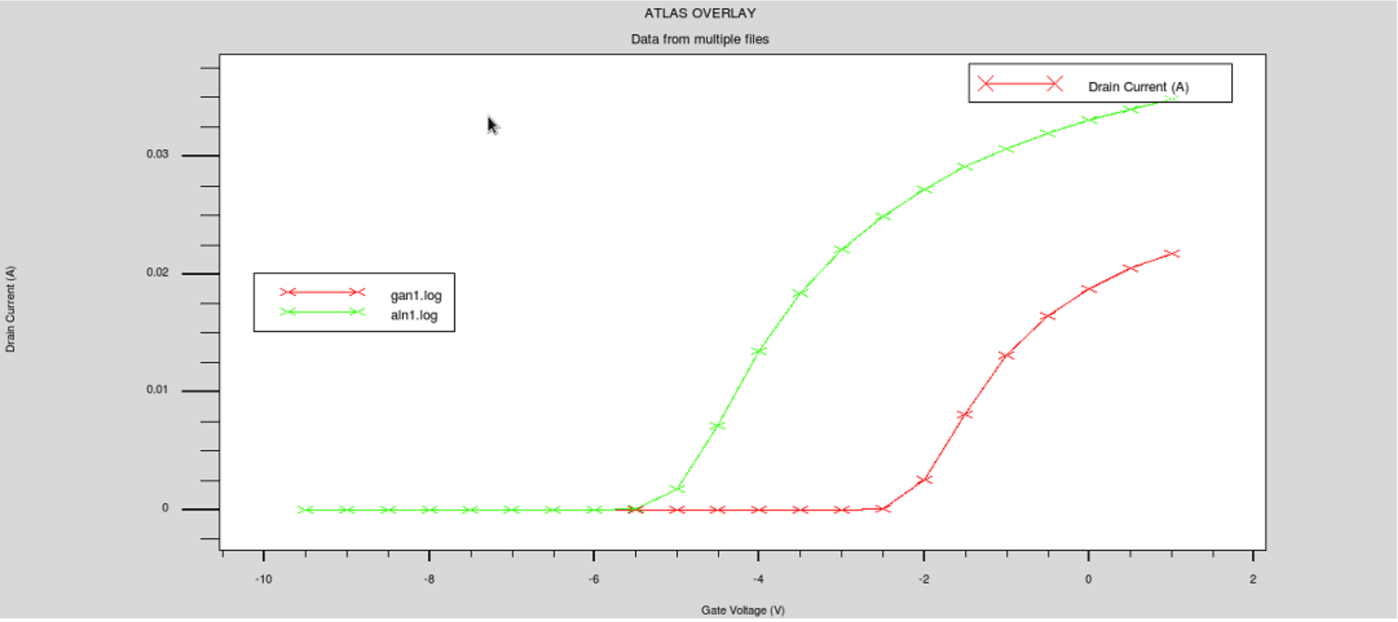


Figure6.9-Comparision of Transfer Characteristics of Model1 and Model2

6.7.2 Output Characteristics:

The Output characteristics is between the output voltage that is Vds and the output current that is Id. Here the compared results of model1 and 2.

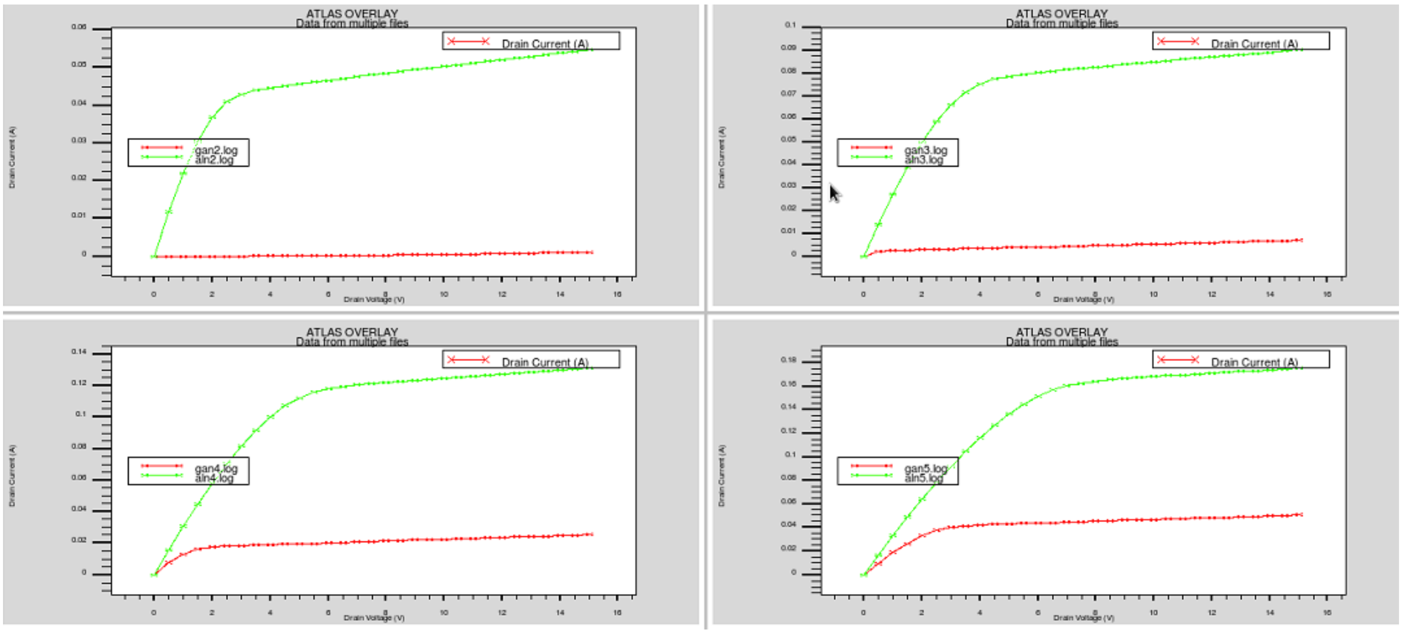


Figure6.10-Comparision of Output Characteristics of Model1 and Model2

Chapter 7

Discussion and Conclusions

7.1 Discussions

The thesis work consist of design and simulation of the HEMT. In this thesis work I mentioned three different types of models. In the everey model from one to other I am trying to improve the electron flow and the current conductivity of the device. The structure 1 is of a simple GaN HEMT. In the second one I introduced a layer called spacer layer or exclusion layer. This layer is of AlN. In the structure 1 the 2DEG will appear in between the GaN and the AlGaN junction. In the 2nd structure we are introducing a AlN layer because of this the the whole 2DEG will come to the GaN buffer layer. Because of this the the there is huge increase in the flow of electrons in the device. Because of this the current flow is increases. With this the transconductance will increases. The main motive of this thesis is have to use the HEMT for high frequency and high power applications. In the next structure that is model 3 I introduced one more layer of AlN as nucleation layer. It increases the compatibility between the substrate and the buffer layer. In the all the structures the substrate is of SiC or Sapphire. The buffer layer is of GaN. With this the formation of the dislocations in the GaN is also decreases so the current floe capability will increase in the device.

The applications of the HEMT in high frequency are very high. Mostly we can use these HEMT in RF electronics systems. Today the power amplifiers are the main area of GaN adoption for these applications. In this the usage is mostly in Wireless Communications, Defence and data broadcast.

In wireless communication LTE long term evolution 0.7 to 2.4 GHz, WiMax 2.3-5GHz. In radar communications the frequency of 2.4 to 12 GHz. In data broadcast CATV want less than 1GHz, Satellite Communication 13-14GHz frequency of transistors needed, in V-Sat 12-40GHz needed. These are the main areas of usages and applications.

The second lasrge consumer of the RF power, the military/defence market can be split into four major end users of dense electronics systems are EW(Electronic Wafare)/IED(Improvised Explosive Device)jammers, Military radars, Electronic Countermeasures, Military Communications.

The power and frequency domain of different transistors are like compared to BJT's the GaN devices are with reduced size and compared to them we can use these for high frequencies. Coming to the power GaN devices we ana use for high power applications.

7.2 Conclusion:

In this thesis work a high speed switching AlGaN/GaN high electron mobility transistor (HEMT) of gate length 1um with incorporation of AlN as a spacer layer of width 2nm and as a nucleation layer of width 150nm. The modelled device gives maximum ON current of 1.8A/micron with a high cut-off frequency of 99GHz and a high switching ratio Ion/Ioff = 10^6 at supply voltage of 10V. This device at a constant drain-source voltage i.e Vds=10V gives a cut-in voltage of -7V and maximum current i.e Imax=5A/mm and a constant drain-source voltage i.e Vds=10V and constant gate-source voltage i.e Vds=-2V gives transconductance i.e g_m=900mS/mm. Thus the device proposed gives superior characteristics in terms of switching speed, switching ration, .high currents, high cut-off frequencies and high break down voltages and becomes a promising candidate for high frequency and high power applications.

7.3 Future Prospects

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PART B:

Developing Child Scheduler Application for SMART TV

Chapter 1

Introduction

1.1Motivation:

Now a days it's a very big problem of parents to control their children by not to make them use of the TVs, computers, smartphones, tabs. Now a days every children know how to use them and they are addicted to the internet gadgets. But for computers, smart phones and all we can set a loch at least. In some sense we can lock the devices. So in this app we are locking the TV.

Child Scheduler app is Smart TV application that monitors and controls the duration of content viewing for children. The users are required to create user ID and password once. Registered users can login to the app and set time duration for the viewing TV by children. The app monitors the time duration and stops viewing content when time limit is reached on real-time. Viewing duration can be further extended by users by providing login credentials again. Date and time of watching TV by children can also be scheduled earlier by the users.

This application provides a good way to monitor children to watch content is good for them and restricting other content. TV watching date and time can be scheduler earlier, so users don't need to schedule every time their children need to watch TV.

1.3 Approach:

Once the app is installed in the Smart TV and the user opens the app. If it is the 1st time user is opening the app then it will ask for the user name and password. Once user successfully registered the 1st page takes the user in to the next page. Here they have to set the time. Starting time and Ending time. The duration between this time they children can watch the TV. After the end time it will ask for the username and password again for the users. If they want to continue the time of watching TV. They have to extend the time by login in to the app again. For starting time and ending time we have to enter 4 digit number. In this 1st two digits represents the hours next two digits represents the minutes. Once user entered the input it will check the duration in between them it always should be a positive number otherwise it won't save user data. The date which is entered by the user is always positive. User can repeat this every day or which day user want to repeat it. For this 7 options will be there. Where ever user put a tick mark it will save as "y" otherwise save as "n". Totally the input have the 16 variable 8 digits for time and for 7 y or n for days. It will save everything in the single variable.

First resolve filesystem. Next find the path of filesystem. Create the directory. Resolve filesystem again. Next Resolve directory. Create File. This is a text file. Write we can write as many times. Next one is read. Next one delete file. Next is delete directory. List files it will give the remaining files which are remaining in the filesystem.

1.2 Thesis Outline:

Chapter2 provides the Introduction to Smart TV, Tizen OS, Java Script, HTML,CSS. What is the advantages of Tizen OS over Android.

Chapter3 It gives the Objective of the present work, app development process flow.

Chapter4 provides the details of work plan and the methodology. Stages of the application launch process. Step by Step process of child scheduler app development.

Chapter5 Tools and languages It gives the details of the Tizen 2.5 studio. What are the languages are using to develop the app.

Chapter6 This is about the discussion and conclusion.

Chapter 2

Introduction

2.1 Smart TVs:

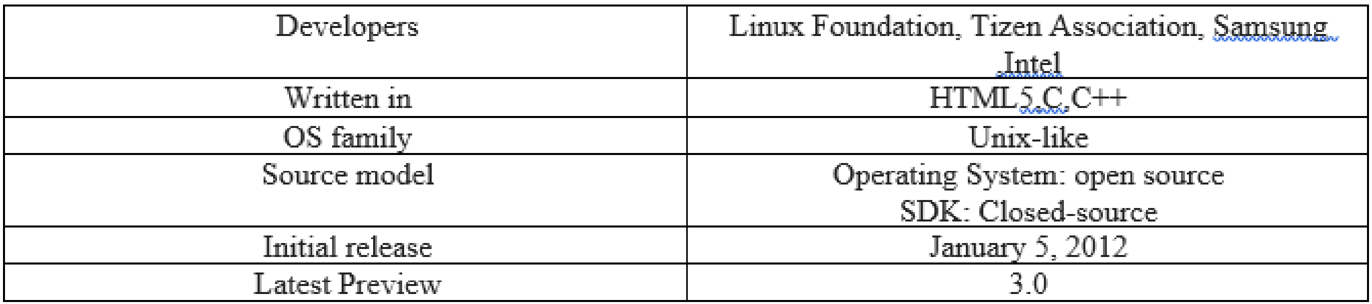
The other names for the Smart TVs are connected TV and hybrid TV. Smart TV is an advanced version of the Television. We can use Smart TV as mini Computer and we can use it as Television and also as set-top box. It provides internet. Besides the advantages of TV and set-top boxes we can use internet facilities and online internet media, over the top content (OTT) and on demand streaming. The manufacturers will load the Operating System in the Smart TVs. Many useful Applications are loaded with the OS in the Smart TVs and if we want we can install new applications via an app marketplace. We can uninstall the apps which are already installed. If the updates are available we can update the available apps same as a smart phone. The upcoming preloaded Operation System(OS) in Samsung Smart TV is **"Tizen".**

2.2 Tizen OS:

Tizen is an Operating System. It's based on the kernel of the linux and library of the GNU C. Linux Application Programming Interface (API) is implemented by the Tizen OS. It works on every variety of the devices almost in all the devise like smartphones, in-vehicle infotainment(IVI), tablets, Smart Cameras, PCs, Wearable Computing like watches, BD's(Blue Ray Players), Printers, Smart Home appliances like refrigerators, washing machines, lighting, air conditioners, ovens/microwaves and robotic vacuum cleaners. The Tizen OS wants to provides a done in the same way over time user experience across all the available devices. In the linux foundation Tizen OS is a project. About this project everything is look after by the Technical Steering Group.

The Tizen OS is incorporating and the developing only by the Samsung. The upcoming all the devices of Samsung is preloaded by the Tizen OS. Samsung made Tizen as a grate part in the device production.

Samsung released a smart camera which is preloaded by the Tizen OS. It was released on October 2013 in South Korea. Systena released the 1st Smart Tablet which was preloaded by the Tizen OS in June 2013. It's an 10-inch quad core ARM with resolution of 1920*1200. In 2014 Samsung released the Smart watches with preloaded Tizen OS. Samsung released smartphones of 3 series Z1,Z2 and Z3 are based on Tizen OS.



Developers	Linux Foundation, Tizen Association, Samsung, Intel
Written in	HTML5,C,C++
OS family	Unix-like
Source model	Operating System: open source SDK: Closed-source
Initial release	January 5, 2012
Latest Preview	3.0

Table2.1 Tizen Details

2.3Advantages of Tizen over Android:

- Compared to the android the Tizen have the faster start-up.
- Scrolling so smooth for the Tizen OS devices. And it gives a very good performance for the web browsing.
- In Tizen there are so many advanced 3D graphics.
- Like an Android preinstalled devices the Tizen OS preinstalled devices are also do multitasking and in this also multi touch availability is there.
- And compared to all Tizen have the advanced version with 64-bit processor. The new version of the Tizen that is version 3.0 have the 64-bit processor. This is the one which google is still working on this and want to add in to the upcoming version.

2.4Advantages of Tizen:

- It supports the JavaScript, HTML5 and JQuery.
- From the version 2.0 onwards Tizen was started providing the Native Applications including with Web Applications. Previous version of Tizen only have the web applications.
- It has a very friendly SDK software development kit. Tizen is a open-source but the SDK is closed source.
- It supports the all the apps which the Android will support in the devices.

Developing of apps for Smart TVs which can be running on the preloaded Tizen OS devices require the knowledge of JavaScript, HTML5. Develop and deploy of apps over the Smart TVs or over cross platforms devise we need above languages.

2.5Architechture of the Tizen OS:

There are three layers in the Tizen OS architecture. Application Layer, Core and finally is the Kernel. In this there are inner layers also there. In the Applications Layer there are 2 types of applications are there. One is Native Apps and 2nd one is Web Apps. In the previous versions there are only Web apps are available. But from the version 2.0 native apps are also available.

In the Core one layer is called Application Programming Interface of Web Apps are there it also called Web Apps Frame Work. Same Frame Work Of the Native apps are won’t be in this layer. It included in the Components of core layer. Next layer is of Kernel in this linux kernel is there and the drivers will be available here.

In the coming chapter I am going to explain the Native and web apps clearly. What is meant and when we have to use and what are the requirements and advantages over one another. And I will explain which app is we are going to develop in this work .

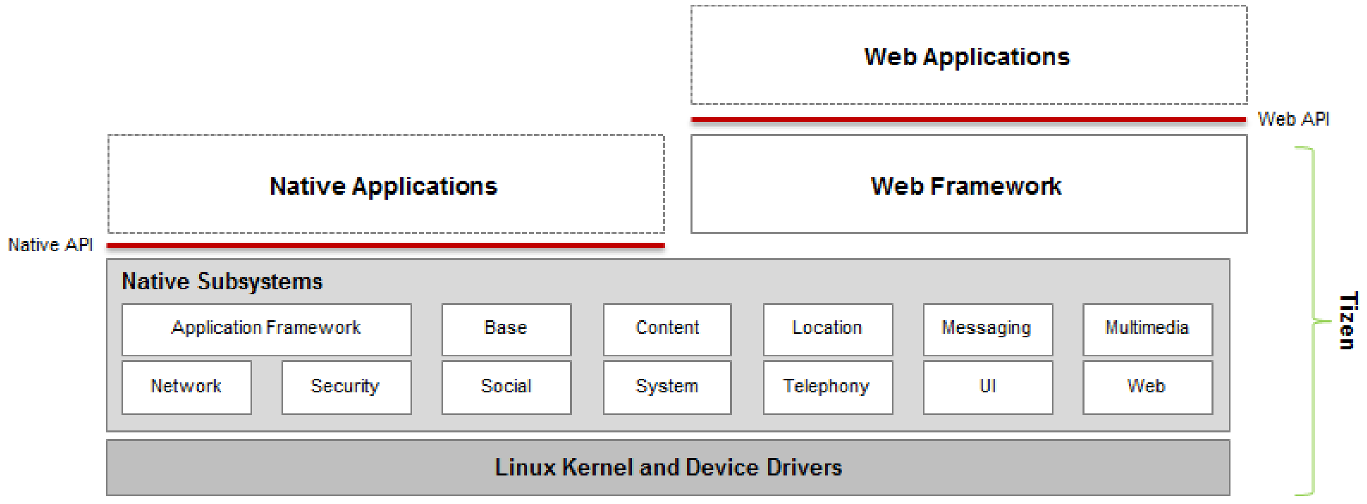


Figure 2.1.1 Architecture of Tizen

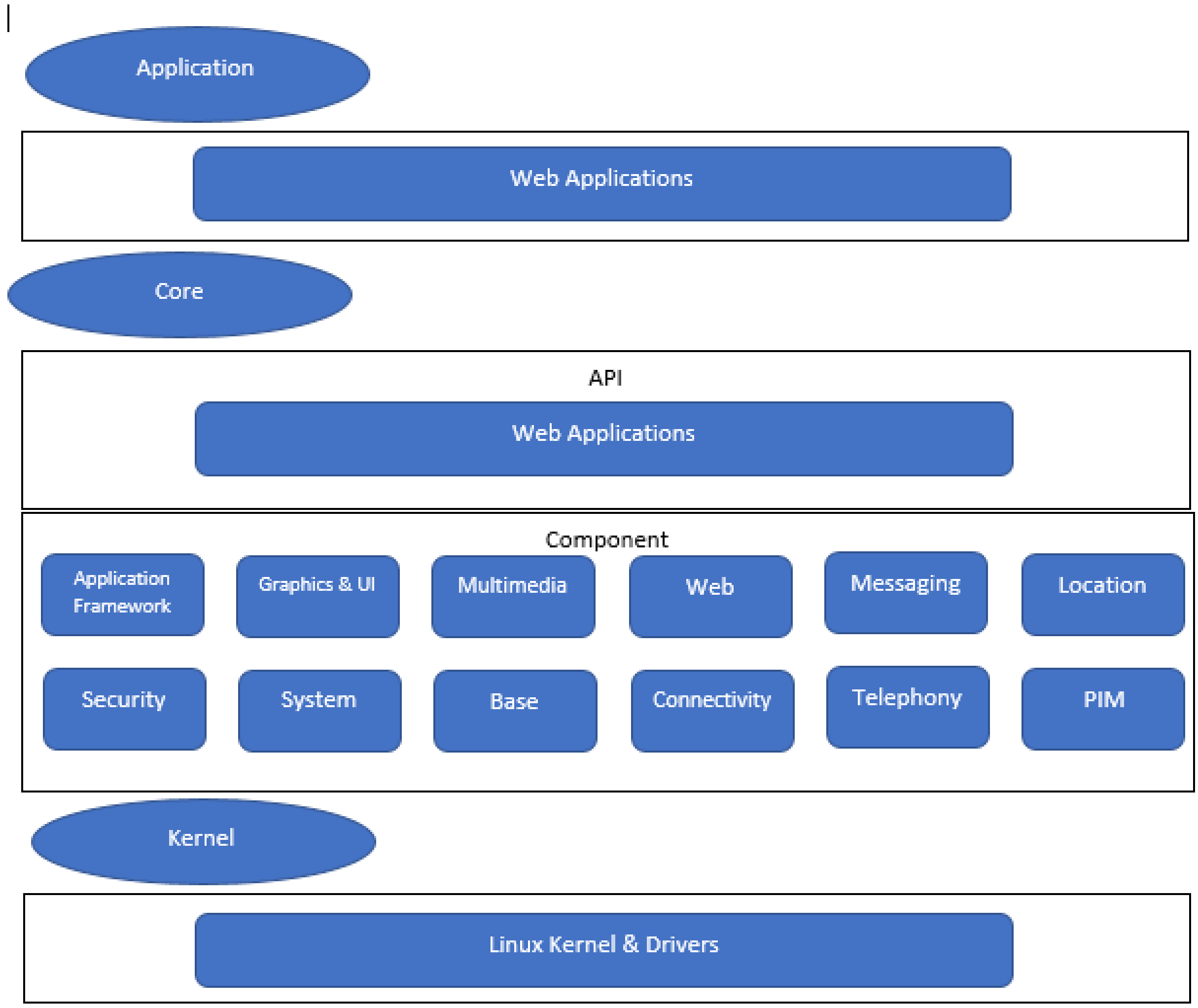


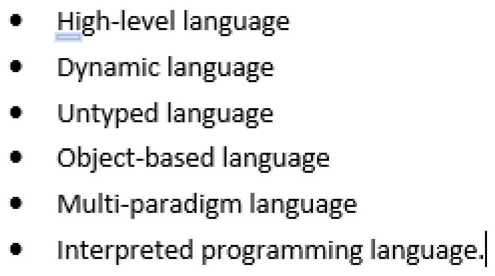
Figure2.1.2 Architecture of the Tizen OS

There are three main core technologies are there for content production of World Wide Web(W3C). Those are

- JavaScript(JS)
- Hyper Text Mark-up Language(HTML)
- Cascading Style Sheets(CSS)

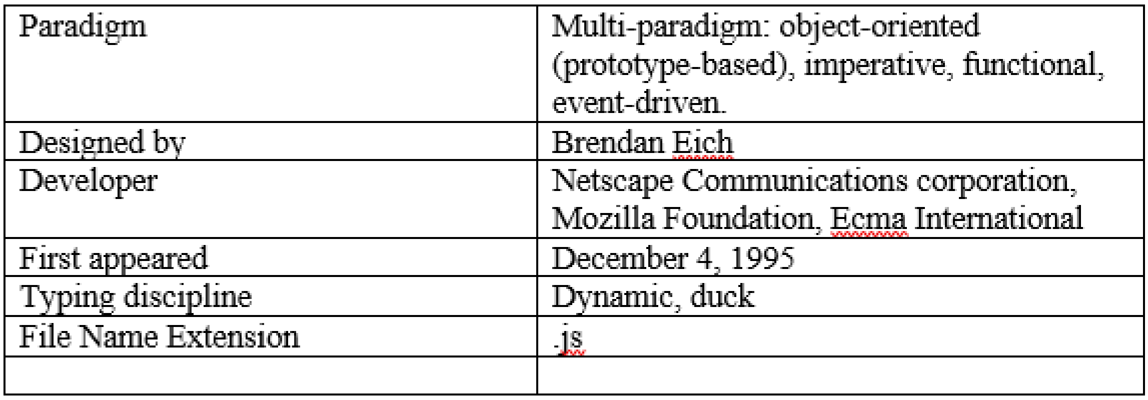
2.5JavaScript:

JavaScript is one of the scripting language which is a high-level programming language (HLL).



- High-level language
- Dynamic language
- Untyped language
- Object-based language
- Multi-paradigm language
- Interpreted programming language.

Without need the of plug-in's JS supports all the modern web browsers.



Paradigm	Multi-paradigm: object-oriented (prototype-based), imperative, functional, event-driven.
Designed by	Brendan Eich
Developer	Netscape Communications corporation, Mozilla Foundation, Ecma International
First appeared	December 4, 1995
Typing discipline	Dynamic, duck
File Name Extension	.js

Table2.2JS Descriptions

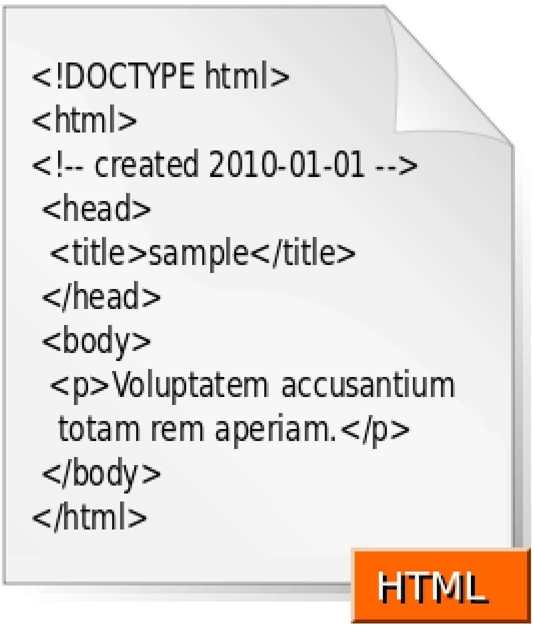
2.6HTML:

Creating of Web pages and Web applications HTML(Hyper Text Markup Language) is a mark-up language. This is the reason of appearance of the websites and structures of the webpages. From the web servers or local renders web browsers receive documents of the HTML convert them in to multimedia web pages.

Building blocks of HTML pages were the HTML pages. With HTML constructs, images and other objects, such as interactive forms, may be embedded into the rendered page. It provides a means to create structured documents by denoting structural semantics for text such as headings, paragraphs, lists, links, quotes and other items. HTML elements are delineated by *tags*, written using angle brackets. Browsers do not display the HTML tags, but use them to interpret the content of the page.

File name	.html
Extension	.htm
Internet media type	Text/html
Type Code	TEXT
Developed by	W3C & WHATWG
Initial release	1993
Latest release	5.0
Type of format	Document file format

Table2.3 HTML Details



```
<!DOCTYPE html>
<html>
<!-- created 2010-01-01 -->
 <head>
  <title>sample</title>
 </head>
 <body>
  <p>Voluptatem accusantium
   totam rem aperiam.</p>
 </body>
</html>
```

Figure2.2Example of HTML

2.7Cascading Style Sheets:

Documents commonly wrote in mark-up language, if we want to add some style to your body or your page for this we will use the Cascading Style Sheet language. We can use the same CSS file for any XML document.

Initially it was developed to give a gap between the presentation and the content like layout, font, colours and all. This will increase the accessibility of content and in the specification of presentation it will gives the more flexibility and control. We can use the same .css file for any HTML page and multiple HTML pages at a time if the .css file suits the specific requirements. In structural content this will reduce tht repletion and complexity.

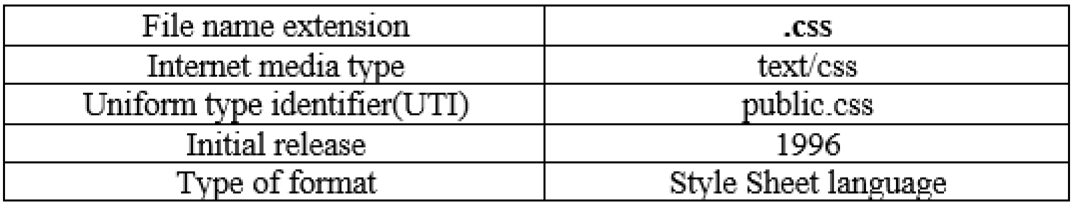
It can even change the graphics design of HTML documents. We have to edit few line in the CSS file that's it. It is very easy task. Depending upon the screen size and viewing device it can display the webpage differently in different devices.

If for a particular element or a document we can apply more than one CSS file then there is a priority scheme is there it will take care of this and gives which to apply and which suites more. World Wide Web Consortium will take care of the all the specifications of the CSS.

```
h1 { color: white;
  background: orange;
  border: 1px solid bla
  padding: 0 0 0 0;
  font-weight: bold;
}
/* begin: seaside-theme */

body {
  background-color:white;
  color:black;
  font-family:Arial,sans-serif;
  margin: 0 4px 0 0;
  border: 12px solid;
}
```

Figure2.3CSS example



File name extension	.css
Internet media type	text/css
Uniform type identifier(UTI)	public.css
Initial release	1996
Type of format	Style Sheet language

Table2.4 CSS Details

Chapter3

Application Description

3.1 Description:

Child Scheduler app is Smart TV application that monitors and controls the duration of content viewing for children. The users are required to create user ID and password once. Registered users can login to the app and set time duration for the viewing TV by children. The app monitors the time duration and stops viewing content when time limit is reached on real-time. Viewing duration can be further extended by users by providing login credentials again. Date and time of watching TV by children can also be scheduled earlier by the users.

This application provides a good way to monitor children to watch content is good for them and restricting other content. TV watching date and time can be scheduler earlier, so users don't need to schedule every time their children need to watch TV.

When we are going to develop an application first we have decide which type of app we are planning to develop. This is of two types. One is of native apps and another one is of web apps. In this work I develop an web app. Basically what is the difference in the native and web app is native apps we will writ in c/c++. But coming to the web apps we will write this one in JavaScript and HTML. If we want present that in an nice way then we will use CSS. And native apps didn't need the internet connection once we downloaded or preinstalled in the device. And web apps are enabled internet apps. To use these apps they need internet. And native apps are designed particular devices. But web apps are not like this. Example of native app is camera in the mobile. Compare to native apps web apps are easy to develop. And compare to web apps native apps are more accurate in the sense web apps are having their own limitations in application.

3.2 Objective of present work:

The objective of present work is to develop a Smart TV application "Child Scheduler" which can monitor and control content viewing for children.

Development of Smart TV app will be achieved as follows:

- Understanding the architecture of the SMART TV.
- Understanding JavaScript and Tizen Studio 2.5.
- Developing the application.
- Bug fixing.
- Feature testing.
- Deploying the app on Smart TV.

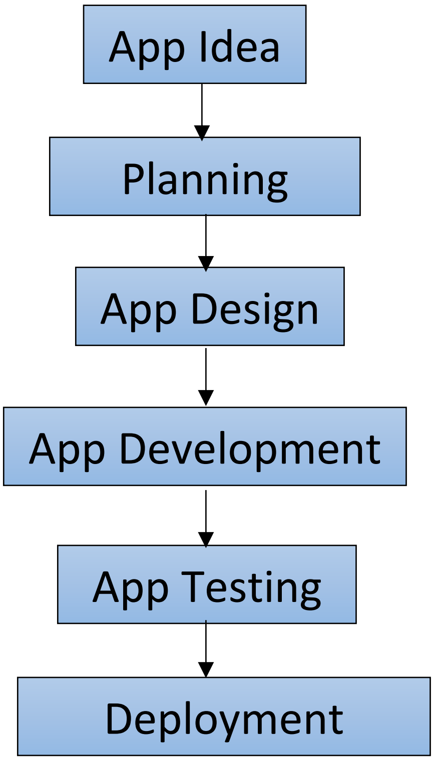
In the 1st we have know all the things about the architecture of the SMART TV. And we have to design a suitable app for this architecture. The usage of the app also plays a major role in the development. And which type of we are going to develop. Native app or web app based on this the language will change. Native apps will developed in c and the web apps are develops in JS,HTML. In this I developed an app which is of web app. So all of my code will be in JS and HTML only.

The very next step is to know about the language in which we are going to develop the app. So we should have knowledge of the language in which we are going to develop. And in which we are going to develop the app we should know that platform. In this I used the Tizen Studio 2.5. Tizen is open-source but the SDK is closed source Software development kit is of closed source.

Next one is to developing the application. In the Tizen Studio we have to develop the app using JS and HTML. For the way of presentation, font, colour it depends on the CSS. This is of our choice. After this we will check if is there any bugs are there, if there we have to fix them it comes under bug fixing.

Once the app is developed and we fixed the all bugs and now it is ready to use. Then we installed this on the device and we will check everything is working fine or not. And it's giving the exact results that what we really want if yes we will send this to deploying the app on smart TV. Other wise we will check this again we have to fix all the bugs and then deploy the app.

3.3 App Development Process Flow:



This is the flow chart of the app development process flow. 1st we have to get an idea of the app. This is the basic idea about the app. What is the requirement. And then we have to plan for the app how to process. After that we will design the app. After that we will develop the app. Next we will test the app. Then Deployment the app on the device.

In the 1st we have know all the things about the architecture of the SMART TV. And we have to design a suitable app for this architecture. The usage of the app also plays a major role in the development. And which type of we are going to develop. Native app or web app based on this the language will change. Native apps will developed in c and the web apps are develops in JS,HTML. In this I developed an app which is of web app. So all of my code will be in JS and HTML only.

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There are three layers in the Tizen OS architecture. Application Layer, Core and finally is the Kernel. In this there are inner layers also there. In the Applications Layer there are 2 types of applications are there. One is Native Apps and 2nd one is Web Apps. In the previous versions there are only Web apps are available. But from the version 2.0 native apps are also available.

In the Core one layer is called Application Programming Interface of Web Apps are there it also called Web Apps Frame Work. Same Frame Work Of the Native apps are won't be in this layer. It included in the Components of core layer. Next layer is of Kernel in this linux kernel is there and the drivers will be available here.

In the coming chapter I am going to explain the Native and web apps clearly. What is meant and when we have to use and what are the requirements and advantages over one another. And I will explain which app is we are going to develop in this work.

Chapter4

Work plan and Methodology:

4.1 Work plan:

The objective of present work is to develop a Smart TV application “Child Scheduler” which can monitor and control content viewing for children.

Development of Smart TV app will be achieved as follows:

- Understanding the architecture of the SMART TV.
- Understanding JavaScript and Tizen Studio 2.5.
- Developing the application.
- Bug fixing.
- Feature testing.
- Deploying the app on Smart TV.

Improvement in performance of app can be achieved by:

- Understanding the architecture of Smart TV, JavaScript and Tizen Studio 2.5.
- Developing the child scheduler application
- Bug fixing, feature testing and modification (if required)
- Deploying the final app and build on Smart TV.

4.2 Stages of Application Launch Process:

There are various stages of applications launch process. Understanding each stage for application development allows developers to design a stable and application. Each stage is an event or a set of events which affects the launch of application. The various stages in application launch process and applications start logic are shown below.

- User clicks on application
- App panel disappears & system loader appears
- Initialization of Tizen application
- Smart TV app preparing for launch
- App splash screen appears
- App is rendered and ready to use
- App is launched and running.

There are totally 6 stages are there in the stages of application launch process. Stage 1 is between the User clicks on application and App panel disappears & system loader appears. Stage 2 is between the App panel disappears & system loader appears and Initialization of Tizen application. Stage 3 is between the Initialization of Tizen application and and Smart TV app preparing for launch. Stage 4 is between Smart TV app preparing for launch and App splash screen appears. Stage 5 is between App splash screen appears and App is rendered and ready to use. Stage 6 is between App is rendered and ready to use and App launched and running.

Details of stages:

- Frame work setup
- App logic
- Authorization
- Dependency

Frame work setup is under Stage2 and Stage3 and authorization is comes under the app logic and the entire app logic comes under the stage 4. Dependency comes under the Stage5.

4.3 Step by step process for the child scheduler Smart TV app:

- User Start app.
- User provides credentials to login.
- User sets content to be viewed and time duration of viewing content.
- Child watches TV till time limit is reached.
- Application stops displaying content.
- Application asks to further extent time. If yes application asks user to login, extend time.
- Application is exit by the user.

Child Scheduler app is Smart TV application that monitors and controls the duration of content viewing for children. The users are required to create user ID and password once. Registered users can login to the app and set time duration for the viewing TV by children. The app monitors the time duration and stops viewing content when time limit is reached on real-time. Viewing duration can be further extended by users by providing login credentials again. Date and time of watching TV by children can also be scheduled earlier by the users.

This application provides a good way to monitor children to watch content is good for them and restricting other content. TV watching date and time can be scheduler earlier, so users don’t need to schedule every time their children need to watch TV.

4.4Filesystem:

It is used to control how data is stored and retrieved. Without a file system, information placed in a storage medium would be one large body of data with no way to tell where one piece of information stops and the next begins. By separating the data into pieces and giving each piece a name, the information is easily isolated and identified. There are many different kinds of file systems. Each one has different structure and logic, properties of speed, flexibility, security, size and more. Some file systems have been designed to be used for specific applications.

First resolve filesystem. Next find the path of filesystem. Create the directory. Resolve filesystem again. Next Resolve directory. Create File. This is a text file. Write we can write as many times. Next one is read. Next one delete file. Next is delete directory. List files it will give the remaining files which are remaining in the filesystem.

Function	**For**
tizen.filesystem.resolve	**wgt-private**
Create Directory	**wgt-private/abc**
tizen.filesystem.resolve	**wgt-private/abc**
Create File	**wgt-private/abc/xyz.txt**
Write	**wgt-private/abc/xyz.txt**
Read	**wgt-private/abc/xyz.txt**
Delete File	**wgt-private/abc/xyz.txt**
Delete Directory	**wgt-private/abc**
List Files	**wgt-private**

Table 4.1-Filesystem

Chapter5

Tools and Languages:

4.5 Tizen Studio 2.5:

Tizen IDE provides application development tools based on the JavaScript libraries. C++ native application framework is also available on versions 2.0 or higher. The software development kit (SDK) allows developers to use HTML5 and relate web technologies to write applications that run on supported devices.

- Smack is utilized to sandbox HTML5 web applications
- The X window System with Enlightenment Foundation Libraries is used.
- Wayland: Tizen up to 2.x supports Wayland in in-vehicle infotainment(IVI) setups and from 3.0 onwards defaults to Wayland.
- ZYpp is a package management system.
- ConnMan is used as over Network Manager.

By using Tizen IDE we can also compile platform modules directly from Tizen IDE by selecting appropriate architectures & root strap. With Tizen IDE root strap can be automatically updated from IDE. We can minimize the usage of terminal window by enabling Platform Development using Tizen IDE. Tizen IDE also provides for perform debugging of modules inside Tizen IDE after building and updating root strap.

Tizen is an Operating System. It’s based on the kernel of the linux and library of the GNU C. Linux Application Programming Interface (API) is implemented by the Tizen OS. It works on every variety of the devices almost in all the devise like smartphones, in-vehicle infotainment(IVI), tablets, Smart Cameras, PCs, Wearable Computing like watches, BD’s(Blue Ray Players), Printers, Smart Home appliances like refrigerators, washing machines, lighting, air conditioners, ovens/microwaves and robotic vacuum cleaners. The Tizen OS wants to provides a done in the same way over time user experience across all the available devices. In the linux foundation Tizen OS is a project. About this project everything is look after by the Technical Steering Group.

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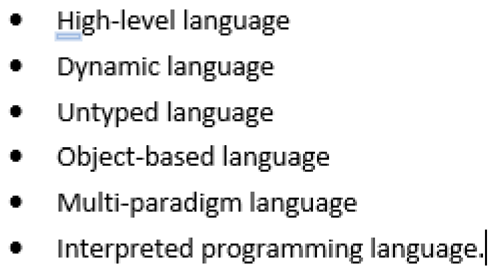
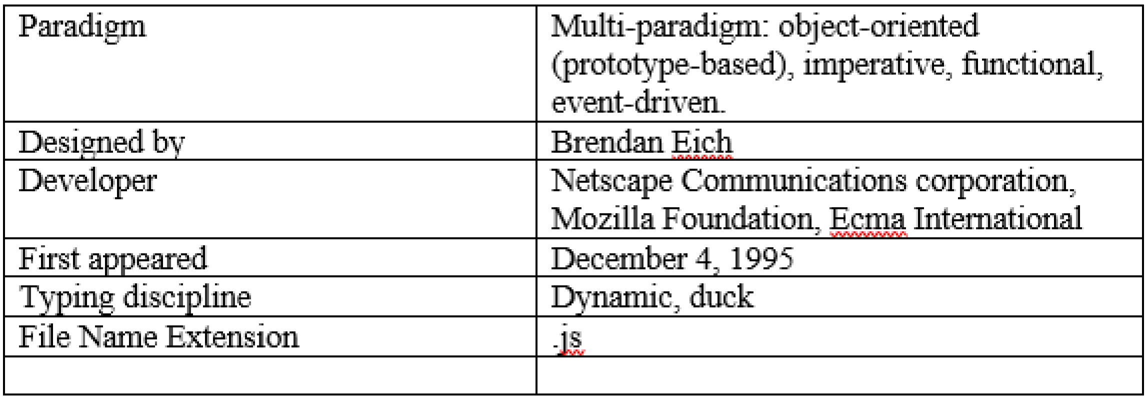
5.2JavaScript:

JavaScript is one of the scripting language which is a high-level programming language (HLL).



- High-level language
- Dynamic language
- Untyped language
- Object-based language
- Multi-paradigm language
- Interpreted programming language.

Without need the of plug-in's JS supports all the modern web browsers.



Paradigm	Multi-paradigm: object-oriented (prototype-based), imperative, functional, event-driven.
Designed by	Brendan Eich
Developer	Netscape Communications corporation, Mozilla Foundation, Ecma International
First appeared	December 4, 1995
Typing discipline	Dynamic, duck
File Name Extension	.js

Table5.1JS Descriptions

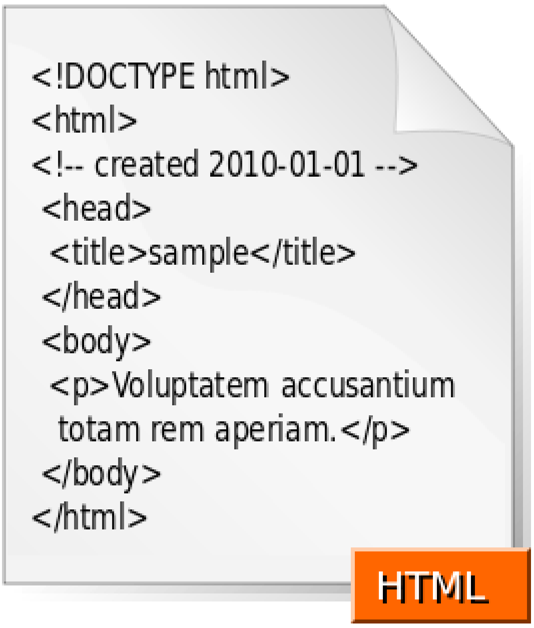
5.3HTML:

Creating of Web pages and Web applications HTML(Hyper Text Markup Language) is a mark-up language. This is the reason of appearance of the websites and structures of the webpages. From the web servers or local renders web browsers receive documents of the HTML convert them in to multimedia web pages.

Building blocks of HTML pages were the HTML pages. With HTML constructs, images and other objects, such as interactive forms, may be embedded into the rendered page. It provides a means to create structured documents by denoting structural semantics for text such as headings, paragraphs, lists, links, quotes and other items. HTML elements are delineated by *tags*, written using angle brackets. Browsers do not display the HTML tags, but use them to interpret the content of the page.

File name	.html
Extension	.htm
Internet media type	Text/html
Type Code	TEXT
Developed by	W3C & WHATWG
Initial release	1993
Latest release	5.0
Type of format	Document file format

Table5.2 HTML Details



```
<!DOCTYPE html>
<html>
<!-- created 2010-01-01 -->
 <head>
  <title>sample</title>
 </head>
 <body>
  <p>Voluptatem accusantium
   totam rem aperiam.</p>
 </body>
</html>
```

Figure5.1Example of HTML

5.4Cascading Style Sheets:

Documents commonly wrote in mark-up language, if we want to add some style to your body or your page for this we will use the Cascading Style Sheet language. We can use the same CSS file for any XML document.

Initially it was developed to give a gap between the presentation and the content like layout, font, colours and all. This will increase the accessibility of content and in the specification of presentation it will gives the more flexibility and control. We can use the same .css file for any HTML page and multiple HTML pages at a time if the .css file suits the specific requirements. In structural content this will reduce tht repletion and complexity.

It can even change the graphics design of HTML documents. We have to edit few line in the CSS file that’s it. It is very easy task. Depending upon the screen size and viewing device it can display the webpage differently in different devices.

If for a particular element or a document we can apply more than one CSS file then there is a priority scheme is there it will take care of this and gives which to apply and which suites more. World Wide Web Consortium will take care of the all the specifications of the CSS.

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If for a particular element or a document we can apply more than one CSS file then there is a priority scheme is there it will take care of this and gives which to apply and which suites more. World Wide Web Consortium will take care of the all the specifications of the CSS.

```
h1 { color: white;
  background: orange;
  border: 1px solid bla
  padding: 0 0 0 0;
  font-weight: bold;
}
/* begin: seaside-theme */

body {
  background-color:white;
  color:black;
  font-family:Arial,sans-serif;
  margin: 0 4px 0 0;
  border: 12px solid;
}
```

Figure5.2CSS example

File name extension	.css
Internet media type	text/css
Uniform type identifier(UTI)	public.css
Initial release	1996
Type of format	Style Sheet language

Table5.3CSS Details

Chapter6

Discussion and Conclusions

6.1 Discussion:

Once the app is installed in the Smart TV and the user opens the app. If it is the 1st time user is opening the app then it will ask for the user name and password. Once user successfully registered the 1st page takes the user in to the next page. Here they have to set the time. Starting time and Ending time. The duration between this time they children can watch the TV. After the end time it will ask for the username and password again for the users. If they want to continue the time of watching TV. They have to extend the time by login in to the app again. For starting time and ending time we have to enter 4 digit number. In this 1st two digits represents the hours next two digits represents the minutes. Once user entered the input it will check the duration in between them it always should be a positive number otherwise it won't save user data. The date which is entered by the user is always positive. User can repeat this every day or which day user want to repeat it. For this 7 options will be there. Where ever user put a tick mark it will save as "y" otherwise save as "n". Totally the input have the 16 variable 8 digits for time and for 7 y or n for days. It will save everything in the single variable.

First resolve filesystem. Next find the path of filesystem. Create the directory. Resolve filesystem again. Next Resolve directory. Create File. This is a text file. Write we can write as many times. Next one is read. Next one delete file. Next is delete directory. List files it will give the remaining files which are remaining in the filesystem.

6.2 Conclusion:

Child Scheduler app is Smart TV application that monitors and controls the duration of content viewing for children. The users are required to create user ID and password once. Registered users can login to the app and set time duration for the viewing TV by children. The app monitors the time duration and stops viewing content when time limit is reached on real-time. Viewing duration can be further extended by users by providing login credentials again. Date and time of watching TV by children can also be scheduled earlier by the users.

This application provides a good way to monitor children to watch content is good for them and restricting other content. TV watching date and time can be scheduler earlier, so users don't need to schedule every time their children need to watch TV.

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