CHARACTERIZATION OF THE ELECTRICAL AND PHYSICAL PROPERTIES OF SCANDIUM NITRIDE GROWN USING HYDRIDE VAPOR PHASE EPITAXY

by

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MASTER OF SCIENCE

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Abstract

It is important in semiconductor manufacturing to understand the physical and electrical characteristics of new proposed semiconductors to determine their usefulness. Many tests are used in order to achieve this goal, such as x-ray diffraction, Hall effect measurements, and the scanning electron microscope. With these tests, the usefulness of the semiconductor can be determined, leading to more possibilities for growth in industry.

The purpose of the present study was to look at the semiconductor scandium nitride (ScN), grown using the hydride vapor phase epitaxy (HVPE) method on various substrates, and determine the physical and electrical properties of the sample. This study also sought to answer the following questions: 1) Can any trends be found from the results?, and 2) What possible application could scandium nitride be used for in the future?

A sample set of scandium nitride samples was selected. Each one of these samples was checked for contaminants from the growth procedure, such as chlorine, under the scanning electron microscope and checked for good conduction of current needed for the Hall effect measurements.

The thickness of the scandium nitride layer was computed using the scanning electron microscope. Using the thickness of the scandium nitride, Hall effect measurement values were computed. The plane the samples lie on was checked using x-ray diffraction. The test results shed light on many trends in the scandium nitride. Many of the samples were determined to have an aluminum nitride (AlN) contamination. This contamination led to a much higher resistivity and a much lower mobility no matter what thickness the scandium nitride was. The data from the samples was then used to offer suggestions on how to improve the growth process.

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Tim Bohnen, for the donation of the scandium nitride samples which this research is based upon. Without your support I don't know what form this thesis would have taken or where my collegiate career would have gone.

To all other friends and family, throughout this project, you were supportive and caring. Encouraged me constantly and helped me continue when I thought it impossible to finish.

Dedication

This report would not be complete without mention of the support my parents gave me. They offered encouragement when I felt overwhelmed and listened to my thoughts even though they had no interest other than I was working on it. Without their support, I doubt this project would have come to fruition.

Preface

This report is the culmination of two years of work. It has been created in order to assist others working in the field of semiconductors, by providing comprehensive data on the physical and electrical characteristics of the scandium nitride samples received as well as any trends that may be present.

CHAPTER 1 - Introduction

Introduction

Transition metal nitrides (TMN) have become the subject of much attention recently. TMNs are metallic compounds that exhibit high hardness and mechanical strength, chemical inertness, low electrical resistivities, corrosion resistance, and a high melting temperature [1 - 5]. This great strength and durability allows for TMNs to work at extreme conditions of temperature and pressure, making the materials extremely useful. These traits allow TMNs to be used in a wide variety of technical applications [6, 7]. They are regarded for their usefulness in fabricating light emitting diodes (LEDs) and lasers [4]. However, they also span other technological fields, such as cutting tools, the hard coatings for magnetic storage devices, high power energy industrial applications, diffusion barriers, and optoelectronics [1, 3, 8 - 12].

Transition metal nitrides are so called due to their rock-salt structures the materials crystallize in allowing them to be metals or semiconductors [4]. TMNs, also known as Group III nitrides, have large forbidden band gaps, large bulk moduli, and high thermal conductivities [13]. TMNs are good candidates for tough demanding environments [14], which is a main reason for TMNs being on the center stage of R&D in the last decade [15]. One material at the forefront of this research is scandium nitride (ScN), due mainly to its electronic properties and possible combination with gallium nitride (GaN) [16].

Scandium Nitride

ScN is a group IIIB transition metal nitride [17, 18]. Early experiments into ScN seemed to indicate that it was an indirect semimetal [4, 12]. This idea propagated for a long time [19], however recently ScN has been proven to be a semiconductor material [3, 4]. Like many Group III TMNs, ScN assumes the rock-salt structure as its ground-state configuration [5, 7, 20] that is uncommon among nitride semiconductors [21]. The TMNs that crystallize in the rock-salt structure at ambient temperature are typically found in 3d, 4d and 5d metals on the left-hand side of the periodic table [13]. Figure 1.1 provides examples of the ScN crystal structure. It can be seen that TMN tend to form face centered cubic (fcc), hexagonal closed packed (hcp), or simple hexagonal (hex) structures, with the nitrogen atoms located in the interstitial sites of octahedral or cubic prismatic geometries [6]. These crystal structures allow for those properties of high hardness, mechanical strength, high temperature stability, and electronic transport properties [7, 17]. These excellent mechanical properties are due to the strong covalent-ionic bonds between the group III metal and the nitrogen ions resulting from the fully occupied nitrogen 2s and 2p bands, however this leaves the Sc 3d bands empty [1] .

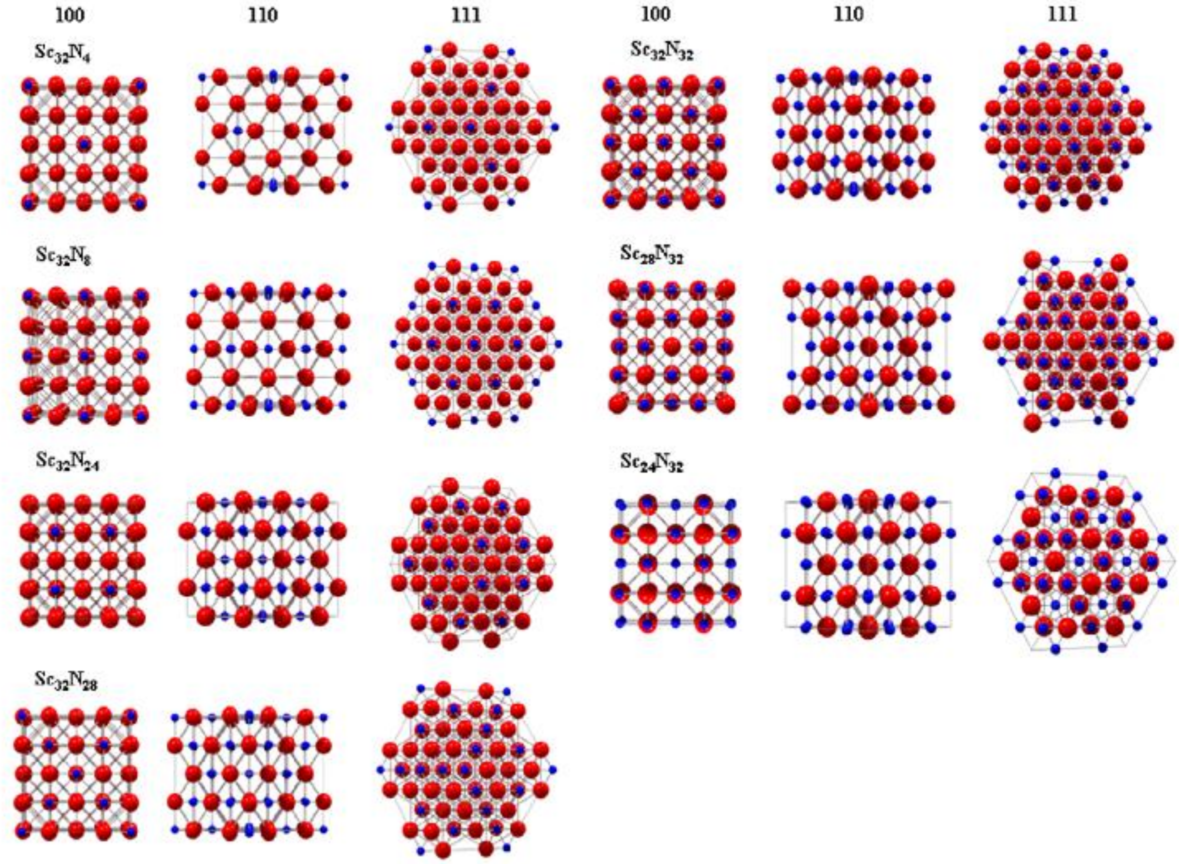

Figure 1.1: Crystal Structures of ScN [6]

ScN is a great candidate material to be a high hardness coating, has very good resistance against wear at high temperatures, and has been proposed in a number of different semiconductor applications [14]. ScN is reported to have the smallest direct band gap of about 1.58 eV and an indirect band gap of about 1 eV [12, 19, 22]. The combination of scandium and nitrogen allows for a single-crystal of ScN film that is reported to have a hardness of 21 GPa, which is on par with that of titanium nitride (TiN) [14]. As previously reported this combination of elements leads to a rock-salt crystal structure, with a lattice constant of 4.501 Å and a melting point of 2600°C [10, 17, 23].

Many growth techniques are used in the production of ScN, such as chemical vapor deposition, molecular beam epitaxy (employing an RF or ECR nitrogen source), magnetron sputtering, and plasma-assisted vapor deposition, on a variety of substrates such as sapphire (Al_2O_3) and silicon carbide (SiC) [10, 20]. As a result, in order to understand the nature and behavior of this material, it is very important to have a firm understanding of its bulk properties, with respect to the growth technique used [8]. Therefore, the scope of this report will be to grasp a clear understanding of the physical and electrical properties of ScN, with an emphasis on the Hydride Vapor Phase Epitaxy (HVPE) growth technique.

HVPE Horizontal Reactor

The ScN samples used were grown on a variety of substrates using a horizontal HVPE reactor similar to that pictured in Fig. 1.2.

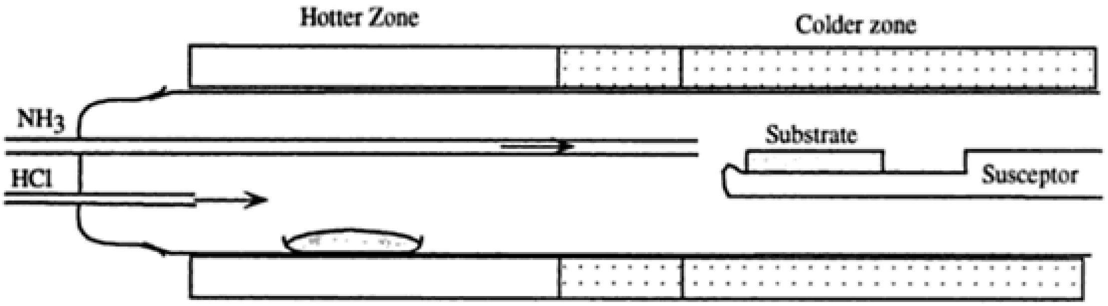

Figure 1.2: HVPE Horizontal Reactor

The conventional HVPE reactor is hot-walled and made of quartz. It operates at atmospheric pressure, and does not require vacuum pumps or seals [24]. The chemical reactions that take place in the reactors require at least two temperature zones, which can be seen in figure 2. Most reactors have more than the required number of temperature zones, for better reaction control or for the ability to use additional metal sources [24]. A hot wall reactor is used to avoid condensation of the metal chloride on an unheated reactor wall, resulting in a cleaner reactor [24]. There is also the possibility of delivering the gasses at different pressures, allowing for more control over the growth process [25]. The source gasses, NH_3 and HCl, need to have a purity of 99.9999% as they enter the reactor. The active gases are delivered to the mixing point through separated parallel quartz glass liners, but coaxial arrangement of the gas inlet tubes may also be used [24]. The vapor-phase composition, partial pressures of the gases, and the temperature of the various reactor zones determine the growth rate and composition of the epitaxial layer [25].

The advantage of the horizontal reactor is the ease with which the system can be altered, the ease of cleaning the system, and the quickness of reloading material into the system [26]. Unlike MOVPE or MBE, very high growth rates can be easily achieved as well as an extremely low group III chloride adsorption on the dielectric mask with respect to the semiconductor surface. As a result, an inherent property of HVPE is its ability to selectively grow materials [25].

CHAPTER 2 - Instrumentation and Evaluation

To gain an understanding of the ScN samples, it was prudent to characterize both the physical and electrical properties of the samples and how they are affected by substrate type. The results are outlined in Chapter 3. In the sections below the fundamental principles behind the characterization tests are outlined.

X-Ray Diffraction

In order to verify the sample's crystal structure, x-ray diffraction was used. This test bombards the samples with x-rays and is based upon the interference of x-rays scattering off of sets of parallel planes, also called Bragg planes [29]. Figure 2.1 provides a figure to help visualize this principle. Using Bragg's condition, $2 d \sin \Theta = m \lambda$, where m is an integer that indicates a position when the x-rays will strike the two planes and cause waves to scatter from two successive atoms within a plane and interfere constructively [29]. The crystal structure of the samples can be determined from these results. This was done by comparing a sample under test's results (e.g. see Fig 2.2) with those of a sample with the expected crystal structure to make sure that it was the correct material. This test brought possible contaminants to light, due to extra peaks appearing on the graph.

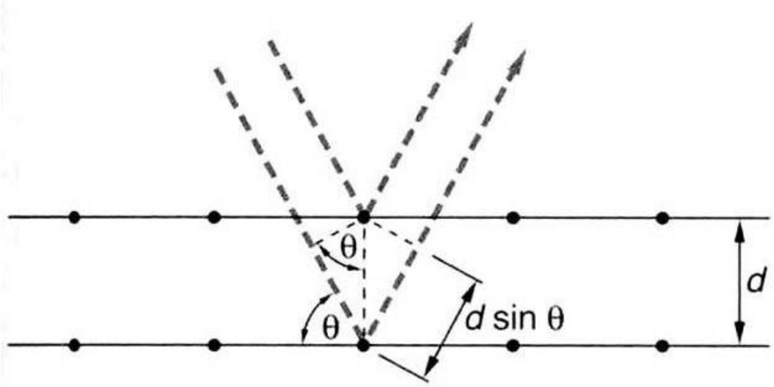

Figure 2.1: Example of Bragg Scattering [29]

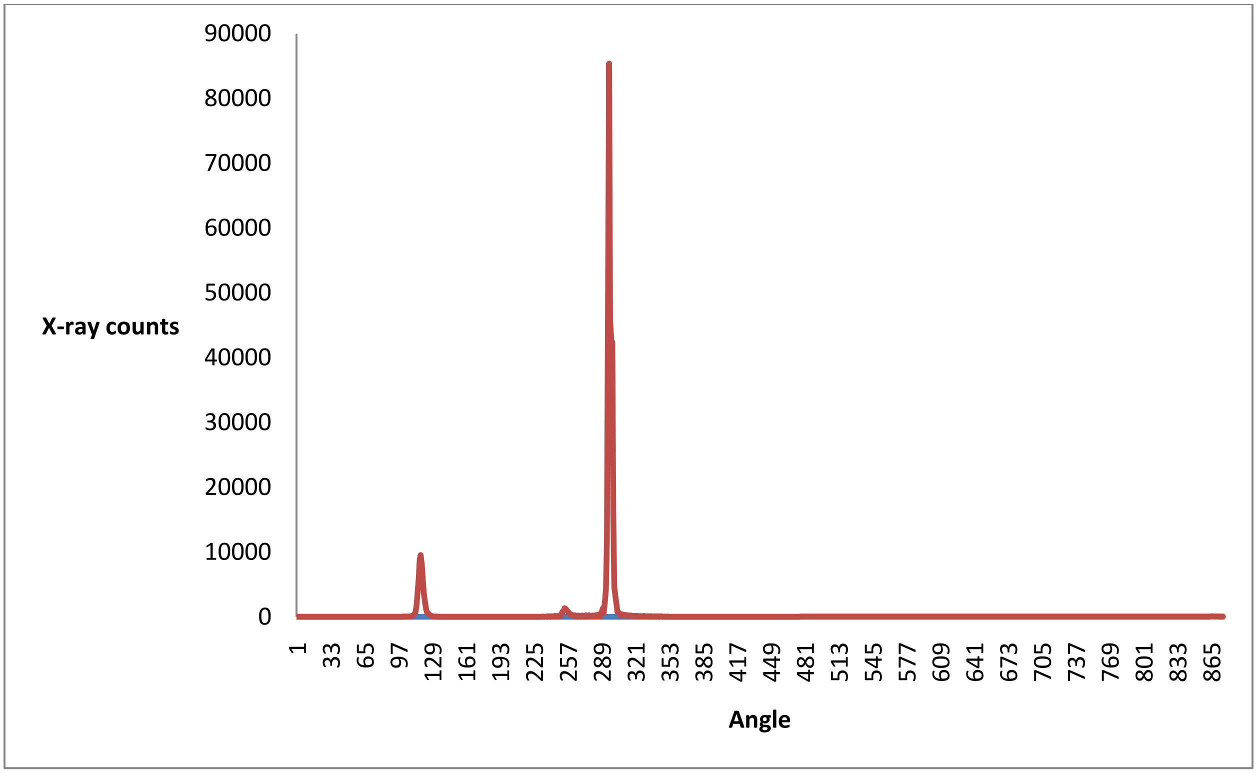

Figure 2.2: Example of XRD pattern containing main ScN (111)

Scanning Electron Microscopy

The scanning electron microscope provides a tightly focused, high energy beam of electrons that is scanned over the surface of a sample. The numbers of backscattered and secondary electrons produced from the electron beam are measured using detectors. The number of electrons that are emitted from the sample depend upon the composition and topography of the individual samples. Even though electrons are emitted, the SEM is a nondestructive and noncontact metrology tool. These emitted electrons are collected by an electron detector, which in conjunction with the beam detector, produces an image of the surface of the sample [30, 31]. This is useful in determining the thickness of the conductive layer of the sample, figure 2.3.

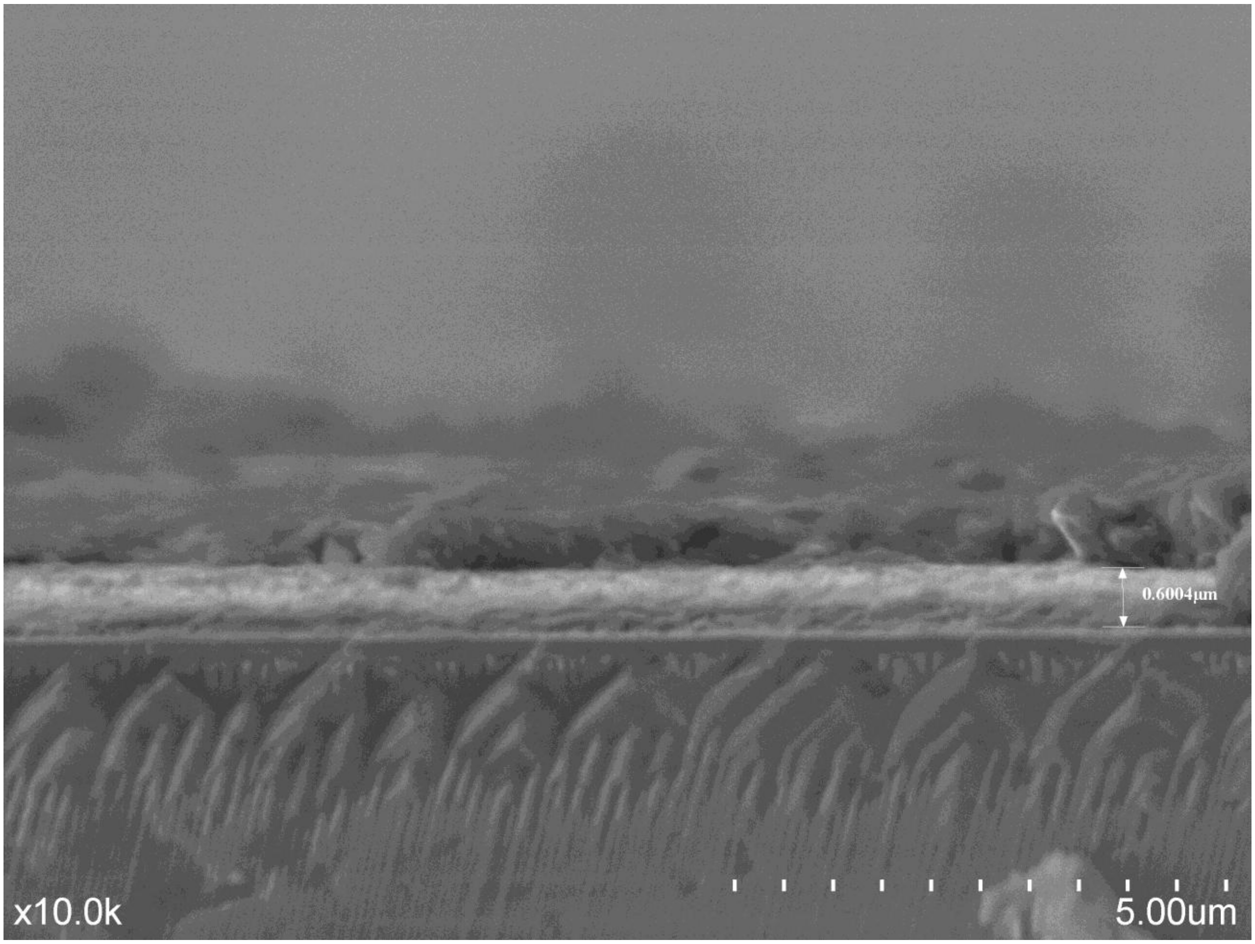

Figure 2.3: Cross-sectional image of ScN sample

The same electron beam can be used to create an element composition maps of the sample, figure 2.4. When the electron beam described above, interacts with the surface of the sample a variety of emissions are produced [32]. With an accompanying energy-dispersive (EDS) detector, the emissions can be separated into energy spectrums. Software can be used to analyze this data and display it as a graphical overlay showing where the different elements are accumulated on the sample surface [32]. Using this image, it is easy to determine if there is any surface contamination. The software can also extrapolate out to determine the chemical composition of the sample.

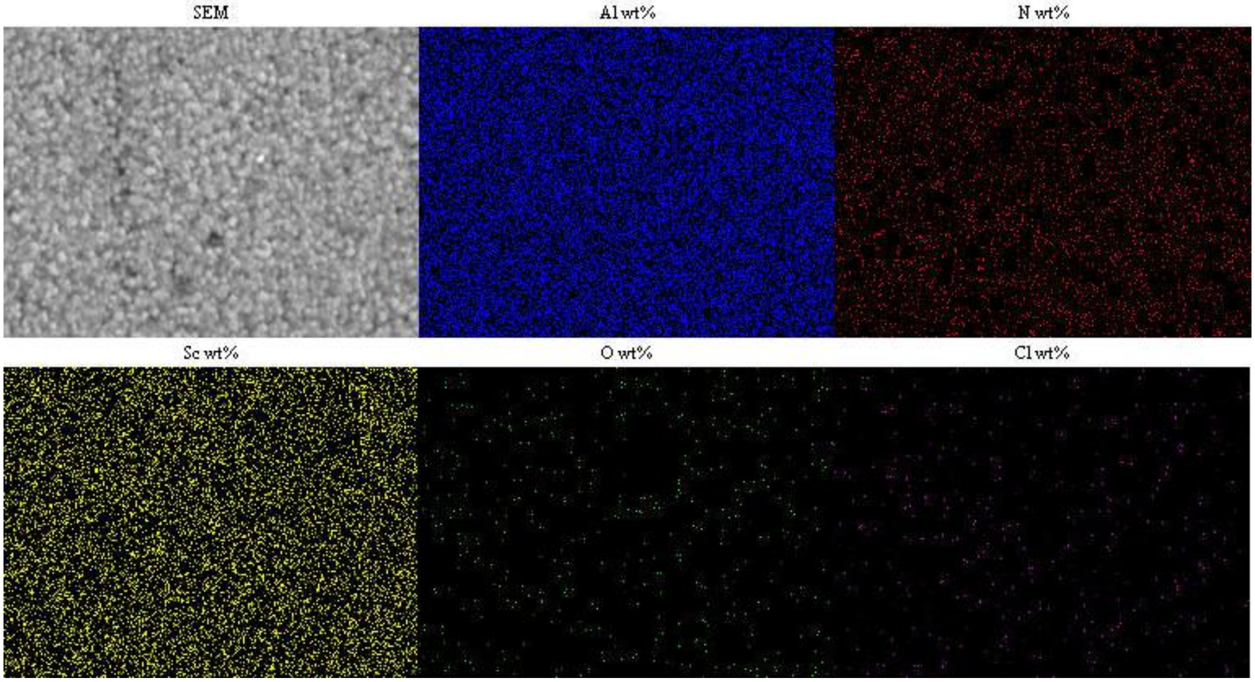

Figure 2.4: Surface morphology accompanied by chemical composition mapping

Hall Effect Measurement System

The Hall effect is a phenomenon that occurs in conductors that are carrying a current when they are placed inside of a magnetic field perpendicular to the applied current. This magnetic field also gives rise to an electric field, that is perpendicular to both the magnetic field and the current, by deflecting charge carriers in the conductor [33]. The basic principle underlying the Hall effect is the Lorentz force [34], which is present due to the magnetic field that is perpendicular to the direction of the current [35]. This is the force, F, that a moving charge, q, in a magnetic field, B, experiences when it is moving at a velocity, v, that is proportional to the magnitude of its charge, velocity, and magnetic field such that $F = qv \times B$ [36]. As a result of this force there is a potential difference, or Hall voltage, to be induced across the conductor, as indicated by the electric field [33, 35].

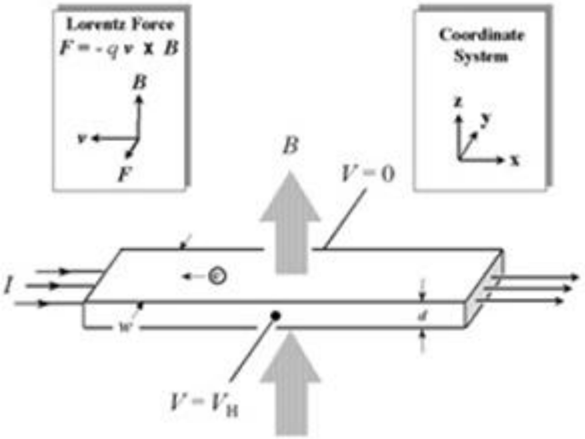

Figure 2.5: Lorentz force and the Hall effect [34]

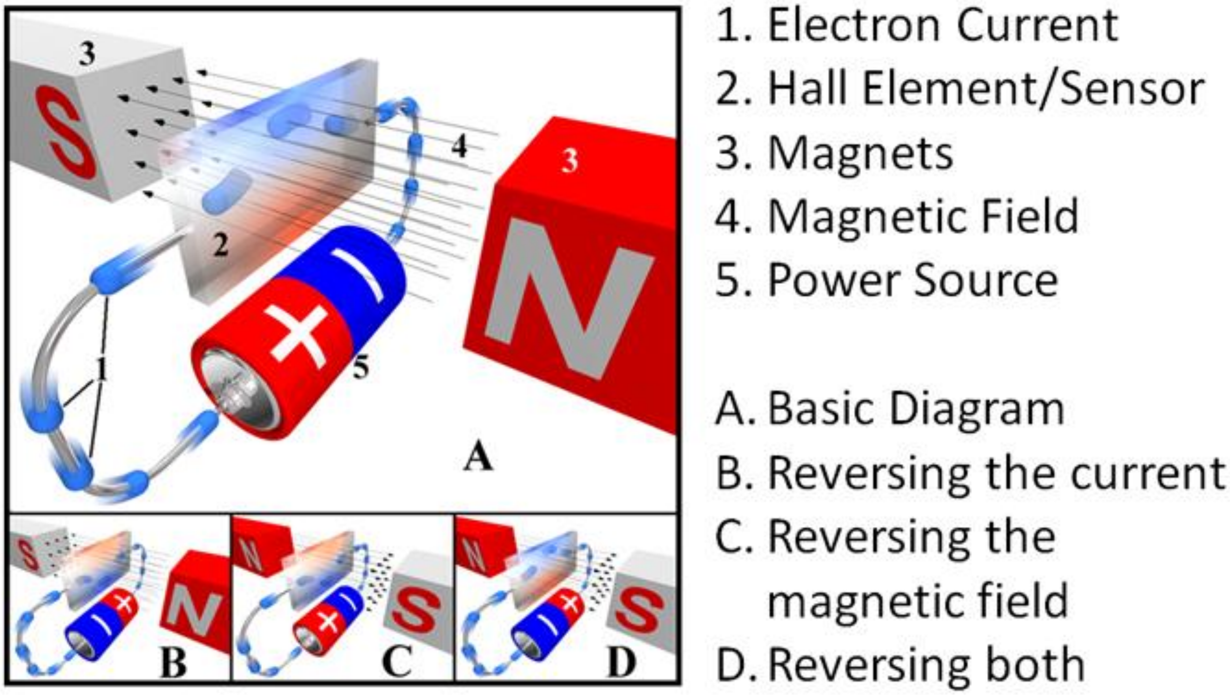

Figure 2.6: Hall effect [37]

Using the Hall effect it is possible to characterize semiconductors. For the case of these tests, the value of the current and the magnetic field are held constant, while the instrumentation measures the Hall voltage as well as the sheet resistance, R_S of the material under test. Starting with the equation for the Hall voltage, $V_H = \frac{-IB}{dne}$, where I is the current, B is the magnetic field, d is the thickness of the conductive layer, obtained from the scanning electron microscope, n is the charge carrier density, and e is the elementary charge []. From here a few different characteristics may be solved for. The carrier type can be solved for, for n-type material the Hall voltage is negative and positive for p-type material [34], as well as the sheet density using the equation $n_s = \frac{IB}{q|V_H|}$. With a known value for the sheet density and the sheet resistance, one can determine the Hall mobility, ⍰$_S$, from the equation ⍰$_S = \frac{|V_H|}{R_S IB} = \frac{1}{qn_S R_S}$ [34]. Knowing the sheet resistance offers more insight into characteristics of the material under test. Using it one can determine the bulk resistivity, $\rho = R_S d$, and the bulk density, $n = \frac{n_s}{d}$ [34].

The data gathered from these tests is very useful in the characterization of semiconductors, however preparation of the samples should be considered. For the case of the above tests, it is important that the samples adhere to the van der Pauw technique. Not only is the configuration of the contacts on the sample and the sample geometry important, but it is important to have ohmic contacts. Otherwise, the IV curve is not linear and skews the results of the tests.

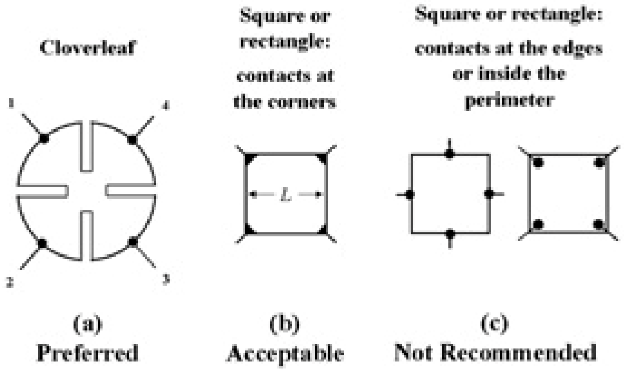

Figure 2.7: Van der Pauw Geometries [34]

CHAPTER 3 - Results

The physical characteristics, shown in Table 3.1, will help to determine what changes, if any, in the HVPE growth process need to occur and what effect the various substrates have on the electrical characteristics of the samples. The samples in the first column are listed by the batch number and then by the substrate the ScN was grown on. The two samples marked misoriented originally started in the (111) and were tilted toward a different crystal orientation. If more than one sample was taken from a particular batch and substrate type then it was assigned a sample number. The substrate type is important as it helps define the crystal orientation of the resulting ScN layer. By having a number of different substrates under test, problems with dislocations due to lattice mismatch will be detected and either the growth process can be altered or that substrate will not be used any longer.

Table 3.1: Physical characteristics sorted by substrate type and batch number

Substrate	Thickness (µm)	# of Peaks	Location of Peaks	Carrier Type	AlN peak present?
32 - c plane Al_2O_3 misoriented	0.600	2.00	(111) and (200)	n	Yes
52 - c plane Al_2O_3 misoriented	1.000	1.00	(111)	n	No
54 - c plane Al_2O_3	0.600	1.00	(111)	n	No
62 - c plane Al_2O_3	1.100	1.00	(111)	n	No
68 - c plane Al_2O_3 sample 1	0.290	1.00	(111)	n	No
68 - c plane Al_2O_3 sample 2	0.263	1.00	(111)	n	No
68 - c plane Al_2O_3 sample 3	0.321	1.00	(111)	n	No
84 - c plane Al_2O_3 sample 1	1.073	1.00	(111)	n	Yes
84 - c plane Al_2O_3 sample 2	0.572	1.00	(111)	n	Yes
84 - c plane Al_2O_3 sample 3	1.436	1.00	(111)	n	Yes
98 - c plane Al_2O_3	0.500	1.00	(111)	n	Yes
107 - c plane Al_2O_3	1.000	1.00	(111)	n	No
108 - c plane Al_2O_3	0.500	1.00	(111)	n	Yes
28 - r plane Al_2O_3 sample 2	1.604	1.00	(220)	n	No
30 - r plane Al_2O_3	0.500	1.00	possible very weak peak at (111)	n	Yes
32 - MOCVD GaN	0.550	1.00	(111)	n	No
52 - MOCVD GaN	2.000	1.00	(111)	n	No
69 - SiC sample 1	1.216	2.00	(200) and very weak peak at (220)	n	No
69 - SiC sample 2	1.409	1.00	(200)	n	No
69 - SiC sample 3	1.277	1.00	(200)	n	No

Variable Field Measurement Results

The first electrical characteristic tests were done in order to conclude how the samples reacted under variable magnetic fields. This test was done using a current of 1 mA across the sample, using the Van der Pauw geometries, as well as a magnetic field that sweeps from 1 kG to 16 kG perpendicular to the sample, according to figure 2.6. The single exception to this was ScN-54 on c-plane sapphire. This sample was done using a current of 2 mA and a magnetic field of 16 kG.

Each sample's results in this section of the chapter will be broken down into 3 parts. The first is a graph of the Hall resistance for that sample, the second is that sample's carrier density, and the final graph is of the sample's mobility. These results will be discussed in the Variable Field Measurement Discussion section that follows this one.

A. Batch 32 c-plane Al_2O_3 misoriented

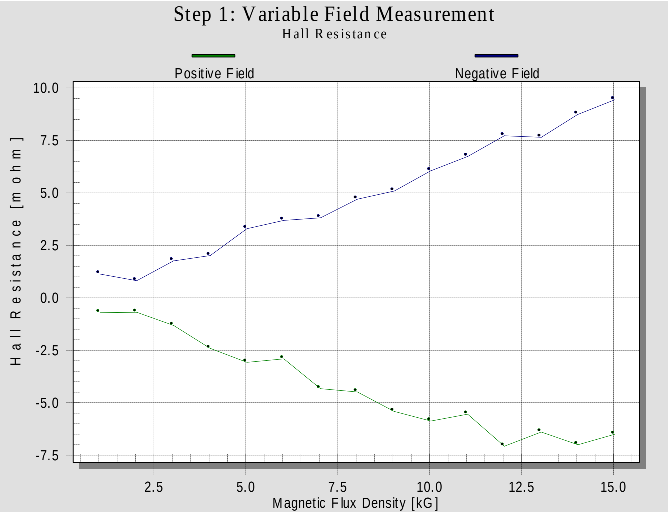

Figure 3.1: Hall Resistance of 32-c plane Al_2O_3 misoriented versus magnetic flux density

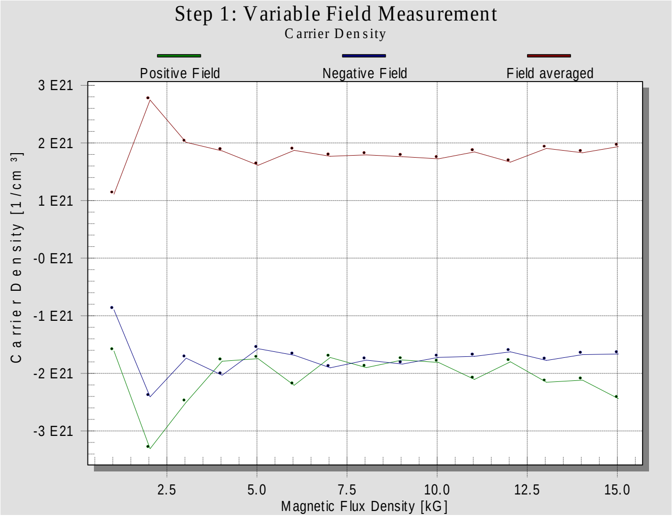

Figure 3.2: Carrier density of 32-c plane Al_2O_3 misoriented versus magnetic flux density

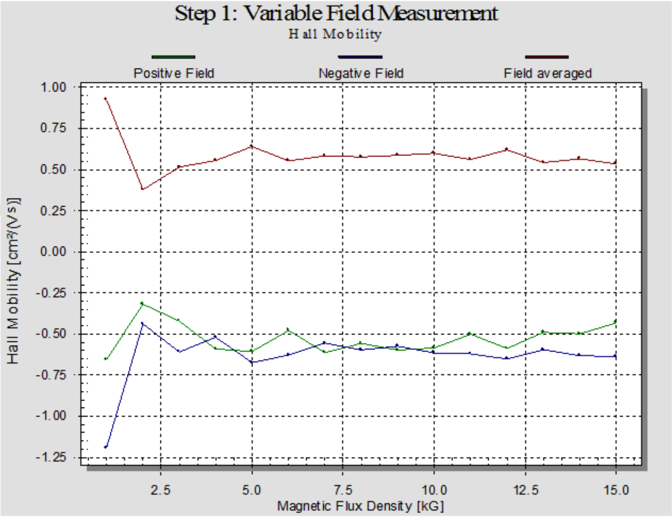

Figure 3.3: Hall mobility of 32-c plane Al_2O_3 misoriented versus magnetic flux density

B. Batch 52 c-plane Al_2O_3 misoriented substrate

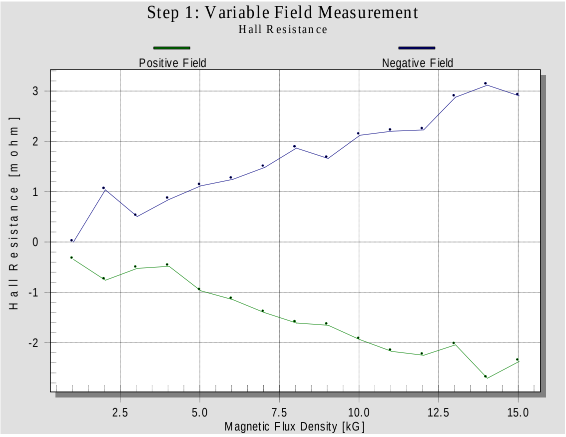

Figure 3.4: Hall resistance of 52-c plane Al_2O_3 misoriented versus magnetic flux density

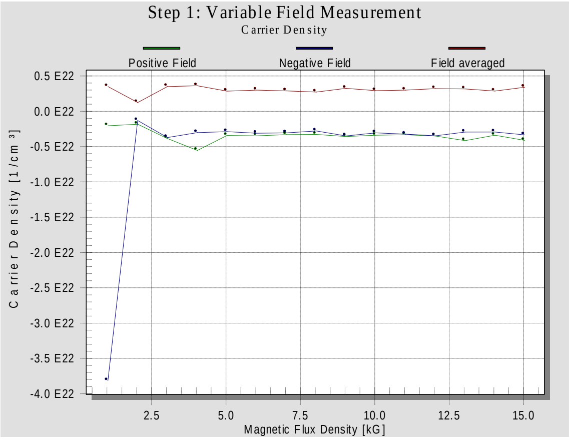

Figure 3.5: Carrier density of 52-c plane Al_2O_3 misoriented versus magnetic flux density

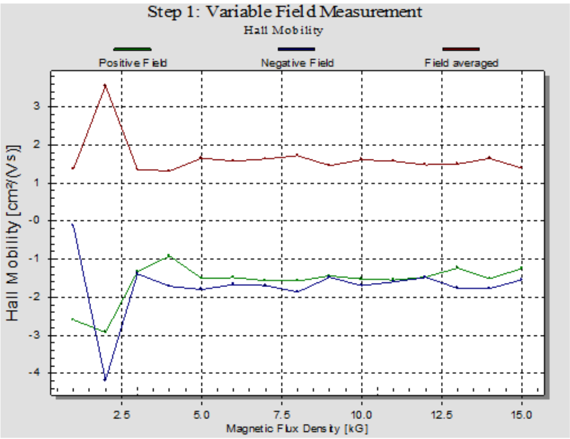

Figure 3.6: Hall mobility of 52-c plane Al_2O_3 misoriented versus magnetic flux density

C. Batch 54 c-plane Al_2O_3 substrate

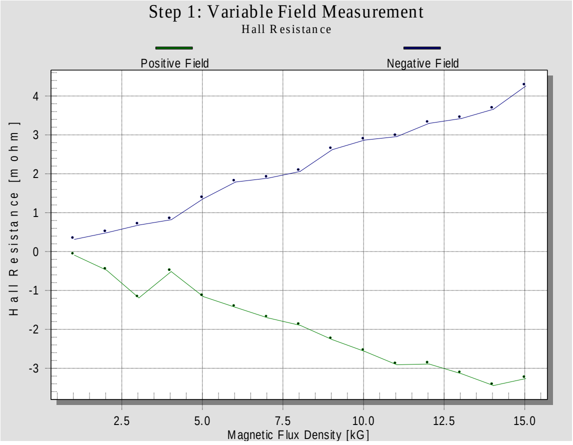

Figure 3.7: Hall resistance of 54-c plane Al_2O_3 versus magnetic flux density

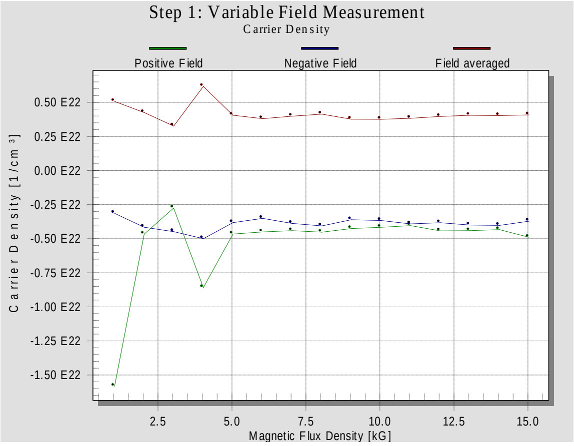

Figure 3.8: Carrier density of 54-c plane Al_2O_3 versus magnetic flux density

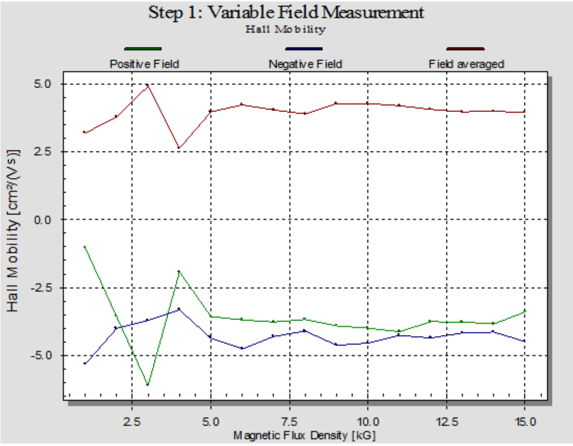

Figure 3.9: Hall mobility of 54-c plane Al_2O_3 versus magnetic flux density

D. Batch 62 c-plane Al_2O_3 substrate

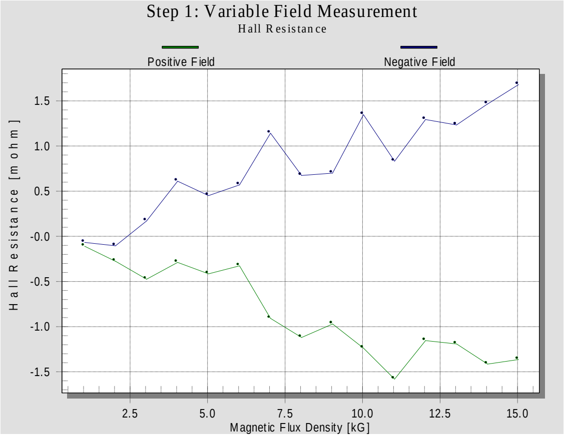

Figure 3.10: Hall resistance of 62-c plane Al_2O_3 versus magnetic flux density

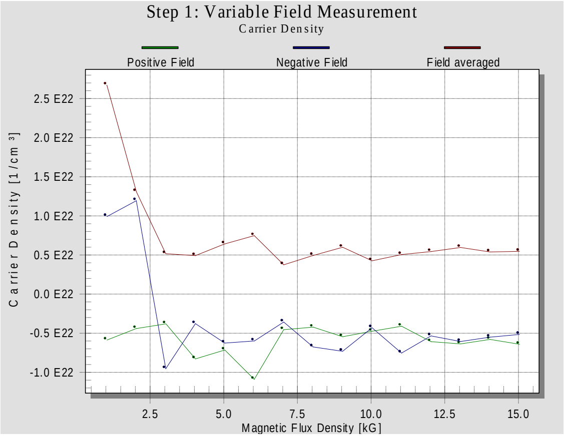

Figure 3.11: Carrier density of 62-c plane Al_2O_3 versus magnetic flux density

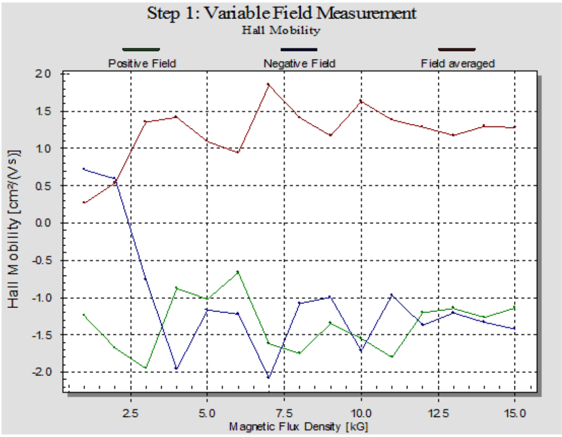

Figure 3.12: Hall mobility of 62-c plane Al_2O_3 versus magnetic flux density

E. Batch 68 c-plane Al_2O_3 substrate sample 1

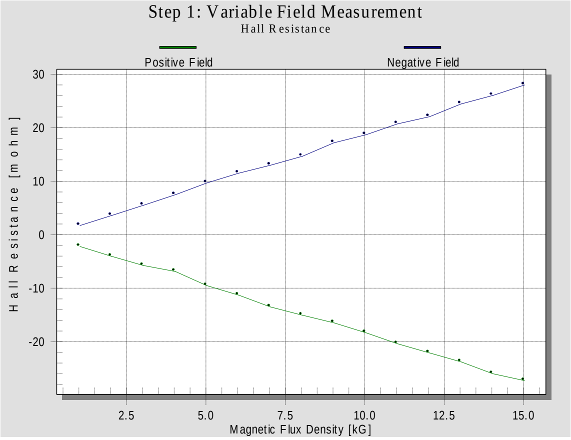

Figure 3.13: Hall Resistance of 68-c plane Al_2O_3 sample 1 versus magnetic flux density

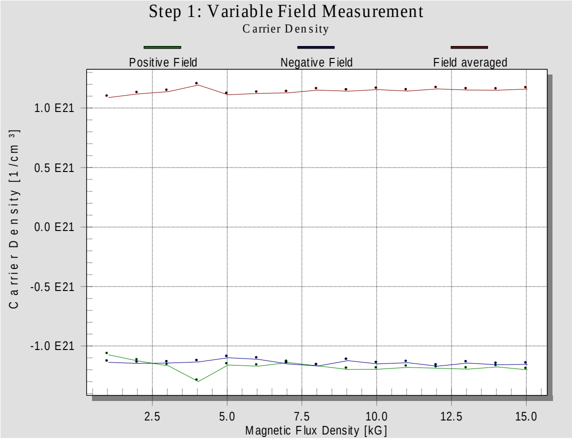

Figure 3.14: Carrier density of 68-c plane Al_2O_3 sample 1 versus magnetic flux density

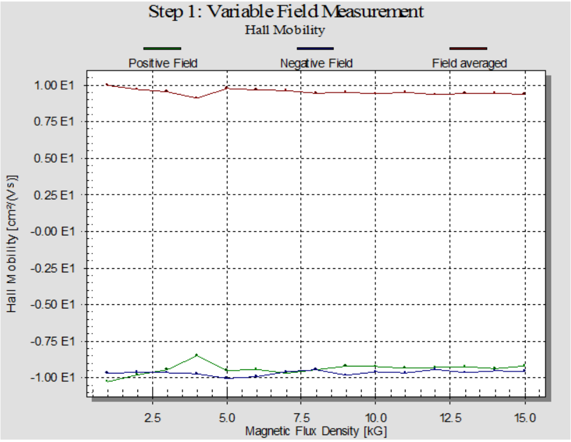

Figure 3.15: Hall mobility of 68-c plane Al_2O_3 sample 1 versus magnetic flux density

F. Batch 68 c-plane Al_2O_3 substrate sample 2

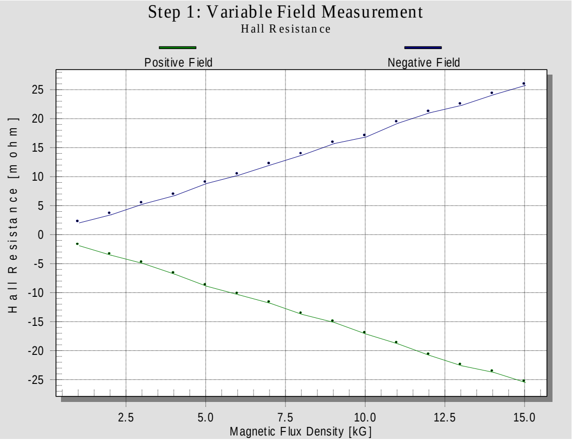

Figure 3.16: Hall resistance of 68-c plane Al_2O_3 sample 2 versus magnetic flux density

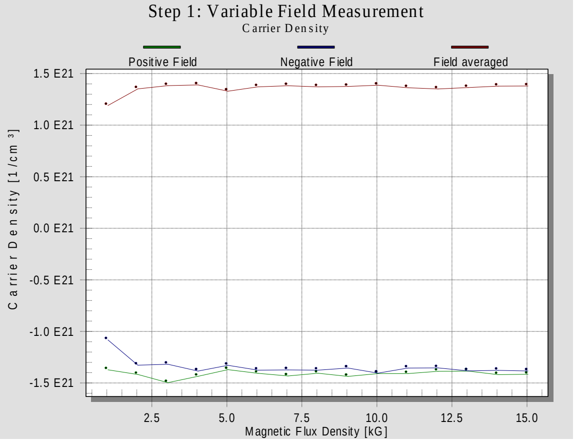

Figure 3.17: Carrier density of 68-c plane Al_2O_3 sample 2 versus magnetic flux density

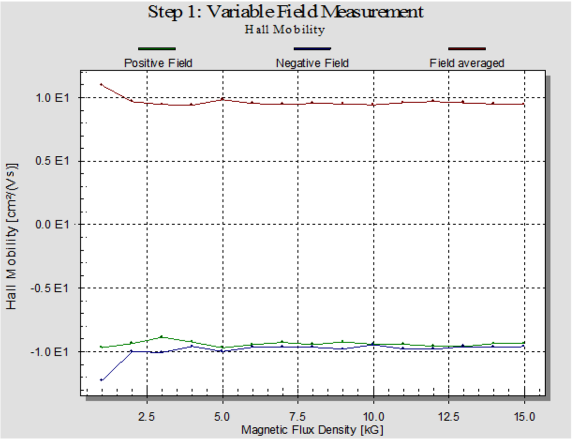

Figure 3.18: Hall mobility of 68-c plane Al_2O_3 sample 2 versus magnetic flux density

G. Batch 68 c-plane Al_2O_3 substrate sample 3

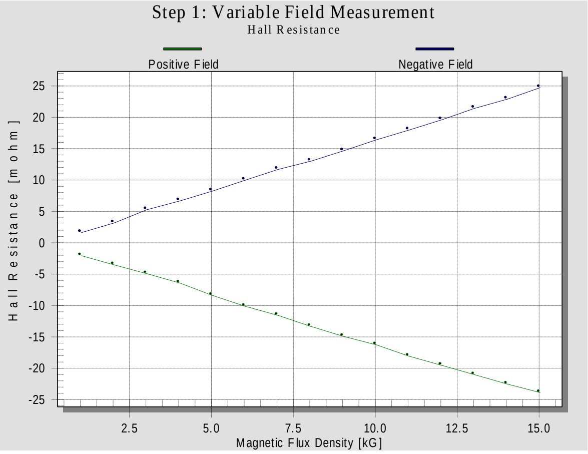

Figure 3.19: Hall resistance of 68-c plane Al_2O_3 sample 3 versus magnetic flux density

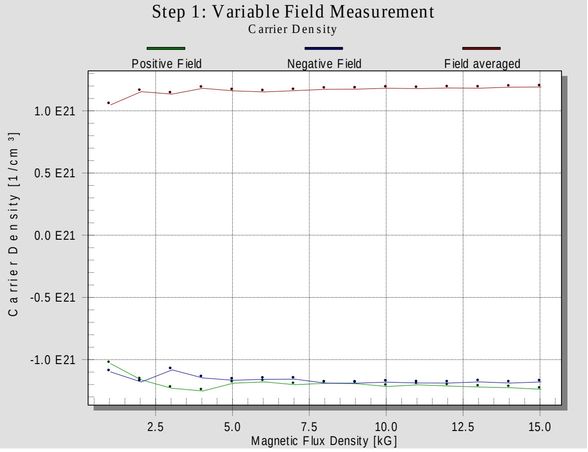

Figure 3.20: Carrier density of 68-c plane Al_2O_3 sample 3 versus magnetic flux density

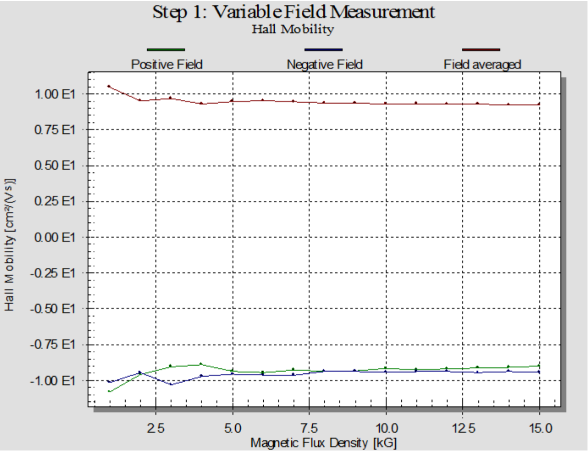

Figure 3.21: Hall mobility of 68-c plane Al_2O_3 sample 3 versus magnetic flux density

H. Batch 84 c-plane Al_2O_3 substrate sample 1

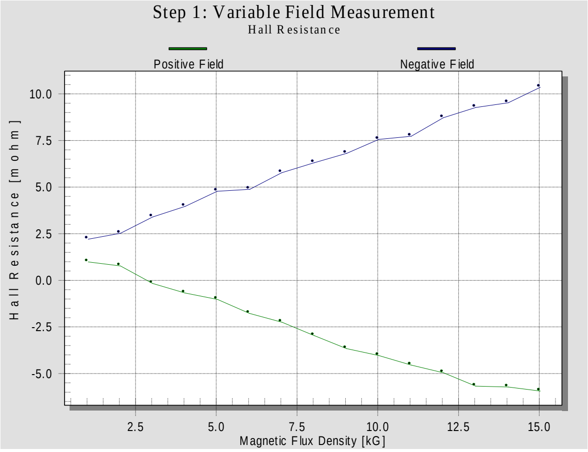

Figure 3.22: Hall resistance of 84-c plane Al_2O_3 sample 1 versus magnetic flux density

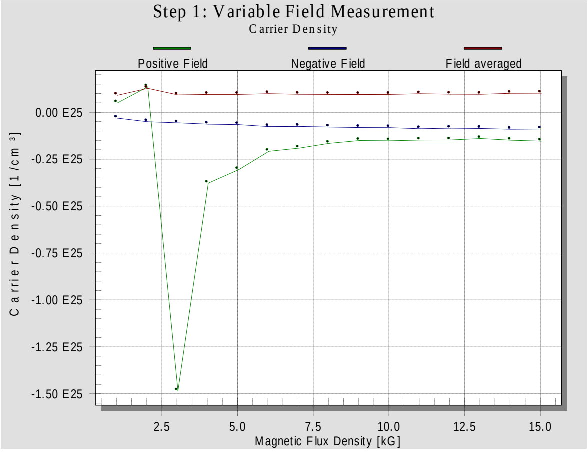

Figure 3.23: Carrier density of 84-c plane Al_2O_3 sample 1 versus magnetic flux density

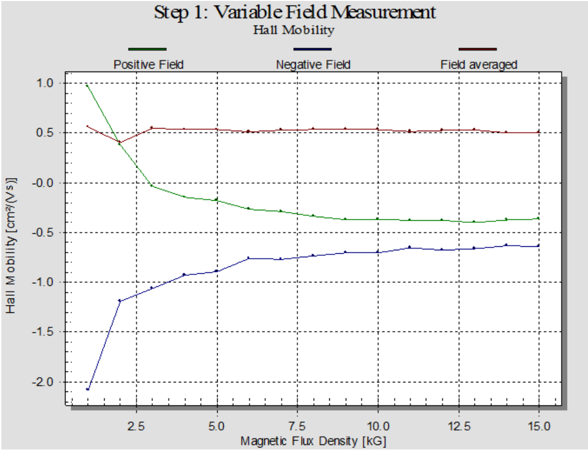

Figure 3.24: Hall mobility of 84-c plane Al_2O_3 sample 1 versus magnetic flux density

I. Batch 84 c-plane Al_2O_3 substrate sample 2

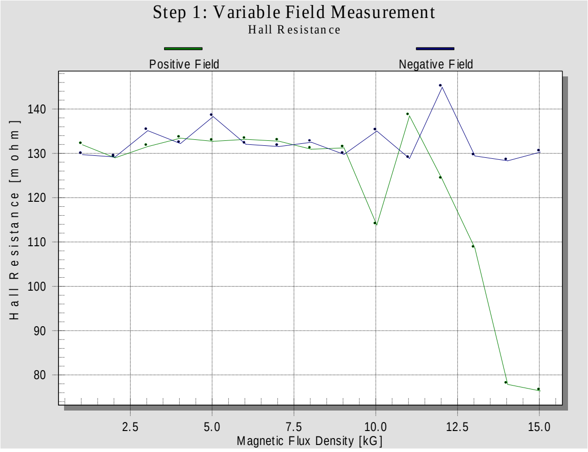

Figure 3.25: Hall resistance of 68-c plane Al_2O_3 sample 1 versus magnetic flux density

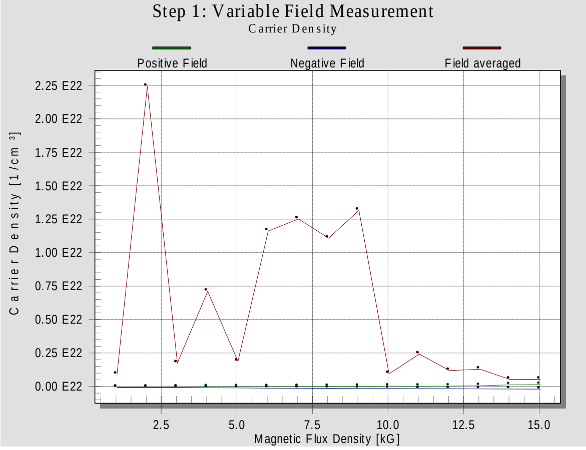

Figure 3.26: Carrier density of 68-c plane Al_2O_3 sample 1 versus magnetic flux density

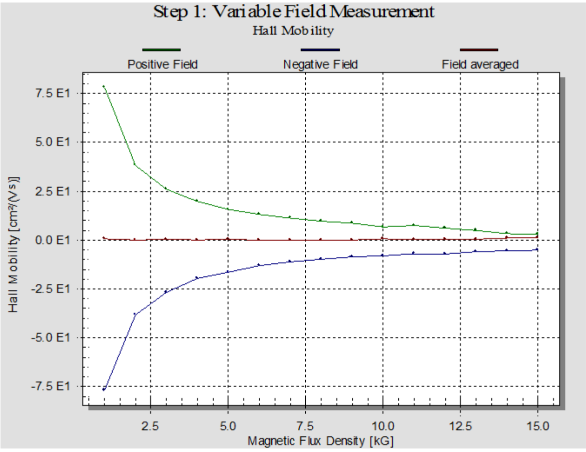

Figure 3.27: Hall mobility of 68-c plane Al_2O_3 sample 1 versus magnetic flux density

J. Batch 84 c-plane Al_2O_3 substrate sample 3

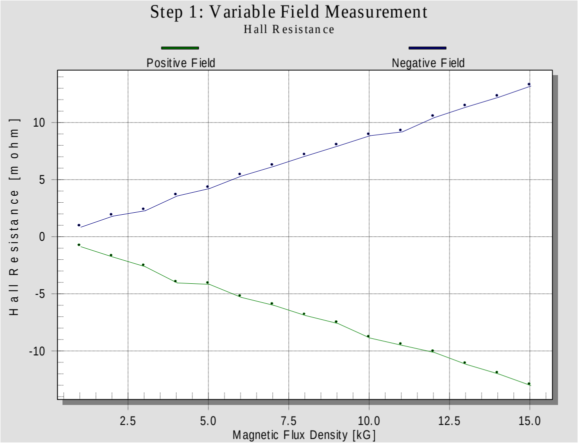

Figure 3.28: Hall resistance of 84-c plane Al_2O_3 sample 3 versus magnetic flux density

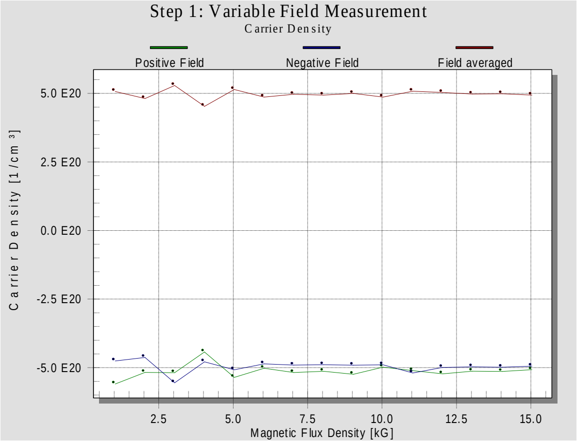

Figure 3.29: Carrier density of 84-c plane Al_2O_3 sample 3 versus magnetic flux density

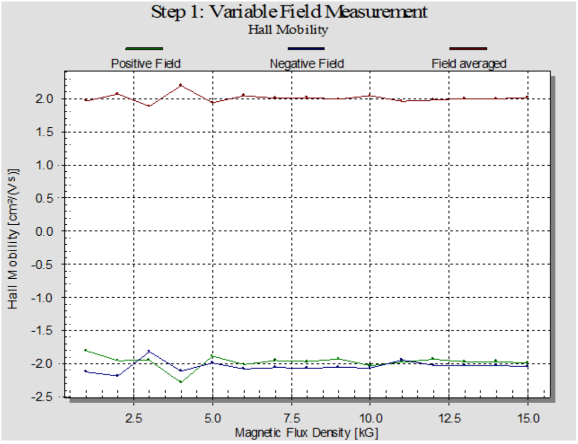

Figure 3.30: Hall mobility of 84-c plane Al_2O_3 sample 3 versus magnetic flux density

K. Batch 98 c-plane Al_2O_3 substrate

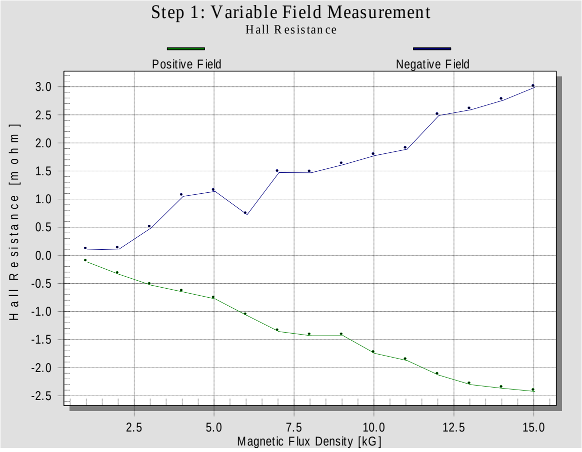

Figure 3.31: Hall resistance of 98-c plane Al_2O_3 versus magnetic flux density

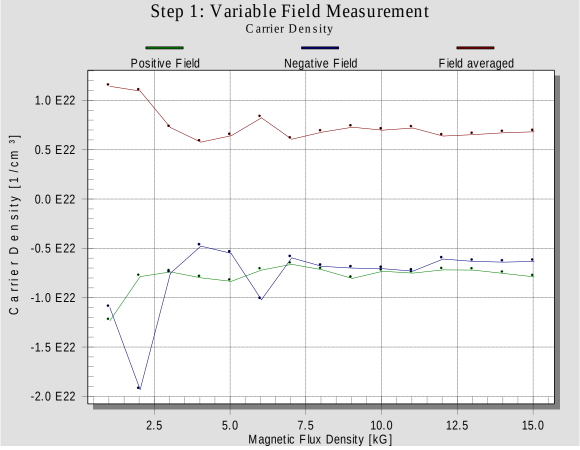

Figure 3.32: Carrier density of 98-c plane Al_2O_3 versus magnetic flux density

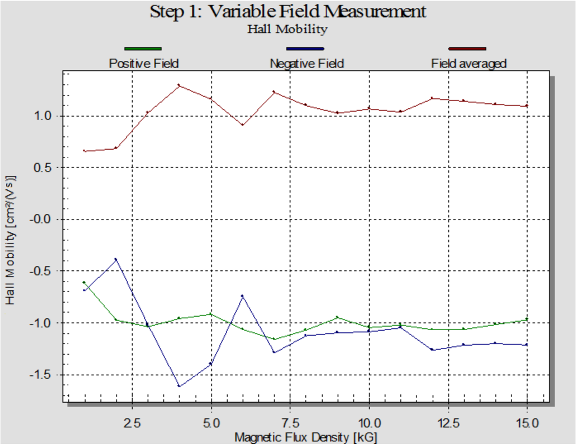

Figure 3.33: Hall mobility of 98-c plane Al_2O_3 versus magnetic flux density

L. Batch 107 c-plane Al_2O_3 substrate

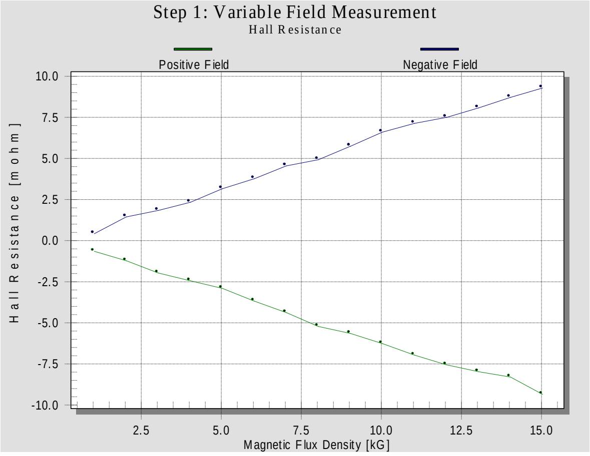

Figure 3.34: Hall resistance of 107-c plane Al_2O_3 versus magnetic flux density

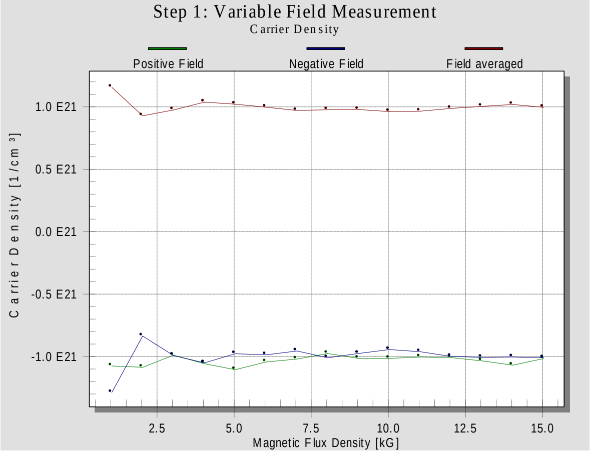

Figure 3.35: Carrier density of 107-c plane Al_2O_3 versus magnetic flux density

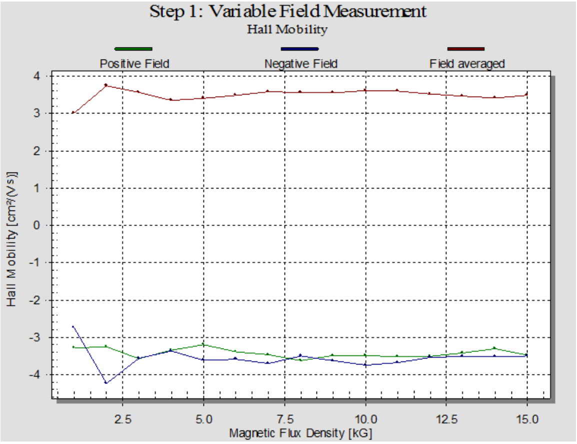

Figure 3.36: Hall mobility of 107-c plane Al_2O_3 versus magnetic flux density

M. Batch 108 c-plane Al_2O_3 substrate

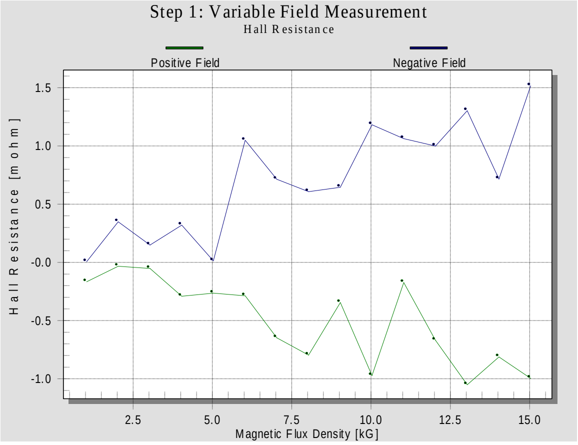

Figure 3.37: Hall resistance of 108-c plane Al_2O_3 sample 1 versus magnetic flux density

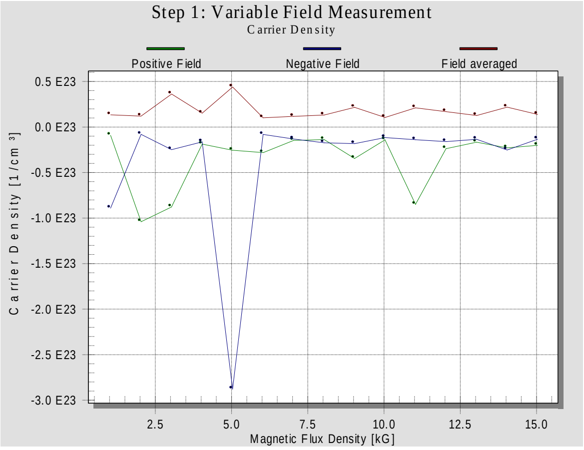

Figure 3.38: Carrier density of 108-c plane Al_2O_3 sample 1 versus magnetic flux density

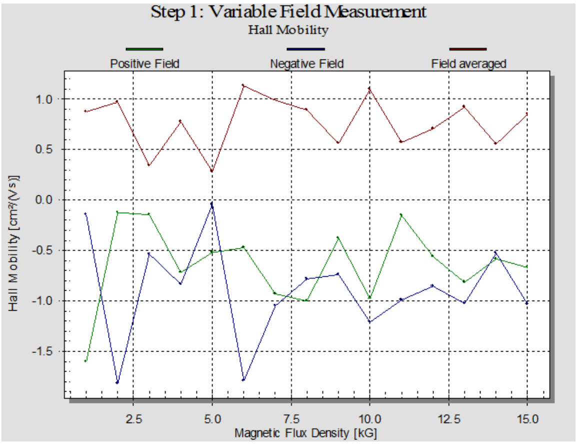

Figure 3.39: Hall mobility of 108-c plane Al_2O_3 sample 1 versus magnetic flux density

N. Batch 28 r-plane Al_2O_3 substrate sample 2

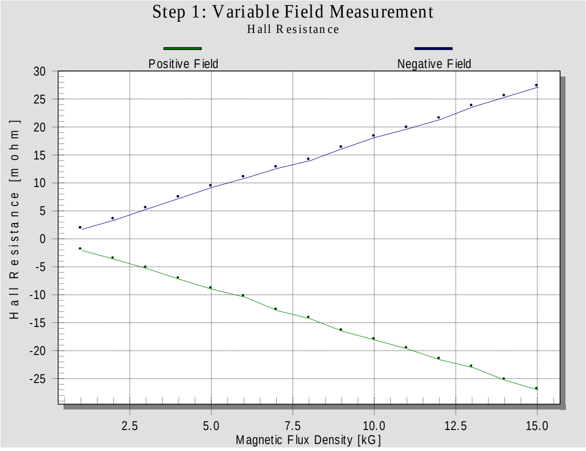

Figure 3.40: Hall resistance of 28-r plane versus magnetic flux density

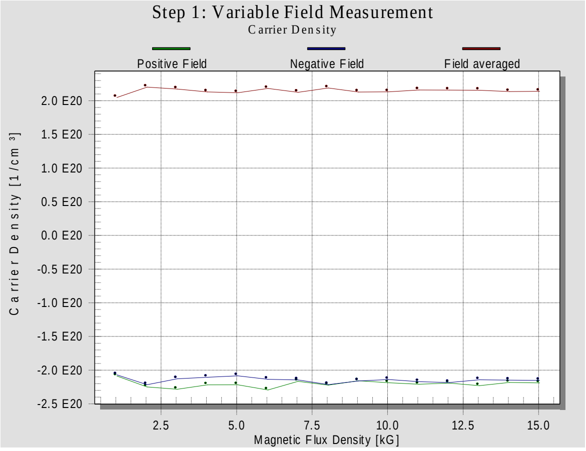

Figure 3.41: Carrier density of 28-r plane Al_2O_3 versus magnetic flux density

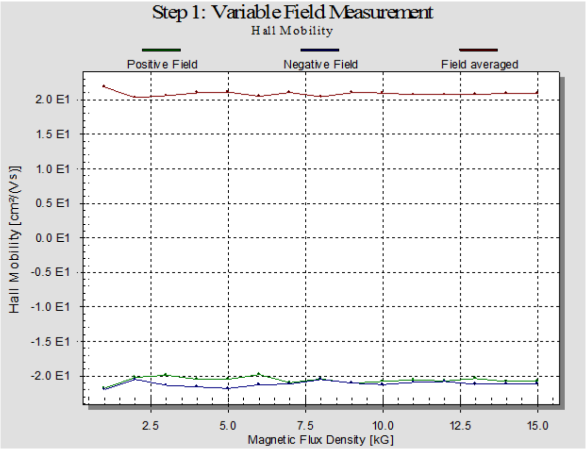

Figure 3.42: Hall mobility of 28-r plane Al_2O_3 misoriented versus magnetic flux density

O. Batch 30 r-plane Al_2O_3 substrate

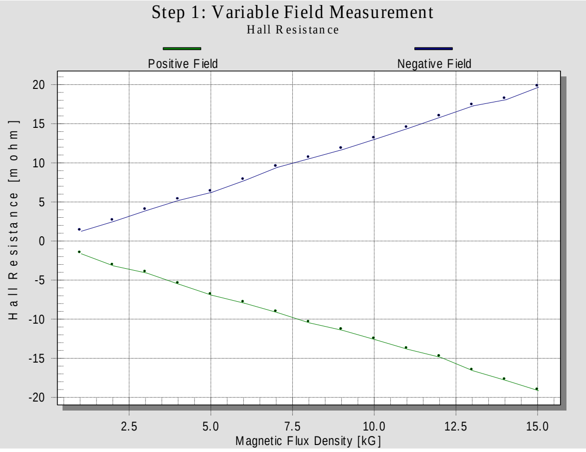

Figure 3.43: Hall resistance of 30-r plane Al_2O_3 versus magnetic flux density

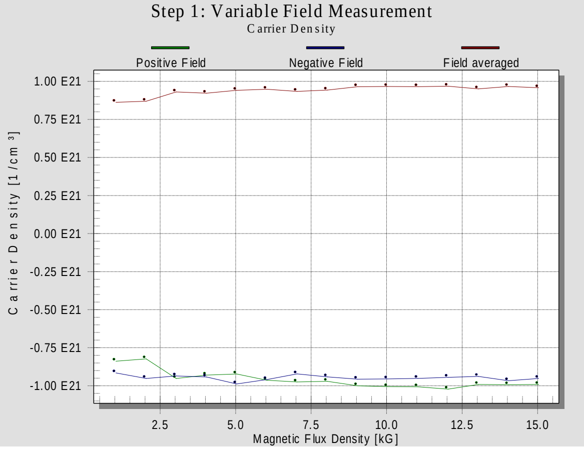

Figure 3.44: Carrier density of 30-r plane Al_2O_3 versus magnetic flux density

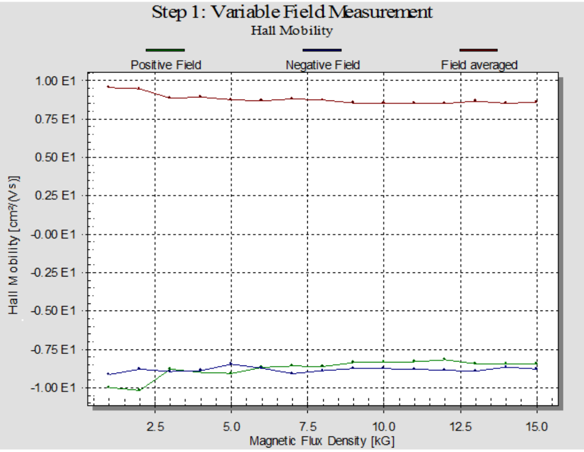

Figure 3.45: Hall mobility of 30-r plane Al_2O_3 versus magnetic flux density

P. Batch 32 MOCVD GaN substrate

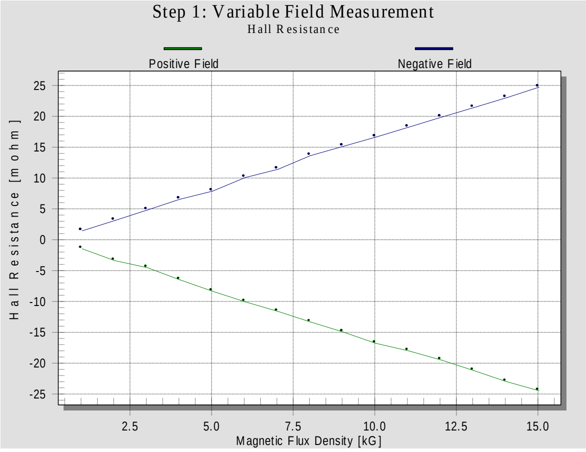

Figure 3.46: Hall resistance of 32-MOCVD GaN versus magnetic flux density

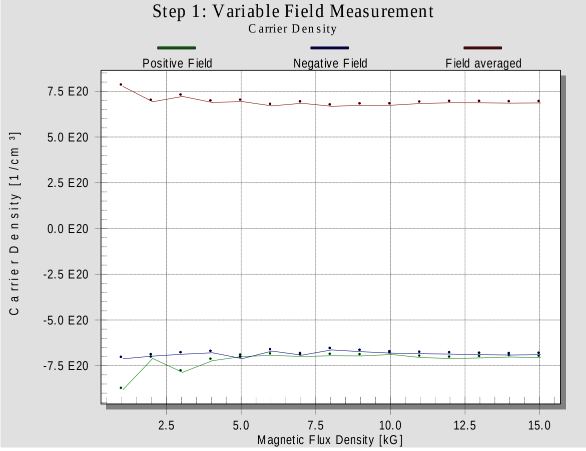

Figure 3.47: Carrier density of 32-MOCVD GaN versus magnetic flux density

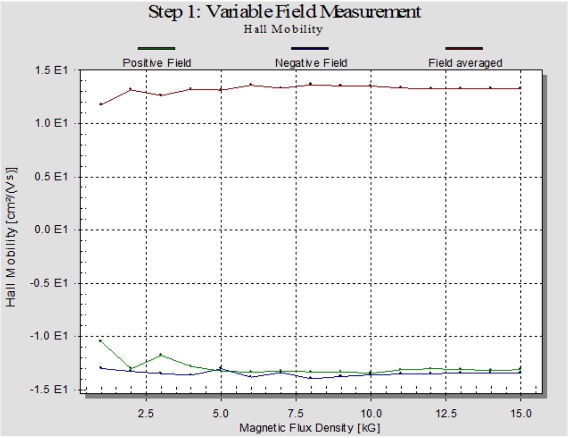

Figure 3.48: Hall mobility of 32-MOCVD GaN versus magnetic flux density

Q. Batch 52 MOCVD GaN substrate

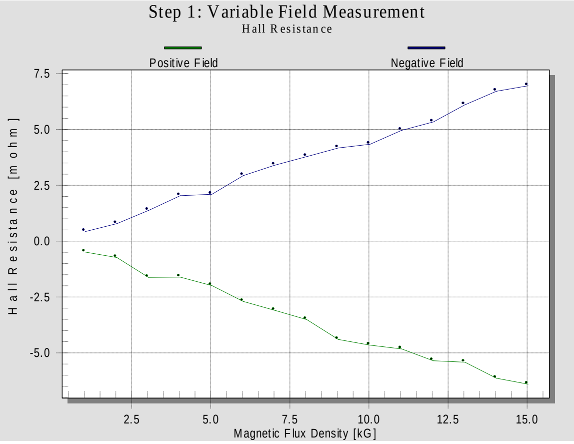

Figure 3.49: Hall resistance of 52-MOCVD GaN versus magnetic flux density

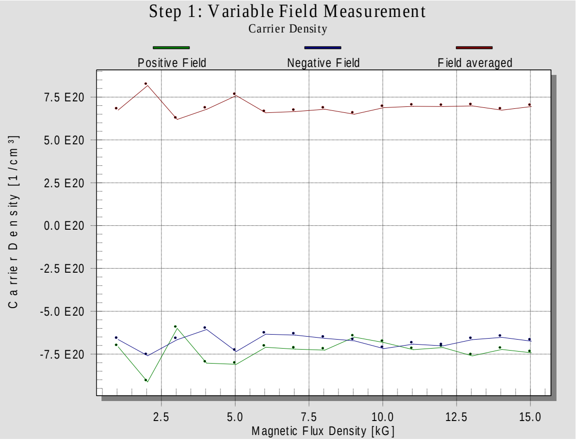

Figure 3.50: Carrier density of 52-MOCVD GaN versus magnetic flux density

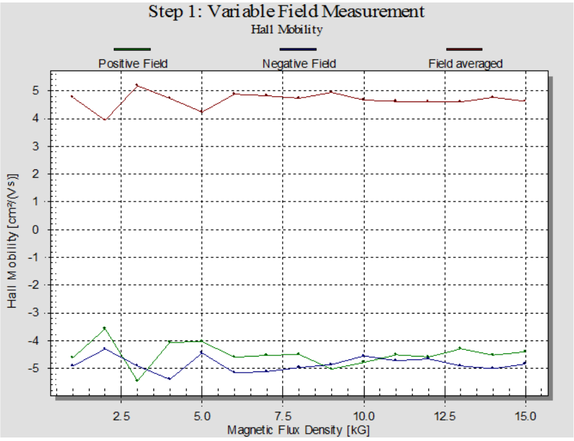

Figure 3.51: Hall mobility of 52-MOCVD GaN versus magnetic flux density

R. Batch 69 SiC substrate sample 1

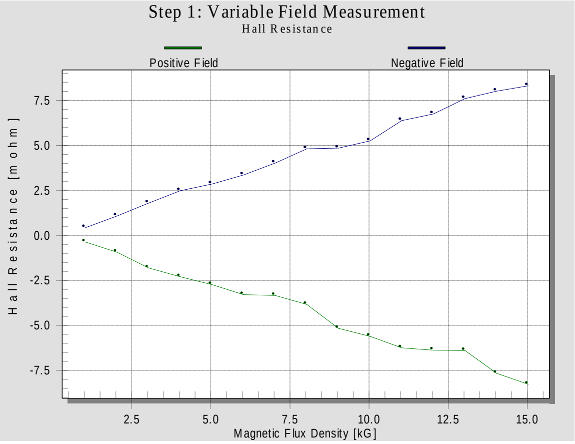

Figure 3.52: Hall resistance of 69-SiC substrate sample 1 versus magnetic flux density

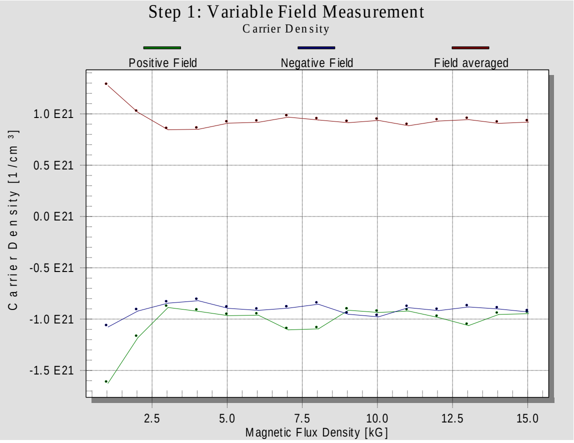

Figure 3.53: Carrier density of 69-SiC substrate sample 1 versus magnetic flux density

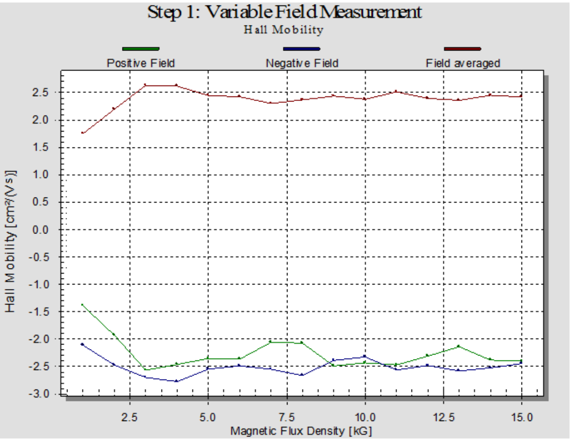

Figure 3.54: Hall mobility of 69-SiC substrate sample 1 versus magnetic flux density

S. Batch 69 SiC substrate sample 2

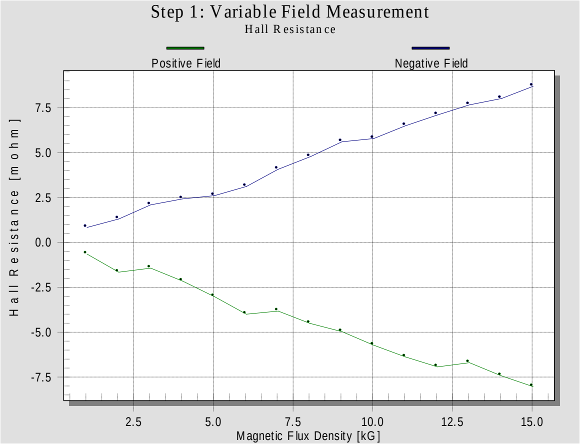

Figure 3.55: Hall resistance of 69-SiC substrate sample 2 versus magnetic flux density

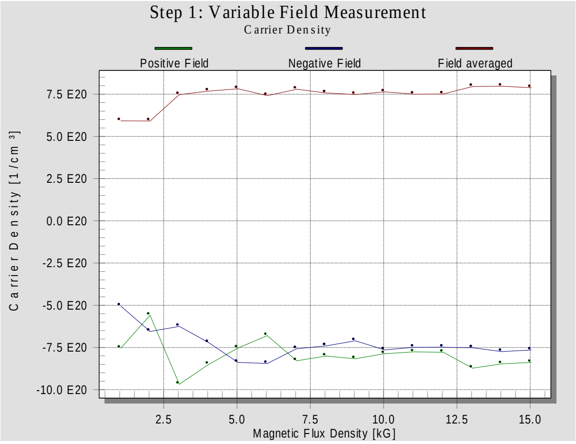

Figure 3.56: Carrier density of 69-SiC substrate sample 2 versus magnetic flux density

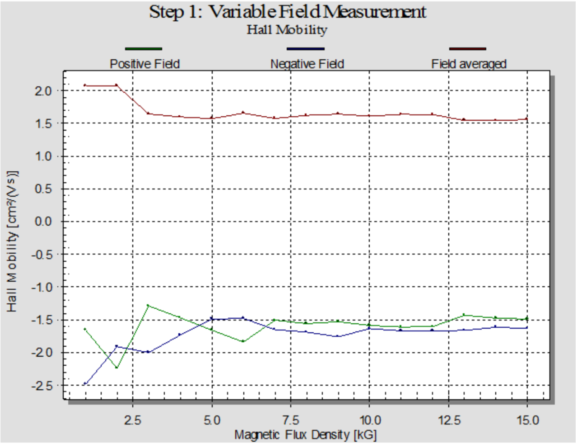

Figure 3.57: Hall mobility of 69-SiC substrate sample 2 versus magnetic flux density

T. Batch 69 SiC substrate sample 3

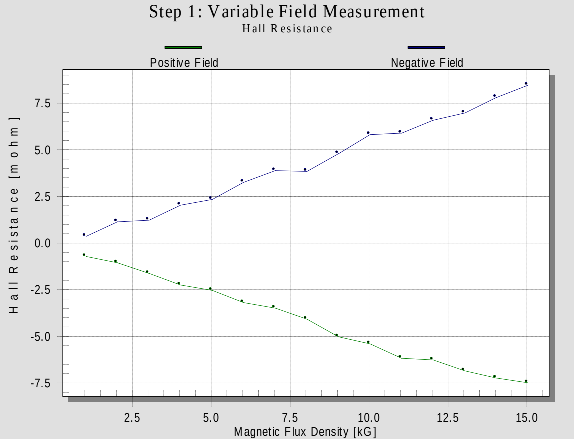

Figure 3.58: Hall Resistance of 69-SiC substrate sample 3 versus magnetic flux density

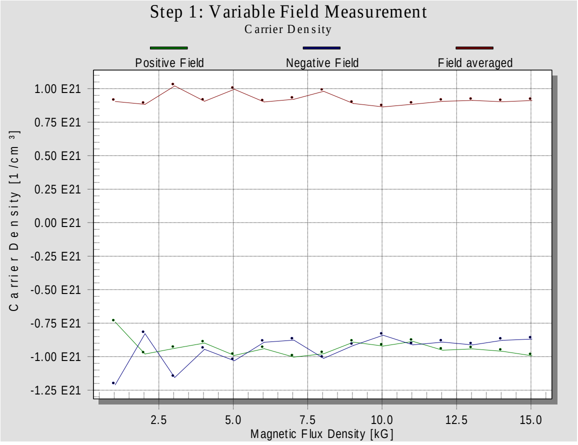

Figure 3.59: Carrier density of 3269-SiC substrate sample 3 versus magnetic flux density

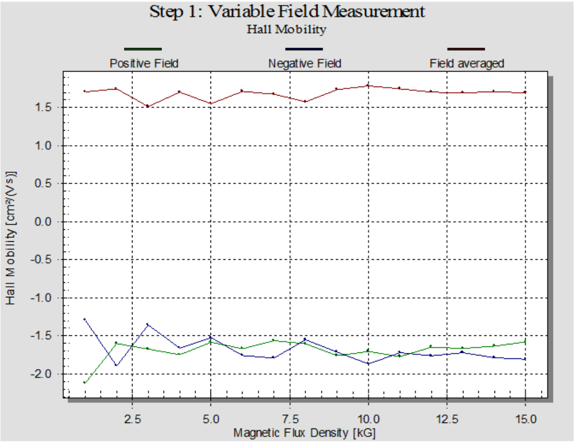

Figure 3.60: Hall mobility of 69-SiC substrate sample 3 versus magnetic flux density

Variable Field Measurement Discussion

Throughout the sample set, patterns start to emerge. In all the samples, the Hall resistance goes up as a function of magnetic flux density, the opposite of the relationship normally seen from semiconductors. However, this is on par with the results seen from metals. This is due to Sc being a transition metal, having properties of both semiconductors and metals. Another readily apparent trait is the high carrier densities. In most cases it was hard to see changes in the carrier density, since they were so high to begin with.

Special attention should be given to samples D, H, I, and M, as they vary wildly from the trends shown by the others. Samples H, I, and M contain the aluminum nitride, AlN, impurity and are impacted heavily by it. Sample D does not contain the impurity, but appears to be an outlier most likely due to some other contamination or some sort of surface abnormality that wasn't caught with the SEM.

Sample 32-c plane Al_2O_3 misoriented gives unique insight into this substrate, as it is the only sample that contained a peak on the (200) crystalline plane, as well as on the (111) plane. This sample has the highest of the resistivities and the second lowest mobility. It had an average thickness and was on the lower end carrier concentration. This sample also included the AlN peak, however the other samples which included this peak did not yield similar results. Thus it can be concluded that the presence of the second peak is detrimental to the mobility of the sample.

Sample 52-c plane Al_2O_3 misoriented only has a single peak and does not include the AlN contamination. Its thickness is slightly larger than that of the 32-c plane Al_2O_3 misoriented. As a result resistivity drops by almost a factor of 5 and the mobility doubles. The exact same results can be seen in the second sample of 52-c plane Al_2O_3 misoriented.

Sample 54-c plane sapphire has similar characteristics to that of the 52-c plane Al_2O_3 misoriented, however isn't as thick a sample. By removing .4 μm worth of material the mobility rises by 2 cm^2/Vs and the resistivity dropped by a factor of 10. This leads to the belief that the thinner the conductive layer on c-plane sapphire the greater the mobility.

Sample 62-c plane sapphire has very similar characteristics to that of sample 54-c plane sapphire, however the thickness is greater. This caused the mobility to drop significantly. This helps to prove the belief that the conductive layer should be thinner on c-plane sapphire.

The 3 samples of 68-c plane sapphire show that the thinner the conductive layer the greater the mobility is conclusively. However is should be noted that at this thickness there is among the lowest of the carrier concentrations. The mobility of sample 2 calls for inspection of its resistivity. It has an almost completely negligible change, total of approximately .4 μΩ·cm, over the course of the range of 1 kG to 15 kG. Oddly, after the initial drop in resistivity due to the magnetic field, the resistivity grows as a greater field is introduced. For a better look at this trend the resistance measurements are presented in figure 3.1 and then in each subsequent section thereafter.

Sample 98- c plane sapphire offers mediocre results. It also contains the AlN contamination, but has the highest carrier concentration. It appears that on average samples with a thicker conductive layer have a larger carrier concentration.

Sample 107-c plane sapphire has no AlN peak, but does not offer any new insights. Sample 108- c plane sapphire, however contains the AlN peak and has interestingly contains a low resistivity and a low mobility.

It appears that except for ScN-32 c plane Al_2O_3 misoriented sample, the growth of the ScN is exclusively on (111) crystal plane. The dual peaks in the 32-c plane Al_2O_3 misoriented sample affects the resistivy and mobility due to the presence of the AlN contamination. However the dual peaks do not appear to have an effect on the carrier concentration.

The 68-c plane sapphire sample 2 has the highest mobility and a lack of AlN contamination. In figure 3.15, it can be seen that after a small drop in the mobility after a magnetic field was applied, there were negligible changes in the values no matter how high the magnetic field introduced was.

Moving onto the r-plane substrates, it is hard to characterize the whole of the r-plane sapphire subset, however those samples provided can be compared to the results from the c-plane sapphire. Looking at the 62-c plane sapphire sample, it appears that r-plane sapphire offers quite a bit different results from those of the c-plane subset. This sample offers the largest of the mobilities at the greatest conductive layer thickness. At the same time this mobility is achieved with a comparable carrier concentration and oddly a resistivity that is on par with the c-plane sapphire. These results may be due to this sample being the only one that has its peak on the (220).

Looking at the other sample, 30-r plane sapphire, that was provided, an interesting result appears. For example, this sample has the AlN peak present and still gives results close to the best that were found using a c-plane sapphire substrate at double the conductive layer thickness.

The MOCVD sample set offers very similar results to those of the c-plane sapphire. The mobility is at a maximum when in sample 32-MOCVD GaN. This shows that there is a good correlation between a thinner conductive layer to a larger resistivity. However, sample 52-MOCVD GaN has a conductive layer as thickness 4 times that of the first. As expected the sample's mobility is significantly lower, but the carrier concentration of both samples is the same.

The SiC subset offers similar results to those of the c-plane sapphire. This substrate allows for the conductive layer to grow on the (200) crystal plane. Interestingly it does not have an AlN peak, which could be due to either the plane the conductive material lays on or perhaps the substrate material itself. This material offers fairly mediocre results when compared to those of the MOCVD GaN substrate and the r-plane sapphire substrate.

Variable Temperature Measurement Results

This set of electrical characteristic tests was done in order to conclude how the samples reacted under variable temperatures. This test was done using a current of 1 mA through the sample and a 13 kG magnetic field perpendicular to the sample, according to Fig. 2.3, in an oven that ranged from 300 K to 500 K.

As with the Variable Field Measurement Results section, each sample's results in this section of the chapter will be broken down into 3 parts. The first is a graph of the Hall resistance for that sample, the second is that sample's carrier density, and the final graph is of the sample's mobility. These results will be discussed in the Variable Temperature Measurement Discussion section that follows this one.

Each individual graph is further broken down into different data sets. Each graph has at least two data sets, one for if there is a positive magnetic field and one for a reversed, negative, magnetic field. This is why some of the data appears to be negative, indicating directionality. Some of the graphs have an extra dataset that is the fields averaged together.

A. Batch 32 c-plane Al_2O_3 misoriented substrate

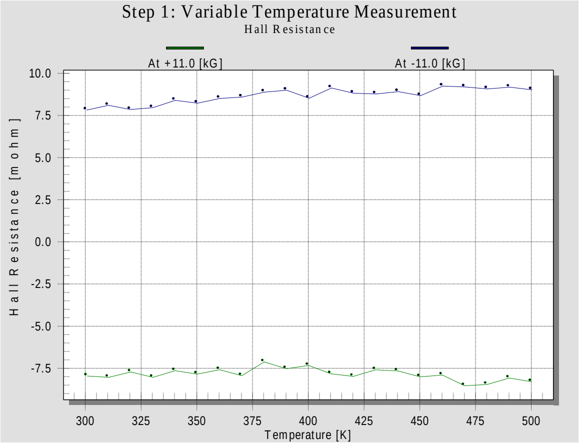

Figure 3.61: Hall resistance of 32-c plane Al_2O_3 misoriented versus temperature

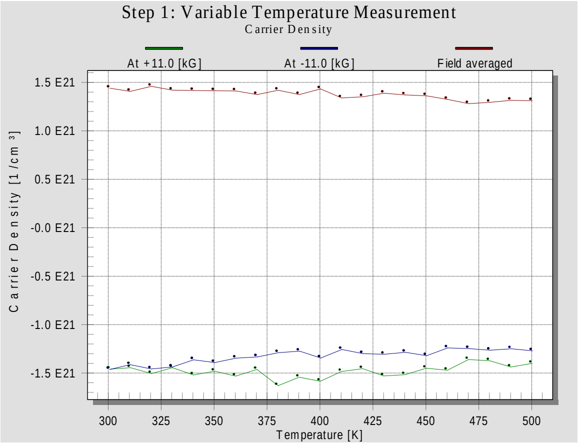

Figure 3.62: Carrier density of 32-c plane Al_2O_3 misoriented versus temperature

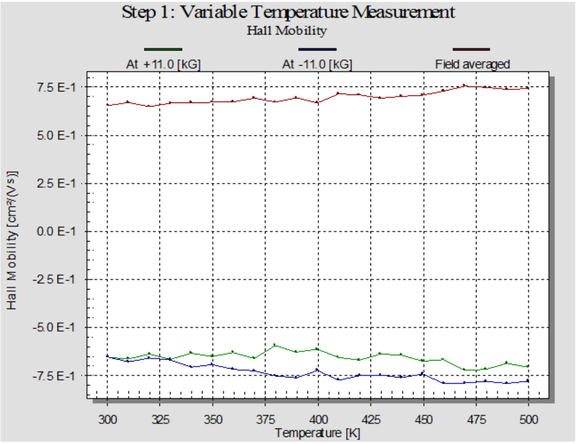

Figure 3.63: Hall mobility of 32-c plane Al_2O_3 misoriented versus temperature

B. Batch 52 c-plane Al_2O_3 misoriented substrate

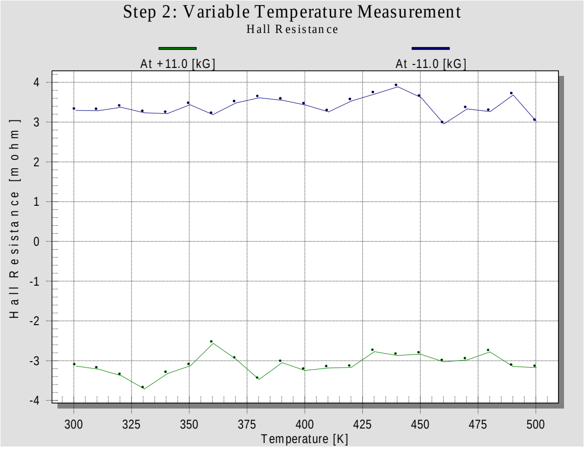

Figure 3.64: Hall resistance of 52-c plane Al_2O_3 misoriented versus temperature

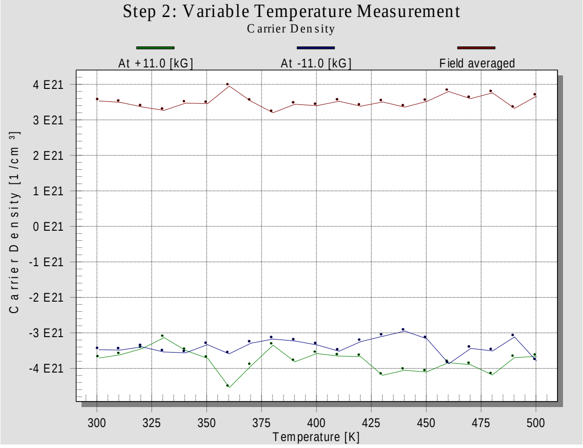

Figure 3.65: Carrier density of 52-c plane Al_2O_3 misoriented versus temperature

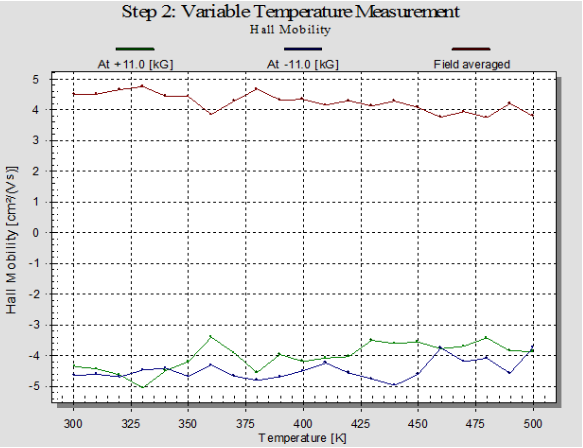

Figure 3.66: Hall mobility of 52-c plane Al_2O_3 misoriented versus temperature

C. Batch 62 c-plane Al_2O_3 substrate

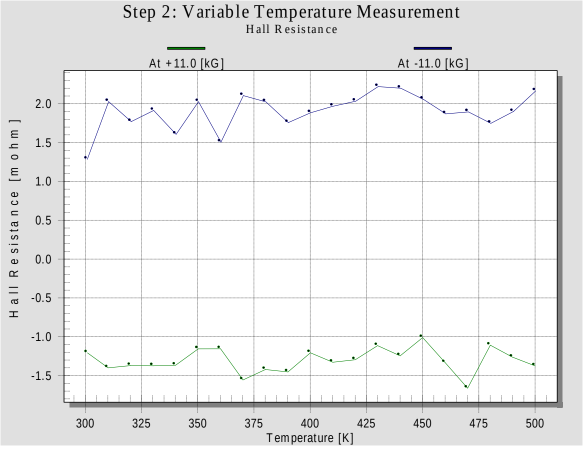

Figure 3.67: Hall resistance of 62-c plane Al_2O_3 versus temperature

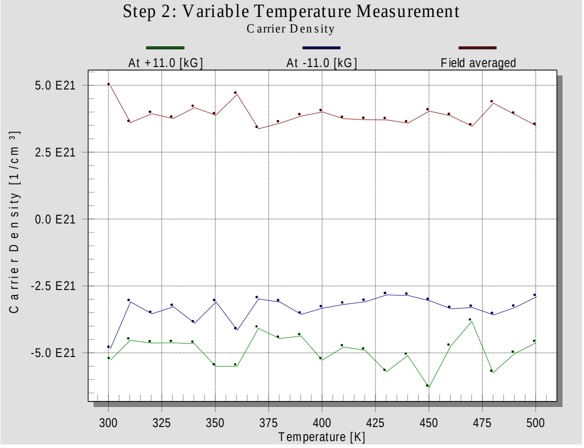

Figure 3.68: Carrier density of 62-c plane Al_2O_3 versus temperature

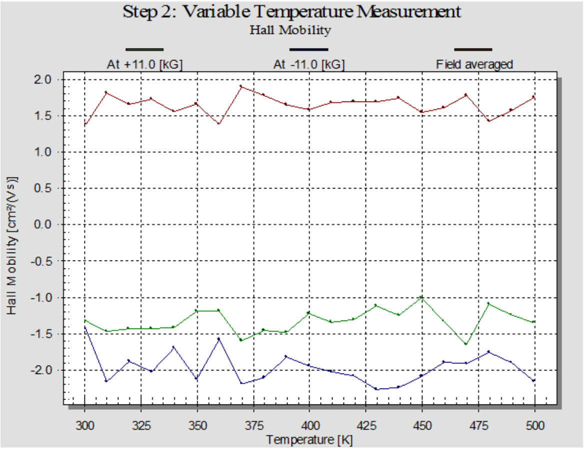

Figure 3.69: Hall mobility of 62-c plane Al_2O_3 versus temperature

D. Batch 68 c-plane Al_2O_3 substrate sample 1

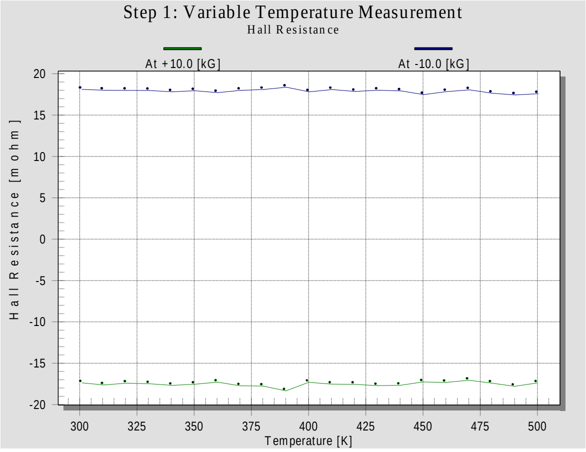

Figure 3.70: Hall resistance of 68-c plane Al_2O_3 substrate sample 1 versus temperature

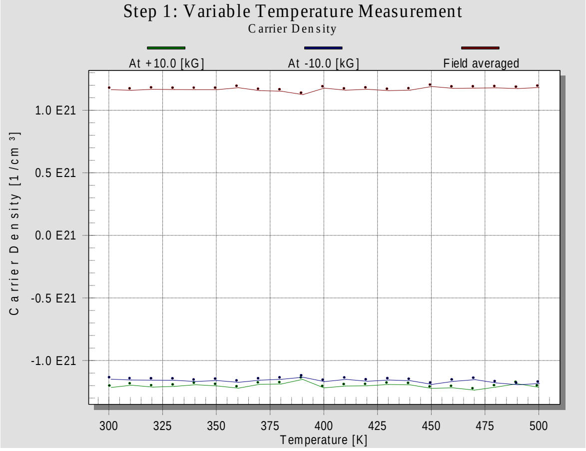

Figure 3.71: Carrier density of 68-c plane Al_2O_3 substrate sample 1 versus temperature

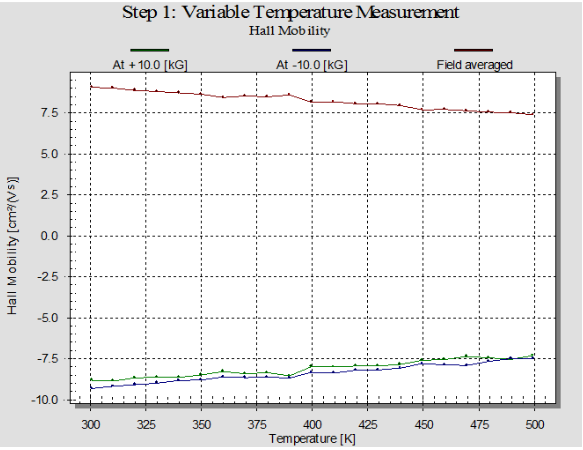

Figure 3.72: Hall mobility of 68-c plane Al_2O_3 substrate sample 1 versus temperature

E. Batch 84 c-plane Al_2O_3 substrate sample 1

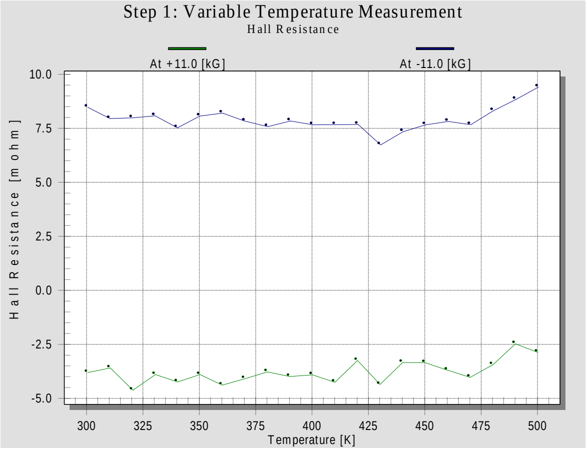

Figure 3.73: Hall resistance of 82-c plane Al_2O_3 sample 1 versus temperature

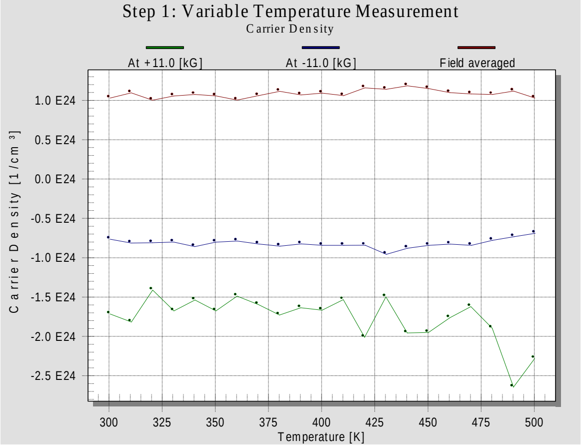

Figure 3.74: Carrier density of 82-c plane Al_2O_3 sample 1 versus temperature

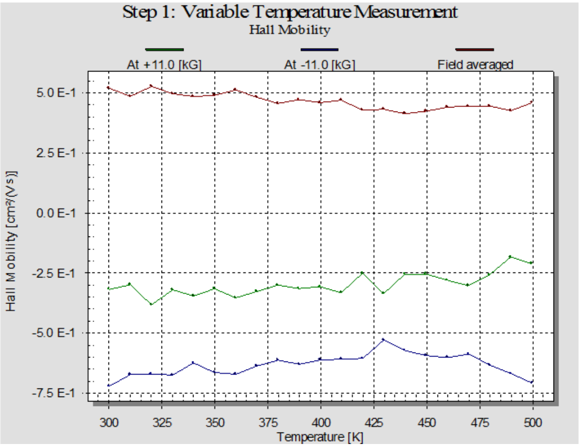

Figure 3.75: Hall mobility of 82-c plane Al_2O_3 sample 1 versus temperature

F. Batch 98 c-plane Al_2O_3 substrate

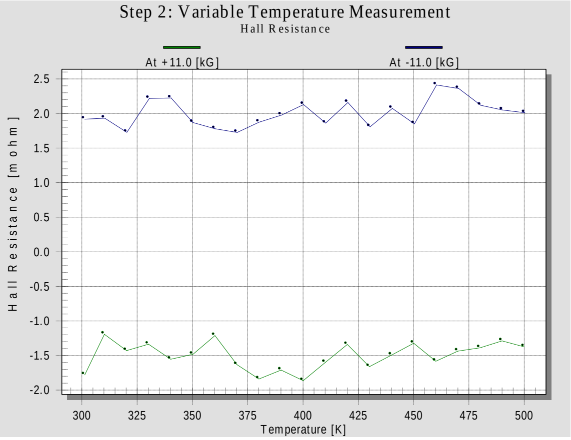

Figure 3.76: Hall resistance of 98-c plane Al_2O_3 versus temperature

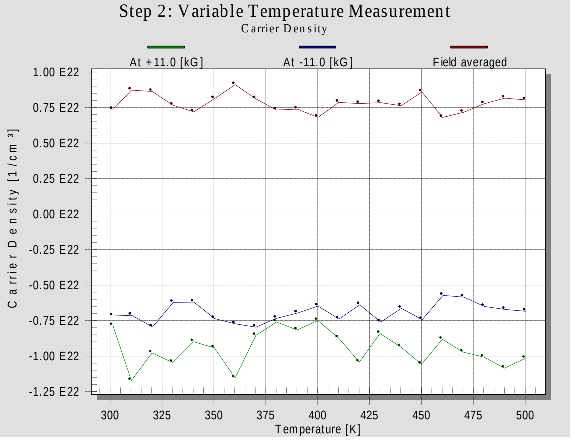

Figure 3.77: Carrier density of 98-c plane Al_2O_3 versus temperature

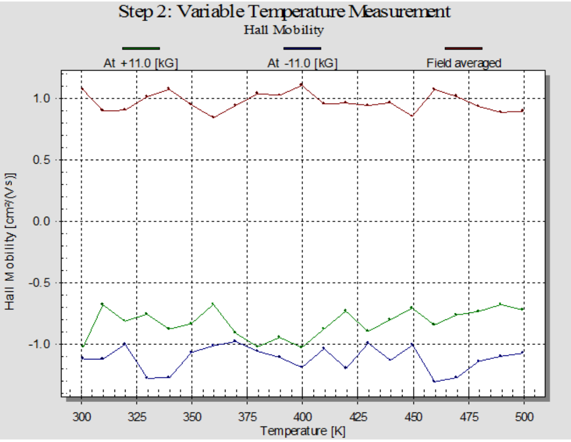

Figure 3.78: Hall mobility of 98-c plane Al_2O_3 versus temperature

G. Batch 107 c-plane Al_2O_3 substrate

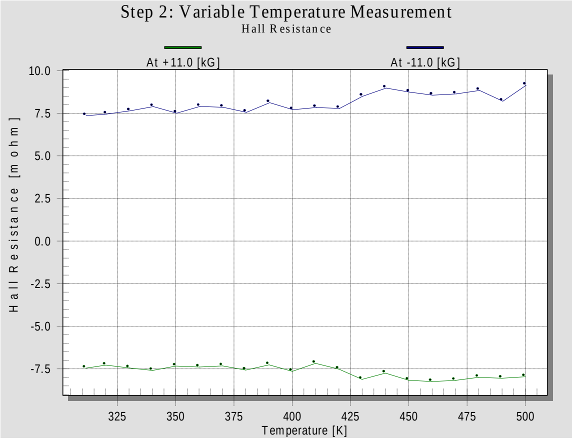

Figure 3.79: Hall resistance of 107-c plane Al_2O_3 versus temperature

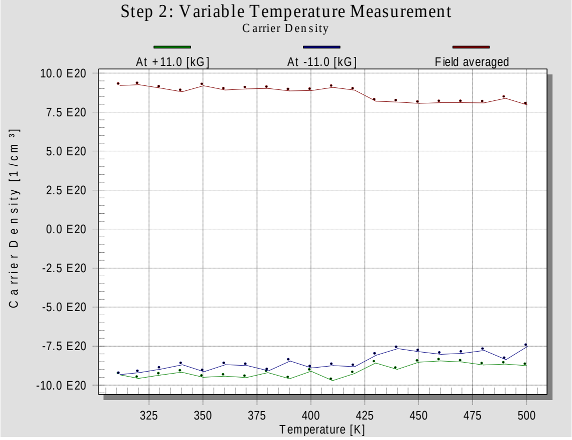

Figure 3.80: Carrier density of 107-c plane Al_2O_3 versus temperature

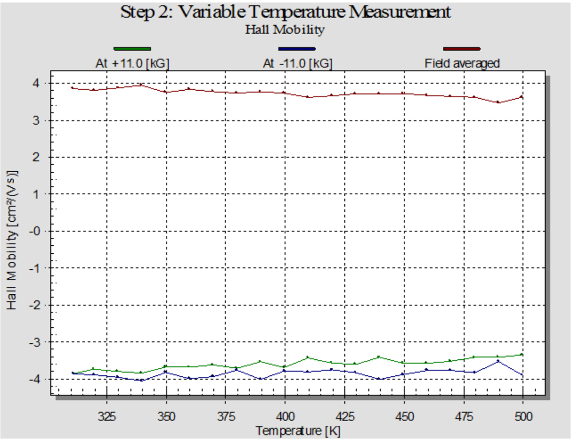

Figure 3.81: Hall mobility of 107-c plane Al_2O_3 versus temperature

H. Batch 108 c-plane Al_2O_3 substrate

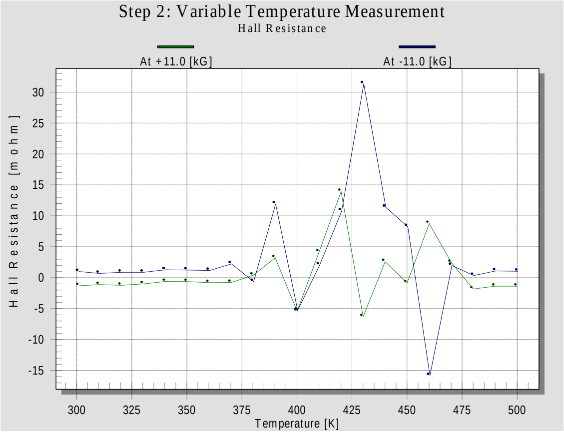

Figure 3.82: Hall resistance of 108-c plane Al_2O_3 versus temperature

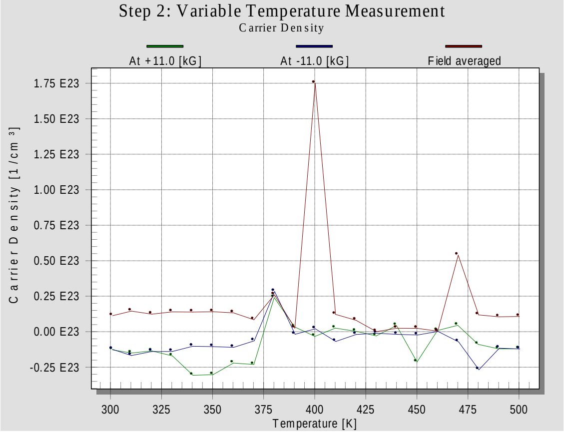

Figure 3.83: Carrier density of 108-c plane Al_2O_3 versus temperature

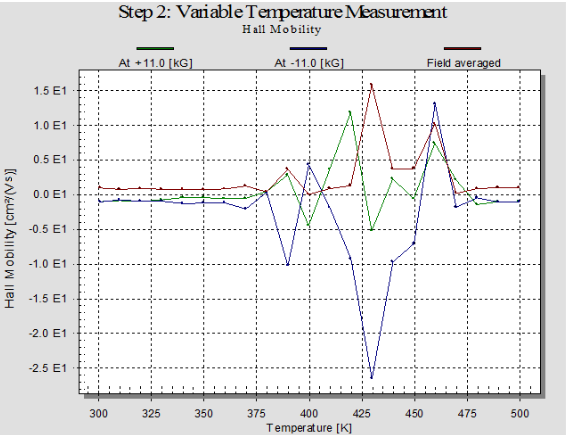

Figure 3.84: Hall mobility of 108-c plane Al_2O_3 versus temperature

I. Batch 28 r-plane Al_2O_3 substrate sample 2

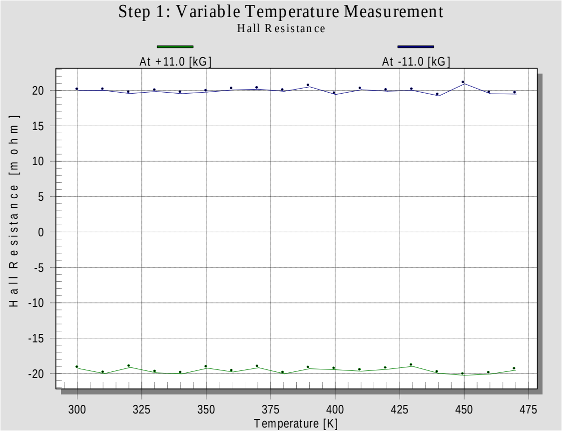

Figure 3.85: Hall resistance of 28-r plane Al_2O_3 sample 2 versus temperature

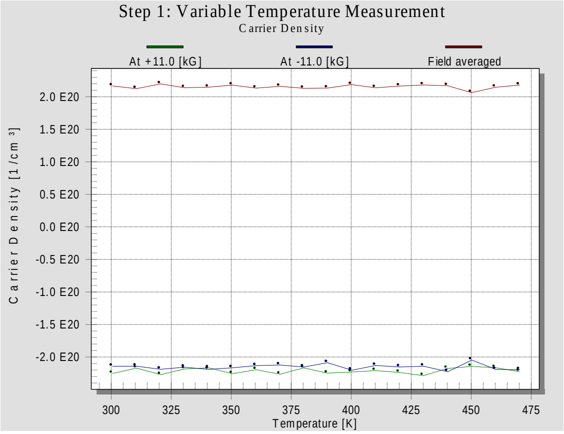

Figure 3.86: Carrier density of 28-r plane Al_2O_3 sample 2 versus temperature

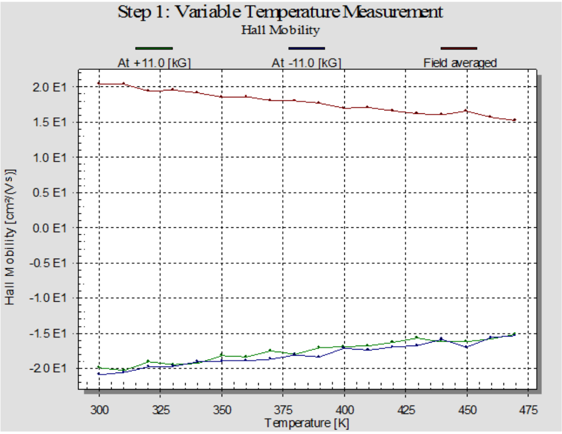

Figure 3.87: Hall mobility of 28-r plane Al_2O_3 sample 2 versus temperature

J. Batch 32 MOCVD GaN substrate

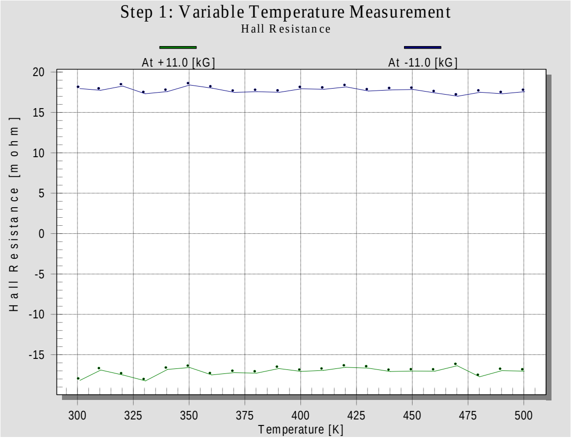

Figure 3.88: Hall resistance of 32-MOCVD GaN versus temperature

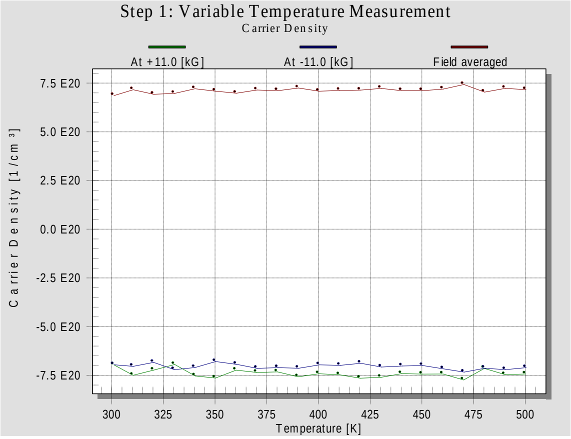

Figure 3.89: Carrier density of 32-MOCVD GaN versus temperature

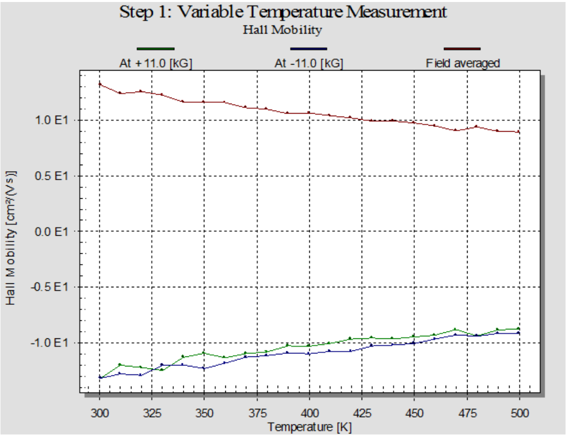

Figure 3.90: Hall mobility of 32-MOCVD GaN versus temperature

K. Batch 52 MOCVD GaN substrate

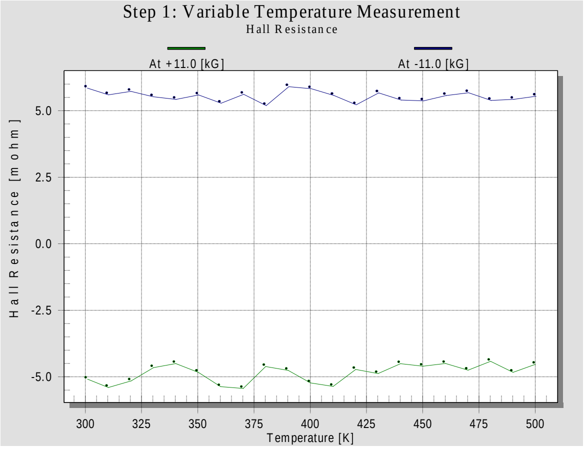

Figure 3.91: Hall resistance of 52-MOCVD GaN versus temperature

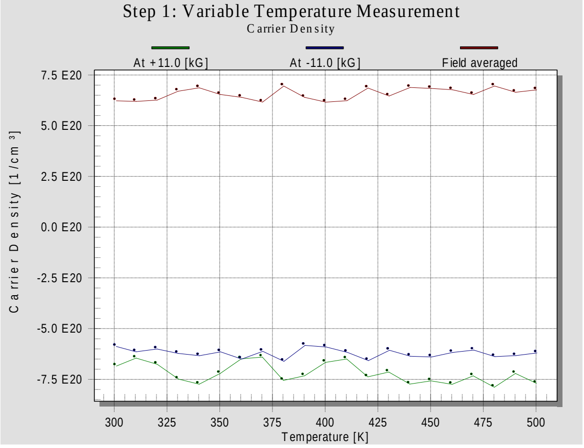

Figure 3.92: Carrier density of 52-MOCVD GaN versus temperature

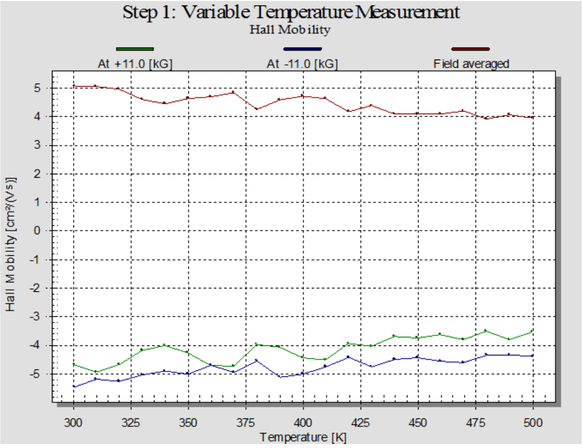

Figure 3.93: Hall mobility of 52-MOCVD GaN versus temperature

L. Batch 69 SiC substrate sample 1

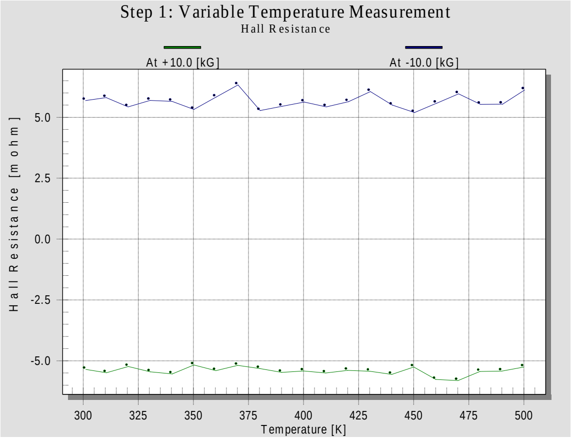

Figure 3.94: Hall resistance of 69-SiC versus temperature

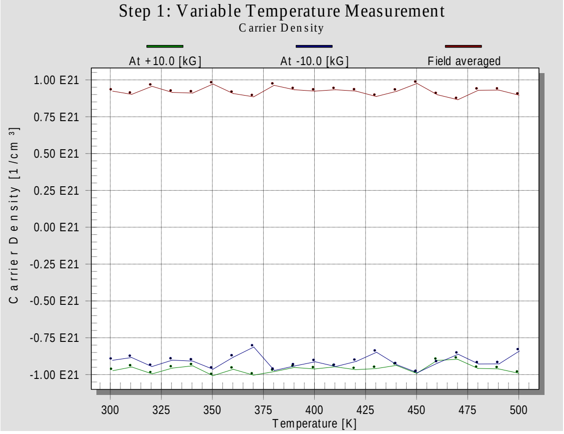

Figure 3.95: Carrier density of 69-SiC versus temperature

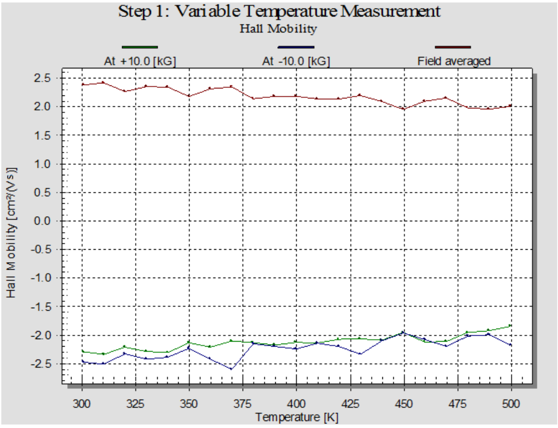

Figure 3.96: Hall mobility of 69-SiC versus temperature

Variable Temperature Measurement Discussion

Just as with the variable field measurements, the AlN has a critical impact on sample H. Sample C also shows critical issues, but as discussed in the variable field measurements discussion this is most likely due to some other contamination.

Most of the samples have a downward trend in mobility, however a few of the c-plane Al_2O_3 substrate samples still tend to trend upwards and we never see that downward trend begin to approach. This may lend to the c-plan substrates being useful in high temperature applications.

Across both the variable field and temperature testing, the r-plane substrate offered the largest mobilities and the thickest conductive layer. The other samples have trended towards higher mobilities at lower conductive layer thicknesses. This lends to the idea that if we decrease the thickness of the r-plane ScN, greater mobilities could be achieved.

CHAPTER 4 - Conclusion

The c-plane sapphire substrate holds great promise for high temperature applications. It was the only sample that had a mobility that rose during testing. However due to the high rate of AlN contamination in the samples, much care must be given during the growth process to minimize this issue.

The AlN contamination has large ramifications on the mobility of a sample and everything that can be done to minimize it should. This may be accomplished by the use of a horizontal HVPE reactor or an inverted horizontal reactor. This would allow for greater control over the growth technique. However, it would add new layers of complexity to the process.

The r-plane sapphire substrate allows for a much thicker conductive layer to be grown and still achieve similar results as the other substrates. Under high temperature testing, the r-plane sapphire substrate performed remarkably well, with the highest mobility. However, with the limited number of samples of r-plane sapphire in this control group, more studies should be done. This substrate, while still obtaining the highest mobility in the temperature testing, lost almost a fifth of its value. Over all the r-plane sapphire samples appear to hold much promise.

Appendix A - Variable Field Measurements

32 - c plane Al_2O_3 misoriented

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 600.0 [nm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 11/1/2007 12:22:57 PM
Time Completed: 11/1/2007 1:23:25 PM
Elapsed Time: 1:0:27

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 5.9710E-3
at Field [G] = -9.3375E-3
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
9.9995E+2	5.9699E-3	-5.5234E-3	n	1.1301E+21	9.2504E-1	ERROR
2.0000E+3	5.9700E-3	-2.2576E-3	n	2.7650E+21	3.7809E-1	ERROR
3.0000E+3	5.9699E-3	-3.0757E-3	n	2.0295E+21	5.1510E-1	ERROR
4.0000E+3	5.9698E-3	-3.3170E-3	n	1.8819E+21	5.5552E-1	ERROR
5.0000E+3	5.9699E-3	-3.8228E-3	n	1.6329E+21	6.4022E-1	ERROR
6.0000E+3	5.9700E-3	-3.3015E-3	n	1.8907E+21	5.5292E-1	ERROR
7.0000E+3	5.9700E-3	-3.4895E-3	n	1.7888E+21	5.8442E-1	ERROR
8.0000E+3	5.9699E-3	-3.4442E-3	n	1.8124E+21	5.7683E-1	ERROR
9.0000E+3	5.9700E-3	-3.5029E-3	n	1.7820E+21	5.8665E-1	ERROR
1.0000E+4	5.9702E-3	-3.5786E-3	n	1.7443E+21	5.9933E-1	ERROR
1.1000E+4	5.9701E-3	-3.3495E-3	n	1.8636E+21	5.6096E-1	ERROR
1.2000E+4	5.9701E-3	-3.6986E-3	n	1.6877E+21	6.1943E-1	ERROR
1.3000E+4	5.9702E-3	-3.2422E-3	n	1.9253E+21	5.4299E-1	ERROR
1.4000E+4	5.9702E-3	-3.3752E-3	n	1.8494E+21	5.6527E-1	ERROR
1.5000E+4	5.9704E-3	-3.1892E-3	n	1.9573E+21	5.3411E-1	ERROR

52 - c plane Al_2O_3 misoriented

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.0 [µm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 11/2/2007 10:33:24 AM
Time Completed: 11/2/2007 11:33:51 AM
Elapsed Time: 1:0:28

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 1.2639E-3
at Field [G] = 1.7888E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
9.9999E+2	1.2621E-3	-1.7194E-3	n	3.6304E+21	1.3604E+0	ERROR
2.0001E+3	1.2620E-3	-4.4876E-3	n	1.3910E+21	3.5505E+0	ERROR
3.0000E+3	1.2620E-3	-1.7144E-3	n	3.6410E+21	1.3564E+0	ERROR
4.0000E+3	1.2620E-3	-1.6611E-3	n	3.7578E+21	1.3143E+0	ERROR
5.0000E+3	1.2621E-3	-2.0861E-3	n	2.9923E+21	1.6505E+0	ERROR
6.0000E+3	1.2621E-3	-1.9888E-3	n	3.1387E+21	1.5735E+0	ERROR
7.0000E+3	1.2621E-3	-2.0607E-3	n	3.0292E+21	1.6304E+0	ERROR
8.0000E+3	1.2621E-3	-2.1718E-3	n	2.8742E+21	1.7183E+0	ERROR
9.0000E+3	1.2621E-3	-1.8412E-3	n	3.3903E+21	1.4567E+0	ERROR
1.0000E+4	1.2621E-3	-2.0323E-3	n	3.0714E+21	1.6080E+0	ERROR
1.1000E+4	1.2621E-3	-1.9883E-3	n	3.1395E+21	1.5731E+0	ERROR
1.2000E+4	1.2621E-3	-1.8656E-3	n	3.3459E+21	1.4761E+0	ERROR
1.3000E+4	1.2621E-3	-1.8929E-3	n	3.2976E+21	1.4977E+0	ERROR
1.4000E+4	1.2622E-3	-2.0794E-3	n	3.0019E+21	1.6452E+0	ERROR
1.5000E+4	1.2624E-3	-1.7587E-3	n	3.5494E+21	1.3914E+0	ERROR

54 - c plane sapphire

```
[Sample parameters]
Sample Type:      van der Pauw
Hall Factor =     1.0
Thickness =       600.0 [nm]
L =       15.0 [mm]
Depletion Layer Correction:         Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time:       1/16/2009 1:11:18 PM
Time Completed:   1/16/2009 1:53:26 PM
Elapsed Time:     0:42:8

Field profile:    Linear Sweep with Field Reversal
Maximum Field:    15.0 [kG]
Minimum Field:    1.0 [kG]
Field Step:       1.0 [kG]
Direction:        Positive to Negative
Measurement Type:         Hall and Resistivity Measurement
Excitation Current:       1.0 [mA]
Resistance Range:         Low
Dwell Time:       2.0 [Sec]
Current Reversal: On
Geometry selection:       A and B

Use Zero-field Resistivity to calculate Hall Mobility:  Yes
Zero-field Resistivity [ohm cm] =   3.8134E-4
at Field [G] =    -5.6038E-2
at Temperature [K] = ERROR


Field[G]   Resistivity[Ωcm]   HallCoeff.[cm³/C]   Type  CarrierDensity[cm⁻³] HallMobility[cm²/(Vs)] Temp[K]

9.9999E+2     3.8142E-4      -1.2145E-3      n      5.1399E+21      3.1847E+0      ERROR
2.0000E+3     3.8146E-4      -1.4437E-3      n      4.3237E+21      3.7859E+0      ERROR
3.0001E+3     3.8143E-4      -1.8724E-3      n      3.3338E+21      4.9101E+0      ERROR
4.0000E+3     3.8147E-4      -1.0006E-3      n      6.2382E+21      2.6240E+0      ERROR
4.9999E+3     3.8140E-4      -1.5125E-3      n      4.1272E+21      3.9662E+0      ERROR
6.0000E+3     3.8144E-4      -1.6121E-3      n      3.8721E+21      4.2275E+0      ERROR
6.9999E+3     3.8146E-4      -1.5392E-3      n      4.0554E+21      4.0364E+0      ERROR
8.0000E+3     3.8140E-4      -1.4836E-3      n      4.2074E+21      3.8906E+0      ERROR
9.0000E+3     3.8137E-4      -1.6282E-3      n      3.8338E+21      4.2697E+0      ERROR
1.0000E+4     3.8148E-4      -1.6298E-3      n      3.8300E+21      4.2739E+0      ERROR
1.1000E+4     3.8145E-4      -1.5995E-3      n      3.9026E+21      4.1944E+0      ERROR
1.2000E+4     3.8145E-4      -1.5472E-3      n      4.0344E+21      4.0574E+0      ERROR
1.3000E+4     3.8151E-4      -1.5142E-3      n      4.1225E+21      3.9707E+0      ERROR
1.4000E+4     3.8143E-4      -1.5224E-3      n      4.1002E+21      3.9923E+0      ERROR
1.5000E+4     3.8148E-4      -1.5042E-3      n      4.1499E+21      3.9445E+0      ERROR
```

62 - c plane sapphire

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.1 [µm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 1/14/2009 12:24:56 PM
Time Completed: 1/14/2009 1:07:03 PM
Elapsed Time: 0:42:7

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 8.7179E-4
at Field [G] = 3.4338E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
9.9999E+2	8.7199E-4	-2.3246E-4	n	2.6852E+22	2.6665E-1	ERROR
2.0000E+3	8.7202E-4	-4.7194E-4	n	1.3227E+22	5.4134E-1	ERROR
3.0000E+3	8.7198E-4	-1.1808E-3	n	5.2865E+21	1.3544E+0	ERROR
4.0000E+3	8.7196E-4	-1.2364E-3	n	5.0485E+21	1.4183E+0	ERROR
5.0000E+3	8.7200E-4	-9.5371E-4	n	6.5452E+21	1.0940E+0	ERROR
6.0001E+3	8.7204E-4	-8.2199E-4	n	7.5940E+21	9.4288E-1	ERROR
7.0000E+3	8.7198E-4	-1.6105E-3	n	3.8759E+21	1.8474E+0	ERROR
8.0000E+3	8.7191E-4	-1.2332E-3	n	5.0619E+21	1.4145E+0	ERROR
9.0000E+3	8.7195E-4	-1.0207E-3	n	6.1159E+21	1.1708E+0	ERROR
1.0000E+4	8.7198E-4	-1.4223E-3	n	4.3888E+21	1.6315E+0	ERROR
1.1000E+4	8.7194E-4	-1.2061E-3	n	5.1755E+21	1.3835E+0	ERROR
1.2000E+4	8.7192E-4	-1.1216E-3	n	5.5652E+21	1.2866E+0	ERROR
1.3000E+4	8.7185E-4	-1.0257E-3	n	6.0858E+21	1.1765E+0	ERROR
1.4000E+4	8.7202E-4	-1.1318E-3	n	5.5152E+21	1.2983E+0	ERROR
1.5000E+4	8.7197E-4	-1.1161E-3	n	5.5930E+21	1.2802E+0	ERROR

68 - c plane sapphire sample 1

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 290.0 [nm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/1/2007 4:00:12 PM
Time Completed: 8/1/2007 5:00:55 PM
Elapsed Time: 1:0:43

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 5.7048E-4
at Field [G] = -1.0191E-1
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0000E+3	5.6935E-4	-5.6937E-3	n	1.0963E+21	9.9805E+0	ERROR
2.0000E+3	5.6935E-4	-5.5363E-3	n	1.1275E+21	9.7047E+0	ERROR
3.0000E+3	5.6935E-4	-5.4447E-3	n	1.1465E+21	9.5441E+0	ERROR
4.0000E+3	5.6934E-4	-5.1933E-3	n	1.2020E+21	9.1035E+0	ERROR
5.0000E+3	5.6937E-4	-5.5732E-3	n	1.1200E+21	9.7693E+0	ERROR
5.9999E+3	5.6937E-4	-5.5175E-3	n	1.1313E+21	9.6717E+0	ERROR
7.0000E+3	5.6939E-4	-5.4931E-3	n	1.1364E+21	9.6290E+0	ERROR
8.0000E+3	5.6935E-4	-5.3857E-3	n	1.1590E+21	9.4407E+0	ERROR
9.0000E+3	5.6937E-4	-5.4256E-3	n	1.1505E+21	9.5107E+0	ERROR
1.0000E+4	5.6940E-4	-5.3643E-3	n	1.1637E+21	9.4032E+0	ERROR
1.1000E+4	5.6942E-4	-5.4222E-3	n	1.1512E+21	9.5046E+0	ERROR
1.2000E+4	5.6941E-4	-5.3367E-3	n	1.1697E+21	9.3549E+0	ERROR
1.3000E+4	5.6942E-4	-5.3809E-3	n	1.1601E+21	9.4322E+0	ERROR
1.4000E+4	5.6954E-4	-5.3891E-3	n	1.1583E+21	9.4466E+0	ERROR
1.5000E+4	5.6969E-4	-5.3447E-3	n	1.1679E+21	9.3687E+0	ERROR

68 - c plane sapphire sample 2

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 263.0 [nm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/7/2007 12:23:27 PM
Time Completed: 8/7/2007 1:23:58 PM
Elapsed Time: 1:0:30

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 4.7388E-4
at Field [G] = -9.3500E-3
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0001E+3	4.7322E-4	-5.2020E-3	n	1.2000E+21	1.0977E+1	ERROR
2.0000E+3	4.7321E-4	-4.5861E-3	n	1.3611E+21	9.6778E+0	ERROR
3.0000E+3	4.7322E-4	-4.4825E-3	n	1.3926E+21	9.4591E+0	ERROR
4.0000E+3	4.7322E-4	-4.4596E-3	n	1.3997E+21	9.4108E+0	ERROR
5.0000E+3	4.7322E-4	-4.6606E-3	n	1.3394E+21	9.8350E+0	ERROR
6.0000E+3	4.7325E-4	-4.5197E-3	n	1.3811E+21	9.5378E+0	ERROR
7.0000E+3	4.7325E-4	-4.4844E-3	n	1.3920E+21	9.4631E+0	ERROR
8.0000E+3	4.7325E-4	-4.5210E-3	n	1.3807E+21	9.5404E+0	ERROR
9.0000E+3	4.7326E-4	-4.5076E-3	n	1.3848E+21	9.5121E+0	ERROR
1.0000E+4	4.7326E-4	-4.4686E-3	n	1.3969E+21	9.4298E+0	ERROR
1.1000E+4	4.7327E-4	-4.5500E-3	n	1.3719E+21	9.6016E+0	ERROR
1.2000E+4	4.7325E-4	-4.5883E-3	n	1.3605E+21	9.6824E+0	ERROR
1.3000E+4	4.7327E-4	-4.5442E-3	n	1.3737E+21	9.5893E+0	ERROR
1.4000E+4	4.7332E-4	-4.4973E-3	n	1.3880E+21	9.4905E+0	ERROR
1.5000E+4	4.7342E-4	-4.4915E-3	n	1.3898E+21	9.4783E+0	ERROR

68 - c plane sapphire sample 3

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 321.0 [nm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/7/2007 11:13:01 AM
Time Completed: 8/7/2007 12:13:39 PM
Elapsed Time: 1:0:38

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 5.6402E-4
at Field [G] = -7.9725E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
9.9998E+2	5.6348E-4	-5.9084E-3	n	1.0565E+21	1.0475E+1	ERROR
2.0000E+3	5.6350E-4	-5.3695E-3	n	1.1625E+21	9.5199E+0	ERROR
3.0000E+3	5.6348E-4	-5.4597E-3	n	1.1433E+21	9.6800E+0	ERROR
4.0000E+3	5.6348E-4	-5.2496E-3	n	1.1891E+21	9.3075E+0	ERROR
5.0000E+3	5.6350E-4	-5.3401E-3	n	1.1689E+21	9.4679E+0	ERROR
6.0000E+3	5.6349E-4	-5.3791E-3	n	1.1605E+21	9.5370E+0	ERROR
7.0000E+3	5.6354E-4	-5.3326E-3	n	1.1706E+21	9.4546E+0	ERROR
8.0000E+3	5.6356E-4	-5.2838E-3	n	1.1814E+21	9.3681E+0	ERROR
9.0000E+3	5.6360E-4	-5.2770E-3	n	1.1829E+21	9.3561E+0	ERROR
1.0000E+4	5.6364E-4	-5.2449E-3	n	1.1902E+21	9.2990E+0	ERROR
1.1000E+4	5.6358E-4	-5.2605E-3	n	1.1866E+21	9.3267E+0	ERROR
1.2000E+4	5.6360E-4	-5.2360E-3	n	1.1922E+21	9.2833E+0	ERROR
1.3000E+4	5.6361E-4	-5.2415E-3	n	1.1909E+21	9.2930E+0	ERROR
1.4000E+4	5.6359E-4	-5.2074E-3	n	1.1987E+21	9.2326E+0	ERROR
1.5000E+4	5.6367E-4	-5.2015E-3	n	1.2001E+21	9.2222E+0	ERROR

84 - c plane sapphire sample 1

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.073 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/1/2007 2:51:48 PM
Time Completed: 8/1/2007 3:52:40 PM
Elapsed Time: 1:0:52

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 1.1619E-2
at Field [G] = 2.4300E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
9.9997E+2	1.1613E-2	-6.5096E-3	n	9.5893E+20	5.6027E-1	ERROR
2.0000E+3	1.1613E-2	-4.7041E-3	n	1.3270E+21	4.0487E-1	ERROR
3.0000E+3	1.1613E-2	-6.3835E-3	n	9.7787E+20	5.4941E-1	ERROR
4.0000E+3	1.1613E-2	-6.2291E-3	n	1.0021E+21	5.3613E-1	ERROR
5.0000E+3	1.1613E-2	-6.2234E-3	n	1.0030E+21	5.3564E-1	ERROR
6.0000E+3	1.1613E-2	-5.9552E-3	n	1.0482E+21	5.1255E-1	ERROR
7.0000E+3	1.1614E-2	-6.1480E-3	n	1.0153E+21	5.2914E-1	ERROR
8.0000E+3	1.1614E-2	-6.2205E-3	n	1.0035E+21	5.3538E-1	ERROR
9.0000E+3	1.1614E-2	-6.2427E-3	n	9.9992E+20	5.3730E-1	ERROR
1.0000E+4	1.1615E-2	-6.2185E-3	n	1.0038E+21	5.3522E-1	ERROR
1.1000E+4	1.1614E-2	-5.9856E-3	n	1.0429E+21	5.1516E-1	ERROR
1.2000E+4	1.1614E-2	-6.1167E-3	n	1.0205E+21	5.2645E-1	ERROR
1.3000E+4	1.1615E-2	-6.1685E-3	n	1.0119E+21	5.3091E-1	ERROR
1.4000E+4	1.1615E-2	-5.8420E-3	n	1.0685E+21	5.0281E-1	ERROR
1.5000E+4	1.1615E-2	-5.8278E-3	n	1.0711E+21	5.0158E-1	ERROR

84 - c plane sapphire sample 2

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 572.0 [nm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/6/2007 5:18:29 PM
Time Completed: 8/6/2007 6:19:08 PM
Elapsed Time: 1:0:39

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 850.0 [µA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 9.6664E-3
at Field [G] = 2.3938E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0000E+3	9.6530E-3	6.3986E-3	p	9.7556E+20	6.6194E-1	ERROR
2.0000E+3	9.6526E-3	-2.7742E-4	n	2.2501E+22	2.8700E-2	ERROR
3.0000E+3	9.6518E-3	-3.4207E-3	n	1.8248E+21	3.5388E-1	ERROR
4.0000E+3	9.6525E-3	8.6867E-4	p	7.1860E+21	8.9865E-2	ERROR
5.0000E+3	9.6526E-3	-3.1938E-3	n	1.9545E+21	3.3040E-1	ERROR
6.0000E+3	9.6524E-3	5.3355E-4	p	1.1699E+22	5.5196E-2	ERROR
7.0001E+3	9.6533E-3	4.9581E-4	p	1.2590E+22	5.1292E-2	ERROR
8.0000E+3	9.6531E-3	-5.5905E-4	n	1.1166E+22	5.7834E-2	ERROR
9.0001E+3	9.6538E-3	4.7167E-4	p	1.3234E+22	4.8795E-2	ERROR
1.0000E+4	9.6533E-3	-6.0634E-3	n	1.0295E+21	6.2727E-1	ERROR
1.1000E+4	9.6536E-3	2.5013E-3	p	2.4956E+21	2.5876E-1	ERROR
1.2000E+4	9.6528E-3	-4.9481E-3	n	1.2615E+21	5.1188E-1	ERROR
1.3000E+4	9.6533E-3	-4.5758E-3	n	1.3642E+21	4.7337E-1	ERROR
1.4000E+4	9.6557E-3	-1.0303E-2	n	6.0588E+20	1.0658E+0	ERROR
1.5000E+4	9.6559E-3	-1.0274E-2	n	6.0760E+20	1.0628E+0	ERROR

84 - c plane sapphire sample 3

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.486 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/6/2007 12:29:41 PM
Time Completed: 8/6/2007 1:30:19 PM
Elapsed Time: 1:0:38

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 6.4412E-3
at Field [G] = 1.3000E-3
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm³/C]	Type	CarrierDensity[cm⁻³]	HallMobility[cm²/(Vs)]	Temp[K]
1.0000E+3	6.4349E-3	-1.2655E-2	n	4.9327E+20	1.9646E+0	ERROR
2.0000E+3	6.4350E-3	-1.3323E-2	n	4.6852E+20	2.0684E+0	ERROR
3.0000E+3	6.4351E-3	-1.2131E-2	n	5.1455E+20	1.8834E+0	ERROR
3.9999E+3	6.4349E-3	-1.4152E-2	n	4.4108E+20	2.1971E+0	ERROR
5.0000E+3	6.4352E-3	-1.2478E-2	n	5.0024E+20	1.9373E+0	ERROR
6.0000E+3	6.4353E-3	-1.3170E-2	n	4.7397E+20	2.0446E+0	ERROR
7.0000E+3	6.4355E-3	-1.2913E-2	n	4.8339E+20	2.0048E+0	ERROR
8.0000E+3	6.4356E-3	-1.2985E-2	n	4.8073E+20	2.0159E+0	ERROR
9.0000E+3	6.4357E-3	-1.2832E-2	n	4.8646E+20	1.9922E+0	ERROR
1.0000E+4	6.4356E-3	-1.3173E-2	n	4.7387E+20	2.0451E+0	ERROR
1.1000E+4	6.4360E-3	-1.2628E-2	n	4.9430E+20	1.9605E+0	ERROR
1.2000E+4	6.4359E-3	-1.2740E-2	n	4.8998E+20	1.9778E+0	ERROR
1.3000E+4	6.4361E-3	-1.2886E-2	n	4.8442E+20	2.0005E+0	ERROR
1.4000E+4	6.4362E-3	-1.2860E-2	n	4.8538E+20	1.9966E+0	ERROR
1.5000E+4	6.4368E-3	-1.2988E-2	n	4.8060E+20	2.0164E+0	ERROR

98 - c plane sapphire

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 500.0 [nm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 1/13/2009 11:40:56 AM
Time Completed: 1/13/2009 12:23:07 PM
Elapsed Time: 0:42:11

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 8.2569E-4
at Field [G] = 3.4375E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0000E+3	8.2632E-4	-5.4154E-4	n	1.1527E+22	6.5586E-1	ERROR
1.9999E+3	8.2634E-4	-5.6452E-4	n	1.1057E+22	6.8370E-1	ERROR
3.0000E+3	8.2637E-4	-8.4912E-4	n	7.3514E+21	1.0284E+0	ERROR
4.0000E+3	8.2635E-4	-1.0637E-3	n	5.8684E+21	1.2883E+0	ERROR
5.0000E+3	8.2634E-4	-9.5651E-4	n	6.5260E+21	1.1584E+0	ERROR
6.0000E+3	8.2629E-4	-7.4821E-4	n	8.3429E+21	9.0616E-1	ERROR
7.0000E+3	8.2637E-4	-1.0115E-3	n	6.1714E+21	1.2250E+0	ERROR
8.0000E+3	8.2629E-4	-9.0612E-4	n	6.8890E+21	1.0974E+0	ERROR
9.0001E+3	8.2626E-4	-8.4520E-4	n	7.3854E+21	1.0236E+0	ERROR
1.0000E+4	8.2629E-4	-8.8040E-4	n	7.0902E+21	1.0663E+0	ERROR
1.1000E+4	8.2625E-4	-8.5469E-4	n	7.3035E+21	1.0351E+0	ERROR
1.2000E+4	8.2619E-4	-9.6293E-4	n	6.4825E+21	1.1662E+0	ERROR
1.3000E+4	8.2622E-4	-9.4098E-4	n	6.6337E+21	1.1396E+0	ERROR
1.4000E+4	8.2619E-4	-9.1540E-4	n	6.8191E+21	1.1087E+0	ERROR
1.5000E+4	8.2617E-4	-9.0214E-4	n	6.9194E+21	1.0926E+0	ERROR

107 - c plane sapphire

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.0 [µm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 1/15/2009 12:41:29 PM
Time Completed: 1/15/2009 1:23:36 PM
Elapsed Time: 0:42:7

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 1.7810E-3
at Field [G] = 6.2738E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[$cm^2/(Vs)$]	Temp[K]
1.0000E+3	1.7824E-3	-5.3610E-3	n	1.1644E+21	3.0102E+0	ERROR
2.0000E+3	1.7823E-3	-6.6657E-3	n	9.3647E+20	3.7428E+0	ERROR
3.0000E+3	1.7824E-3	-6.3502E-3	n	9.8300E+20	3.5656E+0	ERROR
4.0000E+3	1.7824E-3	-5.9699E-3	n	1.0456E+21	3.3521E+0	ERROR
5.0000E+3	1.7824E-3	-6.0639E-3	n	1.0294E+21	3.4048E+0	ERROR
6.0000E+3	1.7824E-3	-6.2081E-3	n	1.0055E+21	3.4858E+0	ERROR
7.0000E+3	1.7823E-3	-6.3791E-3	n	9.7853E+20	3.5819E+0	ERROR
8.0000E+3	1.7823E-3	-6.3411E-3	n	9.8440E+20	3.5605E+0	ERROR
9.0000E+3	1.7823E-3	-6.3273E-3	n	9.8654E+20	3.5528E+0	ERROR
9.9999E+3	1.7822E-3	-6.4328E-3	n	9.7037E+20	3.6120E+0	ERROR
1.1000E+4	1.7822E-3	-6.4091E-3	n	9.7397E+20	3.5987E+0	ERROR
1.2000E+4	1.7822E-3	-6.2707E-3	n	9.9545E+20	3.5210E+0	ERROR
1.3000E+4	1.7821E-3	-6.1686E-3	n	1.0119E+21	3.4637E+0	ERROR
1.4000E+4	1.7821E-3	-6.0765E-3	n	1.0273E+21	3.4119E+0	ERROR
1.5000E+4	1.7822E-3	-6.2116E-3	n	1.0049E+21	3.4878E+0	ERROR

108 - c plane sapphire

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 500.0 [nm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 1/16/2009 2:20:12 PM
Time Completed: 1/16/2009 3:02:19 PM
Elapsed Time: 0:42:7

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 4.9153E-4
at Field [G] = 8.0000E-4
at Temperature [K] = ERROR

Field [G]	Resistivity [ohm cm]	Hall Coefficient [cm³/C]	Type	Carrier Density [1/cm³]	Hall Mobility [cm²/(VS)]	Temperature [K]
1.0000E+3	4.9193E-4	-4.3022E-4	n	1.4509E+22	8.7526E-1	ERROR
1.9999E+3	4.9195E-4	-4.7737E-4	n	1.3076E+22	9.7119E-1	ERROR
2.9999E+3	4.9188E-4	-1.6756E-4	n	3.7253E+22	3.4090E-1	ERROR
4.0000E+3	4.9193E-4	-3.8165E-4	n	1.6356E+22	7.7645E-1	ERROR
5.0000E+3	4.9189E-4	-1.3860E-4	n	4.5037E+22	2.8198E-1	ERROR
6.0000E+3	4.9193E-4	-5.5624E-4	n	1.1222E+22	1.1317E+0	ERROR
7.0000E+3	4.9191E-4	-4.8646E-4	n	1.2832E+22	9.8967E-1	ERROR
7.9999E+3	4.9192E-4	-4.3849E-4	n	1.4236E+22	8.9210E-1	ERROR
9.0000E+3	4.9191E-4	-2.7489E-4	n	2.2708E+22	5.5925E-1	ERROR
9.9999E+3	4.9191E-4	-5.3845E-4	n	1.1593E+22	1.0955E+0	ERROR
1.1000E+4	4.9190E-4	-2.8076E-4	n	2.2233E+22	5.7119E-1	ERROR
1.2000E+4	4.9187E-4	-3.4763E-4	n	1.7956E+22	7.0724E-1	ERROR
1.3000E+4	4.9189E-4	-4.5271E-4	n	1.3789E+22	9.2101E-1	ERROR
1.4000E+4	4.9191E-4	-2.7286E-4	n	2.2877E+22	5.5512E-1	ERROR
1.5000E+4	4.9191E-4	-4.1856E-4	n	1.4913E+22	8.5155E-1	ERROR

28 - r plane sapphire sample 2

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.608 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/7/2007 2:44:32 PM
Time Completed: 8/7/2007 3:45:05 PM
Elapsed Time: 1:0:33

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 5.7501E-3
at Field [G] = 1.8538E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm³/C]	Type	CarrierDensity[cm⁻³]	HallMobility[cm²/(Vs)]	Temp[K]
1.0000E+3	5.7467E-3	-1.1903E-2	n	5.2441E+20	2.0701E+0	ERROR
2.0000E+3	5.7466E-3	-1.1923E-2	n	5.2353E+20	2.0736E+0	ERROR
3.0000E+3	5.7467E-3	-9.4540E-3	n	6.6027E+20	1.6441E+0	ERROR
4.0000E+3	5.7467E-3	-9.1997E-3	n	6.7852E+20	1.5999E+0	ERROR
5.0001E+3	5.7469E-3	-9.0435E-3	n	6.9024E+20	1.5728E+0	ERROR
6.0000E+3	5.7468E-3	-9.5337E-3	n	6.5475E+20	1.6580E+0	ERROR
6.9999E+3	5.7468E-3	-9.0697E-3	n	6.8825E+20	1.5773E+0	ERROR
7.9999E+3	5.7469E-3	-9.3309E-3	n	6.6898E+20	1.6227E+0	ERROR
9.0000E+3	5.7469E-3	-9.4481E-3	n	6.6068E+20	1.6431E+0	ERROR
1.0000E+4	5.7469E-3	-9.2568E-3	n	6.7433E+20	1.6099E+0	ERROR
1.1000E+4	5.7469E-3	-9.4222E-3	n	6.6250E+20	1.6386E+0	ERROR
1.2000E+4	5.7469E-3	-9.4052E-3	n	6.6370E+20	1.6357E+0	ERROR
1.3000E+4	5.7469E-3	-8.8854E-3	n	7.0253E+20	1.5453E+0	ERROR
1.4000E+4	5.7471E-3	-8.8700E-3	n	7.0374E+20	1.5426E+0	ERROR
1.5000E+4	5.7478E-3	-8.9695E-3	n	6.9594E+20	1.5599E+0	ERROR

30 - r plane sapphire

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 500.0 [nm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 11/2/2007 9:02:06 AM
Time Completed: 11/2/2007 10:02:41 AM
Elapsed Time: 1:0:35

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 7.5197E-4
at Field [G] = -1.8875E-3
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
9.9996E+2	7.3973E-4	-7.1842E-3	n	8.6887E+20	9.5539E+0	ERROR
2.0000E+3	7.4040E-4	-7.1231E-3	n	8.7633E+20	9.4725E+0	ERROR
3.0000E+3	7.3790E-4	-6.6612E-3	n	9.3709E+20	8.8584E+0	ERROR
4.0000E+3	7.3750E-4	-6.7176E-3	n	9.2923E+20	8.9333E+0	ERROR
4.9999E+3	7.3901E-4	-6.5874E-3	n	9.4760E+20	8.7601E+0	ERROR
6.0000E+3	7.4003E-4	-6.5372E-3	n	9.5488E+20	8.6934E+0	ERROR
7.0000E+3	7.4060E-4	-6.6337E-3	n	9.4099E+20	8.8217E+0	ERROR
8.0000E+3	7.4045E-4	-6.5756E-3	n	9.4930E+20	8.7445E+0	ERROR
9.0000E+3	7.3886E-4	-6.4266E-3	n	9.7130E+20	8.5463E+0	ERROR
1.0000E+4	7.3966E-4	-6.4161E-3	n	9.7290E+20	8.5323E+0	ERROR
1.1000E+4	7.4015E-4	-6.4232E-3	n	9.7182E+20	8.5418E+0	ERROR
1.2000E+4	7.3903E-4	-6.4027E-3	n	9.7493E+20	8.5146E+0	ERROR
1.3000E+4	7.3810E-4	-6.5198E-3	n	9.5742E+20	8.6703E+0	ERROR
1.4000E+4	7.3791E-4	-6.4143E-3	n	9.7317E+20	8.5300E+0	ERROR
1.5000E+4	7.4115E-4	-6.4713E-3	n	9.6459E+20	8.6058E+0	ERROR

32 - MOCVD GaN

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 550.0 [nm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 11/1/2007 9:57:03 AM
Time Completed: 11/1/2007 10:57:40 AM
Elapsed Time: 1:0:37

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 6.7921E-4
at Field [G] = 5.9938E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0000E+3	6.7854E-4	-7.9805E-3	n	7.8218E+20	1.1750E+1	ERROR
2.0000E+3	6.7859E-4	-8.9390E-3	n	6.9831E+20	1.3161E+1	ERROR
3.0000E+3	6.7863E-4	-8.5807E-3	n	7.2747E+20	1.2633E+1	ERROR
4.0000E+3	6.7861E-4	-8.9871E-3	n	6.9458E+20	1.3232E+1	ERROR
5.0000E+3	6.7870E-4	-8.9241E-3	n	6.9948E+20	1.3139E+1	ERROR
6.0000E+3	6.7873E-4	-9.2335E-3	n	6.7604E+20	1.3595E+1	ERROR
7.0000E+3	6.7882E-4	-9.0470E-3	n	6.8997E+20	1.3320E+1	ERROR
8.0000E+3	6.7883E-4	-9.2702E-3	n	6.7336E+20	1.3649E+1	ERROR
9.0000E+3	6.7892E-4	-9.1924E-3	n	6.7906E+20	1.3534E+1	ERROR
1.0000E+4	6.7892E-4	-9.1874E-3	n	6.7943E+20	1.3527E+1	ERROR
1.1000E+4	6.7891E-4	-9.0581E-3	n	6.8913E+20	1.3336E+1	ERROR
1.2000E+4	6.7892E-4	-9.0086E-3	n	6.9292E+20	1.3263E+1	ERROR
1.3000E+4	6.7889E-4	-9.0123E-3	n	6.9263E+20	1.3269E+1	ERROR
1.4000E+4	6.7891E-4	-9.0320E-3	n	6.9112E+20	1.3298E+1	ERROR
1.5000E+4	6.7892E-4	-9.0176E-3	n	6.9222E+20	1.3277E+1	ERROR

52 - MOCVD GaN

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 2.0 [μm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 10/31/2007 2:34:45 PM
Time Completed: 10/31/2007 3:35:17 PM
Elapsed Time: 1:0:32

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 1.9269E-3
at Field [G] = 1.8175E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
9.9999E+2	1.9264E-3	-9.1812E-3	n	6.7989E+20	4.7647E+0	ERROR
2.0000E+3	1.9263E-3	-7.5856E-3	n	8.2290E+20	3.9367E+0	ERROR
3.0000E+3	1.9264E-3	-9.9800E-3	n	6.2547E+20	5.1792E+0	ERROR
4.0000E+3	1.9265E-3	-9.1114E-3	n	6.8510E+20	4.7285E+0	ERROR
5.0000E+3	1.9265E-3	-8.1662E-3	n	7.6440E+20	4.2380E+0	ERROR
6.0000E+3	1.9265E-3	-9.3984E-3	n	6.6417E+20	4.8775E+0	ERROR
7.0000E+3	1.9267E-3	-9.2915E-3	n	6.7182E+20	4.8219E+0	ERROR
8.0000E+3	1.9268E-3	-9.1166E-3	n	6.8470E+20	4.7312E+0	ERROR
9.0000E+3	1.9267E-3	-9.5232E-3	n	6.5547E+20	4.9422E+0	ERROR
1.0000E+4	1.9266E-3	-8.9919E-3	n	6.9420E+20	4.6665E+0	ERROR
1.1000E+4	1.9266E-3	-8.8949E-3	n	7.0177E+20	4.6161E+0	ERROR
1.2000E+4	1.9264E-3	-8.9051E-3	n	7.0097E+20	4.6214E+0	ERROR
1.3000E+4	1.9262E-3	-8.8649E-3	n	7.0415E+20	4.6005E+0	ERROR
1.4000E+4	1.9263E-3	-9.1800E-3	n	6.7997E+20	4.7641E+0	ERROR
1.5000E+4	1.9259E-3	-8.9055E-3	n	7.0094E+20	4.6216E+0	ERROR

69 - SiC sample 1

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.216 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/1/2007 5:07:54 PM
Time Completed: 8/1/2007 6:08:30 PM
Elapsed Time: 1:0:36

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 2.7737E-3
at Field [G] = -7.1800E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0001E+3	2.7701E-3	-4.8575E-3	n	1.2851E+21	1.7513E+0	ERROR
2.0000E+3	2.7699E-3	-6.0961E-3	n	1.0240E+21	2.1978E+0	ERROR
3.0000E+3	2.7699E-3	-7.2994E-3	n	8.5517E+20	2.6316E+0	ERROR
4.0000E+3	2.7699E-3	-7.2630E-3	n	8.5945E+20	2.6185E+0	ERROR
5.0000E+3	2.7698E-3	-6.7892E-3	n	9.1943E+20	2.4477E+0	ERROR
6.0000E+3	2.7698E-3	-6.7298E-3	n	9.2755E+20	2.4263E+0	ERROR
7.0000E+3	2.7700E-3	-6.3848E-3	n	9.7767E+20	2.3019E+0	ERROR
8.0000E+3	2.7700E-3	-6.5681E-3	n	9.5038E+20	2.3680E+0	ERROR
9.0000E+3	2.7700E-3	-6.7618E-3	n	9.2316E+20	2.4378E+0	ERROR
1.0000E+4	2.7700E-3	-6.5986E-3	n	9.4599E+20	2.3790E+0	ERROR
1.1000E+4	2.7701E-3	-6.9775E-3	n	8.9462E+20	2.5156E+0	ERROR
1.2000E+4	2.7702E-3	-6.6440E-3	n	9.3953E+20	2.3954E+0	ERROR
1.3000E+4	2.7703E-3	-6.5444E-3	n	9.5382E+20	2.3595E+0	ERROR
1.4000E+4	2.7705E-3	-6.8036E-3	n	9.1748E+20	2.4529E+0	ERROR
1.5000E+4	2.7710E-3	-6.7190E-3	n	9.2904E+20	2.4224E+0	ERROR

69 - SiC sample 2

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.409 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/7/2007 2:44:32 PM
Time Completed: 8/7/2007 3:45:05 PM
Elapsed Time: 1:0:33

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 5.0385E-3
at Field [G] = 1.8538E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0000E+3	5.0355E-3	-1.0430E-2	n	5.9848E+20	2.0701E+0	ERROR
2.0000E+3	5.0354E-3	-1.0448E-2	n	5.9748E+20	2.0736E+0	ERROR
3.0000E+3	5.0355E-3	-8.2840E-3	n	7.5353E+20	1.6441E+0	ERROR
4.0000E+3	5.0355E-3	-8.0612E-3	n	7.7435E+20	1.5999E+0	ERROR
5.0001E+3	5.0357E-3	-7.9243E-3	n	7.8773E+20	1.5728E+0	ERROR
6.0000E+3	5.0356E-3	-8.3538E-3	n	7.4723E+20	1.6580E+0	ERROR
6.9999E+3	5.0356E-3	-7.9472E-3	n	7.8545E+20	1.5773E+0	ERROR
7.9999E+3	5.0356E-3	-8.1761E-3	n	7.6347E+20	1.6227E+0	ERROR
9.0000E+3	5.0357E-3	-8.2789E-3	n	7.5399E+20	1.6431E+0	ERROR
1.0000E+4	5.0357E-3	-8.1113E-3	n	7.6957E+20	1.6099E+0	ERROR
1.1000E+4	5.0357E-3	-8.2561E-3	n	7.5607E+20	1.6386E+0	ERROR
1.2000E+4	5.0357E-3	-8.2412E-3	n	7.5743E+20	1.6357E+0	ERROR
1.3000E+4	5.0357E-3	-7.7857E-3	n	8.0175E+20	1.5453E+0	ERROR
1.4000E+4	5.0358E-3	-7.7723E-3	n	8.0314E+20	1.5426E+0	ERROR
1.5000E+4	5.0365E-3	-7.8595E-3	n	7.9423E+20	1.5599E+0	ERROR

69 - SiC sample 3

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.277 [μm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Field Measurement>
Start Time: 8/7/2007 1:30:49 PM
Time Completed: 8/7/2007 2:31:29 PM
Elapsed Time: 1:0:41

Field profile: Linear Sweep with Field Reversal
Maximum Field: 15.0 [kG]
Minimum Field: 1.0 [kG]
Field Step: 1.0 [kG]
Direction: Positive to Negative
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Use Zero-field Resistivity to calculate Hall Mobility: Yes
Zero-field Resistivity [ohm cm] = 4.0097E-3
at Field [G] = 5.0313E-2
at Temperature [K] = ERROR

Field[G]	Resistivity[Ωcm]	HallCoeff.[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]	Temp[K]
1.0000E+3	4.0062E-3	-6.8451E-3	n	9.1192E+20	1.7071E+0	ERROR
2.0001E+3	4.0063E-3	-7.0070E-3	n	8.9085E+20	1.7475E+0	ERROR
3.0001E+3	4.0062E-3	-6.0726E-3	n	1.0279E+21	1.5145E+0	ERROR
3.9999E+3	4.0062E-3	-6.8300E-3	n	9.1393E+20	1.7034E+0	ERROR
5.0000E+3	4.0063E-3	-6.2241E-3	n	1.0029E+21	1.5523E+0	ERROR
6.0000E+3	4.0064E-3	-6.8699E-3	n	9.0863E+20	1.7133E+0	ERROR
7.0000E+3	4.0064E-3	-6.7238E-3	n	9.2838E+20	1.6769E+0	ERROR
8.0001E+3	4.0064E-3	-6.3205E-3	n	9.8761E+20	1.5763E+0	ERROR
9.0000E+3	4.0065E-3	-6.9619E-3	n	8.9662E+20	1.7363E+0	ERROR
1.0000E+4	4.0065E-3	-7.1627E-3	n	8.7149E+20	1.7863E+0	ERROR
1.1000E+4	4.0064E-3	-7.0034E-3	n	8.9132E+20	1.7466E+0	ERROR
1.2000E+4	4.0066E-3	-6.8353E-3	n	9.1323E+20	1.7047E+0	ERROR
1.3000E+4	4.0066E-3	-6.7872E-3	n	9.1970E+20	1.6927E+0	ERROR
1.4000E+4	4.0069E-3	-6.8601E-3	n	9.0993E+20	1.7109E+0	ERROR
1.5000E+4	4.0074E-3	-6.7890E-3	n	9.1946E+20	1.6931E+0	ERROR

Appendix B - Variable Temperature Measurements

32 - c plane Al_2O_3 misoriented

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 600.0 [nm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Temperature Measurement>
Start Time: 11/9/2007 9:46:37 AM
Time Completed: 11/9/2007 2:58:11 PM
Elapsed Time: 5:11:34

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [Gauss]	Zero-field Resistivity [Ωcm]
300.665	-4.5300E-2	6.5754E-3
310.115	2.8750E-3	6.5645E-3
320.054	2.5138E-2	6.5527E-3
330.002	1.1513E-2	6.5450E-3
339.847	-9.1250E-4	6.5353E-3
349.765	5.7275E-2	6.5252E-3
359.717	-1.8463E-2	6.5151E-3
369.683	-1.0025E-2	6.5056E-3
379.634	1.3150E-2	6.4960E-3
389.578	-2.7825E-2	6.4865E-3
399.521	-5.1000E-2	6.4780E-3
409.49	4.2000E-2	6.4683E-3
419.456	1.5000E-4	6.4587E-3
429.435	1.7563E-2	6.4487E-3
439.421	-8.6500E-3	6.4376E-3
449.432	-1.4563E-2	6.4257E-3
459.453	-1.4925E-2	6.4127E-3
469.463	-9.1750E-3	6.4005E-3
479.472	-1.1875E-2	6.3888E-3
489.491	7.0513E-2	6.3768E-3
499.54	2.1400E-2	6.3639E-3

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.268	1.1000E+4	6.5754E-3	-4.3032E-3	n	1.4506E+21	6.5444E-1
309.97	1.1000E+4	6.5645E-3	-4.4008E-3	n	1.4184E+21	6.7040E-1
319.918	1.1000E+4	6.5526E-3	-4.2461E-3	n	1.4701E+21	6.4799E-1
329.885	1.1000E+4	6.5448E-3	-4.3619E-3	n	1.4311E+21	6.6645E-1
339.859	1.1000E+4	6.5352E-3	-4.3752E-3	n	1.4267E+21	6.6948E-1
349.865	1.1000E+4	6.5250E-3	-4.3824E-3	n	1.4244E+21	6.7161E-1
359.873	1.1000E+4	6.5148E-3	-4.3886E-3	n	1.4224E+21	6.7360E-1
369.874	1.1000E+4	6.5055E-3	-4.5079E-3	n	1.3847E+21	6.9292E-1
379.881	1.1000E+4	6.4958E-3	-4.3669E-3	n	1.4294E+21	6.7225E-1
389.873	1.1000E+4	6.4863E-3	-4.5056E-3	n	1.3854E+21	6.9462E-1
399.877	1.1000E+4	6.4778E-3	-4.3242E-3	n	1.4435E+21	6.6752E-1
409.876	1.1000E+4	6.4682E-3	-4.6234E-3	n	1.3501E+21	7.1478E-1
419.87	1.1000E+4	6.4585E-3	-4.5819E-3	n	1.3624E+21	7.0942E-1
429.87	1.1000E+4	6.4483E-3	-4.4637E-3	n	1.3984E+21	6.9218E-1
439.864	1.1000E+4	6.4370E-3	-4.5187E-3	n	1.3814E+21	7.0193E-1
449.861	1.1000E+4	6.4254E-3	-4.5494E-3	n	1.3721E+21	7.0800E-1
459.857	1.1000E+4	6.4124E-3	-4.6750E-3	n	1.3352E+21	7.2903E-1
469.854	1.1000E+4	6.4004E-3	-4.8344E-3	n	1.2912E+21	7.5531E-1
479.855	1.1000E+4	6.3884E-3	-4.7825E-3	n	1.3052E+21	7.4857E-1
489.851	1.1000E+4	6.3767E-3	-4.7071E-3	n	1.3261E+21	7.3815E-1
499.846	1.1000E+4	6.3639E-3	-4.7227E-3	n	1.3217E+21	7.4211E-1

54 - c plane sapphire

```
[Sample parameters]
Sample Type:        van der Pauw
Hall Factor =       1.0
Thickness =         600.0 [nm]
L =        15.0 [mm]
Depletion Layer Correction:         Off

[Measurements]
<Step 1: IV Curve Measurement>
Start Time:         1/23/2009 8:24:07 AM
Time Completed:     1/23/2009 8:29:01 AM
Elapsed Time:       0:4:55

Starting Current:   -1.0 [mA]
Ending Current:     1.0 [mA]
Current Step:       200.0 [µA]
Resistance Range:             Low
Dwell Time:         2.0 [Sec]

Contact Sets:       R12,12
Best Fit Resistance [ohm] =         9.935E+0
Best Fit Offset [V] =         5.8112E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99861E-4         -9.87666E-3         -6.8205E+1          296.15
-7.99941E-4         -7.88774E-3         -6.8242E+1          296.14
-5.99992E-4         -5.89843E-3         -6.8265E+1          296.13
-3.99980E-4         -3.91704E-3         -6.8304E+1          296.12
-1.99969E-4         -1.93597E-3         -6.8237E+1          296.12
9.29043E-12         5.94106E-5          -6.8261E+1          296.11
1.99914E-4          2.04550E-3          -6.8269E+1          296.11
3.99759E-4          4.03094E-3          -6.8298E+1          296.1
5.99764E-4          6.01754E-3          -6.8329E+1          296.09
7.99699E-4          8.00325E-3          -6.8283E+1          296.08
9.99635E-4          9.98878E-3          -6.8270E+1          296.07

Contact Sets:       R23,23
Best Fit Resistance [ohm] =         1.441E+1
Best Fit Offset [V] =         -3.8399E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99873E-4         -1.44436E-2         -6.8264E+1          296.07
-7.99941E-4         -1.15654E-2         -6.8369E+1          296.06
-5.99991E-4         -8.68502E-3         -6.8310E+1          296.05
-3.99976E-4         -5.80355E-3         -6.8335E+1          296.05
-1.99963E-4         -2.92144E-3         -6.8363E+1          296.04
1.46092E-11         -3.98119E-5         -6.8325E+1          296.03
1.99914E-4          2.84173E-3          -6.8372E+1          296.02
3.99770E-4          5.72227E-3          -6.8323E+1          296.02
5.99775E-4          8.60532E-3          -6.8288E+1          296.01
7.99720E-4          1.14860E-2          -6.8339E+1          296.0
9.99650E-4          1.43680E-2          -6.8274E+1          296.0
```

```
Contact Sets:       R34,34
Best Fit Resistance [ohm] =         1.5818E+1
Best Fit Offset [V] =       6.4207E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99887E-4         -1.57494E-2         -6.8332E+1          295.99
-7.99952E-4         -1.25887E-2         -6.8343E+1          295.98
-5.99994E-4         -9.42748E-3         -6.8333E+1          295.98
-3.99979E-4         -6.26416E-3         -6.8321E+1          295.97
-1.99967E-4         -3.10031E-3         -6.8310E+1          295.97
2.13814E-13         6.26671E-5          -6.8325E+1          295.96
1.99920E-4          3.22572E-3          -6.8339E+1          295.95
3.99775E-4          6.38712E-3          -6.8418E+1          295.95
5.99786E-4          9.55216E-3          -6.8336E+1          295.94
7.99719E-4          1.27150E-2          -6.8354E+1          295.94
9.99653E-4          1.58790E-2          -6.8397E+1          295.93

Contact Sets:       R41,41
Best Fit Resistance [ohm] =         1.5213E+1
Best Fit Offset [V] =       4.7477E-6
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99895E-4         -1.52037E-2         -6.8313E+1          295.93
-7.99954E-4         -1.21630E-2         -6.8463E+1          295.92
-5.99998E-4         -9.12388E-3         -6.8325E+1          295.92
-3.99986E-4         -6.08186E-3         -6.8400E+1          295.91
-1.99975E-4         -3.03867E-3         -6.8410E+1          295.9
9.07780E-12         2.83442E-6          -6.8396E+1          295.9
1.99920E-4          3.04493E-3          -6.8379E+1          295.89
3.99783E-4          6.08642E-3          -6.8343E+1          295.89
5.99796E-4          9.12978E-3          -6.8329E+1          295.88
7.99745E-4          1.21716E-2          -6.8414E+1          295.88
9.99685E-4          1.52143E-2          -6.8399E+1          295.87

<Step 2: Variable Temperature Measurement>
Start Time:         1/23/2009 8:29:02 AM
Time Completed: 1/23/2009 2:47:03 PM
Elapsed Time:       6:18:2

Starting Temperature:       300.0 [K]
Ending Temperature:         500.0 [K]
Spacing:Linear Spacing
Temperature Step:           10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type:           Hall and Resistivity Measurement
Excitation Current:         1.0 [mA]
Resistance Range:           Low
Dwell Time:         2.0 [Sec]
Current Reversal:On
Geometry selection:         A and B
```

Temp [K]	Field [G]	Zero-field Resistivity[Ωcm]
300.683	1.7138E-2	3.8986E-4
310.207	3.7538E-2	3.9242E-4
320.188	4.0000E-2	3.9520E-4
330.244	5.7875E-3	3.9808E-4
340.177	-6.6125E-3	4.0104E-4
350.106	-4.0650E-2	4.0402E-4
359.958	3.8663E-2	4.0714E-4
369.907	2.4750E-3	4.1018E-4
379.816	-3.9188E-2	4.1327E-4
389.734	-8.8750E-2	4.1632E-4
399.66	2.9175E-2	4.1939E-4
409.62	-2.2013E-2	4.2236E-4
419.601	1.2875E-2	4.2549E-4
429.579	-1.9213E-2	4.2824E-4
439.586	3.3825E-2	4.3000E-4
449.614	7.6875E-3	4.3157E-4
459.653	2.0000E-3	4.3386E-4
469.666	5.5375E-3	4.3663E-4
479.69	-2.3500E-3	4.3942E-4
489.733	3.1625E-2	4.4229E-4
499.872	3.9300E-2	4.4503E-4

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.526	1.1000E+4	3.8974E-4	-1.7536E-3	n	3.5596E+21	4.4981E+0
310.071	1.1000E+4	3.9235E-4	-1.7724E-3	n	3.5219E+21	4.5166E+0
320.057	1.1000E+4	3.9521E-4	-1.8405E-3	n	3.3917E+21	4.6570E+0
330.096	1.1000E+4	3.9804E-4	-1.8944E-3	n	3.2950E+21	4.7590E+0
340.035	1.1000E+4	4.0102E-4	-1.7829E-3	n	3.5012E+21	4.4456E+0
349.957	1.1000E+4	4.0400E-4	-1.7905E-3	n	3.4863E+21	4.4316E+0
359.851	1.1000E+4	4.0710E-4	-1.5686E-3	n	3.9794E+21	3.8528E+0
369.817	1.1000E+4	4.1016E-4	-1.7583E-3	n	3.5502E+21	4.2866E+0
379.795	1.1000E+4	4.1326E-4	-1.9326E-3	n	3.2300E+21	4.6763E+0
389.795	1.1000E+4	4.1644E-4	-1.7997E-3	n	3.4685E+21	4.3228E+0
399.802	1.1000E+4	4.1952E-4	-1.8209E-3	n	3.4280E+21	4.3418E+0
409.816	1.1000E+4	4.2256E-4	-1.7566E-3	n	3.5536E+21	4.1590E+0
419.799	1.1000E+4	4.2556E-4	-1.8285E-3	n	3.4138E+21	4.2975E+0
429.796	1.1000E+4	4.2824E-4	-1.7673E-3	n	3.5320E+21	4.1269E+0
439.804	1.1000E+4	4.3009E-4	-1.8429E-3	n	3.3871E+21	4.2859E+0
449.788	1.1000E+4	4.3155E-4	-1.7604E-3	n	3.5458E+21	4.0791E+0
459.779	1.1000E+4	4.3392E-4	-1.6317E-3	n	3.8256E+21	3.7609E+0
469.778	1.1000E+4	4.3659E-4	-1.7222E-3	n	3.6245E+21	3.9443E+0
479.776	1.1000E+4	4.3955E-4	-1.6479E-3	n	3.7880E+21	3.7502E+0
489.77	1.1000E+4	4.4227E-4	-1.8616E-3	n	3.3531E+21	4.2090E+0
499.787	1.1000E+4	4.4501E-4	-1.6890E-3	n	3.6958E+21	3.7952E+0

62 - c plane sapphire

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.1 [µm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: IV Curve Measurement>
Start Time: 1/28/2009 8:16:29 AM
Time Completed: 1/28/2009 8:21:23 AM
Elapsed Time: 0:4:54

Starting Current: -1.0 [mA]
Ending Current: 1.0 [mA]
Current Step: 200.0 [µA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]

Contact Sets: R12,12
Best Fit Resistance [ohm] = 1.3186E+1
Best Fit Offset [V] = 5.5782E-5
Correlation = 1.E+0

Current [A]	Voltage [V]	Field [G]	Temperature [K]
-9.99891E-4	-1.31283E-2	-6.7291E+1	296.42
-7.99964E-4	-1.04931E-2	-6.7348E+1	296.41
-6.00021E-4	-7.85665E-3	-6.7355E+1	296.4
-4.00013E-4	-5.21902E-3	-6.7417E+1	296.39
-1.99970E-4	-2.58047E-3	-6.7383E+1	296.38
1.78226E-11	5.61773E-5	-6.7485E+1	296.38
1.99905E-4	2.69255E-3	-6.7424E+1	296.37
3.99717E-4	5.32687E-3	-6.7534E+1	296.36
5.99724E-4	7.96463E-3	-6.7529E+1	296.36
7.99661E-4	1.05994E-2	-6.7521E+1	296.35
9.99581E-4	1.32347E-2	-6.7560E+1	296.34

Contact Sets: R23,23
Best Fit Resistance [ohm] = 1.4606E+1
Best Fit Offset [V] = -2.3203E-5
Correlation = 1.E+0

Current [A]	Voltage [V]	Field [G]	Temperature [K]
-9.99906E-4	-1.46248E-2	-6.7619E+1	296.33
-7.99972E-4	-1.17076E-2	-6.7595E+1	296.33
-6.00021E-4	-8.78810E-3	-6.7598E+1	296.32
-4.00020E-4	-5.86684E-3	-6.7609E+1	296.31
-1.99981E-4	-2.94536E-3	-6.7638E+1	296.31
1.45552E-11	-2.45098E-5	-6.7646E+1	296.3
1.99912E-4	2.89588E-3	-6.7661E+1	296.3
3.99716E-4	5.81434E-3	-6.7731E+1	296.29
5.99731E-4	8.73676E-3	-6.7802E+1	296.28
7.99663E-4	1.16573E-2	-6.7766E+1	296.28
9.99583E-4	1.45788E-2	-6.7810E+1	296.27

Contact Sets: R34,34
Best Fit Resistance [ohm] = 1.4782E+1
Best Fit Offset [V] = 6.7996E-5
Correlation = 1.E+0

Current [A]	Voltage [V]	Field [G]	Temperature [K]
-9.99907E-4	-1.47091E-2	-6.7775E+1	296.26
-7.99970E-4	-1.17570E-2	-6.7832E+1	296.26
-6.00033E-4	-8.80270E-3	-6.7869E+1	296.25
-4.00012E-4	-5.84643E-3	-6.7785E+1	296.25
-1.99978E-4	-2.89014E-3	-6.7822E+1	296.24
1.22255E-11	6.58874E-5	-6.7883E+1	296.24
1.99915E-4	3.02120E-3	-6.7900E+1	296.23
3.99731E-4	5.97677E-3	-6.7872E+1	296.23
5.99741E-4	8.93469E-3	-6.7836E+1	296.22
7.99684E-4	1.18904E-2	-6.7987E+1	296.22
9.99616E-4	1.48464E-2	-6.7931E+1	296.21

Contact Sets: R41,41
Best Fit Resistance [ohm] = 1.4275E+1
Best Fit Offset [V] = 2.5563E-6
Correlation = 1.E+0

Current [A]	Voltage [V]	Field [G]	Temperature [K]
-9.99917E-4	-1.42676E-2	-6.7915E+1	296.21
-7.99976E-4	-1.14166E-2	-6.7922E+1	296.2
-6.00030E-4	-8.56329E-3	-6.7949E+1	296.2
-4.00011E-4	-5.70888E-3	-6.7996E+1	296.19
-1.99976E-4	-2.85397E-3	-6.7972E+1	296.19
1.82767E-11	9.64323E-8	-6.7978E+1	296.18
1.99922E-4	2.85448E-3	-6.7981E+1	296.18
3.99741E-4	5.70753E-3	-6.8079E+1	296.17
5.99747E-4	8.56422E-3	-6.8015E+1	296.17
7.99681E-4	1.14192E-2	-6.8049E+1	296.16
9.99617E-4	1.42758E-2	-6.7982E+1	296.16

<Step 2: Variable Temperature Measurement>
Start Time: 1/28/2009 8:21:24 AM
Time Completed: 1/28/2009 2:22:00 PM
Elapsed Time: 6:0:37

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.627	-1.3425E-2	9.0275E-4

68 - c plane sapphire sample 1

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 290.0 [nm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Temperature Measurement>
Start Time: 8/13/2007 11:27:53 AM
Time Completed: 8/13/2007 5:26:05 PM
Elapsed Time: 5:58:12

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 10.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.718	4.5013E-2	5.6756E-4
310.197	-3.1038E-2	5.7264E-4
320.159	-4.6500E-3	5.7821E-4
330.142	-3.9250E-2	5.8384E-4
340.033	-3.7750E-2	5.8957E-4
349.897	2.5350E-2	5.9535E-4
359.839	2.2100E-2	6.0110E-4
369.752	2.6338E-2	6.0682E-4
379.704	5.4063E-2	6.1256E-4
389.626	2.5500E-2	6.1857E-4
399.565	-3.4688E-2	6.2450E-4
409.528	2.1863E-2	6.3046E-4
419.497	1.5688E-2	6.3645E-4
429.472	1.4875E-3	6.4254E-4
439.455	-5.9375E-3	6.4870E-4
449.451	5.0375E-3	6.5485E-4
459.453	-1.4538E-2	6.6087E-4
469.466	-1.6763E-2	6.6700E-4
479.464	-5.0975E-2	6.7322E-4
489.443	-6.6500E-3	6.7955E-4
499.444	9.1000E-3	6.8579E-4

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.571	1.0000E+4	5.6749E-4	-5.1449E-3	n	1.2133E+21	9.0651E+0
310.063	1.0000E+4	5.7261E-4	-5.1674E-3	n	1.2080E+21	9.0239E+0
320.025	1.0000E+4	5.7812E-4	-5.1317E-3	n	1.2164E+21	8.8751E+0
330.0	1.0000E+4	5.8381E-4	-5.1428E-3	n	1.2138E+21	8.8085E+0
339.898	1.0000E+4	5.8953E-4	-5.1464E-3	n	1.2129E+21	8.7291E+0
349.821	1.0000E+4	5.9532E-4	-5.1463E-3	n	1.2130E+21	8.6441E+0
359.798	1.0000E+4	6.0113E-4	-5.0760E-3	n	1.2297E+21	8.4444E+0
369.805	1.0000E+4	6.0691E-4	-5.1798E-3	n	1.2051E+21	8.5360E+0
379.803	1.0000E+4	6.1270E-4	-5.2005E-3	n	1.2003E+21	8.4897E+0
389.819	1.0000E+4	6.1871E-4	-5.3231E-3	n	1.1727E+21	8.6055E+0
399.821	1.0000E+4	6.2474E-4	-5.0934E-3	n	1.2255E+21	8.1560E+0
409.825	1.0000E+4	6.3068E-4	-5.1647E-3	n	1.2086E+21	8.1919E+0
419.822	1.0000E+4	6.3673E-4	-5.1342E-3	n	1.2158E+21	8.0669E+0
429.82	1.0000E+4	6.4281E-4	-5.1795E-3	n	1.2052E+21	8.0609E+0
439.822	1.0000E+4	6.4899E-4	-5.1608E-3	n	1.2095E+21	7.9556E+0
449.827	1.0000E+4	6.5515E-4	-5.0374E-3	n	1.2392E+21	7.6925E+0
459.812	1.0000E+4	6.6116E-4	-5.0991E-3	n	1.2242E+21	7.7158E+0
469.819	1.0000E+4	6.6731E-4	-5.0926E-3	n	1.2257E+21	7.6351E+0
479.807	1.0000E+4	6.7354E-4	-5.0828E-3	n	1.2281E+21	7.5499E+0
489.805	1.0000E+4	6.7983E-4	-5.1076E-3	n	1.2221E+21	7.5161E+0
499.803	1.0000E+4	6.8612E-4	-5.0710E-3	n	1.2310E+21	7.3943E+0

84 - c plane sapphire sample 1

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.073 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Temperature Measurement>
Start Time: 8/2/2007 11:14:18 AM
Time Completed: 8/2/2007 5:48:09 PM
Elapsed Time: 6:33:50

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.071	-9.9000E-2	1.1506E-2
310.174	-3.5475E-2	1.1588E-2
320.171	3.5125E-3	1.1668E-2
330.201	6.8500E-3	1.1747E-2
340.066	-2.4313E-2	1.1825E-2
349.897	-4.9313E-2	1.1904E-2
359.808	-1.6738E-2	1.1982E-2
369.733	4.7000E-3	1.2058E-2
379.675	8.7000E-3	1.2136E-2
389.619	3.3250E-3	1.2214E-2
399.575	2.6250E-4	1.2292E-2
409.539	5.7225E-2	1.2368E-2
419.523	-2.9000E-3	1.2444E-2
429.505	-2.1750E-3	1.2517E-2
439.496	-2.6000E-3	1.2594E-2
449.49	2.1600E-2	1.2671E-2
459.494	-4.9500E-3	1.2742E-2
469.498	-2.7225E-2	1.2816E-2
479.492	7.7375E-3	1.2876E-2
489.47	5.6875E-2	1.2950E-2
499.49	1.5550E-2	1.3020E-2

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.08	1.1000E+4	1.1506E-2	-5.9877E-3	n	1.0425E+21	5.2039E-1
310.021	1.1000E+4	1.1587E-2	-5.6308E-3	n	1.1086E+21	4.8592E-1
320.005	1.1000E+4	1.1666E-2	-6.1479E-3	n	1.0153E+21	5.2692E-1
330.007	1.1000E+4	1.1745E-2	-5.8388E-3	n	1.0691E+21	4.9704E-1
339.898	1.1000E+4	1.1823E-2	-5.7378E-3	n	1.0879E+21	4.8522E-1
349.85	1.1000E+4	1.1904E-2	-5.8330E-3	n	1.0702E+21	4.8998E-1
359.854	1.1000E+4	1.1982E-2	-6.1395E-3	n	1.0167E+21	5.1240E-1
369.879	1.1000E+4	1.2059E-2	-5.8147E-3	n	1.0735E+21	4.8222E-1
379.896	1.1000E+4	1.2138E-2	-5.5377E-3	n	1.1272E+21	4.5631E-1
389.911	1.1000E+4	1.2216E-2	-5.7680E-3	n	1.0822E+21	4.7225E-1
399.925	1.1000E+4	1.2295E-2	-5.6484E-3	n	1.1051E+21	4.5953E-1
409.918	1.1000E+4	1.2371E-2	-5.8147E-3	n	1.0735E+21	4.7014E-1
419.925	1.1000E+4	1.2447E-2	-5.3284E-3	n	1.1715E+21	4.2820E-1
429.926	1.1000E+4	1.2521E-2	-5.4101E-3	n	1.1538E+21	4.3220E-1
439.927	1.1000E+4	1.2597E-2	-5.2118E-3	n	1.1977E+21	4.1384E-1
449.925	1.1000E+4	1.2674E-2	-5.3714E-3	n	1.1621E+21	4.2391E-1
459.923	1.1000E+4	1.2745E-2	-5.6177E-3	n	1.1112E+21	4.4088E-1
469.914	1.1000E+4	1.2819E-2	-5.7033E-3	n	1.0945E+21	4.4502E-1
479.916	1.1000E+4	1.2879E-2	-5.7351E-3	n	1.0884E+21	4.4540E-1
489.916	1.1000E+4	1.2953E-2	-5.5178E-3	n	1.1313E+21	4.2607E-1
499.915	1.1000E+4	1.3022E-2	-5.9876E-3	n	1.0425E+21	4.5987E-1

98 - c plane sapphire

```
[Sample parameters]
Sample Type:        van der Pauw
Hall Factor =       1.0
Thickness =         500.0 [nm]
L =         15.0 [mm]
Depletion Layer Correction:         Off

[Measurements]
<Step 1: IV Curve Measurement>
Start Time:         2/2/2009 10:52:03 AM
Time Completed:     2/2/2009 10:56:58 AM
Elapsed Time:       0:4:54

Starting Current:   -1.0 [mA]
Ending Current:     1.0 [mA]
Current Step:       200.0 [µA]
Resistance Range:           Low
Dwell Time:         2.0 [Sec]

Contact Sets:       R12,12
Best Fit Resistance [ohm] =         1.8661E+1
Best Fit Offset [V] =       6.0552E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99906E-4         -1.85986E-2         -6.6268E+1          294.52
-7.99968E-4         -1.48677E-2         -6.6059E+1          294.52
-6.00020E-4         -1.11372E-2         -6.6118E+1          294.52
-3.99997E-4         -7.40412E-3         -6.6110E+1          294.51
-1.99974E-4         -3.67077E-3         -6.6192E+1          294.51
1.62456E-11         6.07794E-5          -6.6181E+1          294.51
1.99924E-4          3.79191E-3          -6.6228E+1          294.51
3.99777E-4          7.52170E-3          -6.6240E+1          294.5
5.99781E-4          1.12534E-2          -6.6294E+1          294.5
7.99722E-4          1.49836E-2          -6.6330E+1          294.5
9.99662E-4          1.87145E-2          -6.6314E+1          294.5

Contact Sets:       R23,23
Best Fit Resistance [ohm] =         3.5519E+1
Best Fit Offset [V] =       -1.9826E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99908E-4         -3.55357E-2         -6.6426E+1          294.49
-7.99972E-4         -2.84334E-2         -6.6370E+1          294.49
-6.00020E-4         -2.13311E-2         -6.6369E+1          294.49
-4.00004E-4         -1.42269E-2         -6.6435E+1          294.49
-1.99981E-4         -7.12334E-3         -6.6476E+1          294.48
1.80490E-11         -2.04676E-5         -6.6486E+1          294.48
1.99930E-4          7.08156E-3          -6.6494E+1          294.48
3.99774E-4          1.41793E-2          -6.6538E+1          294.48
5.99782E-4          2.12836E-2          -6.6581E+1          294.47
7.99739E-4          2.83853E-2          -6.6530E+1          294.47
9.99669E-4          3.54878E-2          -6.6563E+1          294.47
```

```
Contact Sets:       R34,34
Best Fit Resistance [ohm] =         2.6013E+1
Best Fit Offset [V] =        6.817E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99919E-4         -2.59409E-2         -6.6641E+1          294.47
-7.99979E-4         -2.07409E-2         -6.6638E+1          294.46
-6.00031E-4         -1.55402E-2         -6.6665E+1          294.46
-4.00006E-4         -1.03389E-2         -6.6692E+1          294.46
-1.99977E-4         -5.13554E-3         -6.6667E+1          294.46
1.69076E-11         6.68152E-5          -6.6694E+1          294.46
1.99929E-4          5.26864E-3          -6.6717E+1          294.45
3.99779E-4          1.04673E-2          -6.6782E+1          294.45
5.99795E-4          1.56699E-2          -6.6834E+1          294.45
7.99747E-4          2.08726E-2          -6.6723E+1          294.45
9.99680E-4          2.60754E-2          -6.6793E+1          294.44

Contact Sets:       R41,41
Best Fit Resistance [ohm] =         2.0455E+1
Best Fit Offset [V] =        6.6064E-6
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99940E-4         -2.04445E-2         -6.6774E+1          294.44
-7.99993E-4         -1.63567E-2         -6.6765E+1          294.44
-6.00040E-4         -1.22670E-2         -6.6795E+1          294.44
-4.00006E-4         -8.17659E-3         -6.6848E+1          294.44
-1.99974E-4         -4.08559E-3         -6.6806E+1          294.43
1.42071E-11         5.46424E-6          -6.6829E+1          294.43
1.99942E-4          4.09521E-3          -6.6843E+1          294.43
3.99796E-4          8.18392E-3          -6.6817E+1          294.43
5.99801E-4          1.22752E-2          -6.6912E+1          294.43
7.99755E-4          1.63662E-2          -6.6924E+1          294.43
9.99689E-4          2.04571E-2          -6.6936E+1          294.42

<Step 2: Variable Temperature Measurement>
Start Time:         2/2/2009 10:56:58 AM
Time Completed: 2/2/2009 5:12:04 PM
Elapsed Time:       6:15:6

Starting Temperature:        300.0 [K]
Ending Temperature:          500.0 [K]
Spacing: Linear Spacing
Temperature Step:            10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type:            Hall and Resistivity Measurement
Excitation Current:          1.0 [mA]
Resistance Range:            Low
Dwell Time:         2.0 [Sec]
Current Reversal: On
Geometry selection:          A and B
```

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.915	4.1275E-2	7.8554E-4
309.708	-1.0838E-2	7.8876E-4
319.695	5.7113E-2	7.9222E-4
329.621	-2.1900E-2	7.9576E-4
339.686	8.9125E-3	7.9925E-4
349.727	9.0000E-4	8.0263E-4
359.712	1.4800E-2	8.0594E-4
369.721	1.2513E-2	8.0939E-4
379.69	-9.0125E-3	8.1294E-4
389.66	5.1163E-2	8.1620E-4
399.609	-3.1425E-2	8.1943E-4
409.567	-1.9063E-2	8.2266E-4
419.529	-2.5313E-2	8.2577E-4
429.488	-4.5950E-2	8.3621E-4
439.468	1.0331E-1	8.3925E-4
449.445	-4.4500E-2	8.4250E-4
459.439	3.7075E-2	8.4581E-4
469.429	-3.2050E-2	8.4907E-4
479.447	5.4788E-2	8.5229E-4
489.473	-4.3088E-2	8.5552E-4
499.519	-2.2975E-2	8.5879E-4

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.881	1.1000E+4	7.8556E-4	-8.4025E-4	n	7.4290E+21	1.0696E+0
309.857	1.1000E+4	7.8884E-4	-7.0990E-4	n	8.7930E+21	9.0002E-1
319.882	1.1000E+4	7.9234E-4	-7.1748E-4	n	8.7002E+21	9.0566E-1
329.908	1.1000E+4	7.9585E-4	-8.0788E-4	n	7.7267E+21	1.0152E+0
339.868	1.1000E+4	7.9936E-4	-8.5902E-4	n	7.2666E+21	1.0748E+0
349.818	1.1000E+4	8.0275E-4	-7.6196E-4	n	8.1923E+21	9.4933E-1
359.795	1.1000E+4	8.0612E-4	-6.7986E-4	n	9.1816E+21	8.4356E-1
369.761	1.1000E+4	8.0951E-4	-7.6357E-4	n	8.1750E+21	9.4339E-1
379.746	1.1000E+4	8.1301E-4	-8.4420E-4	n	7.3943E+21	1.0385E+0
389.73	1.1000E+4	8.1630E-4	-8.3778E-4	n	7.4509E+21	1.0264E+0
399.741	1.1000E+4	8.1958E-4	-9.0723E-4	n	6.8805E+21	1.1071E+0
409.757	1.1000E+4	8.2278E-4	-7.8683E-4	n	7.9334E+21	9.5644E-1
419.768	1.1000E+4	8.2595E-4	-7.9548E-4	n	7.8471E+21	9.6331E-1
429.776	1.1000E+4	8.3626E-4	-7.8859E-4	n	7.9156E+21	9.4306E-1
439.824	1.1000E+4	8.3945E-4	-8.1066E-4	n	7.7001E+21	9.6594E-1
449.816	1.1000E+4	8.4268E-4	-7.2117E-4	n	8.6557E+21	8.5598E-1
459.823	1.1000E+4	8.4594E-4	-9.0823E-4	n	6.8729E+21	1.0738E+0
469.82	1.1000E+4	8.4929E-4	-8.6314E-4	n	7.2320E+21	1.0166E+0
479.822	1.1000E+4	8.5253E-4	-7.9703E-4	n	7.8318E+21	9.3517E-1
489.809	1.1000E+4	8.5568E-4	-7.5894E-4	n	8.2249E+21	8.8710E-1
499.805	1.1000E+4	8.5902E-4	-7.6957E-4	n	8.1113E+21	8.9611E-1

107 - c plane sapphire

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.0 [µm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: IV Curve Measurement>
Start Time: 1/30/2009 11:35:11 AM
Time Completed: 1/30/2009 11:40:05 AM
Elapsed Time: 0:4:54

Starting Current: -1.0 [mA]
Ending Current: 1.0 [mA]
Current Step: 200.0 [µA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]

Contact Sets: R12,12
Best Fit Resistance [ohm] = 2.5987E+1
Best Fit Offset [V] = 6.7828E-5
Correlation = 1.E+0

Current [A]	Voltage [V]	Field [G]	Temperature [K]
-1.00014E-3	-2.59231E-2	-5.6017E+1	304.59
-8.00144E-4	-2.07250E-2	-5.6025E+1	304.57
-6.00129E-4	-1.55278E-2	-5.6045E+1	304.56
-4.00049E-4	-1.03289E-2	-5.6107E+1	304.54
-2.00006E-4	-5.12940E-3	-5.6040E+1	304.53
8.49841E-12	6.88047E-5	-5.6048E+1	304.51
2.00039E-4	5.26726E-3	-5.6016E+1	304.49
3.99956E-4	1.04620E-2	-5.6027E+1	304.48
6.00026E-4	1.56607E-2	-5.6066E+1	304.46
8.00021E-4	2.08569E-2	-5.6042E+1	304.44
1.00001E-3	2.60539E-2	-5.6028E+1	304.43

Contact Sets: R23,23
Best Fit Resistance [ohm] = 2.2134E+1
Best Fit Offset [V] = -1.3791E-5
Correlation = 1.E+0

Current [A]	Voltage [V]	Field [G]	Temperature [K]
-1.00014E-3	-2.21477E-2	-5.6047E+1	304.41
-8.00146E-4	-1.77233E-2	-5.6067E+1	304.4
-6.00138E-4	-1.32977E-2	-5.6070E+1	304.38
-4.00057E-4	-8.87009E-3	-5.6031E+1	304.36
-1.99999E-4	-4.44231E-3	-5.6021E+1	304.35
9.43911E-13	-1.50226E-5	-5.5957E+1	304.33
2.00040E-4	4.41249E-3	-5.5969E+1	304.32
3.99957E-4	8.83833E-3	-5.6025E+1	304.3
6.00032E-4	1.32675E-2	-5.6007E+1	304.28
8.00040E-4	1.76951E-2	-5.6004E+1	304.27
1.00004E-3	2.21227E-2	-5.6014E+1	304.25

```
Contact Sets:       R34,34
Best Fit Resistance [ohm] =             2.1581E+1
Best Fit Offset [V] =         6.1399E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-1.00015E-3         -2.15196E-2         -5.6035E+1          304.23
-8.00146E-4         -1.72053E-2         -5.6038E+1          304.22
-6.00136E-4         -1.28905E-2         -5.6016E+1          304.2
-4.00054E-4         -8.57340E-3         -5.6090E+1          304.18
-2.00003E-4         -4.25633E-3         -5.6016E+1          304.17
1.24717E-11         6.01832E-5          -5.6048E+1          304.15
2.00038E-4          4.37697E-3          -5.6056E+1          304.14
3.99955E-4          8.69228E-3          -5.6025E+1          304.12
6.00034E-4          1.30104E-2          -5.5995E+1          304.1
8.00026E-4          1.73272E-2          -5.5960E+1          304.09
1.00002E-3          2.16445E-2          -5.6033E+1          304.07

Contact Sets:       R41,41
Best Fit Resistance [ohm] =             2.3366E+1
Best Fit Offset [V] =         1.4002E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-1.00014E-3         -2.33530E-2         -5.6073E+1          304.05
-8.00145E-4         -1.86810E-2         -5.6064E+1          304.04
-6.00123E-4         -1.40082E-2         -5.6003E+1          304.02
-4.00051E-4         -9.33454E-3         -5.6021E+1          304.0
-2.00002E-4         -4.66144E-3         -5.6061E+1          303.99
-6.53316E-13        1.30106E-5          -5.6050E+1          303.97
2.00039E-4          4.68718E-3          -5.6092E+1          303.95
3.99962E-4          9.35950E-3          -5.6039E+1          303.94
6.00026E-4          1.40343E-2          -5.6107E+1          303.92
8.00039E-4          1.87074E-2          -5.6069E+1          303.9
1.00002E-3          2.33820E-2          -5.6034E+1          303.89

<Step 2: Variable Temperature Measurement>
Start Time:         1/30/2009 11:40:05 AM
Time Completed:     1/30/2009 5:16:49 PM
Elapsed Time:       5:36:44

Starting Temperature:         310.0 [K]
Ending Temperature:           500.0 [K]
Spacing:  Linear Spacing
Temperature Step:             10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type:             Hall and Resistivity Measurement
Excitation Current:           1.0 [mA]
Resistance Range:             Low
Dwell Time:         2.0 [Sec]
Current Reversal:   On
Geometry selection:           A and B
```

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
310.963	-8.0488E-2	1.7464E-3
319.571	5.5500E-3	1.7571E-3
329.592	2.1750E-3	1.7704E-3
339.554	-4.0163E-2	1.7840E-3
349.513	1.2250E-2	1.7982E-3
359.524	-1.6438E-2	1.8121E-3
369.523	-7.0700E-2	1.8265E-3
379.502	1.4425E-2	1.8409E-3
389.507	-3.1763E-2	1.8548E-3
399.475	7.8275E-2	1.8701E-3
409.457	-4.8500E-3	1.8855E-3
419.444	5.8625E-3	1.9008E-3
429.427	-9.3500E-3	2.0326E-3
439.415	-2.2775E-2	2.0490E-3
449.404	-3.7363E-2	2.0650E-3
459.386	-9.7375E-3	2.0804E-3
469.361	1.2325E-2	2.0969E-3
479.36	5.9125E-3	2.1137E-3
489.354	6.7500E-3	2.1301E-3
499.368	6.9250E-3	2.1457E-3

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
311.13	1.1000E+4	1.7468E-3	-6.7350E-3	n	9.2682E+20	3.8564E+0
319.911	1.1000E+4	1.7577E-3	-6.6978E-3	n	9.3197E+20	3.8118E+0
329.928	1.1000E+4	1.7710E-3	-6.8606E-3	n	9.0987E+20	3.8752E+0
339.927	1.1000E+4	1.7848E-3	-7.0401E-3	n	8.8666E+20	3.9463E+0
349.935	1.1000E+4	1.7991E-3	-6.7455E-3	n	9.2539E+20	3.7512E+0
359.899	1.1000E+4	1.8130E-3	-6.9526E-3	n	8.9782E+20	3.8367E+0
369.888	1.1000E+4	1.8272E-3	-6.8982E-3	n	9.0490E+20	3.7768E+0
379.864	1.1000E+4	1.8414E-3	-6.8765E-3	n	9.0776E+20	3.7354E+0
389.843	1.1000E+4	1.8555E-3	-6.9954E-3	n	8.9232E+20	3.7716E+0
399.822	1.1000E+4	1.8711E-3	-6.9807E-3	n	8.9421E+20	3.7327E+0
409.8	1.1000E+4	1.8864E-3	-6.8264E-3	n	9.1442E+20	3.6204E+0
419.781	1.1000E+4	1.9018E-3	-6.9557E-3	n	8.9742E+20	3.6593E+0
429.769	1.1000E+4	2.0337E-3	-7.5560E-3	n	8.2612E+20	3.7174E+0
439.776	1.1000E+4	2.0500E-3	-7.6057E-3	n	8.2073E+20	3.7119E+0
449.775	1.1000E+4	2.0660E-3	-7.6885E-3	n	8.1188E+20	3.7232E+0
459.786	1.1000E+4	2.0816E-3	-7.6425E-3	n	8.1678E+20	3.6736E+0
469.787	1.1000E+4	2.0984E-3	-7.6427E-3	n	8.1676E+20	3.6447E+0
479.812	1.1000E+4	2.1150E-3	-7.6558E-3	n	8.1536E+20	3.6220E+0
489.812	1.1000E+4	2.1313E-3	-7.3908E-3	n	8.4459E+20	3.4697E+0
499.814	1.1000E+4	2.1468E-3	-7.7784E-3	n	8.0251E+20	3.6251E+0

108 - c plane sapphire

```
[Sample parameters]
Sample Type:        van der Pauw
Hall Factor =       1.0
Thickness =         500.0 [nm]
L =       3.0 [mm]
Depletion Layer Correction:         Off

[Measurements]
<Step 1: IV Curve Measurement>
Start Time:         1/26/2009 8:17:11 AM
Time Completed:     1/26/2009 8:22:06 AM
Elapsed Time:       0:4:54

Starting Current:   -1.0 [mA]
Ending Current:     1.0 [mA]
Current Step:       200.0 [µA]
Resistance Range:             Low
Dwell Time:         2.0 [Sec]

Contact Sets:       R12,12
Best Fit Resistance [ohm] =         1.4739E+1
Best Fit Offset [V] =         5.1966E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99891E-4         -1.46841E-2         -6.6328E+1          296.2
-7.99951E-4         -1.17397E-2         -6.6241E+1          296.19
-6.00017E-4         -8.78895E-3         -6.6278E+1          296.18
-4.00007E-4         -5.84718E-3         -6.6321E+1          296.17
-1.99979E-4         -2.89160E-3         -6.6310E+1          296.16
4.98356E-12         5.15516E-5          -6.6369E+1          296.15
1.99909E-4          2.99900E-3          -6.6380E+1          296.14
3.99743E-4          5.93355E-3          -6.6412E+1          296.14
5.99739E-4          8.89347E-3          -6.6462E+1          296.13
7.99681E-4          1.18404E-2          -6.6479E+1          296.13
9.99609E-4          1.47880E-2          -6.6545E+1          296.12

Contact Sets:       R23,23
Best Fit Resistance [ohm] =         1.69E+1
Best Fit Offset [V] =         -3.0741E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99903E-4         -1.69266E-2         -6.6534E+1          296.11
-7.99971E-4         -1.35490E-2         -6.6582E+1          296.11
-6.00030E-4         -1.01718E-2         -6.6646E+1          296.1
-4.00004E-4         -6.79193E-3         -6.6690E+1          296.09
-1.99979E-4         -3.41200E-3         -6.6653E+1          296.09
2.13447E-11         -3.29117E-5         -6.6758E+1          296.08
1.99910E-4          3.34645E-3          -6.6715E+1          296.08
3.99742E-4          6.72481E-3          -6.6672E+1          296.07
5.99754E-4          1.01051E-2          -6.6767E+1          296.06
7.99693E-4          1.34849E-2          -6.6775E+1          296.06
9.99626E-4          1.68651E-2          -6.6760E+1          296.05
```

```
Contact Sets:       R34,34
Best Fit Resistance [ohm] =         1.8578E+1
Best Fit Offset [V] =       6.7603E-5
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99916E-4         -1.85060E-2         -6.6762E+1          296.05
-7.99980E-4         -1.47936E-2         -6.6840E+1          296.04
-6.00027E-4         -1.10810E-2         -6.6823E+1          296.04
-4.00006E-4         -7.36546E-3         -6.6854E+1          296.03
-1.99979E-4         -3.64934E-3         -6.6904E+1          296.03
8.55555E-12         6.60183E-5          -6.6912E+1          296.02
1.99915E-4          3.78146E-3          -6.6887E+1          296.02
3.99753E-4          7.49402E-3          -6.6857E+1          296.01
5.99765E-4          1.12100E-2          -6.6929E+1          296.01
7.99702E-4          1.49254E-2          -6.6975E+1          296.0
9.99641E-4          1.86411E-2          -6.7007E+1          296.0

Contact Sets:       R41,41
Best Fit Resistance [ohm] =         1.6683E+1
Best Fit Offset [V] =       3.2668E-6
Correlation =       1.E+0
Current [A]         Voltage [V]         Field [G]           Temperature [K]
-9.99911E-4         -1.66754E-2         -6.6938E+1          295.99
-7.99992E-4         -1.33413E-2         -6.6909E+1          295.99
-6.00028E-4         -1.00078E-2         -6.6941E+1          295.98
-4.00011E-4         -6.67150E-3         -6.7022E+1          295.98
-1.99982E-4         -3.33472E-3         -6.6947E+1          295.97
3.56100E-12         1.66975E-6          -6.7051E+1          295.97
1.99921E-4          3.33784E-3          -6.7025E+1          295.97
3.99759E-4          6.67196E-3          -6.7035E+1          295.96
5.99768E-4          1.00087E-2          -6.7057E+1          295.96
7.99708E-4          1.33456E-2          -6.7067E+1          295.95
9.99646E-4          1.66822E-2          -6.7116E+1          295.95

<Step 2: Variable Temperature Measurement>
Start Time:         1/26/2009 8:22:06 AM
Time Completed: 1/26/2009 2:24:24 PM
Elapsed Time:       6:2:18

Starting Temperature:       300.0 [K]
Ending Temperature:         500.0 [K]
Spacing: Linear Spacing
Temperature Step:           10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type:           Hall and Resistivity Measurement
Excitation Current:         1.0 [mA]
Resistance Range:           Low
Dwell Time:         2.0 [Sec]
Current Reversal: On
Geometry selection:         A and B
```

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.667	2.3825E-2	5.2167E-4
309.896	-1.3400E-2	5.2283E-4
319.83	-5.4500E-3	5.2408E-4
329.938	-2.1588E-2	5.2526E-4
340.007	3.3625E-2	5.2639E-4
349.833	-1.0500E-3	5.2752E-4
359.73	-1.0713E-2	5.2847E-4
369.687	2.5875E-3	5.3481E-4
379.656	2.3100E-2	5.3529E-4
389.624	-2.0000E-2	5.3659E-4
399.594	-7.1525E-2	5.3770E-4
409.558	-3.7225E-2	5.4087E-4
419.524	-1.5325E-2	5.3993E-4
429.501	-4.9375E-2	5.3968E-4
439.465	-3.9288E-2	5.4174E-4
449.457	-1.4838E-2	5.4299E-4
459.449	-4.7463E-2	5.4429E-4
469.435	2.1025E-2	5.4551E-4
479.416	3.6650E-2	5.4745E-4
489.439	4.8863E-2	5.4855E-4
499.433	7.5250E-2	5.4961E-4

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.56	1.1000E+4	5.2168E-4	-5.2226E-4	n	1.1952E+22	1.0011E+0
309.843	1.1000E+4	5.2299E-4	-4.1163E-4	n	1.5164E+22	7.8732E-1
319.838	1.1000E+4	5.2422E-4	-4.7744E-4	n	1.3074E+22	9.1101E-1
329.844	1.1000E+4	5.2529E-4	-4.2619E-4	n	1.4646E+22	8.1139E-1
339.849	1.1000E+4	5.2634E-4	-4.3013E-4	n	1.4512E+22	8.1713E-1
349.78	1.1000E+4	5.2748E-4	-4.2259E-4	n	1.4771E+22	8.0109E-1
359.809	1.1000E+4	5.2861E-4	-4.4673E-4	n	1.3973E+22	8.4533E-1
369.82	1.1000E+4	5.3488E-4	-6.8277E-4	n	9.1425E+21	1.2767E+0
379.815	1.1000E+4	5.3609E-4	2.3406E-4	p	2.6669E+22	4.3726E-1
389.806	1.1000E+4	5.3777E-4	-1.9778E-3	n	3.1561E+21	3.6859E+0
399.783	1.1000E+4	5.3836E-4	-3.5546E-5	n	1.7561E+23	6.6108E-2
409.786	1.1000E+4	5.3953E-4	4.8520E-4	p	1.2865E+22	8.9708E-1
419.784	1.1000E+4	5.3889E-4	7.1451E-4	p	8.7364E+21	1.3233E+0
429.799	1.1000E+4	5.4054E-4	-8.5547E-3	n	7.2968E+20	1.5852E+1
439.791	1.1000E+4	5.4200E-4	-1.9971E-3	n	3.1257E+21	3.6864E+0
449.791	1.1000E+4	5.4299E-4	-2.0600E-3	n	3.0301E+21	3.7939E+0
459.801	1.1000E+4	5.4443E-4	5.5857E-3	p	1.1175E+21	1.0262E+1
469.802	1.1000E+4	5.4556E-4	1.1435E-4	p	5.4590E+22	2.0961E-1
479.811	1.1000E+4	5.4719E-4	-4.9895E-4	n	1.2511E+22	9.1141E-1
489.798	1.1000E+4	5.4867E-4	-5.5892E-4	n	1.1168E+22	1.0189E+0
499.811	1.1000E+4	5.4987E-4	-5.4646E-4	n	1.1423E+22	9.9427E-1

28 - r plane sapphire sample 2

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.604 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Temperature Measurement>
Start Time: 8/23/2007 10:26:58 AM
Skipped at: 8/23/2007 3:53:55 PM
Elapsed Time: 5:26:57

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 750.0 [µA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.119	-6.0488E-2	1.4039E-3
310.233	4.7100E-2	1.4294E-3
320.29	3.6813E-2	1.4546E-3
330.329	1.0925E-2	1.4811E-3
340.279	4.7200E-2	1.5071E-3
350.219	-5.3250E-3	1.5330E-3
360.128	6.2500E-3	1.5597E-3
370.032	-5.6250E-3	1.5868E-3
379.929	4.0375E-3	1.6140E-3
389.777	-5.9325E-2	1.6404E-3
399.705	6.9500E-3	1.6685E-3
409.663	2.3638E-2	1.6967E-3
419.634	-2.6738E-2	1.7244E-3
429.6	-1.0425E-2	1.7536E-3
439.586	8.2500E-3	1.7817E-3
449.603	-1.3413E-2	1.8107E-3
459.639	6.6988E-2	1.8400E-3
469.652	6.7800E-2	1.8680E-3
0.0	0.0000E+0	1.0000E+101
0.0	0.0000E+0	1.0000E+101
0.0	0.0000E+0	1.0000E+101

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.14	1.1000E+4	1.4043E-3	-2.8623E-2	n	2.1808E+20	2.0388E+1
310.105	1.1000E+4	1.4292E-3	-2.9168E-2	n	2.1401E+20	2.0406E+1
320.152	1.1000E+4	1.4548E-3	-2.8208E-2	n	2.2129E+20	1.9393E+1
330.193	1.1000E+4	1.4808E-3	-2.8981E-2	n	2.1539E+20	1.9568E+1
340.145	1.1000E+4	1.5065E-3	-2.8869E-2	n	2.1622E+20	1.9155E+1
350.082	1.1000E+4	1.5326E-3	-2.8444E-2	n	2.1946E+20	1.8554E+1
359.99	1.1000E+4	1.5596E-3	-2.9055E-2	n	2.1484E+20	1.8629E+1
369.895	1.1000E+4	1.5865E-3	-2.8691E-2	n	2.1756E+20	1.8081E+1
379.816	1.1000E+4	1.6137E-3	-2.9100E-2	n	2.1451E+20	1.8029E+1
389.782	1.1000E+4	1.6409E-3	-2.9041E-2	n	2.1494E+20	1.7704E+1
399.79	1.1000E+4	1.6691E-3	-2.8354E-2	n	2.2015E+20	1.6994E+1
409.79	1.1000E+4	1.6974E-3	-2.8994E-2	n	2.1529E+20	1.7088E+1
419.799	1.1000E+4	1.7252E-3	-2.8644E-2	n	2.1792E+20	1.6611E+1
429.796	1.1000E+4	1.7542E-3	-2.8417E-2	n	2.1967E+20	1.6205E+1
439.797	1.1000E+4	1.7825E-3	-2.8570E-2	n	2.1849E+20	1.6035E+1
449.777	1.1000E+4	1.8117E-3	-3.0029E-2	n	2.0787E+20	1.6584E+1
459.792	1.1000E+4	1.8404E-3	-2.8879E-2	n	2.1615E+20	1.5695E+1
469.785	1.1000E+4	1.8688E-3	-2.8443E-2	n	2.1947E+20	1.5226E+1
0.0	0.0000E+0	1.0000E+101	0.0000E+0	n	0.0000E+0	1.0000E+103
0.0	0.0000E+0	1.0000E+101	0.0000E+0	n	0.0000E+0	1.0000E+103
0.0	0.0000E+0	1.0000E+101	0.0000E+0	n	0.0000E+0	1.0000E+103

32 - MOCVD GaN

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 550.0 [nm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Temperature Measurement>
Start Time: 11/6/2007 8:49:41 AM
Time Completed: 11/6/2007 3:40:47 PM
Elapsed Time: 6:51:6

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.789	5.2600E-2	6.8638E-4
310.081	-6.8450E-2	6.9880E-4
320.01	-1.5000E-4	7.1226E-4
330.137	-1.4150E-2	7.2586E-4
340.082	3.7375E-3	7.3919E-4
349.816	7.8000E-3	7.5299E-4
359.763	1.0675E-2	7.6674E-4
369.725	8.0125E-3	7.7998E-4
379.69	1.2088E-2	7.9389E-4
389.638	5.3488E-2	8.0821E-4
399.595	-3.2163E-2	8.2253E-4
409.568	2.5225E-2	8.3636E-4
419.546	6.0588E-2	8.5057E-4
429.529	-2.8000E-3	8.6480E-4
439.527	4.7000E-2	8.7928E-4
449.533	-1.4025E-2	8.9352E-4
459.543	-6.2663E-2	9.0820E-4
469.533	-5.2675E-2	9.2307E-4
479.538	-2.5188E-2	9.3789E-4
489.541	2.9413E-2	9.5281E-4
499.573	4.8750E-3	9.6729E-4

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.66	1.1000E+4	6.8623E-4	-9.0304E-3	n	6.9124E+20	1.3157E+1
309.951	1.1000E+4	6.9865E-4	-8.6576E-3	n	7.2101E+20	1.2389E+1
319.9	1.1000E+4	7.1217E-4	-8.9446E-3	n	6.9787E+20	1.2558E+1
329.952	1.1000E+4	7.2560E-4	-8.8875E-3	n	7.0235E+20	1.2244E+1
339.878	1.1000E+4	7.3899E-4	-8.5980E-3	n	7.2600E+20	1.1632E+1
349.87	1.1000E+4	7.5312E-4	-8.7438E-3	n	7.1390E+20	1.1612E+1
359.887	1.1000E+4	7.6699E-4	-8.8765E-3	n	7.0323E+20	1.1577E+1
369.896	1.1000E+4	7.8034E-4	-8.6752E-3	n	7.1955E+20	1.1122E+1
379.91	1.1000E+4	7.9438E-4	-8.7141E-3	n	7.1633E+20	1.0976E+1
389.926	1.1000E+4	8.0871E-4	-8.5519E-3	n	7.2992E+20	1.0581E+1
399.937	1.1000E+4	8.2304E-4	-8.7496E-3	n	7.1343E+20	1.0637E+1
409.946	1.1000E+4	8.3696E-4	-8.7006E-3	n	7.1745E+20	1.0403E+1
419.943	1.1000E+4	8.5125E-4	-8.6776E-3	n	7.1934E+20	1.0202E+1
429.936	1.1000E+4	8.6547E-4	-8.5747E-3	n	7.2798E+20	9.9152E+0
439.943	1.1000E+4	8.8005E-4	-8.7167E-3	n	7.1612E+20	9.9134E+0
449.931	1.1000E+4	8.9424E-4	-8.7157E-3	n	7.1620E+20	9.7543E+0
459.925	1.1000E+4	9.0882E-4	-8.6115E-3	n	7.2487E+20	9.4819E+0
469.92	1.1000E+4	9.2374E-4	-8.3450E-3	n	7.4802E+20	9.0405E+0
479.928	1.1000E+4	9.3864E-4	-8.8042E-3	n	7.0900E+20	9.3872E+0
489.925	1.1000E+4	9.5351E-4	-8.5689E-3	n	7.2847E+20	8.9933E+0
499.917	1.1000E+4	9.6782E-4	-8.6524E-3	n	7.2144E+20	8.9450E+0

52 - MOCVD GaN

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 2.0 [μm]
L = 15.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Temperature Measurement>
Start Time: 11/12/2007 10:13:24 AM
Time Completed: 11/12/2007 4:38:21 PM
Elapsed Time: 6:24:57

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 11.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 5.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.625	5.1588E-2	1.9614E-3
309.916	8.5338E-2	1.9764E-3
319.961	-1.6625E-2	1.9928E-3
330.021	4.2763E-2	2.0102E-3
339.821	1.1125E-2	2.0267E-3
349.745	-7.2500E-3	2.0435E-3
359.695	3.9663E-2	2.0605E-3
369.662	-1.7713E-2	2.0772E-3
379.626	-4.7975E-2	2.0943E-3
389.593	-3.4813E-2	2.1115E-3
399.559	-3.2463E-2	2.1287E-3
409.541	4.1125E-3	2.1470E-3
419.515	4.6500E-3	2.1644E-3
429.488	-4.6113E-2	2.1832E-3
439.471	6.5925E-2	2.2016E-3
449.443	2.3163E-2	2.2194E-3
459.448	6.2438E-2	2.2372E-3
469.443	-4.4000E-3	2.2557E-3
479.433	2.3150E-2	2.2740E-3
489.428	-1.3688E-2	2.2931E-3
499.442	7.8750E-4	2.3134E-3

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.491	1.1000E+4	1.9612E-3	-9.9455E-3	n	6.2764E+20	5.0706E+0
309.867	1.1000E+4	1.9763E-3	-9.9965E-3	n	6.2444E+20	5.0579E+0
319.863	1.1000E+4	1.9921E-3	-9.8930E-3	n	6.3097E+20	4.9643E+0
329.857	1.1000E+4	2.0094E-3	-9.2521E-3	n	6.7468E+20	4.6026E+0
339.857	1.1000E+4	2.0266E-3	-9.0254E-3	n	6.9163E+20	4.4531E+0
349.884	1.1000E+4	2.0439E-3	-9.4749E-3	n	6.5881E+20	4.6366E+0
359.899	1.1000E+4	2.0607E-3	-9.6841E-3	n	6.4458E+20	4.6999E+0
369.907	1.1000E+4	2.0777E-3	-1.0048E-2	n	6.2125E+20	4.8372E+0
379.918	1.1000E+4	2.0946E-3	-8.9151E-3	n	7.0018E+20	4.2569E+0
389.92	1.1000E+4	2.1121E-3	-9.6906E-3	n	6.4415E+20	4.5893E+0
399.918	1.1000E+4	2.1297E-3	-1.0050E-2	n	6.2114E+20	4.7210E+0
409.921	1.1000E+4	2.1479E-3	-9.9412E-3	n	6.2791E+20	4.6304E+0
419.916	1.1000E+4	2.1653E-3	-9.0421E-3	n	6.9035E+20	4.1777E+0
429.912	1.1000E+4	2.1839E-3	-9.5880E-3	n	6.5104E+20	4.3918E+0
439.916	1.1000E+4	2.2021E-3	-9.0067E-3	n	6.9306E+20	4.0909E+0
449.909	1.1000E+4	2.2200E-3	-9.0645E-3	n	6.8864E+20	4.0842E+0
459.912	1.1000E+4	2.2382E-3	-9.1530E-3	n	6.8198E+20	4.0912E+0
469.911	1.1000E+4	2.2565E-3	-9.4797E-3	n	6.5848E+20	4.2026E+0
479.916	1.1000E+4	2.2749E-3	-8.9131E-3	n	7.0034E+20	3.9195E+0
489.912	1.1000E+4	2.2945E-3	-9.3239E-3	n	6.6948E+20	4.0662E+0
499.902	1.1000E+4	2.3142E-3	-9.1578E-3	n	6.8163E+20	3.9586E+0

69 - SiC sample 1

[Sample parameters]
Sample Type: van der Pauw
Hall Factor = 1.0
Thickness = 1.216 [µm]
L = 3.0 [mm]
Depletion Layer Correction: Off

[Measurements]
<Step 1: Variable Temperature Measurement>
Start Time: 8/20/2007 8:12:02 AM
Time Completed: 8/20/2007 2:05:05 PM
Elapsed Time: 5:53:2

Starting Temperature: 300.0 [K]
Ending Temperature: 500.0 [K]
Spacing: Linear Spacing
Temperature Step: 10.0 [K]
Field at: 10.0 [kG]
Field Reversal with Positive field first
Measurement Type: Hall and Resistivity Measurement
Excitation Current: 1.0 [mA]
Resistance Range: Low
Dwell Time: 2.0 [Sec]
Current Reversal: On
Geometry selection: A and B

Temperature [K]	Field [G]	Zero-field Resistivity [Ωcm]
300.859	-4.0750E-3	2.8172E-3
310.19	-1.4350E-2	2.8368E-3
320.109	-8.8900E-2	2.8577E-3
330.112	2.9000E-3	2.8794E-3
340.022	3.0750E-3	2.9014E-3
349.869	1.2238E-2	2.9246E-3
359.799	-1.6538E-2	2.9505E-3
369.727	-4.3750E-4	2.9790E-3
379.666	1.9588E-2	3.0089E-3
389.612	2.9925E-2	3.0411E-3
399.559	6.9575E-2	3.0734E-3
409.523	2.2550E-2	3.1070E-3
419.489	-2.1600E-2	3.1409E-3
429.465	5.0825E-2	3.1762E-3
439.452	2.4638E-2	3.2120E-3
449.443	1.4913E-2	3.2488E-3
459.459	-3.2375E-3	3.2862E-3
469.456	-6.4750E-3	3.3237E-3
479.453	-4.9588E-2	3.3631E-3
489.441	2.9925E-2	3.4022E-3
499.443	2.1125E-3	3.4405E-3

Temp[K]	Field[G]	Resistivity[Ωcm]	HallCoeff[cm^3/C]	Type	CarrierDensity[cm^{-3}]	HallMobility[cm^2/(Vs)]
300.655	1.0000E+4	2.8166E-3	-6.7114E-3	n	9.3009E+20	2.3823E+0
310.053	1.0000E+4	2.8365E-3	-6.8693E-3	n	9.0870E+20	2.4216E+0
319.978	1.0000E+4	2.8575E-3	-6.4844E-3	n	9.6265E+20	2.2691E+0
329.978	1.0000E+4	2.8791E-3	-6.7760E-3	n	9.2122E+20	2.3533E+0
339.892	1.0000E+4	2.9013E-3	-6.8045E-3	n	9.1736E+20	2.3453E+0
349.817	1.0000E+4	2.9246E-3	-6.3808E-3	n	9.7827E+20	2.1818E+0
359.8	1.0000E+4	2.9510E-3	-6.8296E-3	n	9.1399E+20	2.3147E+0
369.81	1.0000E+4	2.9796E-3	-7.0021E-3	n	8.9147E+20	2.3505E+0
379.821	1.0000E+4	3.0102E-3	-6.4406E-3	n	9.6920E+20	2.1405E+0
389.825	1.0000E+4	3.0425E-3	-6.6439E-3	n	9.3954E+20	2.1847E+0
399.826	1.0000E+4	3.0753E-3	-6.7131E-3	n	9.2986E+20	2.1843E+0
409.834	1.0000E+4	3.1089E-3	-6.6445E-3	n	9.3946E+20	2.1386E+0
419.825	1.0000E+4	3.1431E-3	-6.7065E-3	n	9.3077E+20	2.1352E+0
429.826	1.0000E+4	3.1784E-3	-6.9834E-3	n	8.9386E+20	2.1987E+0
439.827	1.0000E+4	3.2143E-3	-6.7212E-3	n	9.2873E+20	2.0925E+0
449.825	1.0000E+4	3.2515E-3	-6.3547E-3	n	9.8229E+20	1.9560E+0
459.83	1.0000E+4	3.2887E-3	-6.8942E-3	n	9.0542E+20	2.0979E+0
469.813	1.0000E+4	3.3265E-3	-7.1588E-3	n	8.7196E+20	2.1539E+0
479.813	1.0000E+4	3.3660E-3	-6.6698E-3	n	9.3590E+20	1.9832E+0
489.818	1.0000E+4	3.4047E-3	-6.6624E-3	n	9.3692E+20	1.9583E+0
499.811	1.0000E+4	3.4432E-3	-6.9165E-3	n	9.0251E+20	2.0103E+0

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