DEVELOPMENT OF VERY HIGH FREQUENCY PLASMA ENHANCED CHEMICAL VAPOUR DEPOSITION FOR NANOSTRUCTURE SILICON CARBIDE THIN FILM DEPOSITION

MUHAMMAD FIRDAUS BIN OMAR

UNIVERSITI TEKNOLOGI MALAYSIA

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MUHAMMAD FIRDAUS BIN OMAR

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ABSTRACT

Silicon carbide (SiC) is a semiconductor material which has received a great deal of attention due to its outstanding mechanical properties, chemical inertness, thermal stability, superior oxidation resistance, high hardness, wide band gap and relatively low weight for applications in high frequency and high power systems in extreme environment. SiC particularly amorphous SiC (a-SiC) and polycrystal SiC (pc-SiC) have important roles for several applications such as microelectromechanical systems (MEMS) or nanoelectromechanical Systems (NEMS), thermoelectric cooling (TEC), optoelectronic devices, solar cell or as a substrate for deposition of graphene. However, the present a-SiC and pc-SiC thin film materials are less competitive materials for these applications. Previous researchers reported that, scaling down bulk SiC to nanostructure (ns-SiC) has shown performance improvement in those applications. The structure of ns-SiC thin film can be either in single crystal, polycrystal or nanocrystal (embedded in amorphous layers) forms with layer thickness or grain size in nanometer range. The conventional plasma enhanced chemical vapour deposition (PECVD) technique is mainly needed to grow a-SiC or pc-SiC thin film. High deposition temperature is required in order to improve its crystallinity. However, high deposition temperature would induce thermal stress in deposited thin film. Thus, very high frequency-PECVD (VHF-PECVD) with 150 MHz RF was designed and developed in this work based on direct plasma mode with capacitive couple discharge (CCD) configuration with the aim to deposit ns-SiC at relatively low deposition temperature compared to conventional PECVD. The plasma profile of argon (Ar), hydrogen (H_2), silane (SiH_4) and methane (CH_4) of the system were characterized using optical emission spectrometer (OES). This system is found to be able to fully dissociate SiH_4 plasma at room temperature. Meanwhile Ar and H_2 mixture with CH_4 plasma is needed for CH_4 to fully dissociate at room temperature. The effects of three major parameters, namely the type of dilution gas, CH_4 flow rate and RF power on the properties of the deposited thin film were investigated. The formation of ns-SiC crystal structure is observed at relatively low growth temperature of about 400 °C. Nanocrystal formation is enhanced when H_2 and Ar are added to plasma mixture and the smallest diameter obtained is about 1.5 nm. The trend shows that, the growth mechanism changes from layer-island mechanism to layer-layer mechanism and root mean square roughness (R_{rms}) improves from 84.43 nm to 0.74 nm when CH_4 flow rate is increased. Single crystal epilayer is successfully deposited with a crystal structure assigned as 4H-SiC and confirmed of having 3.26 eV optical band gap. Increasing CH_4 flow rate results in the luminescence emission of ns-SiC to be shifted from green (~ 518 nm) dominant emission to UV-B (~294 nm) dominant luminescence emission. This indicates that the deposited ns-SiC has potential for optoelectronic application in visible light to medium UV range.

ABSTRAK

Silikon karbida (SiC) ialah bahan semikonduktor yang telah menerima banyak perhatian kerana sifat mekanikal yang cemerlang, kelengaian kimia, kestabilan terma, rintangan pengoksidaan yang unggul, kekerasan yang tinggi, jurang jalur yang lebar dan berat yang agak rendah untuk aplikasi dalam sistem berfrekuensi tinggi dan berkuasa tinggi dalam persekitaran yang melampau. SiC terutamanya SiC amorfus (a-SiC) dan SiC polihablur (pc-SiC) mempunyai peranan yang penting untuk beberapa aplikasi seperti sistem mikroelektromekanikal (MEMS) atau sistem nanoelektromekanikal (NEMS), penyejukan termoelektrik (TEC), peranti optoelektronik, sel solar atau sebagai substrat untuk pemendapan grafen. Walaubagaimanapun, bahan saput tipis a-SiC dan pc-SiC terkini ialah bahan yang kurang berdaya saing untuk aplikasi tersebut. Penyelidik terdahulu melaporkan bahawa, mengecilkan SiC pukal kepada SiC nanostruktur (ns-SiC) telah menunjukkan peningkatan prestasi dalam aplikasi tersebut. Struktur saput tipis ns-SiC boleh wujud samada dalam bentuk hablur tunggal, polihablur atau nanohablur (terbenam dalam lapisan amorfus) dengan ketebalan lapisan atau saiz butiran dalam julat nanometer. Teknik pemendapan wap kimia diperkuat plasma (PECVD) konvensional diperlukan terutamanya untuk menumbuhkan saput tipis a-SiC atau pc-SiC. Suhu pemendapan yang tinggi diperlukan dalam usaha untuk meningkatkan penghablurannya. Namun, suhu pemendapan yang tinggi boleh mengakibatkan tegasan terma di dalam saput tipis yang termendap. Oleh itu, frekuensi yang sangat tinggi-PECVD (VHF-PECVD) dengan RF 150 MHz telah direka dan dibangunkan dalam kajian ini berasaskan mod plasma langsung dengan konfigurasi nyahcas gandingan kapasitif (CCD) dengan tujuan untuk memendapkan ns-SiC pada suhu pemendapan yang agak rendah berbanding dengan PECVD konvensional. Profil plasma argon (Ar), hidrogen (H_2), silana (SiH_4) dan metana (CH_4) bagi sistem ini telah dicirikan menggunakan spektroskopi pemancaran optik (OES). Sistem ini didapati dapat memisahkan sepenuhnya SiH_4 plasma pada suhu bilik. Sementara itu campuran Ar dan H_2 dengan CH_4 plasma diperlukan untuk memisahkan CH_4 dengan sepenuhnya pada suhu bilik. Kesan daripada tiga parameter utama iaitu jenis gas pencairan, kadar aliran CH_4 dan kuasa RF terhadap sifat saput tipis yang dimendapkan telah diselidik. Pembentukan struktur hablur diperhatikan pada suhu pemendapan yang rendah kira-kira 400 °C. Pembentukan nanohablur meningkat apabila H_2 dan Ar ditambah kepada campuran plasma dan diameter terkecil diperolehi ialah kira-kira 1.5 nm. Arah aliran menunjukkan bahawa, mekanisma pertumbuhan berubah daripada mekanisma lapisan-pulau kepada mekanisma lapisan-lapisan dan kekasaran punca min kuasa dua (R_{rms}) telah diperbaiki daripada 84.43 nm kepada 0.74 nm apabila kadar aliran CH_4 dipertingkatkan. Lapisan berhablur tunggal telah berjaya dimendapkan dengan struktur hablur boleh diumpukkan sebagai 4H-SiC dan disahkan mempunyai 3.26 eV jurang jalur optik. Peningkatan kadar aliran CH_4 menghasilkan pancaran pendarcahaya untuk ns-SiC telah beralih daripada pancaran hijau (~ 518 nm) yang dominan kepada pancaran pendarcahaya UV-B (~ 294 nm) yang dominan. Ini menandakan ns-SiC yang dimendapkan mempunyai potensi untuk aplikasi optoelektronik dalam julat cahaya nampak hingga UV sederhana.

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LIST OF ABBREVIATIONS

2D - two-dimensional
AC - Alternate current
AFM - Atomic force microscopy
AP - Atmospheric pressure
CB - Conduction band
CCD - Capacitive couple discharge
CG - Corning glass
CVD - Chemical vapor deposition
DC - Direct current
DI - Deionized
DP - Direct plasma
ECR-CVD - Electron cyclotron resonance chemical vapor deposition
EDS - Energy dispersive spectroscopy
EELS - Electron energy loss spectroscopy
FESEM - Field emission scanning electron microscope
FTIR - Fourier transform infrared
FWHM - Full wide half maximum
HWCVD - Hot wall chemical vapor deposition
IR - Infrared
ISO - International standard organization
LED - Light emitting diode
LO - Longitudinal optical
LP - Low pressure
MBE - Molecular beam epitaxy
MEMS - Micro electromechanical system
MFC - Mass flow controller

MO - Metal organic
MOX - Malaysia oxygen
NEMS - Nano electromechanical system
NW - Nanowires
OES - Optical emission spectroscopy
PECVD - Plasma enhanced chemical vapor deposition
PL - Photoluminescence
PLD - Plused laser deposition
PVD - Physical vapor deposition
QD - Quantum dot
QG - Quartz glass
QW - Quantum well
Raman - Raman spectroscopy
RF - Radio frequency
RIE - Reactive ion etching
RP - Rotary pump
RT - Room temperature
SEM - Scanning electron microscope
SiC - Silicon Carbide
SPM - Scanning probe microscope
SSR - Solid state relay
STEM - Scanning/Transmission electron microscopy
TE - Thermoelectric
TEC - Thermoelectric cooling
TMP - Turbo molecular pump
TO - Transverse optical
UV-Vis - Ultraviolet-visible
VB - Valence band
VHF - Very high frequency
VLS - Vapor-liquid-solid
WDS - Wavelength dispersive spectroscopy
XRD - X-ray diffraction
XRR - X-ray reflectivity
NIR - Near infrared

ATR - Attenuated total reflection
µRS - Micro-Raman Spectroscopy
GI-XRD - Glazing incident X-ray diffraction
Op-GI - Out-of plane glazing incident
IP-GI - In-plane glazing incident
CBO - Parabolic multilayer X-ray mirror
PSC - Parallel slit collimeter
PSA - Parallel slit analyzer
EPMA - Electron probe micro analyzer
SE - Secondary electron
BSE - Back scattering electron
FEG - Field emission gun
ICDD - International Centre for Diffraction Data
R_{rms} - Root-mean-square roughness
HAADF - High angle annular dark field
BF - Bright field
sc-SiC - Single crystal silicon carbide

LIST OF SYMBOLS

E_g - Energy Band Gap
SiC - Silicon Carbide
C - Carbon
°C - Degree Celsius
Si - Silicon
SiH_4 - Silane
Si_2H_6 - Disilane
$SiCl_4$ - Tetrachlorosilane
CH_4 - Methane
C_2H_2 - Acetylene
C_3H_8 - Propane
C_7H_8 - Methylbenzene/toluene
C_6H_{14} - Hexane
CH_3Cl - Methyl Chloride
CCl_4 - Carbon Tetrachloride
$(CH_3)_2SiH_2$ - Dimethylsilane
CH_3SiCl_3 - Methyltrichlorosilane
$(CH_3)_4Si$ - Tetramethylsilane
$(CH_3)_6Si_2$, - Hexamethyldisilane
H - Hydrogen
MHz - Megahertz
H_2 - Hydrogen gas
CO_2 - Carbon dioxide
SiH_3CH_3 - Methylsilane
NH_3 - Ammonia

PH_3 - Phosphine
Al - Aluminium
a - Amorphous
nc - Nanocrystal
ns - Nanostructure
pc - Polycrystal
μc - Microcrystal
eV - Electron volt
GaN - Gallium NItride
GaAs - Gallium Arsenide
atm - Atmospheric Pressure
α-SiC - Hexagonal
Å - Angstrom
β-SiC - Cubic SiC
E_c - Critical Electric Breakdown Field
υ_{sat} - Saturated Drift Velocity
μ_e - Electron Mobility
κ - Thermal Conductivity
β - Thermal Expansion Coefficient
T_m - Melting Point
O - Oxygen
λ - Wavelength
κ - Scherer constant
θ_{hkl} - Bragg angle for hkl phase
β_{hkl} - FWHM at (hkl) peak in radian
π - Pi
δ - Bending/deformation vibration
Δx - Uncertainty of position
Δp - Uncertainty of momentum
ħ - Planck constant
m - mass
e- - electron
hυ - photon

Ar - Agon

N_2 - Nitrogen gas

λ_D - Debye length

ε_0 - Permittivity of free space

T_e - Electron temperature

n_e - Electron density

e - Electron charge

V_p - Plasma potential

V_s - Sheath potential

μs - Microsecond

ω_{rf} - RF frequency

ω_{pi} - Ion plasma oscillation frequency

ω_{pe} - Electron plasma oscillation frequency

V - Volt

Ni - Nickel

Cr - Chromium

Ω - Ohm

P_{base} - Base pressure

sccm - Standard cubic centimeters per minute

W - Watt

mTorr - milliTorr

a.u. - Arbitrary unit

H_2SO_4 - Sulphuric Acid

P_{growth} - Growth Pressure

Zn - Zinc

Se - Selenium

He - Helium

Cd - Cadmium

° - Degree (unit angle)

μA - microAmpere

R_{rms} - Root-mean-square roughness

I - Intensity

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CHAPTER 1

INTRODUCTION

1.1 Background of Problem

Since the first illuminating talk on nanotechnology by Richard Feynman, nanoscience and nanomaterial become one of the most fastest grown research field in the world [1]. The purpose of nanoscience is to understand the behavior and properties of material at nano scale or near atomic scale and to explore its potential in nanotechnology field. Most of the studies have shown that enhancement in physical properties occur when the material scale down to nano size [2]–[7].

Recently, requirement of nanomaterial electronics devices for application in extremes environment such as high temperature, high corrosion, high electromagnetic radiation, and high nuclear radiation make it compulsory to use special material as a based material in such extremes condition. Silicon carbide (SiC) is an emerging semiconductor material which has received a great deal of attention due to its application in high frequency and high power systems. SiC has been recognized for several decades as a promising materials to be applied in extreme environment due to its outstanding mechanical properties, chemical inertness, thermal stability, superior oxidation resistance, high hardness, wide band gap and relatively low weight [1], [8]–[11]. Due to its large energy band gap (E_g) material, SiC can minimize the effect of minority carrier when operate at high temperature [12] compare to lower band gap material such as Si.

SiC has gained important role for several applications in the optoelectronic devices [11], [13], [14] such as light emitting diode (LED), electroluminescent devices [15], micro and nanoelectromechanical system (MEMS and NEMS) sensors fabrication [10], [16] and also thermoelectric cooling (TEC) devices for deployment in extreme environments [17] and as biocompatible materials in blood-contacting implants and biomedical devices [18]. But until recently the low material quality has limited the fabrication of high quality devices [19].

First laboratory single crystal SiC has been produced by Achenson in 1892 as a byproduct from abrasives manufacturing industry. In 1955, Lely have grown SiC single crystal by sublimating polycrystalline SiC powder and this method known as Lely method [10]. This method then improved by Tairov and Tsvetkov from Russia in 1987, those make SiC was born in early 1980's. Finally in year 1987, epitaxy SiC on off-axis substrates have been introduced and this technique is called "step-controlled epitaxy" [15], [20].

Today, thin film or epitaxy SiC has been discovered deeply by researcher. To produce SiC wafer from bulk single crystal SiC (sc-SiC) is very challenging due to difficulty to get good single crystal growth without defect and contamination. Defect normally will result grain boundary in the crystal which have a lot of significant effects on the mechanical, physical and electrical properties of materials [21]. SiC sublimation temperature which is about 2500 °C makes it not very suitable for mass production. However epilayer SiC is much easy to be prepared compare to crystal growth technique. In industry, SiC electronic devices are fabricated in higher quality SiC thin film. The structure of SiC thin film can be crystal, amorphous or polymorphous depending on the application need. Well grown SiC film reported to have superior electrical properties [10]. It can be growth at lower temperature [22], impurity can be controlled and reproducible, practical for mass production [23], suitable for large area deposition [10] and possible to obtain high quality homoepitaxy [24].

There are several common preparation methods and different gases have been used to synthesize SiC thin films to obtain desired physical and electronic properties. For gas to solid approach, basically these methods can be classified as physical vapour deposition (PVD) and chemical vapour deposition (CVD). In PVD method, the film growth when the Si and C atoms sputtered from SiC target after hit by high energy gas species like argon (Ar) ion. The sputtered atoms then travel and deposited on the substrate. These common growth techniques are including hot wall CVD (HWCVD), plasma enhanced CVD (PECVD), electron cyclotron resonance CVD (ECR-CVD), magnetron sputtering, pulsed laser deposition (PLD), ion implantation, and molecular beam epitaxy (MBE) [8], [25].

For the source of Si precursors, usually preferred gases are silane (SiH_4), disilane (Si_2H_6), and tetrachlorosilane ($SiCl_4$), and for the source of C precursors methane (CH_4), acetylene (C_2H_2), propane (C_3H_8), methylbenzene/toluene (C_7H_8), hexane (C_6H_{14}), methyl chloride (CH_3Cl), carbon tetrachloride (CCl_4), and other gases have been used for making these films. Various organometallic precursors such as dimethylsilane [$(CH_3)_2SiH_2$, DMS], tetramethylsilane [$(CH_3)_4Si$, TMS], methyltri-chlorosilane [CH_3SiCl_3, MTS], and hexamethyldisilane [$(CH_3)_6Si_2$, MDS] have been also used as single-source system to reduce the growth temperature of SiC:H films. Hydrogen and argon are commonly used as carrier/diluter gas [8], [22], [23], [26]**.**

PECVD have advantage over HWCVD (or in general called CVD) because this method can be a solution when lower temperature deposition and or residual stress control is required [25]. However, common thin film growth technology like conventional 13.56 MHz radio frequency (RF) PECVD thin film deposition technique generally produced amorphous and poly-crystalline SiC type of film [17], [19], [27]. Amorphous (a) and poly-crystalline (pc) of bulk SiC film are less competitive material for applications such as MEMS/NEMS, TEC, optoelectronic devices and solar cell. a-SiC and pc-SiC have low mechanical quality factor Q result from high internal loss which not suitable for MEMS/NEMS. TEC have a material requirement of low thermal conductivity and high electrical conductivity to enhance it figure-of-merit value (Z) which represents TEC efficiency. Thermal conductivity on the other hand can effectively reduce by increasing phonon scattering and carrier scattering in film. Thermal conductivity is dependent on film structure, the grain size and also alloys disorder in the film [12]. Effect of grain size and grain boundary in ns-SiC is also predicted to have higher efficiency if applied as TE material [28], [29]. Electrical conductivity of thin film can be increased by introducing dopant in the deposited film [30]. ns-Si and ns-SiC matrix also reported to have better efficiency if applied in solar cell devices and optoelectronic devices such as LED and photodiode [6], [30]–[34].

Several researchers have reported of using higher RF frequency for PECVD in order to produce better SiC thin film and ns-SiC at low temperature. PECVD which using RF which higher than 13.56 MHz is categorized as very high frequency PECVD (VHF-PECVD). It is well know that PECVD with high excitation frequency have some advantage over conventional PECVD such as high deposition rate, offering good quality film with less defect, higher electron density, lower plasma potential and less reduced ion bombardment effect compared to the conventional[35]. Previous researcher report on obtaining amorphous hydrogenated SiC (a-SiC:H) at temperature below 250 ˚C by using 27.12 MHz [36], 70 MHz [37] and 100 MHz [38] radio frequency. Miyajima and several other researcher report on growth of nanocrystalline cubic SiC (nc-3C-SiC) by using 60 MHz RF with substrate temperature 360 ˚C [32], [34], [39]–[41]. Table 1.1 shows summary of reported work by previous researcher on the fabrication SiC thin film using VHF-PECVD technique and the result obtained by them.

Table 1.1: Summary of previous work on SiC thin film growth by VHF-PECVD

Frequency	Precursor	Temperature (°C)	Structure	Reference
27.12 MHz	Silane (SiH_4), Methane (CH_4)	200	a-$Si_{1-x}C_x$:H	[36]
60 MHz	Monomethylsilane (MMS), Hydrogen (H_2), Dimethylaluminum hydride (DMAH)	390	Al doped: nc-3C-SiC	[32]
60 MHz	Monomethylsilane (MMS), Hydrogen (H_2), Dimethylaluminum hydride (DMAH)	360	Al doped: nc-3C-SiC	[34]
60 MHz	Monomethylsilane (MMS), Carbon Dioxide (CO_2), Hydrogen (H_2)	193 (G), 900 (A)	Si QD in a-SiC SL	[42]
60 MHz	Monomethylsilane (MMS), Hydrogen (H_2)	360	nc-3C-SiC:H	[39]
60 MHz	Monomethylsilane (MMS), Hydrogen (H_2)	425	nc-3C-SiC:H	[43]
60 MHz	Monomethylsilane (MMS), Hydrogen (H_2)	290	nc-3C-SiC:H	[33]
60 MHz	Monomethylsilane (MMS), Hydrogen (H_2), Hexamethyldisilazane (HMDS)	360	nc-3C-SiC:H	[44]
60 MHz	Methylsilane (SiH3CH3), Hydrogen (H_2), NH_3, PH_3	300	μc-3C-SiC:H (n, p)	[45]
60 MHz	Monomethylsilane (MMS), Hydrogen (H_2), Silane (SiH_4)	200	a-SiC:H	[41][46]
100 MHz	Silane (SiH_4), Methane (CH_4), Hydrogen (H_2)	250, 350	a-$Si_{1-x}C_x$:H	[38]

1.2 Problem Statement

SiC has gained important role for applications in the optoelectronic devices [11], [13], [14], electroluminescent devices [15], MEMS and NEMS sensors fabrication [10], [16], TEC devices for deployment in extreme environments [17], as biocompatible materials in blood-contacting implants and biomedical devices [18]. But until recently the low material quality has limited the fabrication of high quality devices [19]. Conventional PECVD techniques are generally needed to grow a-SiC and pc-SiC thin film [17], [19], [27]. The present a-SiC, and pc-SiC thin film material are less competitive material for applications in MEMS/NEMS, TEC, optoelectronic devices, solar cell or as a substrate for deposition of graphene. However, high temperature deposition is required in order to improve of films crystallinity but this technique have lower deposition rate [47] . a-SiC and pc-SiC have low mechanical quality (Q factor) result from high internal loss which not suitable for MEMS/NEMS compare to sc-SiC. TEC have a material requirement of low thermal conductivity and high electrical conductivity to enhance it figure-of-merit value (Z) which represents it efficiency. Thermal conductivity can effectively reduce by increasing phonon scattering and carrier scattering in film [12]. Effect of grain size and grain boundary in ns-SiC thin film was reported of gaining higher TEC efficiency [28], [29]. Electrical conductivity of ns-SiC thin film can be increased by introducing dopant material [30]. Solar cell devices and optoelectronic devices of ns-SiC base was reported to have better performance than bulk-SiC base devices [6], [30]–[34]. Thin film based on ns-SiC is required in order to meet nowadays applications. Although, a few research group were success to produce ns-SiC and nc-SiC thin films such as Miyajima et. al., Hamashita et. al. [32], [34], [46] and Schmittgens et. al. [40], however none was reported fabricating it by using RF-PECVD with the frequency higher than 100 MHz with SiH_4 and CH_4 precursor at low temperature. VHF-PECVD with 150 MHz radio frequency was reported to successfully growth nc-Si at low temperature using SiH_4 precursor [35], [48], [49]. It is expected that ns-SiC thin film also can be grown using VHF-PECVD with this excitation frequency. Most of the studies are focused on to improve SiC thin film crystal quality by manipulating deposition condition. Deposition parameter such as type of gas dilution, CH_4 flow rate and RF power for ns-SiC in this VHF range not reported yet and it is expected to be different with the deposition parameter in lower RF frequency. There are still unrevealed relationship of above deposition parameter to the properties of the deposited ns-SiC such as morphology, topology, structural, crystal phase and chemical state composition within this range.

1.3 Research Objectives

The aim of this study is to deposit ns-SiC at relatively low temperature compare to conventional PECVD technique by using SiH_4 and CH_4 as precursors. To achieve this aim, this study embarks on the following objectives:

1) To design and develop VHF-PECVD system with 150 MHz radio frequency excitation for ns-SiC thin film deposition.
2) To characterize and optimize the developed system using various gases and plasma condition.
3) To determine the deposition parameter to obtain ns-SiC thin film.
4) To validate the formation of ns-SiC by the structural, chemical state, luminescence and morphology properties characterization.

1.4 Research Scope

To achieve above objectives, the following studies must be carried out in this research:

1) Vertical asymmetry capacitive couple discharge (CCD) configuration for direct plasma mode with 150 MHz radio frequency excitation were applied in designing and developing VHF-PECVD system.
2) Optical emission spectroscopy (OES) was used to characterize individual plasma profile of SiH_4, CH_4 and H_2 at different gas flow rate, temperature, RF power and gas mixture ratio.
3) Deposition parameter for type of dilution gas, CH_4 flow rate and RF power were determined prior to ns-SiC thin film deposition.
4) Scanning electron microscope (SEM), scanning probe microscope (SPM) and x-ray reflectivity (XRR) were used to investigete the morphology, topology and thickness of the deposited thin film respectively.
5) The structural properties of deposited thin film were characterized using infrared (IR) spectroscopy and Raman spectroscopy.
6) Elements distribution and chemical state analysis were investigated using electron energy loss spectroscopy (EELS) and x-ray wavelength dispersive spectroscopy (WDS) respectively.
7) Photoluminescence spectroscopy was used to investigate the luminescence properties of deposited thin film.

1.5 Significant of study

There are several significant of this study:

1) New design of VHF-PECVD system to deposite ns-SiC film over large areas of substrate for semiconductor and coating application was successfully developed. Deposited ns-SiC thin film is expected to possess lower grain and structure size, lower surface roughness and better luminescence properties as well as preserving the superior physical properties to be applied in harsh environment. Nano-sized grain of the crystallites, grain boundary effect and quantum effect are the main characteristics of nc-SiC structure which expected to contribute to the above improvement.
2) The characteristic of plasma profile for developed system is obtained and the existence of reactive species in the plasma at measurement condition can be used to relate it with the deposited film.
3) The effect of deposition parameter such as type of dilution gas, CH_4 flow rate and RF power to the morphology, topology, thickness, structural, crystall phase, elements distribution, chemical state composition and luminescence properties of the deposited SiC thin film can be used to obtain the desire thin film properties in the future for application in specific field.

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