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RESEARCH TITLE:

Surface Phonon Polariton Resonance Modulation In Wurtzite III-Nitride Semiconductor System Via Modification Of Surface Structure And Formation Of Alloy Structure

(203 / PFIZIK / 6711282)

Prepared by

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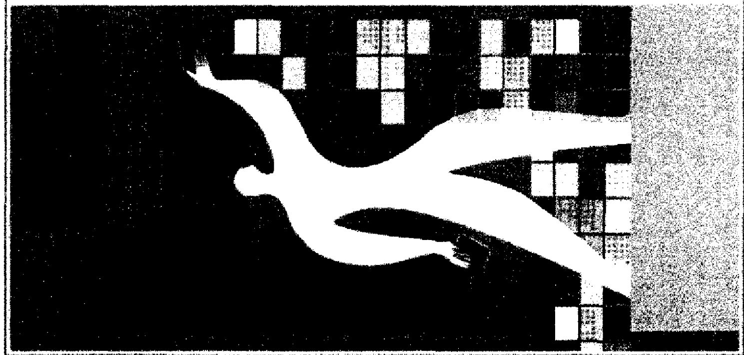

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Dear Dr. Sha Shiong Ng,

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We would like to invite you to visit our research laboratories in our school from 14 Nov. 2014 to 12 Jan. 2015. During your invited visit, we hope to develop research collaboration on nitride thin film growth and optical characterization. In the mean time, we would like to invite you to discuss about the future collaboration between Universiti Sains Malaysia and National Changhua University of Education. It would be our great honor if you can come to National Changhau University of Education.

Yours Sincerely,

Acting Director Ya-Hui Huang 2014-8-19

Dr. Shenghui Cindy Huang, Ph.D.

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Prof. Dr. Wan Haliza Binti Abd Majid
Physics Department, Faculty of Science, University Malaya.

Prof. Dr. Saifollah Abdullah
Faculty of Applied Science, Universiti Teknologi MARA

Prof. Madya Dr Mohd Arif Bin Agam
Faculty of Science, Technology and Human Development
University Tun Hussein Onn Malaysia

Dr. Goh Boon Tong
Physics Department, Faculty of Science, University Malaya.

Date: 17th March 2015

Venue: Conference Room, Level 4, Engineering Tower, Faculty of Engineering, UM

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Organizer	: Nanomaterials Engineering Research Group, University Malaya.
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Program Schedule

8.00am – 8.30am	: Participant registration.
8.30am – 9.30am	: Fourier Transform Infrared Spectroscopy: Fundamental and Applications for Nanomaterials. *Prof. Madya Dr Mohd Arif Bin Agam* *Fakulti Sains, Teknologi Dan Pembangunan Insan* *Universiti Tun Hussein Onn Malaysia (UTHM)*
9.30am – 10.30am	: Fundamental and Importance of Raman Spectroscopy in Nanomaterials. *Prof. Dr. Saifollah Abdullah* *Faculty of Applied Science* *University Teknologi MARA,*
10.30am – 11.00am	: Tea Break.
11.00am – 12.00pm	: Ultraviolet Visual Spectroscopy: UV-Visible Spectroscopy for Nanomaterials Characterization. *Prof. Dr. Wan Haliza Binti Abd Majid* *Department of Physics, Faculty of Science, University Malaya.*
12.00pm – 1.00pm	: High Resolution Transmission Electron Microscopy: Principles and Instrumentation on Nanomaterials. *Dr. Goh Boon Tong* *Department of Physics, Faculty of Science, University Malaya.*
1.00pm – 2.00pm	: Lunch Break.
2.00pm – 5.00pm	: Lab Demonstration of Fourier Transform Infrared Spectroscopy (FTIR), Micro Raman Spectroscopy, UV-Visible Spectroscopy and High Resolution Transmission Electron Microscopy (HRTEM).
5.00pm – 5.30pm	: Closing.

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LIST OF PUBLICATIONS AND CONFERENCES

ISI index journal:

1. Cheah, S.F., Lee, S.C., Ng, S.S., Yam, F.K., Abu Hassan, H., Hassan, Z. (2013) Surface phonon polariton characteristic of honeycomb nanoporous GaN thin films, **Applied Physics Letters,**102 (10) , art. no. 101601. **[Impact factor: 3.515]**
2. Cheah, S.F., Lee, S.C., **Ng, S.S.,** Yam, F.K., Abu Hassan, H., Hassan, Z. (2015) Luminescence evolution of porous GaN thin films prepared via UV-assisted electrochemical etching. **Journal of Luminescence**, 159, pp. 303-311. **[Impact Factor: 2.367]**
3. Fong, C.Y., Ng, S.S., Yam, F.K., Abu Hassan H., and Hassan, Z. (2015). Effects of nitridation temperature on characteristics of gallium nitride thin films prepared via two-step method. **Acta Metallurgica Sinica (English Letters)**, 28, pp. 326-366. **[Impact factor: 0.426]**
4. Fong, C.Y., Ng, S.S., Yam, F.K., Abu Hassan H., and Hassan, Z. (2015). An investigation of sol-gel spin coating growth of wurtzite GaN thin film on 6H-SiC substrate. **Journal of Crystal Growth**, 413, pp.1-4. **[Impact factor: 1.693]**

International Conference Proceedings:

1. Cheah, S.F., Ng, S.S., Yam, F.K., Abu Hassan, H., Hassan, Z. (2014) Formation and optical studies of porous GaN thin films via UV-assisted electrochemical etching approach. **Advanced Material Research**, 895, pp. 45-50. **[Indexed by Scopus, ISI]**
2. Cheah, S.F., Lee, S.C., Ng, S.S., Yam, F.K., Abu Hassan, H., Hassan, Z. (2015) Attenuated total reflection studies of honeycomb nanoporous GaN thin films, **Advanced Materials Research**, 1108, pp. 9-14. **[Indexed by Scopus, ISI]**
3. Pauline Yew, Lee, S.C., Ng, S.S., Yoon, T.L., Abu Hassan, H. (2014) Theoretical studies on optical phonon and surface phonon polariton of wurtzite AlInN alloys, **Advanced Materials Research,** 1107, pp. 565-570. **[Indexed by Scopus, ISI]**
4. Mohd Amin, N., Lee, Z.Y., Fong, C.Y., Ng, S.S. (2013) Growth and characterization of AlN thin film deposited by spin coating and nitridation techniques, **Advanced Materials Research,** 1107, pp. 667-671. **[Indexed by Scopus, ISI]**

National Conference Proceedings

1. Ng, S.S., Pauline Yew, Abu Hassan, H., Hassan, Z. (2014) Attenuated total reflection study of surface phonon polariton characteristics of $Al_xIn_{1-x}N$ thin films grown on 6H-SiC substrate, **Proceedings of International Sciences, Technology and Engineering Conference (ISTEC 2014), p. 15-19.**

National Conferences Presentation:

1. Pauline Yew, Lee, S.C., Ng, S.S., Yoon, T.L., Abu Hassan, H. (2014) Influence of force constant on surface phonon polariton properties of cubic $ZnS_{1-x}Se_x$ crystals, **National Conference on Physics 2014 (PERFIK 2014), 18-19 Nov 2014, Sunway Resort Hotel & Spa, Kuala Lumpur, Malaysia.**

2. Pauline Yew, Lee, S.C., Ng, S.S., Yoon, T.L., Abu Hassan, H., Chen, W.L. (2014) Polarized infrared reststrahlen features of wurtzite InGaN thin film, **28th Regional Conference on Solid State Science & Technology (RCSSST28), 25-27 November 2014, Copthorne Hotel, Cameron Highland, Pahang.**
3. Mohd Amin, N., Fatin Ain, Z.M., Sukma, N.Z., Lee, Z.Y., Fong, C.Y., Ng, S.S. (2014) Growth and characterization of AlN thin film using the spin coating method: Effect of annealing temperature, **28th Regional Conference on Solid State Science & Technology (RCSSST28), 25-27 November 2014, Copthorne Hotel, Cameron Highland, Pahang.**
4. Mohd Amin, N., Ooi, P.K., Ng, S.S. (2014) Deposition of the aluminium nitride on kapton film using sputtering method, **28th Regional Conference on Solid State Science & Technology (RCSSST28), 25-27 November 2014, Copthorne Hotel, Cameron Highland, Pahang.**
5. Lee, Z. Y., Osman, S. A., Ng, S.S. (2014) Radio-frequency Sputtering Growth of Indium Nitride Thin Film on Flexible Substrate, **28th Conference on Solid State Science & Technology (RCSSST28), 25 – 27 November 2014, Copthome Hotel, Cameron Highlands, Pahang, Malaysia.**
6. Mohd Amin, N., Fatin Ain, Z.M., Sukma, N.Z., Lee, Z.Y., Fong, C.Y., Ng, S.S. (2014) A study of AlN thin film on silicon substrate by spin coating method, **1st Meeting of Malaysia Nitrides Research Group (MNRG), 07 April 2014, Auditorium Room, INFORMM, Universiti Sains Malaysia, Penang, Malaysia.**
7. Cheah, S.F., Lee, S.C., Ng, S.S., Yam, F.K., Abu Hassan, H., Hassan, Z. (2013) Attenuated total reflection studies of honeycomb nanoporous GaN thin films, **27th Regional Conference on Solid State Science & Technology (RCSSST27), 20 – 22 December 2013, The Magellan Sutera Resort, Kota Kinabalu, Sabah, Malaysia.**
8. Mohd Amin, N., Lee, Z.Y., Fong, C.Y., Ng, S.S. (2013) Growth and characterization of AlN thin film deposited by spin coating and nitridation techniques, **27th Regional Conference on Solid State Science & Technology (RCSSST27), 20 – 22 December 2013, The Magellan Sutera Resort, Kota Kinabalu, Sabah, Malaysia.**
9. Pauline Yew, Lee, S.C., Ng, S.S., Yoon, T.L., Abu Hassan, H., (2013) Theoretical studies on optical phonon and surface phonon polariton of wurtzite AlInN alloys, **27th Regional Conference on Solid State Science & Technology (RCSSST27), 20 – 22 December 2013, The Magellan Sutera Resort, Kota Kinabalu, Sabah, Malaysia.**

Under Review / Submitted:

1. Pauline Yew, Lee, S.C., Ng, S.S., Yoon, T.L., Abu Hassan, H., W. L. Chen (2015) - Infrared optical responses of wurtzite $In_xGa_{1-x}N$ thin films with porous surface morphology. **Optical Materials**, (Submitted).**[Impact Factor: 2.075]**
2. Pauline Yew, Lee, S.C., Ng, S.S., Yoon, T.L., Abu Hassan, H., Chen, W.L. (2015) Polarized infrared reststrahlen features of wurtzite InGaN thin film, **Advanced Materials Research,** Under Revision. **[Indexed by Scopus, ISI].**
3. Mohd Amin, N., Fatin Ain, Z.M., Sukma, N.Z., Lee, Z.Y., Fong, C.Y., Ng, S.S. (2015) Growth and characterization of AlN thin film using the spin coating method: Effect of annealing temperature, **Advanced Materials Research,** Under Revision. **[Indexed by Scopus, ISI].**
4. Mohd Amin, N., Ooi, P.K., Ng, S.S. (2015) Deposition of the aluminium nitride on kapton film using sputtering method, **Advanced Materials Research,** Under Revision. **[Indexed by Scopus, ISI].**

Human Capital Development:

(1) **1 MSc student - Masters by Research mode:**

(i) Cheah Sook Fong, Morphological and optical properties of porous gallium nitride (GaN) fabricated by photoelectrochemical process. **Main Supervisor. (Graduated 2015)**

(2) **2 Undergraduates (Final Year Project):**

(i) Siti Norshuhadah Ibrahim and Nurul Atikah Mohd. Isa, Fabrication and characterization of porous GaN thin films via UV-Assisted electrochemical etching method. **Main Supervisor. (Completed 2013/2014)**

APPLIED PHYSICS LETTERS 102, 101601 (2013)

Surface phonon polariton characteristic of honeycomb nanoporous GaN thin films

S. F. Cheah,[1,a)] S. C. Lee,[1,2] S. S. Ng,[1] F. K. Yam,[1] H. Abu Hassan,[1] and Z. Hassan[1]
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(Received 1 December 2012; accepted 25 February 2013; published online 11 March 2013)

Nanoporous GaN thin films with honeycomb structure were fabricated via ultra-violet assisted electrochemical etching approach. Under different anodization voltages, two nanoporous samples with different porosity were fabricated. Porosity and surface phonon polariton (SPP) characteristics of the fabricated samples were investigated using polarized infrared attenuated total reflection technique. It was found that the porosity of nanoporous GaN has great influence on its SPP resonant frequency. It can modulate the resonance frequency towards lower value. © *2013 American Institute of Physics*. [http://dx.doi.org/10.1063/1.4794906]

Wide band gap semiconductor gallium nitride (GaN) has attracted extensive attention owing to its numerous potential applications in optoelectronic devices such as light-emitting diodes, laser diodes, sensors, and high-efficiency solar cells, as well as high-speed and high-frequency electronic devices.[1–3] To date, nanoporous GaN has gained substantial interest in the research community. The strong upsurge of interest in nanoporous GaN is mainly attributed to its unique properties such as high surface area per unit volume and high luminescence efficiency. These unique properties are the driving force in developing today's endeavour research technology as they have the intense potential capability in the fabrication of enhanced-performance devices.[4–6]

Most of the techniques used to fabricate the nanoporous GaN are through etching methods. These include the metal-assisted electroless etching,[4,7] photo-electrochemical etching,[8] ultra-violet (UV)-assisted electrochemical etching,[5,6,9] UV-assisted electroless etching,[10,11] and laser-induced etching.[12] In spite of the great number of experimental works on the nanoporous GaN, little is known about its surface phonon polariton (SPP) characteristics.

Polariton, namely hybrid (mixed) mode, is the elementary excitation in dipole active material, where the photon coupled with an elementary particle such as phonon, plasmon, exciton, etc.[13,14] In the case of the infrared (IR) photon couple with an optical photon, the resulting mixed mode is known as phonon polariton. SPP phenomenon arises when the IR photon with transverse magnetic (TM) mode couple to the surface phonon localized near the surface of a polar crystal. The SPP mode travels along a direction perpendicular to the surface normal and its amplitude attenuates exponentially from surface to bulk.[14,15] Knowledge on the SPP properties is crucial because understanding the behaviour of the coupling effect between the photon and surface phonon, is the basis for the development of several modern devices[16,17] such as resonant-based sensor and thermo-photovoltaic system.

In this Letter, the SPP characteristics of two homogeneous honeycomb nanoporous GaN thin films with different porosity were reported. The nanoporous structures were fabricated using UV-assisted electrochemical etching method under different anodization voltages. Nondestructive polarized IR attenuated total reflection (ATR) technique was used to access the thin film thickness, the depth of porous layer, and the porosity as well as the SPP characteristics of the nanoporous GaN samples. Through this study, a clearer picture of the effects of the nanoporous structure and the porosity on the SPP mode is obtained.

The samples used in this study were homogeneous honeycomb nanoporous GaN thin films on sapphire substrates. These samples were fabricated from the commercial silicon (Si) doped GaN thin films on sapphire substrates. The as-grown GaN thin films have a wurtzite structure with c-plane orientation. Its thickness was about 5 μm, which includes two homogeneous layers of GaN, i.e., Si doped GaN as top layer and undoped GaN as sublayer. The carrier concentration of the Si doped layer was approximately (1–4) × 10^{18} cm^{-3}. The nanoporous GaN thin films were obtained using UV-assisted electrochemical etching technique. The electrolyte was potassium hydroxide (KOH) solution and the etching period was one hour. To obtain the porous samples with different porosity, we intentionally set the etching processes under different anodization voltages (i.e., 10 V and 20 V). For clarity, we denote the porous samples by samples A and B, respectively.

Field-emission scanning electron microscope (FESEM, Model FEI Nova NanoSEM 450) was employed to study the surface morphology and layer characteristics of the porous samples. Room temperature polarized IR ATR measurements were carried out using a Fourier transform IR spectrometer (Spectrum GX FTIR, Perkin Elmer) with the aid of an optional diamond ATR accessory (GladiATR, PIKE Technologies). The diamond ATR crystal has a refractive index of 2.4 and an internal incident angle of 45°.[18] To excite the SPP resonance of the studied structures, the ATR measurements are conducted in Otto configuration[19] under p-polarized (TM) mode using a thallium iodide bromide IR polarizer. The ATR spectra were recorded in the frequency

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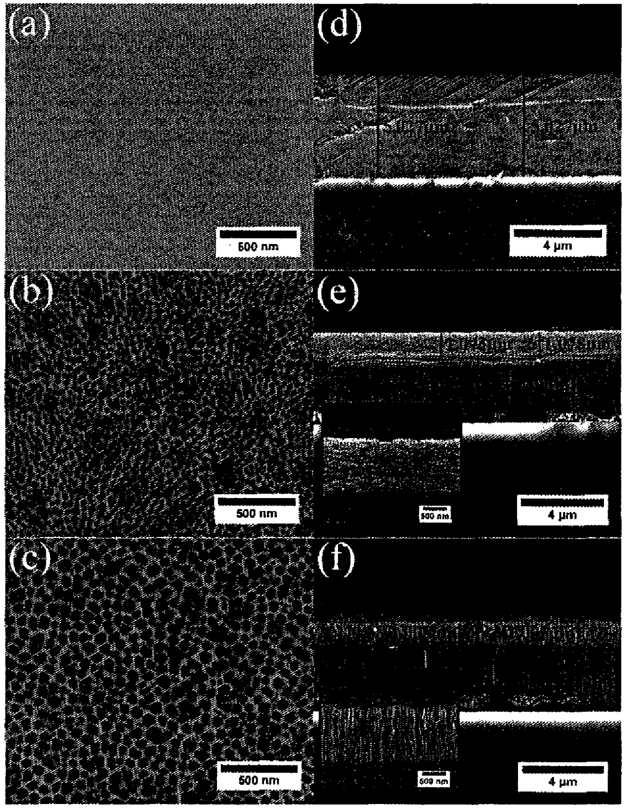

FIG. 1. FESEM top view (left hand side) and cross-sectional (right hand side) images of as-grown GaN ((a), (d)) and nanoporous GaN etched under voltage supply of 10 V ((b), (e)), and 20 V ((c), (f)). The inset figures illustrate the cross-sectional images of porous layer of nanoporous GaN.

range of 400–4000 cm^{-1} with spectral resolution of 4 cm^{-1} using 128 scans.

Figure 1 shows the top view FESEM images of the as-grown and nanoporous GaN thin films on sapphire substrates. Prior to the etching process (Fig. 1(a)), the GaN thin film exhibits a flat and smooth surface morphology (as-grown sample). Upon the etching process (Figs. 1(b) and 1(c)), the GaN thin films exhibit a homogeneous nanoporous structure with hexagonal arrangement (samples A and B). Comparison between samples A and B shows that the pores diameter strongly depends on the anodizing potential used in the electrochemical etching process. The average pore area of each nanoporous GaN thin films has been identified using the standard image processing technique. For similar measuring areas size, sample A exhibits tiny hexagonal pores (approximately 1032 nm^2) whereas sample B exhibits larger hexagonal pores (approximately 2253 nm^2). Besides, it is shown that the pore density of sample A (approximately 4.29 × 10^{-4} nm^{-2}) is greater than sample B (approximately 2.17 × 10^{-4} nm^{-2}), where the pore density is defined as the number of pores per unit surface area. The results indicate that higher anodizing potential in the electrochemical etching will lead to wider pore area and smaller pore density of surface structure (will be explained later).

The cross-sectional FESEM images of the as-grown and nanoporous GaN thin films on sapphire substrates are shown in Figs. 1(e) to 1(f). Prior to the etching process (Fig. 1(e)), the thickness of the as-grown GaN thin film is about 5 μm. Due to the homogeneous characteristics of the two layers, the Si-doped and undoped GaN sublayers cannot be distinguished from the FESEM image. Consequently, the individual thicknesses of the two layers are inaccessible from FESEM image. Nevertheless, by obtaining the best fit of experimental and theoretical ATR spectra (see Fig. 2), the thicknesses of the two layers can be determined, i.e., about 1.9 μm for the Si-doped GaN layer and 3.2 μm for the undoped GaN layer. Upon the etching process (Figs. 1(f) and 1(g)), the thickness of the GaN thin films are reduced from 5 μm to 4.334 μm and

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Luminescence evolution of porous GaN thin films prepared via UV-assisted electrochemical etching

S.F. Cheah [a,*], S.C. Lee [a,b], S.S. Ng [a], F.K. Yam [a], H. Abu Hassan [a], Z. Hassan [a]

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ABSTRACT

Porous gallium nitride (GaN) thin films with different surface morphologies and free carriers properties were fabricated from Si-doped GaN thin films using ultra-violet assisted electrochemical etching approach under various etching voltages. Fluctuation of luminescence signals was observed in the photoluminescence spectra of porous GaN thin films. Taking advantage of the spectral sensitivity of infrared attenuated total reflection spectroscopy on semiconductor materials, roles of free carriers and porous structure in controlling luminescence properties of GaN were investigated thoroughly. The results revealed that enhancement in luminescence signal is not always attained upon porosification. Although porosification is correlated to the luminescence enhancement, however, free carrier is the primary factor to enhance luminescence intensity. Due to unavoidable significant reduction of free carriers from Si-doped GaN in the porosification process, control of etching depth (i.e., thickness of porous layer formed from the Si-doped layer) is critical in fabricating porous GaN thin film with enhanced luminescence response.

1. Introduction

Fabrication of porous gallium nitride (GaN) thin film has triggered massive interest in the field of semiconductor. Compared to raw GaN with flat surface, GaN with porous surface exhibits larger surface area which peculiarly enables more optical activities on the GaN surface, leading to the enhancement of luminescence efficiency. The capability of porous GaN in modulating optical responses improves the adaptability of GaN in various device applications [1,2].

Etching is a promising technique to fabricate porous materials. Numerous works have been devoted to the development of wet etching techniques in producing porous GaN [3–7]. Photoelectrochemical wet etching has been frequently employed to fabricate porous GaN due to its simple setup and low-cost advantages [8]. A clear understanding of luminescence properties is important to optimize device performance of GaN-based optical device. Despite tremendous investigations on the porous GaN fabrication, profound study of luminescence properties of porous GaN is scant.

Porosification is a common approach to enhance luminescence of semiconductor. Enhancement of luminescence emission of low doped n-type (or undoped) GaN can be easily achieved after porosification. Most studies are fallen in this group [9–11]. However, when Si-doped n-type GaN is adopted as raw wafer, the luminescence emission is not always attained upon porosification. Quenching of luminescence has been found after porosification [12,13]. There is also one report on the enhancement of luminescence after porosification [6]. Consequently, factors that contribute to the luminescence response of porous GaN are ambiguous.

Photoluminescence (PL) spectroscopy is a versatile and non-destructive tool to characterize the luminescence properties of semiconductor materials [14]. Useful material information can be extracted through analyzing the feature of the emission spectrum. For instances, the position of emission spectrum can be used to determine the band gap energy of semiconductor; the indication of thin film quality through the linewidth of emission spectrum. PL spectroscopy is also a sensitive probe for impurities [15–17]. In this work, PL spectroscopy was applied to investigate porous GaN thin films with different surface morphologies and free carriers properties. Attention is paid to the clarification of the roles of the porous structure and the free carriers in controlling the luminescence emission of porous GaN.

2. Experimental details

Porous GaN thin films with different surface morphologies and free carriers properties were fabricated from Si-doped GaN thin films using ultra-violet (UV)-assisted electrochemical etching approach under various etching voltages. To comprehensively understand the

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effects of Si-dopants on the luminescence properties of porous GaN, two GaN wafers with different free carriers properties were chosen as raw materials to produce porous GaN thin films, namely, unintentionally doped n-type GaN (labelled as u-GaN) and n-type Si-doped GaN (labelled as n-GaN) thin films on sapphire substrates. The free carrier concentrations of the u-GaN and n-GaN thin films were about $\sim 10^{17}$ and $\sim 10^{18}$ cm^{-3}, respectively. The thicknesses of the u-GaN and n-GaN thin films were about 5.4 and 5.1 μm, respectively.

An electrochemical etching process of GaN strongly depends on the electrical conductivity of the raw wafer. Choosing appropriate electrolyte is important to effectively etch the GaN samples. Two types of electrolytes were used for porosification, i.e., aqueous potassium hydroxide (KOH) and sulfuric acid (H_2SO_4). To gently control the etching process of n-GaN, KOH is chosen as the etchant for n-GaN because KOH has a low etching strength. Because of low conductivity of u-GaN, KOH is difficult to initiate the porosification process of u-GaN. Therefore, H_2SO_4, which is known as a promising etchant, is chosen as the electrolyte to etch u-GaN sample. For clarity, the porous GaN samples fabricated from u-GaN and n-GaN thin films are labelled with initial codes U and S, respectively. The UV-assisted electrochemical etching was conducted in a two-electrode cell at room temperature under various etching voltages with the illumination of 150 W. Table 1 tabulates the porous GaN thin films conducted under various applied voltages.

A field-emission scanning electron microscope (FESEM, Model FEI Nova NanoSEM 450) was employed to study the surface morphology and layer characteristics of the porous GaN. To investigate the luminescence characteristics of porous GaN, room temperature PL measurements were performed using a Horiba Jobin Yvon HR800UV system. The PL spectra were recorded using an integrated confocal micro PL setup with the 325 nm line excitation of the helium-cadmium laser. To investigate the role of free carriers in controlling the luminescence emission of porous GaN, room temperature p-polarized infrared (IR) attenuated total reflection (ATR) measurements were carried out using a Fourier transform IR spectrometer (Spectrum GX FTIR, Perkin Elmer) with the aid of an optional diamond ATR accessory (GladiATR, PIKE Technologies) and a thallium iodide bromide IR polarizer. Taking advantage of the spectral sensitivity of IR attenuated total reflection (ATR) spectroscopy on semiconductor materials [18–20], the free carriers properties of the samples were determined.

3. Results and discussion

3.1. Determination of the carrier concentration in raw GaN thin films

Fig. 1 shows the p-polarized ATR spectra of raw GaN thin films with different carrier concentrations. Attention is paid to the most pronounced dip (labelled as ∗), which is corresponding to the surface phonon polariton (SPhP) mode of GaN [21,22]. As seen in Fig. 1, the SPhP modes of u-GaN thin films (about 700 cm^{-1}) have smaller resonant frequencies and the SPhP dips are sharper than n-GaN thin films (760 cm^{-1}). To compare the broadening features of the SPhP dips, full width at half-maximum (FWHM) of the SPhP dips are labelled in Fig. 1.

Table 1
The electrochemical etching processes were conducted under various applied voltages.

Raw materials	Samples code	Applied voltage (V)	Electrolyte solution
Unintentionally doped (u-) GaN	U1	10	H_2SO_4
	U2	20	
	U3	30	
Si-doped (n-) GaN	S1	1	KOH
	S2	2	
	S3	4	
	S4	7	
	S5	10	
	S6	20	

Dielectric function components are the main parameters related to the SPhP modes. The samples used in this work have multilayer structure. Provided that the dielectric tensor components and the thickness of each layer are known, the ATR spectrum can be simulated using the standard multilayer optics technique [23]. Prior to porosification, the dielectric tensor components of GaN along x(y) and z-axes, namely, $\varepsilon_{xx}(\nu)$,$\varepsilon_{yy}(\nu)$, and $\varepsilon_{zz}(\nu)$, are given by [17]:

$$\varepsilon_{\perp(\parallel)}(\nu) = \varepsilon_{\infty,\perp(\parallel)}\left(\frac{\nu^2_{LO,\perp(\parallel)} - \nu^2 - i\nu\gamma_{LO,\perp(\parallel)}}{\nu^2_{TO,\perp(\parallel)} - \nu^2 - i\nu\gamma_{TO,\perp(\parallel)}} - \frac{\nu^2_{p,\perp(\parallel)}}{\nu^2 + i\nu\gamma_{p,\perp(\parallel)}}\right). \quad (1)$$

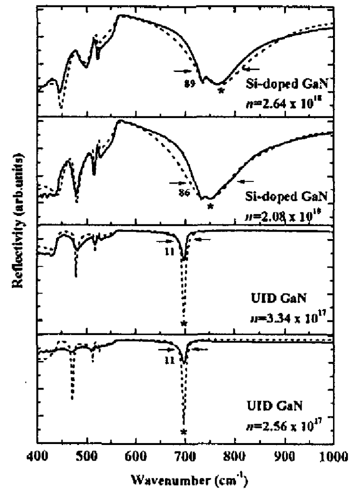

Fig. 1. Room temperature p-polarized ATR spectra of raw GaN samples with different carrier concentrations. The dotted and solid lines indicate the theoretical and experimental ATR spectra, respectively. The symbol ∗ represents the SPP resonance.

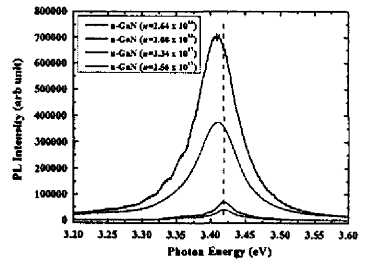

Fig. 2. Room temperature PL spectra of raw GaN samples with different carrier concentrations.

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Effects of Nitridation Temperature on Characteristics of Gallium Nitride Thin Films Prepared Via Two-Step Method

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Abstract In this research, the growth of GaN thin films on *c*-plane sapphire (0001) substrates via two-step method without the assist of buffer layer and catalysts was demonstrated. First, gallium oxide (Ga_2O_3) thin films were deposited on sapphire substrates by radio frequency magnetron sputtering method. The deposited Ga_2O_3 thin films were then nitridated at various temperatures. In this research, attention is focused on the influence of nitridation temperatures on the structural and optical properties of the synthesized GaN thin films. It is revealed that 950 °C is the optimal nitridation temperature for synthesizing hexagonal wurtzite GaN thin film with preferential (0002) growth direction.

KEY WORDS: Sputtering; Nitridation; Gallium oxide; Gallium nitride

1 Introduction

Since the early 1990s, much effort has been made to prepare a wide band gap gallium nitride (GaN) semiconductor [1]. This is owing to its outstanding fundamental physical and chemical properties, such as direct and wide band gaps of 3.39 eV at room temperature, high breakdown field voltage [2] and high thermal, mechanical and chemical stabilities. These unique properties make GaN a promising material in numerous optoelectronic and electronic applications such as light-emitting diodes, laser diodes, sensors and high-efficiency solar cells, as well as high-speed and high-frequency electronic devices.

Several research groups have recently succeeded in synthesizing GaN thin films on silicon substrates via various methods such as molecular beam epitaxy (MBE), radio frequency (RF) magnetron sputtering and metalorganic chemical vapor deposition (MOCVD). However, most of the methods used have complicated setups and costly productions. RF magnetron sputtering method is a rather simple and easy method among all of the methods mentioned above, though it is one of the most popular methods for early investigations of GaN thin films [3]. Furthermore, this method is also highly useful in semiconductor technology industry [4]. Until now, only a few reports have appeared on sputtered GaN, including the work of Xie et al. [5], who have shown that nanocrystalline GaN thin films have been prepared using DC magnetron sputtering of Ga target and annealed in nitrogen ambient. Besides, GaN target have been used by Xiao et al. [6] for the growth of polycrystalline GaN thin films on Si (111) substrates. The direct growth of GaN using the GaN target has rarely been used by researchers because of its very high cost compared with a gallium oxide (Ga_2O_3) target. For the above-mentioned reasons, there is a need to search for an alternative target material to be used for the sputtering of GaN thin films. Our motivation is to use the cheap Ga_2O_3 target to overcome the problem.

In this paper, we will report the deposition of GaN thin films on *c*-plane Al_2O_3 (0001) substrates via two-step method, in which the Ga_2O_3 thin films will be first deposited on *c*-plane Al_2O_3 (0001) by RF magnetron sputtering method, then the deposited Ga_2O_3 thin films will be transformed into GaN through nitridation process. No additional metal catalyst and buffer layer will be used throughout the processes. In this work, attention will be focused on the influences of the nitridation temperatures to the structural and optical properties of the deposited GaN thin films. Various characterization techniques will be employed including X-ray diffraction (XRD), scanning probe microscope (SPM), field emission scanning electron microscopy (FESEM) and Raman spectroscopy.

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2 Experimental

2.1 Preparation of Gallium Oxide Thin Films

The 1 cm × 1 cm *c*-plane Al_2O_3 (0001) substrates were sonically cleaned using acetone and deionized water for 10 min each before the deposition of the Ga_2O_3 thin films. The Ga_2O_3 films were deposited on the *c*-plane Al_2O_3 (0001) substrates using a conventional RF magnetron sputtering technology system. High-purity Ga_2O_3 target and argon gas with purity of 99.99 and 99.999%, respectively, were used. The target-to-substrate distance is around 10 cm. The thin films were grown at RF power of 150 W, and gas pressure was kept constant at 2.2×10^{-2} Pa for 2 h. The thermal annealing process was carried out after the RF sputtering process. The thin films were annealed in a horizontal tube furnace at a temperature of 950 °C for 2 h in N_2 ambient.

2.2 Formation of Gallium Nitride Thin Films

The coated Ga_2O_3 thin films were nitridated in two-zone conventional tube furnaces. The first zone of the tube furnace was ramped up and fixed from room temperature to 1,000 °C. The second zone of the tube furnace, on the other hand, was heated up to the required temperature that ranged from 850 to 1,050 °C. When the furnaces were heated up to the designed temperature, the quartz boat that was filled with the coated Ga_2O_3 thin films was placed at the center of the second zone of tube furnace. The coated Ga_2O_3 thin films were then nitridated under a constant flow of highly pure ammonia (NH_3) gas with a flow rate of 300 mL/min for 1 h at the temperature of 850, 950 and 1,050 °C, respectively. Ammonia reacted with Ga_2O_3 thin films at a high temperature. The reaction could be described by:

$$Ga_2O_3 + 2NH_3 \rightarrow 2GaN + 3H_2O. \quad (1)$$

After nitridation process, NH_3 was switched off and nitrogen (N_2) gas was flowed in order to flush out the excess NH_3 inside the tube furnaces. Finally, the thin films were taken out for characterization.

2.3 Characterization of Thin Films

A variety of methods was applied to characterize the structural and optical properties of the thin films. High-resolution XRD (PANalytical X'Pert Pro MRD) system with a Cu$K_{\alpha 1}$ radiation source ($\lambda = 0.15406$ nm) was used to identify the crystalline structures and properties of the deposited thin films. All the XRD measurements were taken under 2θ–ω scan mode. A scanning probe microscope (SPM-9600, Shimadzu) was used to investigate the surface morphologies and the surface roughness of the deposited thin films. A field emission scanning electron microscope (FESEM, NOVA NANOSEM 450) was used to examine the morphology and microstructures of the as-synthesized thin films. The optical quality of GaN thin films was studied using Raman spectroscopy (Horiba Jobin-Yvon HR800UV). An argon ion laser (514.5 nm) with 20 mW was used as an excitation source for Raman measurements. The thickness of the GaN thin films nitridated at 850, 950 and 1,050 °C was measured using the Filmetrics model F 20, which was 0.49, 0.48 and 0.37 μm, respectively.

3 Results and Discussion

3.1 Analysis of Structural Properties

3.1.1 XRD Study

Figure 1 shows the XRD patterns of GaN thin films nitridated after flowing NH_3 for 1 h at temperatures ranging from 850 to 1,050 °C. As observed in Fig. 1, the diffraction peaks correspond to the wurtzite GaN (JCPDS File No. 05-0792) and the Ga_2O_3 (JCPDS Card No. 41-1103). The GaN thin film nitridated at temperature 850 °C resulted in a broad preference plane GaN (0002) peak and exhibits a Ga_2O_3 peak at around $2\theta = 41.59°$ in the XRD spectrum. The presence of the Ga_2O_3 peak was due to the fact that Ga_2O_3 does not have enough energy to fully convert into GaN during the nitridation process at 850 °C [7]. Ga_2O_3 has been partially converted into GaN at this nitridation temperature. As the nitridation temperature increases to 950 °C, three dominant diffraction peaks can be observed at $2\theta = 32.44°$, $2\theta = 34.61°$ and $2\theta = 36.83°$, which are the characteristics of the GaN $(10\bar{1}0)$, GaN (0002) and GaN $(10\bar{1}1)$ peaks, respectively. All the diffraction peaks were ascribed to the formation of wurtzite structure GaN. No Ga_2O_3 peak was detected in the XRD spectrum. The reason lies in that the grains in the film obtained enough

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An investigation of sol–gel spin coating growth of wurtzite GaN thin film on 6H–SiC substrate

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ABSTRACT

In this study, wurtzite gallium nitride (GaN) thin film was directly grown on hexagonal silicon carbide (6H–SiC) substrate without buffer layer using sol–gel spin coating method followed by annealing and nitridation process. The entire growth process was investigated in-depth. The results revealed that the conversion of GaN thin film proceeds through an intermediate of amorphous gallium(I) sub-oxide (Ga_2O). In this case, the amorphous Ga_2O was converted into GaN thin film after being nitridated at 950 °C under ammonia ambient. The intermediate of amorphous Ga_2O can only be identified through infrared reflectance measurements.

1. Introduction

Wide direct bandgap gallium nitride (GaN) semiconductors with a wide direct band gap of 3.4 eV at room temperature has received considerable attention as an ideal material for various optoelectronic device applications. These applications include ultraviolet and blue emitters, spintronics, high temperature, high power, and radiation-resistant electronic devices [1,2].

Metal organic chemical vapor deposition, molecular beam epitaxy, metal–organic vapor phase epitaxy, and hydride vapor phase epitaxy methods are the preferred manufacturing technology for growing epitaxial GaN thin films. However, these methods involve complicated setup procedures that demand high production cost. Therefore, simple and cost effective techniques such as sol–gel spin coating for growing GaN thin films are highly recommended [3,4]. However, studies that investigated sol–gel spin coating are limited and many growth mechanisms remain unknown. A systematic investigation of sol–gel spin coating for the growth of GaN thin films was conducted to provide experimental information about this approach. The details provided regarding each step of the growth process may guide researchers regarding the growth of GaN thin films through sol–gel spin coating method. Jung et al. and Othonos et al. studied the conversion of gallium oxide (Ga_2O_3) to GaN, but they used different growth process and substrates [5–7]. Different changes, substitutions, machines, compositions of matter, methods, and steps can produce different outcomes because different growth process produce different results. Thus, studying the sol–gel spin coating growth process is very important to researchers in this field.

In this study, wurtzite GaN thin film was grown directly on a bare 6H–SiC substrate via sol–gel spin coating method followed by annealing and nitridation. Some space were devoted to the systematic investigation of the entire GaN thin film growth process, starting from sol–gel spin coating until the nitridation process, which include some chemical reaction processes. A 6H–SiC substrate is used in this study because the low lattice constant mismatch between GaN and 6H–SiC is approximately 3.4%. The lattice mismatch is much smaller compared with other substrates such as sapphire (approximately 16%) [8] and silicon (approximately 17%) [9]. Hence, the GaN films have lower screw and edge dislocation density [8]. Thus, buffer layer was no longer necessary to relax the strain and reduce the defects for the growth of GaN films.

2. Experimental details

Gallium nitrate(III) hydrate ($Ga(NO_3)_3 \cdot xH_2O$) powder, ethanol (99.7% purity), distilled water, and diethanolamine (DEA) were used as the starting material, solvent, and surfactant, respectively. To prepare the precursor, $Ga(NO_3)_3 \cdot xH_2O$ powder was dissolved in distilled water and ethanol with a purity of 99.7%. DEA was then

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added slowly. The resulting precursor was stirred to yield a homogenous and transparent solution. Prior to the growth of GaN thin film, a bare 6H–SiC substrate (resulted sample denoted as S1) was cleaned ultrasonically in acetone and deionized water for 5 min each. Spin coating was accomplished by dropping the prepared precursor onto bare 6H–SiC substrate and spun in an ambient condition for 30 s at 3000 rpm. The spin coating process was accomplished repeatedly to obtain film of varying thickness. The thin film was then annealed in a tube furnace at 950 °C for 2 h with a flow of nitrogen (N_2) gas (resulted sample devoted as S2). Finally, the coated thin film was nitridated under NH_3 gas ambient with flow rate of 300 sccm at 950 °C for 75 min (resulted sample devoted as S3). After cooling, the tube was flushed with nitrogen gas and the sample was removed for subsequent analysis.

The crystalline structure of the deposited thin films was examined through X-ray diffraction (XRD) phase analysis using a PANalytical X'Pert system with CuKα (λ = 1.5418 Å) X-ray source. The surface morphologies of the as-synthesized thin films were examined by field-emission scanning electron microscopy (FESEM, FEI Nova NanoSEM 450 system). Energy-dispersive X-ray (EDX) attached to FESEM was used to estimate the element compositions in the films. The lattice vibrational properties of the deposited thin films were investigated using Fourier transform infrared (FT-IR) spectrometer (Spectrum GX FT-IR, Perkin-Elmer).

3. Results and discussions

Fig. 1 shows the XRD spectra of samples (a) S1, (b) S2, and (c) S3 measured under the absolute scan of 2theta-omega (2θ–ω) scan mode in the range of 20° to 80°. For sample S1, the two sharp peaks that originated from the first and second order of 6H–SiC substrate can be clearly observed at 35.5° and 75.2°, respectively (Fig. 1(a)). When the film was annealed in the furnace at 950 °C under N_2 ambient (sample S2), no peak was observed in the XRD spectrum, except at the peak from the 6H–SiC substrate (Fig. 1(b)). Thus, the deposited film is in an amorphous phase. When the film is nitridated under NH_3 ambient (sample S3), four dominant diffraction peaks can be observed at 32.54°, 34.57°, 36.90°, and 73.03° (Fig. 1(c)). These diffraction peaks exhibit the characteristics of wurtzite GaN(1 0 0), GaN(0 0 2), GaN(1 0 1), and GaN(0 0 4) peaks (JCPDS file no. 05-0792), respectively. The intense and sharp diffraction peak at 34.57° indicates that the GaN crystals preferred to orient along the *c*-axis, and the product grew in the (0 0 2) direction. This result may be attributed to the hexagonal 6H–SiC substrate, which has the same crystal structure with the wurtzite GaN. The lattice mismatch is small in their basal plane.

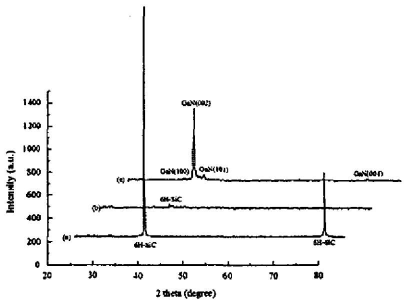

Fig. 1. XRD patterns of samples: (a) S1, (b) S2, and (c) S3 measured under the 2θ–ω scan mode.

The growth of GaN thin films through sol–gel spin coating is relatively scarce. Thus, very little is known about the growth mechanism. Several chemical reactions are involved in this approach. The chemical reaction process in the annealing stage could be expressed in the following equation:

$$4Ga(NO_3)_3(s) \rightarrow 2Ga_2O(s) + 12NO_2(g) + 5O_2(g) \quad (1)$$

Amorphous Ga_2O is formed during this stage, as shown in Fig. 1(b). The presence of this material cannot be detected through XRD measurement. However, amorphous Ga_2O exhibits two prominent IR peaks. The presence of these two prominent IR peaks is an important indicator that GaN has successfully reached the nitridation stage.

For the nitridation process, the NH_3 was decomposed stepwise into various species (NH_2, NH and N) at 1000 °C [10]. The species reacted with Ga_2O to form GaN thin film. Thus, the chemical reaction process in the nitridation stage could be expressed as

$$Ga_2O(s) + 2NH_3(g) \rightarrow 2GaN(s) + H_2O(g) + 4H_2(g) \quad (2)$$

To the best of our knowledge, the mechanism was possibly operating when Ga_2O_3 was transformed into GaN in NH_3 ambient. However, different cases may transform volatile Ga_2O into GaN. Wagner et al. and Kisailus et al. reported that Ga_2O was further reacted with NH_3 or amine species to form GaN [11,12].

Fig. 2 shows the top view FESEM images of samples (a) S1, (b) S2, and (c) S3 captured at higher magnification (×100 K). Interestingly, the surface morphology of all the samples differ significantly. The FESEM images for S1 and S2 exhibit a relatively smooth surface. However, very fine grains can be observed in the FESEM image of S2. The FESEM image for S3 clearly demonstrated hexagonal-shaped morphology; these hexagons were most likely composed of high crystallinity GaN(0 0 2) crystal planes [13]. The FESEM results of S2 and S3 were consistent with the XRD results (see Fig. 1), which means that no XRD diffraction peak originated

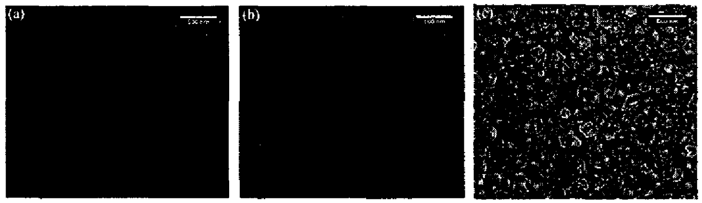

Fig. 2. Top view FESEM images of samples: (a) S1, (b) S2, and (c) S3 captured at higher-magnification (×100 K).

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THEORETICAL STUDIES ON OPTICAL PHONON AND SURFACE PHONON POLARITON OF WURTZITE AlInN ALLOYS

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Keywords: Wurtzite AlInN; MREI model; Phonon; Surface phonon polariton

Abstract

The lattice vibrational properties of wurtzite ternary mixed crystal aluminium indium nitride ($Al_xIn_{1-x}N$) are investigated thoroughly using modified random element iso-displacement (MREI) model and Born-Huang procedure. MREI model, which considers the nearest neighbour interactions, is used to predict the composition dependence of longitudinal and transverse optical phonon frequencies. For $Al_xIn_{1-x}N$ alloy, oscillator strength of its weak mode is sufficiently significant for composition range of $0 \le x \le 0.4$. As a result, $Al_xIn_{1-x}N$ alloy is deduced to exhibit mixed-mode behaviour. Finally, the calculated dielectric functions for the entire composition range ($0 \le x \le 1$) are used to simulate the surface phonon polariton characteristics of the $Al_xIn_{1-x}N$ alloy.

Introduction

Wurtzite ternary mixed crystal aluminium indium nitride ($Al_xIn_{1-x}N$) has received considerable attention from semiconductor research community in recent decades. Due to the tuneable energy band gap of $Al_xIn_{1-x}N$ from near-infrared (IR) to ultraviolet (UV) region [1], $Al_xIn_{1-x}N$ becomes a promising candidate in realizing various electronic and optoelectronic devices such as light-emitting diode and laser diode [2].

In the long wavelength limit, the IR optical response of a material is described by the optical phonon modes, namely, transverse optical (TO) and longitudinal optical (LO) phonon modes. The ternary mixed crystal $AB_{1-x}C_x$ possesses two sets of TO and LO phonon modes, namely TO1-LO1 pair and TO2-LO2 pair, which may exhibit either one-mode, two-mode or mixed-mode behaviour. The classification of the mode behaviours depends on oscillator strength of each TO-LO pair. In one-mode behaviour system, one of the TO-LO pairs has relative low oscillator strength over the entire composition range. If both oscillator strengths of the two TO-LO pairs are significant for the whole range of composition x, it belongs to two-mode behaviour system. The mixed-mode system exhibits one-mode behaviour over certain composition range whereas two-mode for the remaining composition range.

Surface phonon polariton (SPP) is the elementary excitation resulting from the coupling between IR photon (with transverse magnetic mode) with optical phonon near the surface of a polar crystal [3]. A deep understanding of the SPP can be utilized in designing photonic devices [4]. Until now, very few experimental [5-8] and theoretical [9] investigations have been devoted to the optical phonon properties of wurtzite $Al_xIn_{1-x}N$. In particular, no experiment has been conducted to investigate the SPP of wurtzite $Al_xIn_{1-x}N$.

Optical phonon modes are the prerequisite parameters to calculate the dielectric function of a material while the dielectric function is a fundamental parameter to predict the SPP mode. The SPP characteristics of wurtzite $Al_xIn_{1-x}N$ have been theoretically studied using a linear interpolation of dielectric function [10]. This may not describe the system correctly because the dielectric function changes in a non-linear manner in general. To obtain the dielectric function more accurately, a physics model, namely, modified random element iso-displacement (MREI) model can be adopted. MREI model has been shown as a successful model to predict the optical phonon and dielectric

properties of various ternary mixed crystals [11, 12]. Note that the SPP characteristics of several ternary mixed crystals have also been investigated using MREI approach [13]. However, previous works focused only on cubic ternary crystals.

In this paper, optical phonon modes of wurtzite $Al_xIn_{1-x}N$ are calculated based on MREI model and Born-Huang procedure. Subsequently, a theoretical study on the SPP characteristics of wurtzite $Al_xIn_{1-x}N$ alloys is presented. The SPP dispersion curves are simulated for various composition i.e., x = 0, 0.2, 0.7 and 1 by an anisotropic model.

Theory

The first assumption in MREI model is iso-displacement, which suggests that the anions and cations of similar species vibrate with the same amplitude and phase. Randomness is the second assumption that infers the force which each ion experiences is provided by a statistical average of the interaction with its neighbour [14]. The use of local field on complete determination of phonon mode by macroscopic parameters of the pure end members was emphasized by Genzel et al. [11].

Consider the splitting of transverse mode into A_1 and E_1 modes in wurtzite structure, the local electric field $\boldsymbol{E}_{loc}$ is given by,

$$\mathbf{E}_{loc} = \mathbf{E} + \left(\frac{4\pi}{3} + C_i\right)\mathbf{P}, \quad (1)$$

where C_i is a constant and subscript 1 or 2 represents the value for parallel (A_1) and perpendicular (E_1) to optical axis, c_{axis} respectively. For an ideal wurtzite structure, $C_1 = 0.2$ and $C_2 = -0.1$ [15]. By using eq. (1) in Genzel approach [11], the optical phonon modes of wurtzite $Al_xIn_{1-x}N$ as a function of x can be calculated. The required parameters in the calculation are taken from Refs. [16-19].

Consider the optical axis c_{axis} is parallel to the surface normal ($c_{axis} \parallel z$) and perpendicular to the direction of propagation ($c_{axis} \perp x$), the dielectric function of a wurtzite ternary nitride mixed crystal can be written as [20]:

$$\varepsilon_{\parallel(\perp)}(\omega) = \varepsilon_\infty \prod_j^2 \left(\frac{\omega_{LOj}^2 - \omega^2 - i\omega\gamma_{LOj}}{\omega_{TOj}^2 - \omega^2 - i\omega\gamma_{TOj}} \right)_{\parallel(\perp)}, \quad (2)$$

where ω, ε_∞, ω_{TO}, ω_{LO} are the angular frequency, high frequency dielectric constant, TO and LO phonon modes, respectively. The subscript j represents the specific number of oscillator. By inserting the optical phonon modes deduced from MREI model into Eq. (2), the dielectric function of the studied crystal can be obtained.

Once the dielectric function is known, the dispersion properties of the SPP can be deduced from the surface polariton (SP) dispersion relation. Taking the anisotropy of the material into account, the SP dispersion relation of a two layer system can be expressed as [21]:

$$k_x(\omega) = \frac{\omega}{c}\sqrt{\frac{\varepsilon_{l\parallel}(\varepsilon_{l+1,\perp}\varepsilon_{l+1,\parallel} - \varepsilon_{l,\perp}\varepsilon_{l+1,\parallel})}{\varepsilon_{l+1,\perp}\varepsilon_{l+1,\parallel} - \varepsilon_{l,\perp}\varepsilon_{l\parallel}}}. \quad (3)$$

The subscript l refers to the specific layer in the system, $l = 1$ for the vacuum, $l = 2$ for the semi-infinite wurtzite $Al_xIn_{1-x}N$ crystal. k_x is the wavevector of the SP along x direction and c is the velocity of light in vacuum, i.e., 3×10^8 ms^{-1}. The dielectric function of vacuum is considered as isotropic and is given by $\varepsilon_\parallel = \varepsilon_\perp = 1$. To ensure the calculated SPP has physical meaning, Eq. (3) should satisfy the localization condition of surface modes. The localization of the SPP mode can be

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GROWTH AND CHARACTERIZATION OF AlN THIN FILM DEPOSITED BY SOL-GEL SPIN COATING TECHNIQUES

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Keywords: AlN, Silicon, Spin coating, Thin Film.

Abstract. This study signifies the growth and characterization of aluminium nitride (AlN) thin film deposited on the atmospheric plasma treated n-type silicon [n-Si (100)]. Basically, the low cost spin coating technique which emphasized the production of a thin and uniform film on a flat substrate through a dilute solution is adopted. For the precursor preparation, the main ingredient of aluminium nitrate hydrate is dissolved with an organic solvent. The nitridation process is carried out on the deposited coating at 1100 °C for 1 hour. The surface morphology and structural properties of the thin film were investigated by field-emission scanning electron microscope, atomic force microscopy energy, dispersive X-ray spectroscopy and X-ray diffraction; while the optical properties of the deposited thin film was determined by using Fourier transform infrared spectrometer. All the results revealed that AlN thin film was successfully deposited on n-Si (100) substrate.

Introduction

Aluminium nitride (AlN) is an III-V family compound with a hexagonal close-packed wurtzite structure [1]. The semiconductor AlN has potential for applications in high-temperature/high-power electronic devices [2], surface acoustic wave devices, actuator, transparent hard coatings and AlN composites for light-emitting devices [3]. AlN is also a potential candidate for use in the fabrication of blue-violet light emitting diodes, short wavelength lasers, and ultraviolet light detectors [4]. Furthermore, AlN also has been used as buffer layer for the growth of gallium nitride [5]. AlN has attracted much attention because of its wide direct-band gap of 6.2 eV, high thermal conductivity (320 W/m·K), high electric resistivity ($10^{14}\Omega$) [6], good insulator ($>10^{11}\Omega$), large hardness [7], high chemical and thermal stabilities, high breakdown dielectric strength and high surface acoustic wave velocity [8].

A variety of deposition methods have been reported for the growth of AlN thin film such as metal–organic chemical vapor deposition [9], radio-frequency sputtering [10], pulsed laser deposition [11] and molecular beam epitaxy [12]. The preparation of the AlN thin film by using the methods mentioned above is high in cost and involved in complicated setup. Thus, sol gel spin coating method was explored due to its low cost and easy to handle compared to other methods. Despite the simplicity of the method, relatively little work has been done on the growth of AlN thin film using spin coating method.

In this study, an AlN thin film was deposited on n-type Si (100) substrate by spin coating method followed by the nitridation process. The surface morphology and structural properties of the thin film were investigated by field-emission scanning electron microscope (FESEM), energy dispersive X-ray (EDX), atomic force microscopy (AFM), and X-ray diffraction (XRD); while the optical properties of the deposited thin film were determined by using Fourier transform infrared (FTIR) spectrometer.

Experimental detail

As a starting material, aluminium nitrate hydrate powder was used. Ethanol and diethanolamine were used as solvent and stabilizer, respectively. First, aluminium nitrate hydrate powder was dissolved in the ethanol and DEA solution at room temperature. The precursor was stirred to yield a

clear and homogeneous solution, which served as the coating solution. The prepared solution was spin-coated on the atmospheric plasma treated n-type Si(100) substrate which was rotated at 3000 rpm for 30 s. Then, the film was soft baked on the hot plate at 60 for few minutes. The spin-coating and soft baked were repeated a few times to achieve film with the desired thickness. The thin film was inserted to a furnace and annealed at 950°C for two hours under nitrogen ambient. After the annealing process, the film was nitridated in the tube furnace at 1100°C for one hour under ammonia (NH_3) ambient. The flow of the NH_3 gas was set at 500 sccm. After the completion of the reaction, the furnace was allowed to cool down naturally to room temperature. During the cooling process, nitrogen gas was flowed in order to flush out the excess NH_3.

The surface morphology of the thin film was examined by FE-SEM (FESEM, Model FEI Nova NanoSEM 450) and AFM (Dimension EDGE, BRUKER). The EDX (NOVA NANO SEM450) which attached to the FE-SEM system was used to identify the elemental composition of the deposited thin film. Whereas the structural properties of the thin film were investigated by XRD (PANalytical X'Pert Pro MRD) with a Cu-kα_1 radiation source (λ=1.5406Å). The optical properties of the deposited thin film were determined by using FTIR spectrometer (Spectrum GXFT-IR, Perkin-Elmer).

Results and discussions

Fig. 1(a) shows the FESEM image of the deposited AlN thin film on n-Si (100) substrate captured at high magnifications (×200k). It can be observed from the FESEM image that the surface of the AlN thin film is smooth with fine grain. These results are correlated with the AFM results. The cross-sectional view of the FESEM image is shown in Fig. 1(b). It can be observed that the AlN thin film with an average thickness of approximately 0.595 µm was formed on the Si (100) substrate. Fig. 1(c) shows the AFM image of the deposited AlN thin film on n-Si (100) substrate. The AFM scans area was 5µm×5µm. The image shows that smooth and dense grain AlN thin film with the root mean square (RMS) surface roughness of 2.26 nm was formed.

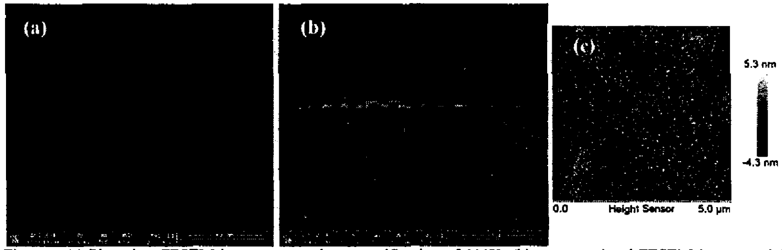

Figure 1 (a) Plan-view FESEM image captured at magnification of 200K, (b) cross-sectional FESEM image, and (c) AFM image of the deposited AlN thin film on n-Si(100) substrate.

Fig. 2 shows the EDX spectrum for the AlN thin film deposited on n-Si (100) substrate. EDX indicates that the thin film consists of aluminium, nitrogen, silicon and oxygen. The presence of the oxygen in the deposited thin film is associated to the common contamination of AlN in non-equilibrium growth techniques such as spin coating [13]. Fig. 3 shows the XRD spectrum of AlN thin film deposited on n-Si (100) substrate and bare Si. No peak was shown on the XRD spectra due to few factors such as the thickness of the AlN thin film is thin and it do not reach the critical thickness for XRD measurement [14]. The peaks that appeared in the XRD spectra come from Si substrate. Nevertheless, the AlN thin film successfully grown on Si substrate and it can be confirmed in the FTIR graph.

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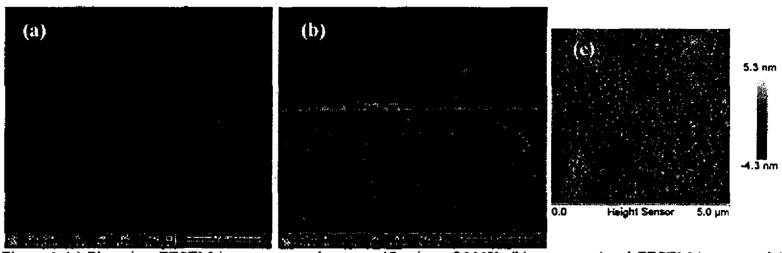

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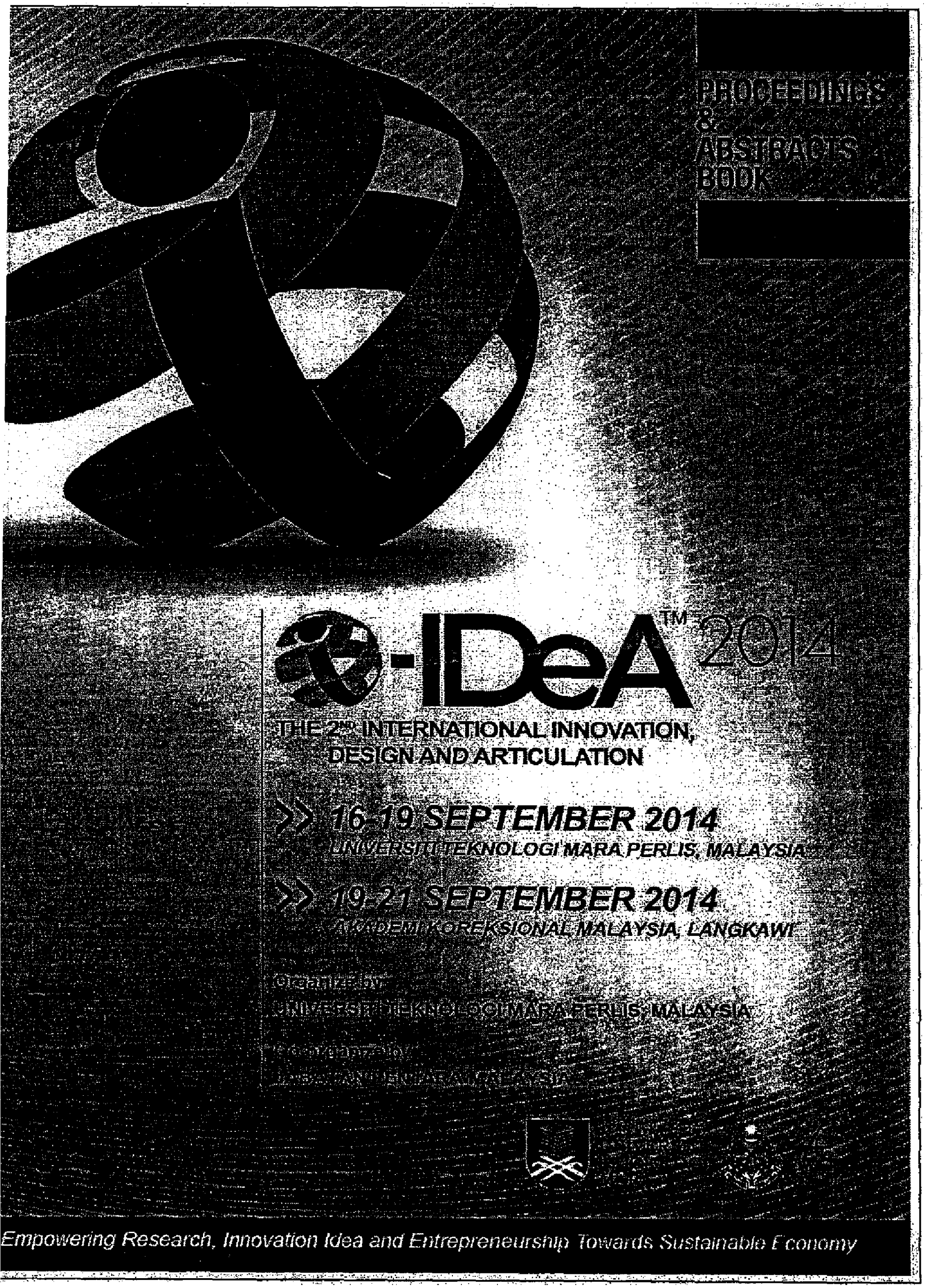

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AS23

Attenuated Total Reflection Study of Surface Phonon Polariton Characteristics of $Al_xIn_{1-x}N$ Thin Films Grown on 6H-SiC Substrate

*Ng Sha Shiong[1], Pauline Yew[1], Haslan Abu Hassan[1] and Zanuriah Hassan[1]

[1]*Nano-Optoelectronics Research and Technology Laboratory, School of Physics, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia*

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Abstract:

In this work, room temperature *p*-polarized infrared attenuated total reflection (ATR) spectroscopy was employed to investigate the SPP characteristics of $Al_xIn_{1-x}N$ thin films. Commercial $Al_xIn_{1-x}N$ thin films silicon carbide (6H-SiC) substrate with different Al compositions ($0.8 \leq x \leq 1.0$) were used. All the ATR spectra exhibit two strong absorption dips corresponding to the SPP mode of the $Al_xIn_{1-x}N$ epilayer and the interface phonon polariton mode of $Al_xIn_{1-x}N$/6H-SiC. The results also revealed that the SPP mode of the $Al_xIn_{1-x}N$ thin films was shifted towards higher frequency as the Al composition was increased. Overall, the obtained SPP modes were in reasonable agreement with the results derived from the theoretical model.

Keywords: AlInN, Ternary alloy, Attenuated total reflection, Surface phonon polariton

Introduction

III-nitride semiconductor ternary alloys, in particularly aluminium indium nitride (AlInN) alloys have attracted considerable attention from the research community. This is mainly due to its unique property of tuneable energy band gap from near-infrared to ultraviolet region (Wu, 2009). Consequently, AlInN becomes a promising candidate for various electronic and optoelectronic devices such as light-emitting diode and laser diode.

In spite of the great potential of this semiconductor, it has received less attention as compared to its family members (i.e., GaN, AlN, AlGaN, and InGaN). This is mainly due to the difficulty to grow good quality AlInN thin films (Matsuoka, 1997). According to Yoshida et al. (2007), the difference between the lattice constants of AlN-InN is 13.5%. Consequently, there is a strong immiscibility and large differences in optimum growth temperatures for this ternary alloy. Since high quality AlInN samples are not widely available, most of its basic properties still remains unknown. For instance, the characteristics and behaviour of its surface phonon polariton (SPP) still remains unclear. Until now, there are very few theoretical studies devoted to the SPP properties of wurtzite AlInN (Ooi et al., 2011; Yew et al., 2013). While there is no experimental work on the SPP characteristics of the AlInN has yet been reported.

Generally, SPP is a mixed electromagnetic mode that resulted from the coupling of an infrared (IR) photon under transverse magnetic (TM or *p*-polarization) field with the surface phonon localized near the surface of a polar crystal. This coupling information has been utilized in various applications, such as surface-enhanced IR absorption spectroscopy (Kim and Cheng, 2010), thermo-photovoltaic system (Francoeur, Mengüç, and Vaillon, 2011), and reflection-type sensor in the mid-IR region (Balin et al., 2009). Therefore, a detailed study is essential for understanding the SPP properties of AlInN.

In year 2011, Ooi et al. conducted theoretical studies of the SPP in AlInN ternary alloy. A linear interpolation of dielectric function was used. Their results revealed that the SPP mode of the AlInN exhibits a mixed-mode behaviour over the entire Al composition range. Typically, the dielectric function varies in a non-linear manner. Consequently, the linear interpretation approach may not describe the alloy system accurately. For this reason, we have performed another theoretical studies on the optical phonon and SPP of AlInN (Yew et al., 2013). Theoretical approach based on modified random element iso-displacement (MREI) model and Born-Huang procedure was sued. Through this approach, more accurate information about the composition dependence of the longitudinal and transverse optical phonon frequencies as well as the dielectric function of the AlInN alloy were determined. We found that both the

optical phonons and the SPP modes of AlInN demonstrate mixed-mode behaviour in the whole Al composition range.

In this work, the SPP characteristics of $Al_xIn_{1-x}N$ thin films with different Al compositions ($0.8 \leq x \leq 1.0$) were investigated. For the experimental study, *p*-polarized IR attenuated total reflection (ATR) method was used. The obtained results were compared to that theoretical results obtained in our previous studied (Yew et al., 2013).

Experimental details

Undoped wurtzite structure $Al_xIn_{1-x}N$ thin films with different Al compositions (x = 0.80, 0.85, 0.90, and 1.00) from NOVAGAN, Switzerland, were used. All the $Al_xIn_{1-x}N$ epilayers were grown on two-sides polished silicon carbide (6H-SiC) substrate with the crystallographic *c*-axis along the growth direction ($c_{axis} \parallel z$). For the growth of $Al_xIn_{1-x}N$ (x = 0.80, 0.85 and 0.90) epilayers, a relatively thin nucleation layer of AlN was used. The thickness of the $Al_xIn_{1-x}N$ epilayers and the AlN nucleation layer is about 500 nm and 60 nm, respectively.

To access the SPP characteristics of the thin films, *p*-polarized IR ATR measurements with Otto configuration were carried out. The schematic representation of the experiment setup is shown in Figure 1.

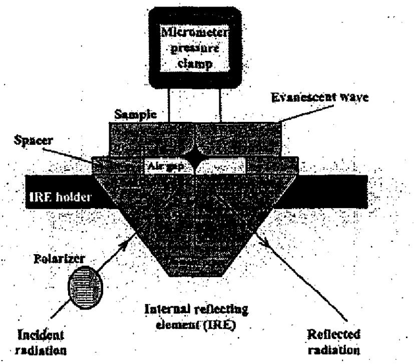

Figure 1. Schematic diagram for the *p*-polarized IR ATR measurements with Otto configuration.

All the measurements were conducted under room temperature using a Fourier transform IR spectrometer (Spectrum GX FTIR, Perkin-Elmer) and an optional single-reflection ***diamond ATR*** accessory (GladiATR, PIKE Technologies). While a wire grid thallium iodide bromide IR polarizer was employed to obtain *p*-polarization spectrum. The internal incident angle, θ, of the ATR accessory is 45° and the refractive index of the diamond prism, n_{prism} is 2.4. The ATR spectra were acquired in the spectral range from 400 to 1200 cm^{-1}. The spectral resolution was 4 cm^{-1} and the number of scans was 16.

Abstract Book

NATIONAL PHYSICS CONFERENCE 2014

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TECHNICAL PROGRAMME SUMMARY

TUESDAY, NOVEMBER 18, 2014

PARALLEL ORAL PRESENTATION SESSION 1

Room	CAYMAN 1	CAYMAN 2	CAYMAN 3	CAYMAN 4	KAY WEST	CANCUN
Topic	Applied and Engineering Physics	High Energy Physics / Quantum Physics	Mathematical & Computational Physics	Plasma Physics	Photonics and Optoelectronics	Material Science
Chaired by	Prof. Dr. Ong Duu Sheng	Dr. Chung Ming-Chiang	Prof. Dr. Sithi V. Muniandy	Dr. Chin Oi Hoong	Prof. Dr. Sulaiman Wadi Harun	Prof. Dr. Zainal Abidin Talib
0900 - 0920	01OP.01	06OP.01	09OP.01	14OP.01	13OP.01	08OP.01
0920 - 0940	01OP.02	06OP.02	09OP.02	14OP.02	13OP.02	08OP.02
0940 - 1000	01OP.03	16OP.01	09OP.03	14OP.03	13OP.03	08OP.03
1000 - 1030	Invited Talk 1 Prof. Dr. Ong Duu Sheng	Invited Talk 2 Dr. Chung Ming-Chiang	Invited Talk 3 Prof. Dr. Sithi V. Muniandy	Invited Talk 4 Dr. Chin Oi Hoong	Invited Talk 5 Prof. Dr. Sulaiman Wadi Harun	Invited Talk 6 Prof. Dr. Zainal Abidin Talib
1030 - 1045	Coffee Break					

	PLENARY SESSION 1 Chaired by Prof. Dr. Wong Chiow San	PLENARY SESSION 2 Chaired by Prof. Dr. Pankaj K. Choudhury
1045 - 1120	**Plenary 1A** Penguin-like Diagrams from the Standard Model Prof. Dr. Chia Swee Ping Universiti Malaya, Malaysia	**Plenary 2A** Shape-Related Useful Properties of Nanostructured Thin Films Prof. Dr. Motofumi Suzuki Kyoto University, Japan
1125 - 1200	**Plenary 1B** Application of Advanced Plasma Technology to Energy Materials and Environmental Problems Prof. Dr. Akira Kobayashi Malaysia-Japan International Institute of Technology, UTM, Malaysia	**Plenary 2B** Spin-Dependent Transport and Spin Coupling in Organic Spintronics Prof. Dr. Lin Minn-Tsong National Taiwan University, Taiwan

1200 - 1230	Poster Session 1

1230 - 1315	KEYNOTE 1 *Chaired by Prof. Dr. Chia Swee Ping* 50 Years of CP Violation — What have we learned? Prof Bruce HJ Mckellar AC University of Melbourne, Australia
1315 - 1425	Group Photo / Lunch

PARALLEL ORAL PRESENTATION SESSION 2

Room	CAYMAN 1	CAYMAN 2	CAYMAN 3	CAYMAN 4	KAY WEST	CANCUN
Topic	Applied and Engineering Physics	Condensed Matter Physics	Astronomy and Astrophysics	Nuclear and Radiation Physics	Material Science	Material Science
Chaired by	Prof. Dr. Chong Kok Keong	Prof. Dr. Pankaj K. Choudhury	Dr. Tan Eng Kiang	Dr. Yong Thian Khok	Prof. Dr. Sulaiman Wadi Harun	Prof. Dr. Zainal Abidin Talib
1430 – 1450	01OP.04	05OP.01	02OP.01	11OP.01	08OP.04	08OP.09
1450 – 1510	01OP.05	05OP.02	02OP.02	11OP.02	08OP.05	08OP.10
1510 – 1530	01OP.06	05OP.03	02OP.03	11OP.03	08OP.06	08OP.11
1530 – 1550	01OP.07	05OP.04	02OP.04	11OP.04	08OP.07	08OP.12
1550 - 1610	01OP.08	05OP.05	02OP.05	11OP.05	08OP.08	08OP.13
1610 - 1630	Coffee Break					

PARALLEL ORAL PRESENTATION SESSION 3

Room	CAYMAN 1	CAYMAN 2	CAYMAN 3	CAYMAN 4	KAY WEST	CANCUN
Topic	Applied and Engineering Physics	-	Multiple Fields	-	Material Science	Material Science
Chaired by	Prof. Dr. Chong Kok Keong	-	Dr. Tan Eng Kiang	-	Dr. Yong Thian Khok	Prof. Dr. Faidz Abd Rahman
1630 – 1650	01OP.09	-	09OP.04	-	08OP.14	08OP.18
1650 – 1710	01OP.10	-	09OP.05	-	08OP.15	08OP.19
1710 – 1730	01OP.11	-	12OP.01	-	08OP.16	08OP.20
1730 - 1750	01OP.12	-	13OP.07	-	08OP.17	08OP.21
1800	End of Day 1					

WEDNESDAY, NOVEMBER 19, 2014

PARALLEL ORAL PRESENTATION SESSION 4

Room	CAYMAN 1	CAYMAN 2	CAYMAN 3	CAYMAN 4	KAY WEST	CANCUN
Topic	Applied and Engineering Physics	Biophysics and Medical Physics	Photonics and Optoelectronics	Plasma Physics	Nuclear and Radiation Physics	Material Science
Chaired by	Prof. Dr. Chong Kok Keong	Prof. Dr. Sim Kok Swee	Dr. Raymond Ooi Chong Heng	Dr. Rattachat Mongkolnavin	Dr. Lau Sing Liong	Prof. Dr. Faidz Abd Rahman
0900 - 0920	01OP.13	04OP.01	13OP.04	14OP.06	11OP.06	08OP.22
0920 - 0940	01OP.14	04OP.02	13OP.05	14OP.07	11OP.07	08OP.23
0940 - 1000	01OP.15	04OP.03	13OP.06	14OP.08	11OP.08	08OP.24
1000 - 1030	Invited Talk 7 Prof. Dr. Chong Kok Keong	Invited Talk 8 Prof. Dr. Sim KoK Swee	Invited Talk 9 Dr. Raymond Ooi Chong Heng	Invited Talk 10 Dr. Rattachat Mongkolnavin	-	-
1030 - 1045	Coffee Break					

	PLENARY SESSION 3 Chaired by Prof. Dr. Hj Mohd Kamil Abd Rahman	PLENARY SESSION 4 Chaired by Prof. Dr. Ong Duu Sheng
1045 - 1120	**Plenary 3A** Glass-based Confined Structures Enabling Light Control Prof. Dr. Maurizio Ferrari Institute for Photonics and Nanotechnologies, Trento, Italy	**Plenary 4A** Functional Boron Nitride Nanotubes and Boron Nitride Nanosheets Prof. Dr. Yap Yoke Khin Michigan Technological University, USA
1125 - 1200	**Plenary 3B** New THz Opportunities based on Graphene Prof. Dr. Hans L. Hartnagel Technical University Darmstadt, Germany	**Plenary 4B** Development of Process Parameters for 22nm PMOS Using 2-D Analytical Modeling Prof. Dr. Ibrahim Ahmad Universiti Tenaga Nasional, Malaysia

1200 - 1230	Poster Session 2

1230 - 1315	KEYNOTE 2 *Chaired by Prof. Dr. Sithi V. Muniandy* Quantum Theory in Fractal and Multifractal Spacetime Prof. Dr. Lim Swee Cheng Multimedia University, Malaysia
1315 - 1425	Lunch

PARALLEL ORAL PRESENTATION SESSION 5

Room	CAYMAN 1	CAYMAN 2	CAYMAN 3	CAYMAN 4	KAY WEST	-
Topic	Instrumentation Physics	Biophysics and Medical Physics	Astronomy and Astrophysics	Nuclear and Radiation Physics	Material Science	-
Chaired by	Dr. Lim Soo King	Prof. Dr. Chong Kok Keong	Prof. Dr. Sithi V. Muniandy	Dr. Lau Sing Liong	Prof. Dr. Faidz Abd Rahman	-
1430 – 1450	07OP.01	04OP.04	02OP.06	11OP.09	08OP.25	-
1450 – 1510	07OP.02	04OP.05	02OP.07	11OP.10	08OP.26	-
1510 – 1530	07OP.03	04OP.06	02OP.08	06OP.06	08OP.27	-
1530 – 1550	07OP.04	04OP.07	02OP.09	06OP.07	08OP.28	-
1550 - 1610	-	04OP.08	-	-	08OP.29	-
1610 - 1630	-	04OP.09	-	-	08OP.30	-
1630 – 1730	Networking Session	Networking Session	Networking Session	Networking Session	Networking Session	-
1730	End of Conference					

P2.13 08A184_PEDB3310192

Characterization of Annealing Temperatures for Surface Functionalization of Reduced Graphene Oxide (RGO) Anodic Films for Improved Biophotovoltaic (BPV) Applications

Siti Aisyah Ibrahim[1], Fong-Lee Ng[2,3], Muhammad Musoddiq Jaafar[1], Kamran Yunus[4], Adrian C. Fisher[4], Siew-Moi Phang[2,3], Vengadesh Periasamy[1*]
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Abstract - In recent times, synthetic photosynthesis have been demonstrated to show possible utilization as a renewable energy source. In particluar, photosynthetic algae biofilms on conventional indium tin oxide (ITO) electrodes were interrogated electrically for its power output. In this work, reduced graphene oxide (rGO) deposited using the Langmuir-Blodgett (LB) method were used instead of the ITO anode. 6 layers of rGO were deposited on a clean quartz substrate prior to the algae growth, *Chlorella sp.* for biophotovoltaic (BPV) measurements. However, adhesion of prior depostions of rGO films following subsequent transfers becomes unstable and peel off with the presence of water molecules upon dipping into the subphase. The current investigation improves adhesion upon introduction of annealing process in vacuum between depostion of each layers. To characterize the multilayer films fabricated, different temperatures were applied (200°C, 250°C, 300°C, 350°C and 400°C) and the electron transport properties of the biofilms studied by means of spectrocopic, structural and electrical studies. The results generally highlights the potential of multilayer rGO anodes as potential candidates for implementation in algae-fuel cells (algae-FCs) promoting improved algae growth, adhesion and photosynthesis yield as an outcome of higher charge mobilty.

Keywords - Temperature Variation, Reduced Graphene Oxide, Langmuir-Blodgett, Bio-photovoltaic, Algae-fuel cells
PACS: 81

P2.14 08A188_PEC32EE0196

Influence of Force Constant on Surface Phonon Polariton Properties of Cubic $ZnS_{1-x}Se_x$ Crystals

P. Yew[1], S. C. Lee[1,2*], S. S. Ng[1], T. L. Yoon[1] and H. Abu Hassan[1]
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Abstract - In this paper, the attention is primarily focused on the influence of force constant on surface phonon polariton (SPP) properties of cubic $ZnS_{1-x}Se_x$ mixed crystals. Two different force constants were used, i.e., one considers only the first nearest neighbour interactions and another considers up to the second nearest neighbour interactions. For the theoretical modelling, modified random element isodisplacement (MREI) model and Born Huang procedure were used. The results revealed that the second nearest neighbour interactions assumption gives significant impact on composition dependence of optical phonon spectra, in which it can produce theoretical results closer to experimental data. Due to the dependence of SPP on optical phonon modes, it is expected that the SPP properties of ternary mixed crystal are also sensitive to the force constant. The SPP dispersion curves are calculated for both of the end member binary crystals ($x = 0$ and 1) and mixed crystal with composition $x = 0.3$, 0.5, and 0.8. Finally, implication of the theoretical results on relevant experiment is discussed.

Keywords MREI, force constant, optical phonon, surface phonon polariton.
PACS: 68.35.Ja, 61.66.Dk, 63.20.D-

P2.15 08A214_PE48F5A0222

WO_3 Nanofibers Gas Sensor

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Abstract - Tungsten oxide (WO_3) is a famous n-type semiconductor with a low band gap of 2.6 eV that has been used not only in catalytic/photocatalytic, electrochromic application but also in solid state gas sensors. The number of research publications where tungsten oxide is used for gas sensing applications has increased dramatically during recent years leading this material to be the second most studied metal oxide sensor for gas sensing applications after SnO_2. In this study of sensors, metal-semiconductor (MS) Schottky contacts using palladium on WO_3 nanofibers have been successfully fabricated. The metal Pt were deposited by sputtering method through metal mask. The source gases 2% H_2 (balance N_2) was used. Data was obtained by Keithley I-V measurement, Schematic diagram for gas sensors measurement.

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28th Regional Conference on Solid State Science and Technology

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25 - 27 November 2014

VENUE
Copthorne Hotel, Cameron Highlands, Pahang, Malaysia

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ORAL PRESENTATIONS

Session 3C : Nanoscience and Nanotechnologies (Kampung Raja)

Time	Title & Presenter	Code
1550 - 1610	AZO (Al:ZnO) nanoparticles by modified sol-gel method *S. Beer Mohamed* **(INVITED)**	3C-1
1610 - 1625	Field Emission Properties of ZnO Nanorods Prepared by Sol-gel Method *Yusuf Mohd Amin*	3C-2
1625 - 1640	Comparison of the coercivity-modifying synthesis processes in the microstructure-magnetic property evolution of $CoFe_2O_4$ and $Co_{0.5}Ni_{0.5}Fe_2O_4$ *Mohd Shamsul Ezzad Shafie*	3C-3
1640 - 1655	Tuning surface plasmon effects in erbium doped boro-tellurite nanoglass via thermal annealing *Zahra Ashur Said Mahraz*	3C-4
1655 - 1710	Synthesis and characterization of TiO_2-doped $ZnAl_2O_4$ nanocrystals via a Sol-Gel Method *Wan Nasarudin Wan Jalal*	3C-5
1930 - 2300	**OPENING CEREMONY AND CONFERENCE DINNER**	

Session 3D : Thin Film Materials and Devices (Terla)

Time	Title & Presenter	Code
1550 - 1610	Innovative Light Sensitive Materials And Their Innovative Applications *Gurumurthy Hegde* **(INVITED)**	3D-1
1610 - 1625	Growth vertical aligned of NiSi/SiC core-shell nanowires by HWCVD *Goh Boon Tong*	3D-2
1625 - 1640	Polarized Infrared Reststrahlen Features of Wurtzite InGaN Thin Film *Pauline Yew*	3D-3
1640 - 1655	Study of annealing effects on Sn thin films prepared by thermal evaporation *Chuah Lee Shiang*	3D-4
1655 - 1710	Influence of precursor concentration on the structural and optical properties of indium oxide thin film prepared by sol-gel method *Lau Lik Nguong*	3D-5
1930 - 2300	**OPENING CEREMONY AND CONFERENCE DINNER**	

ORAL PRESENTATION

3D-2

GROWTH VERTICAL ALIGNED OF NiSi/SiC CORE-SHELL NANOWIRES BY HWCVD

Boon Tong Goh, Najwa Hamzan, Nur Fatin Farhanah Nazarudin, Farah Nadiah Nordin, Saadah Abdul Rahman

Low Dimensional Materials Research Centre (LDMRC), Department of Physics, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia
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NiSi/SiC core-shell nanowires grown on crystal silicon substrates by hot-wire chemical vapour deposition were studied. The growth of these core-shell nanowires were catalyzed by Ni nanoparticles (with sizes in between 18 and 33 nm) and assisted by a thermal irradiation of the hot-filament at temperature above 1800°C. These core-shell nanowires were found to be grown at substrate temperature above 300°C. The nanowires consisted of single crystalline NiSi and amorphous SiC as core and shell of the nanowires, respectively. Increase of the substrate temperature enhances the growth of high density well aligned nanowires. Presence of nano-crystallites embedded within the amorphous SiC matrix in the shell exhibits broad photoluminescence (PL) emission spectra in visible and near infrared region. Furthermore, the high density well aligned nanowires significantly suppressed the PL emission due to the oxygen related defects. The effects of the substrate temperature on the structural and optical properties of the core-shell nanowires are discussed.

3D-3

POLARIZED INFRARED RESTSTRAHLEN FEATURES OF WURTZITE InGaN THIN FILM

Pauline Yew[*1], Lee Sai Cheong[1], Ng Sha Shiong[1], Yoon Tiem Leong[1], Haslan Abu Hassan[1] & Chen Wei Li[2]*

[1] Nano-Optoelectronics Research and Technology Laboratory, School of Physics, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia.
[2] Department of Electronic Engineering, National Changhua University of Education, 500 Taiwan, ROC.
*paulinevcu@hotmail.com

Polarized infrared (IR) reflectance measurement was carried out to investigate the optical phonon modes of wurtzite structure $In_{0.56}Ga_{0.44}N$ thin film grown by molecular beam epitaxy. Composition dependence of IR reststrahlen features was observed. Theoretical polarized IR reflectance spectra were simulated using the standard multilayer optics technique with a multioscillator dielectric function model. By obtaining the best fit of experimental and theoretical spectra, the Brillouin zone center E_1 optical phonon modes together with the dielectric constant, layer thickness, free carriers concentration and mobility were extracted non-destructively. The extracted E_1 optical phonon modes were compared with those generated from Modified Random Element Isodisplacement model.

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41	Zinc Oxide Microrod and Poly(3-Dodecylthiophene) with Melastoma Malabathricum Dye for Hybrid Solar Cell *Hasiah Salleh*	PG-1
42	Fabrication of Novel Spinel Oxide ZnV_2O_4 Nanostructures and their Energy Storage Properties *Faheem K. Butt*	PG-2
43	The Effect of Salt Concentration in Filler Modified PMMA/ENR 50/$LiCF_3SO_3$ Electrolyte *Nunshaimah Salleh*	PG-3
44	Ti doped $LiMn_{1/3}Co_{1/3}Ni_{1/3}O_2$ for Li-ion battery application *Kelimah Anak Elong*	PG-4
45	Utilization of Natural Pigment Extracted from Downy Rose Myrtle Berries as Sensitizer in Dye Sensitized Solar Cell *Norlaily Abdul Rashid*	PG-5
46	Zinc Oxide Microrods and Poly (3-Dodecythiophene)-P3DT with Chlorophyll (Algae) for A Hybrid Solar Cell *Azhar Mohd Sinin*	PG-6

27 NOVEMBER 2014
SESSION 2: 0830 – 1630
VENUE: BALLROOM

No	Title & Presenter	Code
1	Characterizations of MWCNTs Purified by HNO_3:HCl Treatment *Noorezal Atfyinna Mohd Napiah*	PH-1
2	Iron (III) Oxide-Carbon Nanotube Nanocomposite Catalyst in Transesterification of Coconut Oil for Biofuel Formulation *Nor Aziah Buang*	PH-2
3	Microstucture evolution of casting and semi solid A356 containing Sr *Anasyida Abu Seman*	PI-1
4	The Effect of Ta Content on Microstructure and Hardness Properties of $FeNiCrMnCoTa_x$ and $Al_{0.5}FeNiCrMnCoTa_x$ High Entropy Alloys *Siti Sarah Mohd Pauzi*	PI-2
5	Microstructure and Corrosion Properties of Friction Stir Welded Aluminum Alloy 5086 *Farhad Gharavi*	PI-3
6	Isolation of cellulose microfibrils/nanofibrils (CMNF) from pseudostems of banana plants (Musa acuminata) *Noriean Azraaie*	PJ-1

21	Step-By-Step Approach on Growing Zinc Oxide Nanostructure Using Low Cost Spin Coating and Immersion Method *Nur Afiqah Mohammad Suhaimi*	PK-9
22	Growth and characterization of AlN thin film using sping coating method: Effect of annealing temperature *Nurfahana Mohd Amin*	PK-10
23	Thin film of AACVD prepared ZnO fortified with reduced graphene oxide for PEC water splitting *SITI NORMAIMUNAH BT ARIFFIN*	PK-11
24	Titanium Dioxide-reduced Graphene Oxide Thin Film for Photoelectrochemical Water Splitting *Nor Fathin Aini Jumeri*	PK-12
25	Humidity Sensing Properties of Plasticized CA-NH4BF4-PEG600 Thin Films *Nurhana Ilmira Harun*	PK-13
26	Reuse of Palm Oil Sludge in Stoneware: An Eco-friendly Project *Soudeh Salehi*	PL-1
27	Dolomite Addition in Non-Stoichiometric Cordierite Glass-Ceramic: Effects on Dielectric Constant *Hasmaliza Mohamad*	PL-2
28	Effect of Lead on Physical and Optical Properties of $(PbO)_x(B_2O_3)_{1-x}$ Glass System *Halimah Mohamed Kamari*	PL-3
29	Study on preparation and effects of heat treatments on the structural of 45S5 bioglass from waste materials *Nur Fadilah Baharuddin Pallan*	PL-4
30	Thermal Diffusivity of Manganese Doped Willemite Glass Ceramics *Zaidan Abdul Wahab*	PL-5
31	Effect of Samarium Nanoparticles on Optical Properties of Zinc Borotellurite Glass System *Hajer Saad*	PL-6
32	Physical And Structural Properties of $PbO-ZnO-B_2O_3$ *Mardhiah Abdullah*	PL-7
33	Effect of EAF Slag Particle Size and Vitrification Temperature to Properties of Ceramic Tile *Nurulakmal Mohd Sharif*	PL-8
34	Effect Of Rare Earth On The Optical Properties Of Borotellurite Glass *K. Azman*[1]	PL-9

STEP-BY-STEP APPROACH ON GROWING ZINC OXIDE NANOSTRUCTURE USING LOW COST SPIN COATING AND IMMERSION METHOD

Nur Afiqah Mohammad Suhaimi[*,1] *and Sukreeen Hana Herman*[2]

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Electronic devices such as semiconductor and capacitor have gone through numerous improvement before they become as efficient as they are now. Interest of scientists now lies on fabrication of nanostructure based electronic devices because nano-scale devices have shown better performance compared to conventional devices. This research focuses on easy and low cost technique to grow nanostructure zinc oxide to save time, energy and money. There are many materials available but zinc oxide has good quality to be use in electronic device as it has wide band gap and shows excellent electrical properties. Spin coater was used to deposit zinc oxide thin film which act as seed layer, a layer on which the nanostructure will start to growth. Then immersion method was applied on the deposited zinc oxide seed layer to grow zinc oxide nanostructure. Field emission scanning electron microscopy (FESEM) was used to identify the gwoth nanostructure and images obtained shows that the growth is significant. To prove that the growth nanostructure give effects to its performance, a test on its ability to detect pH was done. The zinc oxide nanostructure sample was used as the gate (sensing membrane) for an EGFET pH sensor and its sensitivity was compared to sensitivity of a bare zinc oxide thin film. The results shows that nanostructure zinc oxide sample has higher sensitivity. Hence it can be concluded that low cost but high performance zinc oxide nanostructure can be successfully fabricated using this method.

GROWTH AND CHARACTERIZATION OF ALN THIN FILM USING SPING COATING METHOD: EFFECT OF ANNEALING TEMPERATURE

NurFahana Mohd Amin[*], *Fatin Ain Zatty Mansor, Sukma Nurhayati Zulkifli, Lee Zhi Yin, Fong Chee Yong and Ng Sha Shiong*

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*annanur252@yahoo.com

This paper reports the growth and characterization of aluminium nitride (AlN) thin film deposited on n-type silicon [n-Si(100)] using a versatile and cost effective method namely spin coating method. The main focus is on the effects of annealing temperature on the structural, surface morphological and optical properties of the deposited AlN thin films. For the precursor preparation, the main ingredient of aluminium nitrate hydrate was dissolved with an organic solvent. Subsequently, the precursor was sprung on the atmospheric plasma treated n-Si(100) substrate. The nitridation process was carried out on the deposited coating at 1100°C for 1 hour. Prior to the nitridation process, the deposited films were subjected to various annealing temperatures. The surface morphology and structural properties of the thin film were investigated by field-emission scanning electron microscope, atomic force microscopy energy, dispersive X-ray spectroscopy and X-ray diffraction; while the optical properties of the deposited thin film was determined by using Fourier transform infrared spectrometer.

Growth and characterization of AlN thin film using the spin coating method: Effect of annealing temperature

NurFahana Mohd Amin*, Fatin Ain Zatty Mansor, Sukma Nurhayati Zulkifli, Lee Zhi Yin, Fong Chee Yong, Ng Sha Shiong#

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Keywords: AlN, Thin Film, Spin coating, Silicon.

Abstracts: This paper reports the growth and characterization of aluminum nitride (AlN) thin film deposited on n-type silicon [n-Si(100)] using a versatile and cost effective method namely spin coating. The work focuses on the effects of annealing temperature on the structural, surface morphological and optical properties of the deposited AlN thin films. For the precursor preparation, the main ingredient of aluminum nitrate hydrate was dissolved with an organic solvent. Subsequently, the precursor was sprung onto the atmospheric plasma treated n-Si(100) substrate. The nitridation process was carried out on the deposited coating at 1100°C for one hour. Prior to the nitridation process, the deposited films were subjected to various annealing temperatures. The optical properties of the deposited thin film were determined by using Fourier transform infrared spectrometer. The structural properties and surface morphology of the thin film were investigated by X-ray diffraction, field-emission scanning electron microscope; energy dispersion X-rays spectroscopy and atomic force microscopy.

Introduction

In recent years, aluminum nitride (AlN) thin films are becoming more popular semiconductor in a wide variety of applications such as potential dielectric and passivation layer for gallium arsenide (GaAs) devices, heat sink in electronic packaging applications, component of surface acoustic wave devices [1], and optical coating for spacecraft components [2]. In addition, AlN helps to extend the lifetime of moving mechanical components due to its potential as a wear-resistant hard coating. Besides, AlN thin films are attractive materials for the application as high temperature microelectronic and optoelectronic devices due to its unique properties such as wide band gap (6.2 eV) [3] and high acoustic velocity [4].

Moreover, AlN also possesses some unique properties like moderately high electromechanical coupling coefficient [5], high temperature stability, high resistivity, high dielectric constant [6] and low coefficient of thermal expansion. High heat dissipation of AlN can significantly enhance lifetime and efficiency of semiconductor devices. Furthermore, its lattice matching is near to that of silicon and thus less stress is expected to be generated at the AlN/silicon interface. Owing to these properties, AlN films have received a great interest as an electronic material for thermal dissipation, dielectric and passivation layers for integrated circuits, acoustic devices, resonators and optoelectronic devices [7].

From the past, different techniques have been used to grow AlN thin films. These include molecular beam epitaxy, chemical vapor deposition, radio frequency or direct current sputtering [8, 9], pulsed laser deposition [10] and spin coating [11]. In this project, spin coating method has been chosen for the growth of AlN thin films. Spin coating is a simple technique requires considerably less equipment and is potentially less expensive [12] compared to the conventional thin film growth methods as stated above. In general, the annealing temperature is an extremely important growth parameter in influencing the crystal structure of the crystalline material. In this study, AlN thin films were deposited on n-Si (100) substrate by spin coating method followed by the nitridation process prior to the nitridation process, the deposited films were subjected to various annealing temperatures from 250°C to 850°C. The optical properties of the deposited thin films were determined by using Fourier transform infrared (FTIR) spectrometer; and while the structural and surface morphology properties of the thin films were investigated by X-rays diffraction (XRD), field-emission scanning electron microscope (FESEM), energy dispersive X-rays spectroscopy (EDX) and atomic force microscopy (AFM).

Experimental Detail

Aluminum nitride thin films were deposited onto n-Si (100) substrates by using the spin coating method. Aluminum nitrate hydrate powder was chosen as a starting material. Ethanol and diethanolamine (DEA) were used as solvent and stabilizer, respectively. First, aluminum nitrate hydrate powder was dissolved in the ethanol and DEA solution at room temperature. The precursor was stirred to yield a clear and homogeneous solution, which served as the coating solution. The n-Si (100) substrate was treated with atmospheric plasma prior to the spin coating process. Later, the prepared solution was spin-coated on to the substrate and rotated at 3000 rpm for 30 s. Then, the film was dried through soft baked process on a hot plate at 60°C for a few minutes. Both the spin-coating and soft baked processes were repeated for a few times to achieve the desired total thickness. The thin film was inserted into a furnace and annealed at various annealing temperatures from 250°C to 850 °C for two hours. After the annealing process, the films werenitridated in a tube furnace at 1100°C for one hour under a flow of ammonia (NH_3) gas at 500 sccm. After the completion of the reaction, the furnace was allowed to cool down naturally to room temperature. During the cooling process, nitrogen gas was flowing into the tube in order to flush out the excess NH_3.

The optical properties of the deposited thin films were determined by using a FTIR spectrometer (Spectrum GXFT-IR, Perkin-Elmer) whereas the structural properties of the thin films were investigated by XRD (PANalyticalX'Pert Pro MRD) with a Cu-kα_1 radiation source (λ=1.5406Å). The surface morphology and elementary analysis the thin films were examined by FE-SEM, AFM (Dimension EDGE, BRUKER) and EDX (NOVA NANO SEM450).

Result and Discussion

FTIR is an effective technique to investigate the characteristic vibrational modes of the lattice [13]. Fig. 1 depicts FTIR reflectance spectra for AlN thin films deposited on Si (100) substrates with different annealing temperatures over the entire range from 400 to 7000 cm^{-1}. It is observed that the optical phonon corresponds to the E_1(TO) of the AlN located at approximately 695 cm^{-1}, 696 cm^{-1}, 680 cm^{-1} and 692 cm^{-1} for annealing temperatures at 250 °C, 450 °C, 650 °C and 850 °C, respectively. Obviously, the peak E_1(TO) shifted towards higher wave number after annealed at all different temperatures, but these peaks are quite close to the characteristic value of AlN at 670 cm^{-1} [14]. The strongest AlN peak was observed for the film annealed at 650 °C. As compared to the reported values, it was found that the detected E_1(TO) and A_1(LO) modes display an upward frequency shift of 10 cm^{-1} and 20 cm^{-1}, respectively. This was most probably associated with the crystalline quality of the deposited thin film. The high frequency shifts of the A_1(LO) mode was attributed to the longitudinal phonon-plasmon coupling effect [15]. This phenomenon was most likely induced by the unintentionally doped carriers in the AlN thin film using present technique [16].

28th Regional Conference on Solid State Science and Technology

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Session 2C : Nanoscience and Nanotechnology

Time	Title & Presenter	Code
1400 - 1420	The Growth Study of Graphene by Mechanical Exfoliation Method on Different Porosity of Nanostructured Porous Silicon Substrate *Saifollah Abdullah* **(INVITED)**	2C-1
1420 - 1435	Intercalation of organic-inoragnic–herbicide (2,4,5 Tricholorphenoxy Butyric Acid) Nanohybrid into hydrotalcite like compound : Physicochemical and controlled release studies *Sheikh Ahmad Izaddin Sheikh Mohd Ghazali*	2C-2
1435 - 1450	Current-Voltage Characteristics of Zinc Oxide Nanowires Synthesized by Thermal Evaporation *Naziha Jamaludin*	2C-3
1450 - 1505	Properties of Al-doped ZnO nanorods low temperature hydrothermal method *Khairunisak Abdul Razak*	2C-4
1505 - 1520	Characterization of Cu-Al_2O_3 and Ni-Al_2O_3 Nanocomposites Electrodeposited on Copper Substrate *Eydar Tey*	2C-5
1520 - 1535	Synthesis of Hydroxyapatite nanopowder through precipitation from calcium chloride and potassium hydrophosphate *Monireh Ganjali*	2C-6
1535 - 1550	**BREAK & POSTER EVALUATION**	

Session 2D : Thin Film Materials and Devices

Time	Title & Presenter	Code
1400 - 1415	Lattice Strain Effect In Structural, Magnetic and Electrical Properties of $La_{0.67}Sr_{0.33}MnO_3$ Thin Film *Lim Kean Pah*	2D-1
1415 - 1430	Studies on Fabrications and Characterization of PANI-Ag-Co Nanocomposite Thin Films as Microbial Sensor for E. coli Contamination in Water *Norshafadzila Mohammad Naim*	2D-2
1430 - 1445	Mn dopped Zinc selenite thin film prepared by electrodeposition method *Ghazaleh Bahman Rokh*	2D-3
1445 - 1500	Thin Film of High Quality Mesostructured Silica Composites for Synthesis of Gold Nanoparticles *Mohamad Azani Abd Khadir Jalani*	2D-4

1500 - 1515	Effect of post deposition annealing on sputtered GeSn thin films on Si (100) substrate at room temperature *Hadi Mahmodi*	2D-5
1515 - 1530	Deposition of aluminium nitride thin film on kapton film using sputtering method *Nurfahana Mohd Amin*	2D-6
1530 - 1550	**BREAK & POSTER EVALUATION**	

Time	Title & Presenter	Code
1400 - 1420	Processing and Properties of Recycled Colourless Soda–Lime–Silica *Sidek Ab Aziz* (INVITED)	2E-1
1420 - 1435	On Sm^{3+} Doped Zinc Phosphate Glass With and Without Nickel Nanoparticles *Siti Amlah Mohamad Azmi*	2E-2
1435 - 1450	Effect of BaO Doping on Elastic, Optical and Structural Properties of (80-x)TeO_2-xBaO-20ZnO (x = 0, 5, 10, 15, 20 mol %) Glasses *Muliana Ismail*	2E-3
1450 - 1505	The Preparation and Physical Characteristic of Sm^{3+} doped Borotellurite Glass *Siti Nasuha Mohd Rafien*	2E-4
1505 - 1520	Physical and structural properties of antimony-phosphate glass *Soham Younis Moustafa*	2E-5
1520 - 1535	Spectral modification of Er^{3+}/Au doped zinc-sodium tellurite glass *Asmahani Awang*	2E-6
1535 - 1550	**BREAK & POSTER EVALUATION**	

SESSION 3: 1550 – 1705

Time	Title & Presenter	Code
[illegible] - 1610	Effect of Particles Size and Volume Fraction Concentration on the Thermal Conductivity and Thermal Diffusivity of Al_2O_3 Nanofluids Measured Using Transient Hot –Wire Laser Beam Deflection Technique *Wan Mahmood Mat Yunos* (INVITED)	3A-1

DEPOSITION OF ALUMINIUM NITRIDE THIN FILM ON KAPTON FILM USING SPUTTERING METHOD

*NurFahana Mohd Amin**, *Ooi Poh Kok* & *Ng Sha Shiong*

Nano-Optoelectronics Research and Technology Laboratory, School of Physics, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia.
*annanur252@yahoo.com

Many attempts have been made to deposited aluminium nitride (AlN) thin film by using sputtering method on flexible substrates. Deposition of AlN thin film on kapton film can potentially be used for development of flexible electronics and lab-on-chip systems. In this study, AlN thin films grown on the kapton film using radio-frequency sputtering method were explored. The AlN thin films were deposited by reactive RF sputtering of a pure aluminium target (99.999%), in an argon and nitrogen atmosphere. The surface morphology and structural properties of the deposited thin films were investigated by field-emission scanning electron microscope; atomic force microscopy energy, dispersive X-ray spectroscopy and X-ray diffraction; while the optical properties of the deposited thin films were determined by using Fourier transform infrared spectrometer and Raman spectrometer.

[illegible]CESSING AND PROPERTIES OF RECYCLED COLOURLESS SODA–LIME–SILICA GLASSES CONTAINING ZnO, PbO AND Al_2O_3

*Sidek Ab Aziz**, *Mohd Hafiz Mohd Zaid*, *Khamirul Amin Matori*, *Siti Syuhaida Abdul Rashid*, *Nuraidayani Effendy* & *Nadiah Shahirah Shahidan*

[illegible], Ceramic and Composites Research Group, Department of Physics, Faculty of Science Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
*sidek@upm.edu.my

[illegible] reports the preparation of recycled colorless soda-lime-silicate glass (SLS) containing [illegible] and Al_2O_3 via rapid melt quenching technique. SLS glasses have been known for their high [illegible]perties, good and acceptable mechanical and chemical properties. Also, they have been [illegible]ion-sensitive dosimeter, especially glasses doped with transition metal ions or rare earth [illegible]sses are attractive materials for the fabrication of low cost integrated optical amplifiers, [illegible]mercial tableware and sheet glasses. To understand the role of such oxides in this SLS [illegible], the density and molar volume of each glass series were extensively studied. The [illegible] of each glass series were determined by the Archimedes method with acetone as buoyant [illegible] their molar volume was computed from the molecular weight (M) and density (ρ). To [illegible]phous state, the X-ray diffraction analysis was carried out for each glass sample by [illegible]er-controlled X'pert Pro Panalytical system. The chemical composition of the each [illegible] determined using the Energy Dispersive X-ray Fluorescence (EDXRF). The results [illegible]ensities of the glass samples increased as the ZnO, PbO and Al_2O_3 weight percentage [illegible] molar volume of the each glass series shows the same tendency as the density: the [illegible]creased as the ZnO, PbO and Al_2O_3 contents are added into the SLS glass networks. [illegible] densities and molar mass of each glass series is mainly ascribable to their molecular [illegible]ements.

Deposition of aluminium nitride thin film on kapton film using sputtering method

NurFahana Mohd Amin*, Lee Zhi Yin, Fong Chee Yong, Ooi Poh Kok, Ng Sha Shiong#

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Keywords: Aluminium nitride, Sputtering, Thin film.

Abstract: Many attempts have been made to deposited aluminium nitride (AlN) thin film by using sputtering method on flexible substrates. Deposition of AlN thin film on kapton film can potentially be used for development of flexible electronics and lab-on-chip systems. In this study, AlN thin films grown on the kapton film using radio-frequency sputtering method were explored. The AlN thin films were deposited by reactive RF sputtering of a pure aluminium target (99.999%), in an argon and nitrogen atmosphere. The structural and surface morphology properties of the deposited thin films were investigated by X-ray diffraction , field-emission scanning electron microscope and dispersive X-ray spectroscopy; while the optical properties of the deposited thin films were determined by using Fourier transform infrared spectrometer.

Introduction

Aluminium nitride (AlN) have attracted great interest because of their appealing properties with a wide band gap (6.2eV), high hardness and high thermal conductivity [1]. Moreover, AlN also possesses properties like high resistivity, excellent chemical stability and low dielectric constant [2]. AlN films have received considerable interest as promising candidates in electronic materials for thermal dissipation, dielectric and passivation layers [3]. Its ultrahigh band-gap makes AlN an especially key material for applications in the microelectronic and optoelectronic devices such as ultraviolet detector, light emitting diodes, thermal conductor, buffer layer for GaN and ZnO due to the same wurtzite crystal structure and close lattice parameter [4] and piezoelectric materials in surface acoustic wave devices [5]. In addition to this, thermal and chemical stability of AlN films make it suitable for applications in difficult environment.

There are many techniques for growing AlN films on various substrates, such as metal organic chemical vapor deposition [6], plasma-assisted molecular beam epitaxy [7], pulsed laser deposition [8], and RF reactive sputtering [9]. The flexible substrates such as kapton films that have advantages over those on rigid substrates as they are robust, light weight, low cost and are able to absorb mechanical stress. However, growth of AlN on flexible substrates is very different from that on rigid substrates due to temperature limitations, differences in thermal expansion coefficient, and amorphous state of the polymer substrates, thus presenting a technological challenge to deposit high-quality AlN films on flexible substrates [10]. Although some effort has been made to fabricate AlN thin film-based devices on polymer substrates, the research is at a very early stage.

In this paper, the AlN films were deposited on Kapton polymide film substrates by RF reactive sputtering. The the structural and surface morphology properties of the deposited thin films were determined by using by X-rays diffraction (XRD), field-emission scanning electron microscope (FESEM) and energy dispersive X-rays spectroscopy (EDX) and while optical properties of the thin films were investigated Fourier transform infrared (FTIR) spectrometer.

Experimental Details

The AlN thin films were prepared by RF reactive magnetron sputtering from an aluminum target of 99.99% purity in high purity argon and nitrogen gas mixture. AlN films were deposited onto Kapton polymide film at room temperature (RT) and substrate temperature at 200 °C. The base pressure in the reactor chamber was less than 2×10^{-3} Pa. The applied power was kept constant at 250 W and working pressure was 8.12×10^{-2} Pa. The deposition parameters of AlN films are summarized in Table 1. The structural properties of the thin films were investigated by XRD (PANalyticalX'Pert Pro MRD) with a Cu-kα_1 radiation source (λ=1.5406Å) whereas the surface morphology and elementary analysis the thin films were examined by FE-SEM and EDX (NOVA NANO SEM450). The optical properties of the deposited thin films were determined by using a FTIR spectrometer (Spectrum GXFT-IR, Perkin-Elmer) .

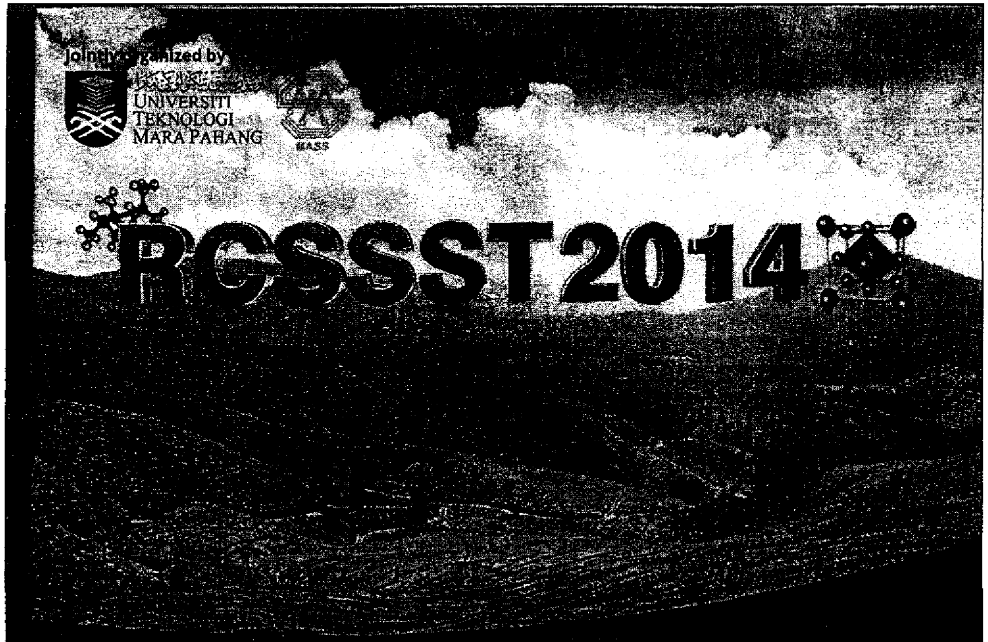
Table 1 Deposition parameters of AlN films.

Al target (purity)	99.99%
RF power (W)	250
Base pressure	Less than 2×10^{-3} Pa
Substrate	Kapton polymide film
Working pressure	8.12×10^{-2} Pa
Substrate temperature	Room temperature, 200 °C

Results and Discussion

Fig. 1 shows XRD pattern of AlN films deposited on Kapton polymide films at room temperature and 200 °C. For thin film deposited at room temperature only peak Kapton polymide film was shown. It has been shown that, for sample at 200 °C, only the low intensity (100) reflection of wurtzite hexagonal phase of AlN was found with an appreciable amount of shift. This may be due to poor crystallinity of films with large amount of stress present, probably due to the low deposition temperature and sputtering power.

Fig. 2 shows the FESEM images of the deposited AlN films at room temperature and 200 °C. It can be seen that at room temperature, the deposited AlN thin film showed a smooth and uniform surface. With the increase of the substrate temperatures at 200 °C [Fig. 2(b)], its exhibited densely packed grains. Besides that, it shows a pebble-like structure. A similar morphology was also observed in other works [11]. In addition, the grain size increases obviously. It is attributed to the improved surface mobility of the adatoms caused by increasing the substrate temperature [2]. These images showed that the application of growth temperature has a significant influence on the surface morphology of the synthesized films.



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41	Zinc Oxide Microrod and Poly(3-Dodecylthiophene) with Melastoma Malabathricum Dye for Hybrid Solar Cell *Hasiah Salleh*	PG-1
42	Fabrication of Novel Spinel Oxide ZnV_2O_4 Nanostructures and their Energy Storage Properties *Faheem K. Butt*	PG-2
43	The Effect of Salt Concentration in Filler Modified PMMA/ENR 50/$LiCF_3SO_3$ Electrolyte *Nunshaimah Salleh*	PG-3
44	Ti doped $LiMn_{1/3}Co_{1/3}Ni_{1/3}O_2$ for Li-ion battery application *Kelimah Anak Elong*	PG-4
45	Utilization of Natural Pigment Extracted from Downy Rose Myrtle Berries as Sensitizer in Dye Sensitized Solar Cell *Norlaily Abdul Rashid*	PG-5
46	Zinc Oxide Microrods and Poly (3-Dodecythiophene)-P3DT with Chlorophyll (Algae) for A Hybrid Solar Cell *Azhar Mohd Sinin*	PG-6

27 NOVEMBER 2014
SESSION 2: 0830 – 1630
VENUE: BALLROOM

No	Title & Presenter	Code
1	Characterizations of MWCNTs Purified by HNO_3:HCl Treatment *Noorezal Atfyinna Mohd Napiah*	PH-1
2	Iron (III) Oxide-Carbon Nanotube Nanocomposite Catalyst in Transesterification of Coconut Oil for Biofuel Formulation *Nor Aziah Buang*	PH-2
3	Microstucture evolution of casting and semi solid A356 containing Sr *Anasyida Abu Seman*	PI-1
4	The Effect of Ta Content on Microstructure and Hardness Properties of $FeNiCrMnCoTa_x$ and $Al_{0.5}FeNiCrMnCoTa_x$ High Entropy Alloys *Siti Sarah Mohd Pauzi*	PI-2
5	Microstructure and Corrosion Properties of Friction Stir Welded Aluminum Alloy 5086 *Farhad Gharavi*	PI-3
6	Isolation of cellulose microfibrils/nanofibrils (CMNF) from pseudostems of banana plants (Musa acuminata) *Noriean Azraaie*	PJ-1

7	Pore Size Controlling of Sol-Gel Nano Biomaterial for Prostate Cancer Biosensor Applications *Mansoor Ani Najeeb*	PJ-2
8	Structural, Morphological and Optical Properties of Mg doped ZnO Nanocrystallites Growth by Aqueous Solution Method *Ruziana Mohamed*	PJ-3
9	Isolation of Microfibrillated Cellulose (MFC) from Local Hardwood Waste, Resak (Vatica spp.) *Nurul Aimi Mohd Zainul Abidin*	PJ-4
10	Optical, Thermal And Dielectric Studies of Silver-Silica Nanoparticles Synthesized Via Sol-Gel Technique *Taifunisyam Taib*	PJ-5
11	Effect of Carbon Nanotubes on Nanocomposite from Nanofibrillated Cellulose *Nur Shazana Atiqa Mohd Zamri*	PJ-6
12	Nb_2O_5 3D Novel Hollow Hierarchical Structures Optical and Efficient Photocatalytic Properties *Faryal Idrees*	PJ-7
13	Effect of Annealing on Structure and Morphology of Poly(vinylidene fluoride) Thin Films for Sensor Application *Ibtisam Yahya Abdullah*	PK-1
14	Effect of Potential on Electrodeposited ZnO Thin Film *Yusran Sulaiman*	PK-2
15	Radio-frequency Sputtering Growth of Indium Nitride Thin Film on Flexible Substrate *Lee Zhi-Yin*	PK-3
16	Effect of Post-deposition Annealing Process on the pH Sensitivity of Spin-coated Titanium Dioxide Thin Film *Rohanieza Abdul Rahman*	PK-4
17	Annealing Temperature Dependence of Spin-coated Titanium Dioxide Thin Films for pH-sensing *Khairul Aimi Yusof*	PK-5
[illegible]	Characterization and Optical Properties of Ionophore Doped Chitosan Sensor Thin Film *Yap Wing Fen*	PK-6
[illegible]	Preparation and Properties of ZnO Microstructures by Electrochemical Method *Chuah Lee Shiang*	PK-7
[illegible]	Selective Deposition of Palladium Nanoparticles on Nickel Film via Chronopotentiometry Technique *Nur Ubaidah Saidin*	PK-8

RADIO-FREQUENCY SPUTTERING GROWTH OF INDIUM NITRIDE THIN FILM ON FLEXIBLE SUBSTRATE

Lee Zhi-Yin, Siti Aisyah Binti Osman, Fong Chee Yong and Ng Sha Shiong*

Nano -Optoelectronics Research and Technology Laboratory, School of Physics, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia.
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The study signifies the radio-frequency (RF) sputtering growth and characterizations of indium nitride (InN) thin films deposited on flexible substrate. A 3 inch diameter indium (In) sputtering target with purity of 99.999% was used. To enhance the crystallinity of the as-prepared samples, the heat treatment under ammonia gas ambient was carried out. The structural and optical properties of both the as-prepared and the treated samples were examined by using atomic force microscopy (AFM), field-emission scanning electron microscopy (FESEM), X-ray diffraction (XRD) as well as Fourier transform infrared (FTIR). All the results revealed that structural and optical properties of the treated sample were significantly improved as compared to the as-prepared sample.

EFFECT OF POST-DEPOSITION ANNEALING PROCESS ON THE pH SENSITIVITY OF SPIN-COATED TITANIUM DIOXIDE THIN FILM

Rohanieza Abdul Rahman[1], Sukreen Hana Herman[1,2] and Wan Fazlida Hanim Abdullah[3]*

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This paper presents an investigation on titanium dioxide (TiO_2) thin film, which is used as sensing membrane for Extended-Gate Field Effect Transistor (EGFET) for pH sensing application.TiO_2 thin films were deposited using sol-gel spin coating method on indium tin oxide (ITO) substrates. After the deposition, the thin films were annealed at 300 °C for 10 and 15 min, while another sample was annealed at 400 °C for 15 min. The sensitivity measurement was taken using the EGFET setup equipment with constant-current (100 μA) and constant-voltage (0.5 V) biasing interfacing circuit. TiO_2 thin film as the pH-sensitive membrane and the working electrode, was connected to a commercial metal-oxide semiconductor FET (MOSFET) . The MOSFET then was connected to the interfacing circuit. The sensitivity of the TiO_2 thin film towards pH buffer solution was measured by dipping the sensing membrane in pH4, pH7 and pH10 buffer solution. For comparison, a sample of bare-ITO was also tested to see its sensitivity. We found that the TiO_2 thin film annealed at 400 °C for 15 min gave the highest sensitivity compared to other annealing conditions and also compared to the bare ITO substrate with the value of 44.30 pH/mV. This showed that TiO_2 thin film can be used for pH sensing and the post-deposition treatment of the thin film can influence the sensing ability. We also measured the TiO_2 thin films' current – voltage (I-V) characteristics. Relating the *I-V* characteristic of the thin films and sensitivity, the sensing membrane with higher conductivity gave better sensitivity.

Radio-frequency Sputtering Growth of Indium Nitride Thin Film on Flexible Substrate

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Keywords: Flexible substrate, Indium nitride, Radio-frequency sputtering.

Abstract. The study signifies the radio-frequency (RF) sputtering growth and characterizations of indium nitride (InN) thin films deposited on flexible substrate. A three-inch diameter indium (In) sputtering target with purity of 99.999% was used. The deposition was carried out at room temperature and with substrate temperature 200 °C. The surface morphology, structural and optical properties of the deposited thin films were examined by using field-emission scanning electron microscopy (FESEM), energy dispersive spectroscopy (EDS), X-ray diffraction (XRD) as well as Fourier transform infrared spectroscopy (FTIR). All the results revealed that InN thin films have been deposited successfully on the flexible substrates in the ratio argon and nitrogen atmosphere.

Introduction

The unique characteristics of III-nitride group compounds have attracted the research interest of the researchers. Among the most challenging is indium nitride (InN), which has the properties included high equilibrium nitrogen vapor pressure, difficult to prepare in stoichiometric form, large lattice mismatch between the film and substrate, as well as the low dissociation temperature [1, 2]. The growth of InN thin film is strongly dependent on the growth parameters, and thus, the suitable condition for the deposition is very stringent. Despite, researchers are working hard in finding a promising method to grow good quality InN thin film owing to its unique properties and applications. The corporation of InN and its alloys with gallium nitride and aluminium nitride has allowed the extension of light emission from ultraviolet to infra-red region [3]. Besides, InN is a potential III-nitride element to be involved in the development of high efficiency low cost solar cell, laser diode and high frequency transistor operating at high power and temperature, as to improve the conventional semiconductor technology. In addition, it has been used as a low resistivity layer that assists ohmic contact formation to other wide band gap nitrides [4].

Various sophisticated growing methods included molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) have been adopted to produce high quality InN thin films [2, 5]. It is surprisingly that the films as grown by these advanced growing methods exhibit the low band gap energy at about 0.7 eV [6, 7]. However, the mentioned deposition methods are expensive and high maintenance cost. A relatively low cost technique yet effective technique, namely radio-frequency (RF) sputtering has been suggested. In the past, most of the researches are highlighted on the growth of InN thin films on silicon substrates [8, 9]. In recent, Amirhoseiny et al. has performed the deposition of InN thin film on silicon substrate with various orientations as well as etched substrate [10]. Besides, Qian et al. has successfully grown InN thin film on gallium arsenide (111) substrate for the application as plasma filter [11].

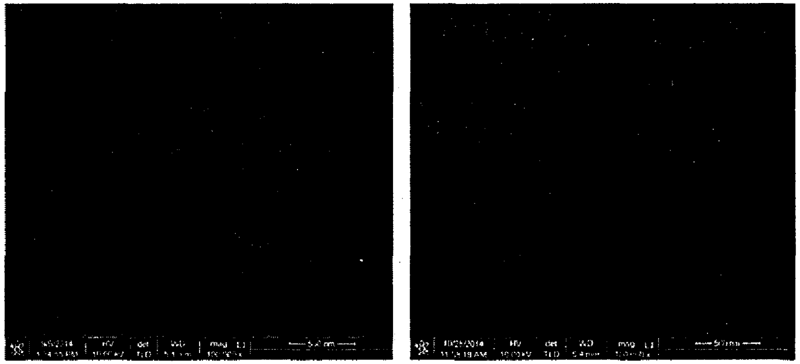
To date, there is still less research has been carried out on the use of flexible substrate. Despite, the flexible substrate is becoming the preferred substrate for macroelectronic applications because of the light weight, flexibility and low cost [12]. Zoita et al. has conducted a study by depositing InN thin film on flexible substrate with an intermediate aluminium nitride nucleation layer by using RF sputtering technique [13]. The work revealed that the high purity InN (002) with wurtzite structure can be obtained in a nitrogen atmosphere at 0.6 Pa and 0.8 Pa. In present work, kapton polyimide has been selected as the flexible substrate for the growth of InN thin films in the ratio argon and nitrogen atmosphere by using RF sputtering method. The surface morphology, structural and optical properties of the deposited thin films are investigated through various characterization techniques such as field-emission scanning electron microscopy, energy dispersive spectroscopy, X-ray diffraction as well as Fourier transform infrared spectroscopy.

Experimental details

In this project, InN thin films were deposited by radio-frequency sputtering of a three-inch diameter indium (In) sputtering target with the purity 99.999% in argon (Ar) and nitrogen (N) atmosphere. The kapton polyimide substrates were cleaned by ultrasonic agitation with ethanol for 15 minutes and later, rinsed with acetone as to remove the possible surface contamination before putting in the substrate holder for deposition. Before the deposition process, the In target was cleaned with a five minutes pre-sputter by Ar plasma. The RF power and gas ratio of $Ar:N_2$ gas were kept at 50 W and 30:70, respectively. The growth processes were performed in the conditions of room temperature and with substrate temperature at 200 °C. InN thin films with the thickness of about 500 nm were deposited. Finally, various characterization techniques were carried out to investigate the surface morphology, structural and optical properties of the deposited thin films.

Results and discussion

The surface morphology, structural and optical properties of the deposited thin films by using RF sputtering at room temperature and with substrate temperature 200 °C were investigated. Figure 1 illustrates the FESEM images of the deposited InN thin films on kapton polyimide substrates at room temperature and with substrate temperature 200 °C. These images showed that the application of growth temperature has a significant influence on the surface morphology of the synthesized films. Although the surface of the film as deposited at room temperature exhibited densely packed grains, it appeared to have inconsistent grain sizes; while the film as deposited at 200 °C appeared to have smoother and consistent nanostructure.



(a) (b)

Figure 1: FESEM images of InN thin films deposited on kapton polyimide substrates at (a) room temperature and (b) with substrate temperature 200 °C.

ABSTRACT

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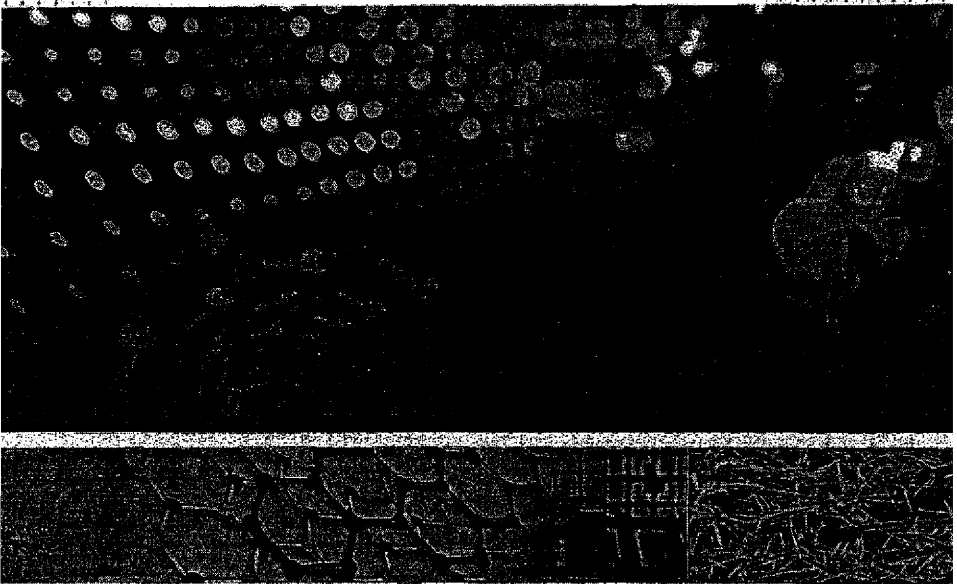

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PROGRAMME

7th April 2014, INFORMM Auditorium Room

Time	Programme	Chairperson
0800-0830	Registration	
0830-1015	1st Session (Growth)	Dr. Ng Sha Shiong
1015-1030	Welcoming Speech & Photo Session	Prof. Dr. Zainuriah Hassan
1030-1045	Tea Break	
1045-1300	2nd Session (Growth)	Dr. Naser Mahmoud Ahmed
1300-1400	Lunch	
1400-1545	3rd Session (Device)	Assoc. Prof. Dr. Mutharasu Devarajan
1545-1600	Tea Break	
1600-1700	4th Session (Device)	Dr. Shanmugam Subramani
1700-1730	Closing Ceremony	

ORAL PRESENTATION

SESSION 1 (GROWTH)		
CHAIRPERSON: DR. NG SHA SHIONG		
0830-0845	GR/01	**Suzuka Nishimura** Growth of Zinc-blende InGaN/GaN on Silicon Substrate
0845-0900	GR/02	**C. W. Chin** Self-assembled $In_{0.5}Ga_{0.5}N$ Quantum Dots Grown by Plasma-assisted Molecular Beam Epitaxy
0900-0915	GR/03	**M. E. A Samsudin** Reduction of Defects Density in GaN Layer Grown by Simpler and Low-cost Effective Technique via Radio-frequency Sputtering
0915-0930	GR/04	**Yusnizam Yusuf** Effect of Target-substrate Distance on Properties of Aluminum Nitride Grown on Silicon (111) Substrate by RF Magnetron Sputtering
0930-0945	GR/05	**Q.N. Abdullah** Synthesis of InGaN Nanostructures Grown on Si via Chemical Vapor Deposition
0945-1000	GR/06	**M. Alizadeh** Effect of Thermal Conductivity of Substrate on Crystallinity of AlN Thin Films Deposited by Plasma Assisted-hot Filament Chemical Vapor Deposition Method
1000-1015	GR/07	**M.Z. Mohd Yusoff** MBE Growth of Aluminum Nitride Heterostructures Grown on Si (111) Substrate
1015-1030	**Walcoming Speech & Photo Session**	
1030-1045	**TEA BREAK**	

MNRG 1st Meeting of Malaysia Nitrides Research Group (MNRG)
7th April 2014

SESSION 2 (GROWTH)		
CHAIRPERSON: DR. NASER MAHMOUD AHMED		
1045-1100	GR/08	**M. Ikram Md Taib** Deposition and Fabrication of GaN on GaAs (100) Substrate via RF Sputtering
1100-1115	GR/09	**F. R. Wong** Electrodeposited GaN on Graphene on Insulator
1115-1130	GR/10	**A. Ariff** Improvement of Grain Coalescence in GaN/*m*-plane Sapphire Grown via RF Sputtering
1130-1145	GR/11	**Nur Fahana Mohd Amin** A Study of AlN Thin Film Deposited on Silicon Substrate by Spin Coating Method
1145-1200	GR/12	**S. N. Waheeda** Investigation of Hexagonal Inclusion in Thick and Bulk Cubic GaN
1200-1215	GR/13	**Lee Zhi-Yin** Growth and Characterizations of Indium Nitride Thin Film by Spin Coating Technique
1215-1230	GR/14	**Mohd Adreen Shah Azman Shah** Effect of DC Magnetron Sputtering on Aluminium Nitride (AlN) Thin Films
1230-1245	GR/15	**R. Radzali** Porous InAlGaN Prepared by Photoelectrochemical Etching
1245-1300	GR/16	**Beh Khi Poay** Characteristics of CVD Grown GaN Nanowires Under Different NH_3 Flow Rate
1300-1400	**LUNCH**	

A STUDY OF AlN THIN FILM DEPOSITED ON SILICON SUBSTRATE BY SPIN COATING METHOD

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Abstract

Aluminium nitride (AlN) was deposited on the atmospheric plasma treated n-type silicon [n-Si (100)] by using a versatile and cost effective method namely spin coating. Basically, the low cost spin coating technique which emphasized the production of a thin and uniform film on a flat substrate through a dilute solution is adopted. For the precursor preparation, the main ingredient of aluminium nitrate hydrate was dissolved with ethanol and diethanolamine. The prepared thin film was annealed at 650°C for 1 hour. Then, thin film was nitridated under a constant flow of highly pure ammonia for 1 hour at the temperature of 1100 °C. The surface morphology and structural properties of the deposited thin film were investigated by field-emission scanning electron microscope, dispersive X-ray spectroscopy and X-ray diffraction; while the optical properties of the deposited thin film was determined by using Fourier transform infrared spectrometer. All the results revealed that AlN thin film was successfully deposited on n-Si (100) substrate.

Keywords: AlN, Thin Film, Spin coating, Silicon.

Introduction

Aluminum nitride, an III-V family compound, has excellent combination of physical, chemical, and mechanical properties. AlN thin films have attracted great interest because of their appealing properties such as a wide band gap (6.2 eV) [1], high acoustic velocity [2] and high thermal conductivity (320 W/m·K) [3]. Besides that, AlN also have high electrical resistivity (10^{13} Ω cm), high refrective index (1.9-2.1 for polycrystalline films), high optical transmittance and good chemical stability [3]. Because of these excellent properties, AlN thin films have a great potential for microelectronic devices [1]. Apart from that, AlN is a group III-V semiconductor with a large optical band gap, which renders it a promising candidate for applications in high power/high frequency devices [4], optoelectronic devices, surface acoustic wave [5], optical devices and insulating layers [6]. Moreover, AlN also have been used as buffer layer for the growth gallium nitride [7] and zinc oxide.

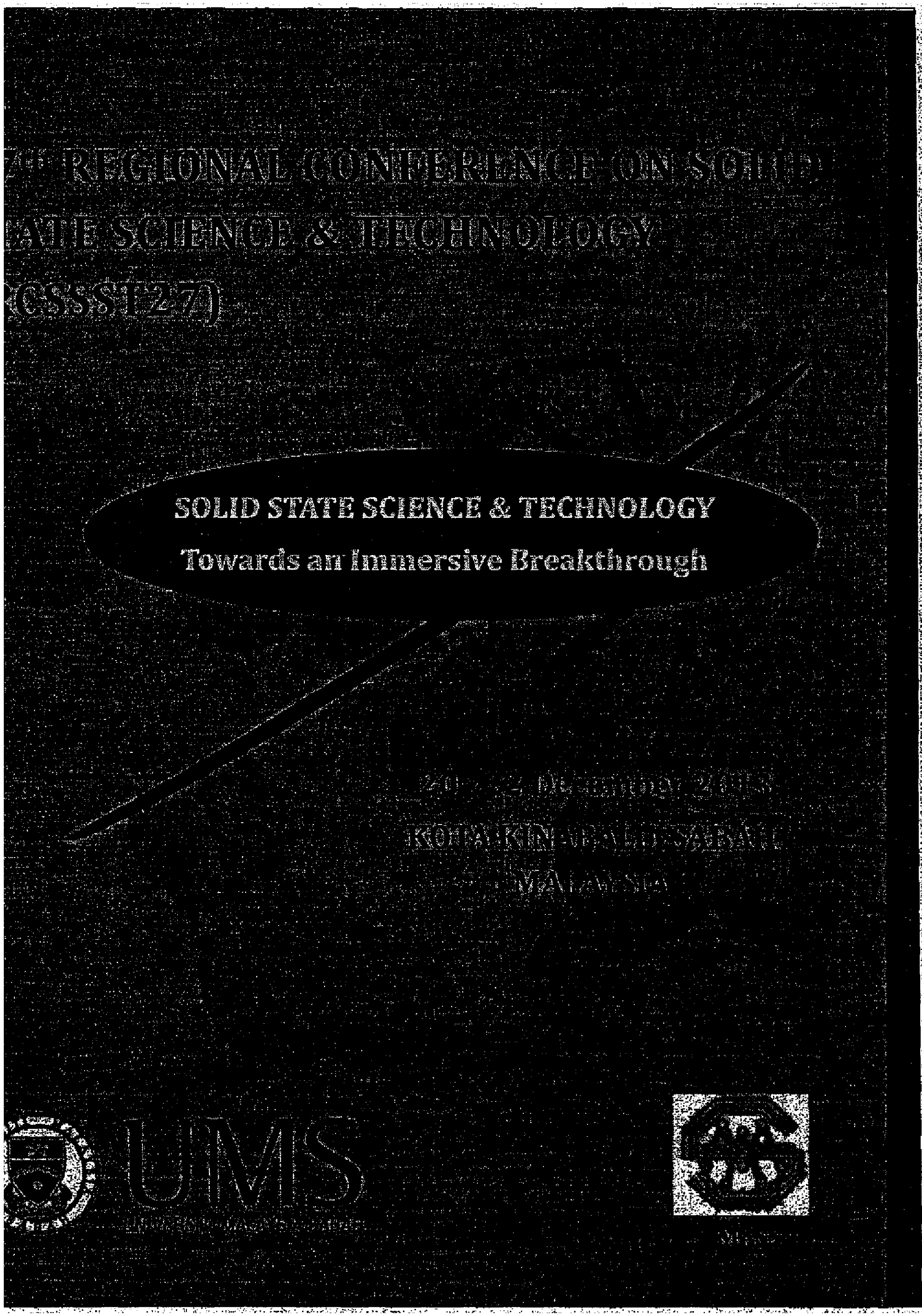
Many studies have reported on the deposition of AlN thin film using molecular beam epitaxy [8], pulsed laser deposition [9], dual ion beam sputtering system [10], metal-organic chemical vapor deposition[7] and radio-frequency sputtering [11]. However, the production cost prepared by the above methods is relatively high and the setup is complicated although the quality of AlN thin films is good. Thus, sol gel spin coating method was explored due to its low cost and easy to handle compared to above methods. Despite the simplicity of the method, less studies report on the growth of AlN thin film deposited using the spin coating method.

In this study, AlN thin film was deposited on n-type Si (100) substrate by spin coating method followed by the nitridation process. The surface morphology and structural properties of the thin film were investigated by field-emission scanning electron microscope (FESEM), energy dispersive X-ray (EDX), atomic force microscopy (AFM), and X-ray diffraction (XRD); while the optical property deposited of the thin film was determined by using Fourier transform infrared (FTIR) spectrocopy.

Experimental detail

Aluminium nitrate hydrate powder was used as a starting material. Ethanol and diethanolamine were used as solvent and stabilizer, respectively. First, aluminium nitrate hydrate powder was dissolved in the ethanol and DEA solution at room temperature. The precursor was stirred to yield a clear and homogeneous solution, which served as the coating solution. The atmospheric plasma was used to treat n-Si (100) substrate. The prepared solution was spin-coated on the substrate which was rotated at 3000 rpm for 30 s. Then, the film was soft baked on hot plate at 60 °C for few minutes. The spin-coating and soft baked processes were repeated a few times to achieve the desired total thickness. The thin film was inserted to a furnace and annealed at 650 °C for two hours. After the annealing process, the film was nitridated in the tube furnace at 1100 °C for one hour. The thin film was heated under a flow of ammonia (NH_3) gas. After the completion of the reaction, the furnace was allowed to cool down naturally to room temperature. During the cooling process, nitrogen gas was flowed in order to flush out the excess NH_3.

The surface morphologies of the thin film were examined by FE-SEM and EDX (NOVA NANO SEM450), AFM (Dimension EDGE, BRUKER), whereas the structural properties of the thin film was investigated by XRD (PANalyticalX'Pert Pro MRD) with a Cu-$K\alpha_1$ radiation source (λ=1.5406Å). The optical property of the deposited thin film was determined by using FTIR spectrometer (Spectrum GXFT-IR, Perkin-Elmer).



Programme and Abstract

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3C-2

THE STRUCTURAL AND OPTICAL CHARACTERISTICS OF POLYVINYLPYRROLIDONE DOPED WITH NANO CRYSTAL NaF FILMS

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The doped PVP with nanostructure NaF using different preparations such as a wet casting, quartz cell and spin -coating techniques with concentrations (0,2,4,6,8,10,12,14wt%) are achieved. The X – ray diffraction of the samples indicate that the pure PVP are amorphous in structure and the doped are polycrystalline for selective 4, 8, 12 and 14 wt% with nanocrystal grain size (30.10, 26.00, 22.86, 31.79 nm) respectively. It was observed that the amorphisation decreases with increasing NaF concentration. The Fourier Transform Infrared (FTIR) spectrometer measurements show that the stretching vibration in the oxygen containing chain polymer changes the covalent bond distribution with fluoride ion bonds that is the greatest. An increment of UV-Vis *absorption* has produced maximum peak absorbance spectra of different techniques at about 0.5 to 0.6 values with a high shifting in a casting method. The indirect Eg_{opt} of pure and doped PVP films were estimated to be decreased about 3.65, 3.57, 3.55, 3.45, 3.33, and 3.25 eV for indirect allowed transitions, whereas the indirect forbidden band gaps were determined as 3.52, 3.50, 3.41, 3.31, 3.18, and 3.13 eV with increase sodium fluoride contents respectively. The prepared samples appeared near band edge peak absorption at about 300 nm of different deposition, which is close to each other for bulk specimens (solution), shifting at higher frequencies.

3C-3

ATTENUATED TOTAL REFLECTION STUDIES OF HONEYCOMB NANOPOROUS GaN THIN FILMS

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In this work, room temperature *p*-polarized infrared attenuated total reflection (ATR) spectroscopy is employed to characterize the characteristics of nanoporous GaN thin film with honeycomb structure. The obtained ATR spectrum is compared with the theoretical result simulated by the effective medium model. Good agreement is achieved between the measured and theoretical spectra. The porous layer thickness, porosity, and surface phonon polariton (SPP) resonance of nanoporous GaN thin film were unambiguously determined through ATR study. It was found that the SPP resonance is shifted toward lower frequency as compared to the as-grown GaN thin film.

3C-4

EFFECTS OF INDIUM TIN OXIDE THIN FILMS THICKNESS ON OPTICAL AND ELECTRICAL CHARACTERISTICS

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This report discussed on the indium tin oxide (ITO) thin films deposited on Si and glass substrates by radio frequency (RF) magnetron sputtering. The ITO transparent conductive oxide (TCO) thin films were prepared at different thicknesses under consistent sputtering conditions. The effects of film thicknesses on optical, electrical and morphological characteristics were investigated by means of UV-Vis spectrophotometer, Hall system and atomic force microscope (AFM), respectively. The light transmittance in visible spectrum is more than 80% for the thinnest film of 40 nm. Thickest film of 239 nm shows lowest resistivity and higher carrier concentrations of 8.6×10^{-4} Ωcm and 11.6×10^{20} cm^{-3}, respectively. From AFM analyses, surface roughness root-mean-square, *Rq* and peak-to-valley, *P-V* of the 40 nm films were measured as 0.44 nm and 0.58 nm, respectively. The results show that the smoothest film surfaces transmit more visible light than the rougher films.

RCSSST_P45

COMPARATIVE STUDIES ON THE MORPHOLOGY AND DIELECTRIC PROPERTIES OF NICKEL-ZINC FERRITE

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The dielectric properties of nickel-zinc ferrites may be affected by the method of preparation and micro-structural problems. Nickel-zinc ferrites were prepared via conventional method and sol-gel method. The sintered ferrites were characterized by X-Ray Diffraction (XRD), Atomic Force Microscope (AFM) and Agilent 4294A Precision Impedance Analyzer. The results showed that the dielectric constant and dielectric loss factor of all samples are frequency and temperature dependent. Sol-gel method produced smaller grain sizes of sample and lower value of the dielectric constant.

RCSSST_P46

THEORETICAL STUDIES ON OPTICAL PHONON AND SURFACE PHONON POLARITON OF WURTZITE AlInN ALLOYS

Pauline Yew*, Lee Sai Cheong, Ng Sha Shiong, Yoon Tiem Leong & H. Abu Hassan
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In the long wavelength limit, the behavior of infrared lattice vibration for mixed crystals aluminium indium nitride ($Al_xIn_{1-x}N$) is studied with a theoretical method based on modified random element isodisplacement (MREI) model and Born-Huang procedure. MREI model which considers the interactions between the nearest neighbor atoms is used to predict the composition dependence of longitudinal (LO) and transverse (TO) optical phonon frequencies. The oscillator strength and dielectric function which are the functions of phonon frequencies are obtained. For $Al_xIn_{1-x}N$ alloy, oscillator strength of its weak mode is sufficiently significant to be considered. Hence, $Al_xIn_{1-x}N$ is deduced to exhibit two-mode behavior. Dielectric functions for whole composition range ($0 \leq x \leq 1$) are calculated and are used to simulate characteristics of surface phonon polariton of the $Al_xIn_{1-x}N$ alloys.

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MORPHOLOGICAL AND OPTICAL PROPERTIES OF POROUS GALLIUM NITRIDE (GaN) FABRICATED BY PHOTOELECTROCHEMICAL PROCESS

CHEAH SOOK FONG

UNIVERSITI SAINS MALAYSIA

2015

MORPHOLOGICAL AND OPTICAL PROPERTIES OF POROUS GALLIUM NITRIDE (GaN) FABRICATED BY PHOTOELECTROCHEMICAL PROCESS

by

CHEAH SOOK FONG

Thesis submitted in fulfillment of the requirements for the degree of Master of Science

January 2015

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by

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