Process dependent strain behaviour, fractal analysis, and bonding network of nc-Si(SiC) thin films

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Research Article

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Abstract

Nanocrystalline silicon embedded silicon carbide, nc-Si(SiC) thin films were deposited on p-type silicon substrates by using a thermal chemical vapor deposition (CVD) with different process temperatures varied from 700-1000 °C. The SEM images reveal the Si particles are embedded with SiC thin films. The estimated lattice-strain of nc-Si(SiC) thin films from Williamson-Hall and Scherer formula was varied from 0.00227 to 0.00469 and 0.000855 to 0.00574 respectively. The Raman signature at 1346.19 cm$^{-1}$, 1491.78 cm$^{-1}$ and 1570.94 cm$^{-1}$ bonding correspond to D, G-Si and G peaks respectively. The estimated band gap from Tauc's plot of nc-Si(SiC) thin films are 3.17 to 2.87 eV respectively with increasing of process temperature. The observed crystalline size of nc-Si in nc-Si(SiC) is from 21 nm to 27 nm from 700 to 1000 °C respectively. The possible bonding network of core-orbital of Si(2p), C(1s), and O(1s) in the C: ZnO thin films have been discussed by deconvolution with the Origin 2018.

1. Introduction

Due to the quantum size effect, quantum-confined silicon dots have been proven to be able to tune the bandgap in a wide range by controlling the dot size. Hence, the absorption of the limit of nano-Si embedded a-SiC: H is an important material for photovoltaics and light-emitting diode applications [1]. However, the real challenge in the ncSi-based technology development is the realization of proper tuning of the material nanomorphology which was synthesized by annealing of silicon-rich amorphous material and various chemical vapor techniques [2, 3, 4, 5, 6, 7]. Parida et al. synthesized 3C-SiC nanoparticles in the Si solar cell prepared by PECVD and investigated that the nc-Si reduces the reflection of light from the surface [8]. Ji et al. investigated high conducting nc-Si(SiC) enhances the optical properties and obtained carrier mobility 630 s/cm [9]. Swain et al. were studied in structural properties of nc-Si(SiC) deposited by hot-wire chemical vapor deposition. Here, we compare to analyze crystallite size among small-angle x-ray diffraction, Raman scattering, and X-ray diffraction of nc-Si embedded in the SiC matrix [2]. Kole et al. investigated oxidized Si nanocrystal embedded with SiC matrix [10]. Kim et al. investigated photoluminescence of nc-Si(SiC) thin films were observed 500–650 nm thickness, which is a tribute quantum confinement of hexagonal crystal structure [11]. Leoper et al. investigated silicon nanocrystals embedded in silicon carbide and its charge carrier transport and recombination process [12]. Park et al. investigated quantum confinement in a-Si quantum dots embedded in the SiN network [13, 14]. Yamada et al. investigated hydrogen plasma treatment for reducing defects in silicon quantum dot superlattice structure with amorphous silicon carbide matrix [15]. Kurokawa et al. investigated the preparation of nc-Si in an amorphous silicon carbide matrix [16]. Song, et al. investigated the structural characterization of annealed Si$_{1-x}$C$_x$/SiC multilayers targeting the formation of Si nanocrystals in a SiC matrix [17]. Song, et al. investigated structural and electronic properties of Si nanocrystals embedded in amorphous SiC matrix [18, 19]. Summonte et al. investigated silicon nanocrystals in carbide matrix. [20], M. Künle, et al. investigated annealing of nm-thin Si$_{1-x}$C$_x$/SiC multilayers [21]. Künle, et al. investigated structural and optical transformations during thermal annealing of Si-rich a-SiC:H thin films [22]. Canino et al. investigated identification and tackling of a parasitic surface compound in SiC and Si-rich carbide films.
[23]. P. Löper, et al. investigated quasi-Fermi-level splitting in ideal silicon nanocrystal superlattices [24]. Generally, nc-Si(SiC) were synthesized by post-annealing of silicon-rich SiC thin films prepared by various deposition techniques. However, in the present scenario, the nc-Si powder was directly taken as precursor materials.

In the article, we emphasized the (a)morphology and fractal dimension of nc-Si(SiC) thin films, (b) comparative lattice-strain study of nc-Si(SiC) estimated from W-H formula and Scherer formula, (c) investigation of structural and vibrational properties of nc-Si(SiC) and (d) electronic environments of nc-Si(SiC) with deferent CVD process temperature.

2. Experimental Details

2.1. Synthesis

The nc-Si(SiC) thin films were deposited on a p-type Si(100) substrate by an LPCVD system. The substrates were cleaned using an ultrasonic treatment in acetone, etched by a 2% hydrogen fluoride solution, rinsed in deionized water, and dried on N₂ gas before loading into the CVD system. Thereafter, the cleaned Si substrate was placed inside an APCVD using Si powder, C₂H₂, and H₂ as the precursor gas. In our deposition process, C₂H₂ and H₂ (100sccm) flow rates were fixed but the processing temperature is varied from 700°C to 900°C. After deposition, the samples were handled carefully to avoid moisture and oxidation from the environment. Deposition parameters are given in Table 1. The structural property and bonding configuration of the ncSi-SiC films were characterized using X-ray diffractometry (XRD), Fourier transfer infrared absorption spectroscopy (FTIR), and X-ray photoelectron spectroscopy (XPS). The microstructure of SiC thin film was observed by a scanning electron microscopy (SEM, JEOL-JEM-3000F). The Raman spectrum was recorded at room temperature with an optical microscope using the 488 nm excitation line of an Ar + laser as an excitation source. The spectral resolution was set as 1 cm⁻¹, acquisition time 10s, and laser power 3 mW. The elemental and composition analysis was carried out by XPS using non-monochromatic Mg Kα X-ray radiation (hν = 1253.6 eV). The full width at half maxima (FWHM) and the binding of core orbital spectra were fitted and manipulated to extract the information of the nc-Si(SiC) thin film. The IR spectra were recorded using a Perkin Elmer model (Spectrum Two) with a resolution of 1 cm⁻¹ in the range of 500–4000 cm⁻¹. The FTIR spectrum of the substrate was recorded as a reference and finally normalized with the FTIR spectrum of the silicon substrate to yield the spectrum of the µc-SiC: H thin film.
### Table 1
Different fractal dimension regions estimated from different regions

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Power spectral density function</th>
<th>Partition Function</th>
<th>Triangular Counting</th>
<th>Cube counting</th>
</tr>
</thead>
<tbody>
<tr>
<td>700°C</td>
<td>(i) region: -0.487 (ii) region: -1.695 (iii) region: -1.618</td>
<td>(i) region: 1.238 (ii) region: 0.385</td>
<td>(i) region: 0.487 (ii) region: 0.273</td>
<td>2.315</td>
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<tr>
<td>800°C</td>
<td>(i) region: -0.642 (ii) region: -2.044 (iii) region: -1.716</td>
<td>(i) region: 1.136 (ii) region: 0.515</td>
<td>(i) region: 0.454 (ii) region: 0.194</td>
<td>2.273</td>
</tr>
<tr>
<td>900°C</td>
<td>(i) region: -0.549 (ii) region: -1.988 (iii) region: -1.657</td>
<td>(i) region: 1.293 (ii) region: 0.469</td>
<td>(i) region: 0.528 (ii) region: 0.209</td>
<td>2.311</td>
</tr>
<tr>
<td>1000°C</td>
<td>(i) region: -0.529 (ii) region: -1.669 (iii) region: -1.625</td>
<td>(i) region: 1.209 (ii) region: 0.452</td>
<td>(i) region: 0.536 (ii) region: 0.217</td>
<td>2.330</td>
</tr>
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</table>

### Table 2
Calculated Crystallite size from (111), (220) and (311) planes and micro-strain calculated from Williamson – Hall and Scherer formula

<table>
<thead>
<tr>
<th>Process Temperature (°C)</th>
<th>The crystallite size (nm)</th>
<th>Lattice-Strain</th>
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<td>(111) (220) (311) Williamson – Hall</td>
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<tr>
<td>1000</td>
<td>28.25 27.51 14.02 40.76</td>
<td>0.00469</td>
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</table>

### 3. Results And Discussion

#### 3.1: Surface morphology

Fig.1 shows the surface morphology of thenc-Si(SiC) films grown at various temperatures (700—1000°C) by a CVD reactor. The grain size of the nc-Si(SiC) thin films was 296.7 nm, 326.7 nm, 324.6 nm, and 447.9 nm for the process temperature varied from 700-1000°C. The RMS surface roughness of nc-Si(SiC) thin films is 195.2 nm, 247.9 nm, 222.8 nm, and 360.4 nm from 700 to 1000°C respectively. However, the SEM grain size is much larger than the XRD crystallite size [2].

#### 3.2 Fractal dimension of nc-Si(SiC) surface
The fractal dimensions of nc-Si(SiC) thin-film surfaces were determined by Gwyddion software with Fourier analysis (power spectrum distribution, partitioning) and the box-counting (cube counting and triangulation methods) respectively. Fig. 2(a) shows the log W(k) vs log (k) plot of nc-Si(SiC) thin films with different process temperatures from 700 to 1000°C. The slope of log W vs. log k has three regions.

Fig. 2(a) shows a log-log plot of power spectral density function (PSDF) with the frequency of surface morphology of nc-Si(SiC) thin films with different process temperatures from 700 to 1000°C. The PSD plots of nickel thin films were considered using the k-correlation model by the k-correlation model for the auto-covariance function $PSD_{ABC}$ for spatial frequency $f$, is given by [25]

$$PSD_{ABC} = \frac{A}{(1 + B^2 f^2)^{\left(\frac{c+1}{2}\right)}}$$  

A obtained at low spatial frequencies that depends to height of rough surface. B represents the slope of a connecting line between two points on the surface. In fact, A and C represents the mean grain size and the slope of the linear part of the PSD plot at high special frequencies, which is greater than 2. The slope of regions (i), $0<\log k<2$ indicated in the intensity of log W(k) for 1000°C is higher than deposited at 700°C, indicated the grain size of nc-Si(SiC) prepared at 1000°C are larger on compared to 700°C or, the nc-Si(SiC) deposited at 1000°C is less thick than the nc-Si(SiC) deposited at 700°C. The (ii) region, $2<\log k < 4$ indicated the new grain distribution smaller than the region (i) associate with the SEM images. The morphology further analyzed by Hurst exponent (H) express as

$$H = \frac{\delta}{2} - 1$$  

H value is 0.532 for nc-Si(SiC) thin films and varied from 0.384 to 0.995 for nc-Si(SiC) thin films. This indicated increasing of the correlated surface with increasing of nc-Si(SiC) thin films with increasing process temperature[25]. The fractal dimension of nc-Si(SiC) films with defined $(D_f=3-H)$ varied from 2.616 to 2.005 with increasing process temperature from 700 to 1000 °C. This indicated decreasing of irregular and fragmenting surface with increasing of process temperature.

If we assume the particle distribution in the SEM images are coalescence nc-Si(SiC) particles and defined by $S(h)=L^x(h)$

Where the positive slope represents the strong coalescence properties and the negative coalescence properties indicated isolation system. Fig. 2(c) shows a log-log plot of partition function as the function of the size of particle distribution in a fractal system is defined by

$$S(h) \propto h^{-a_1/2} \text{ for } 0 < a_1 < 1$$
consideras mass fractal

\[ S(h) \propto h^{-\alpha^2/2} \text{ for } 1 < \alpha^2 < 3 \] .........................................................(3)

where \( \alpha^2 = 2 \) consider as surface fractal in the SEM images

Fig. 2(c & d) shows square and triangular box-counting of undoped and nc-Si(SiC) thin films with different process temperatures from 700-1000 °C. The square and triangular fragment distribution defined

\[ D = \log_{10} N_{\text{square}} - \log_{10} N_{\text{triangular}} \] .........................................................(4)

The details of fractal behavior are shown in table 1.

Fig. 2(d) shows uniformity and the fractal dimension for the cube counting indicates a single slope varied from 2.273-2.330. However, Fig. 2(c) indicates two different fractal dimensions (i) higher slope region varied from 0.454-0.536 and (b) lower slope region which is parallel to the square segment region varied from 0.194-0.273.

3.3: Structural and lattice-strain

Fig. 3(a) shows the XRD pattern of a typical-Si(SiC) film grown on p-type Si(100) substrate at different processing temperatures from 700 to 1000 °C. The XRD planes at 28.66°, 47.66°, and 56.51° corresponding to the (111), (220), and (311) crystallographic planes in the nc-Si(SiC) thin films respectively. The calculated crystallite sizes, D were calculated by a Scherer formula, \( D = 0.9l/b\cos \theta \) from 21 nm to 27 nm from 700 to 1000 °C respectively. The crystalline size of the films indicating multiphase thin films was formed in the SiC films. The ratios of reflection from different planes are shown in Fig.3 (b) \( I_{(220)}/I_{(111)} \) and \( I_{(311)}/I_{(111)} \) value varied between 0.35 and 0.25. Therefore, it is concluded that with an increase in processing temperature the incorporated carbon and hydrogen atom induce amorphization in the Si network due to local deformation caused by carbon and hydrogen atoms.

W-H plot for evaluating micro-strain

\[ \beta \cos \theta = K \lambda / D + 4 \varepsilon \sin \theta \] .........................................................(4)

Whereas evaluating micro-strain from Bragg's law

\[ \varepsilon \tan \theta = -\Delta \theta \] .........................................................(5)
Fig. 2(c) shows $Dq \cos q \text{ vs. } \sin q$ for n-nc-Si(SiC) with different processing temperatures from 700 – 1000 °C. The slope of Fig. 2(c) provides the lattice strain of the nc-Si(SiC) thin films. The $Dq$ is calculated concerning the planes peak 28.443, 44.303, and 56.123° corresponds to (111), (220), and (311) respectively [26]. The lattice strain of the nc-Si(SiC) monotonically increased from 0.000855 to increasing process temperature from 700 to 1000°C. The lattice strain calculates from the Scherrer formula is higher than the lattice strain estimated from the W-H equation.

Fig. 2(a) XRD spectra of nc-Si embedded on a-SiC: H thin films, (b) lattice strain of nc-Si(SiC) thin films, (c) Crystallite size, $I_{(311)}/I_{(111)}$, and $I_{(220)}/I_{(111)}$ with different processing temperature from 700-1000°C.

3.4: Chemical bonding of nc-Si(SiC)

The bonding configurations of the deposited nc-Si(SiC) thin films were investigated by FTIR spectroscopy. Fig. 3 shows the FTIR transmission spectra of nc-Si(SiC) thin films deposited on Si (100) substrates by the CVD method at different processing temperatures. Since the strongest absorption band from nc-Si(SiC) is observed in the range of 500 – 1200 cm$^{-1}$, therefore analysis of this band is the focus of the investigation. As seen from the FTIR spectra, the films deposited at process pressure atmospheric pressure shows the various transmission peaks centred at 652 cm$^{-1}$, 828 cm$^{-1}$, 872 cm$^{-1}$, 1015 cm$^{-1}$, 1043 cm$^{-1}$, 1128 cm$^{-1}$ and 1175 cm$^{-1}$[27-29]. The band at 652 cm$^{-1}$ corresponds to Si–H wagging or rocking mode matched with previous research groups [27] while the strong band at 780-800 cm$^{-1}$ corresponds to Si-C stretching mode [27,28]. However, we observed the SiC stretching vibration at 820-875 cm$^{-1}$ due to contaminating oxygen attached to SiC. These shifts in the vibrational band towards the higher values may be due to the increasing concentration of hydrogen in SiC thin films. Besides, shoulder at around 1015, 1043 cm$^{-1}$ is observed which could be attributed to the rocking and wagging mode of Si–CH$_n$ bonds [30]. The peaks at 1113 cm$^{-1}$, assigned to Si–O stretching vibration, are not associated with the presence of silicon oxide and are attributed to interstitial oxygen impurities dissolved in the Si(100) substrate [31]. Considering this aspect, we may conclude that most parts of the vibrational peaks shifted to higher values due to the presence of impurities such as oxygen and hydrogen.

3.5: Structural network of nc-Si(SiC)

Fig. 4 shows the Raman spectra of nc-Si(SiC) thin films with different process temperatures from 700 to 000°C in the range of 150-1850 cm$^{-1}$. The Raman spectra of nc-Si(SiC) can be classified into four regions (a) the signatures at 206.72 cm$^{-1}$ and 260.86 cm$^{-1}$ corresponds to n-(Si-C) and an-(Si-C) respectively, (b) the signatures at 439.66 cm$^{-1}$ to 514.5 cm$^{-1}$ corresponds to LO-(Si-Si) and TO-(Si-Si) respectively, (c) the TO and LO phonon peaks of Si-C bonding corresponding to 772.47 cm$^{-1}$ and 938.76 cm$^{-1}$ respectively and (d) 1346.19 cm$^{-1}$, 1491.78 cm$^{-1}$ and 1570.94 cm$^{-1}$ bonding corresponds D, G-Si and G peaks respectively. The defective carbon bonding, D and graphitic carbon bonding in the nc-Si(SiC) thin films. The main observations in the nc-Si(SiC) are the following (i) The relative intensity of n-(Si-C) to an-(Si-C) increased
with increasing of process temperature. (ii) The D peak intensity relative decreased with increasing of process temperature indicates the secondary phase Si attached to C bond increased.

3.6: Optical properties

As the both the Si and SiC are indirect semiconductor, the band gap can be determined as the Tauc plot is plotted $\left(a h n\right)^{1/2}$ vs $h n$ with different process temperature from 700 to 1000°C. Where $a$ is the absorption coefficient of the nc-Si(SiC) materials. Fig. 6 shows the square root of the absorption coefficient and Tauc plot with a photon energy of nc-Si(SiC) at various process temperatures from 700 to 1000°C. The absorption coefficient ($a$) of the nc-Si(SiC) thin films were calculated by

$$
\alpha \left( \text{cm}^{-1} \right) = \frac{-1}{t} \ln \left( \frac{1-R^2}{T} \right) \text{..................................................(6)}
$$

Where $R$, $T$ and $t$ are reflectance, transmittance and thickness of the nc-Si(SiC) thin films. The band gap of nc-Si(SiC) thin films varied from 3.19, 3.13, 3.00 and 2.91 eV with the process temperature 700, 800, 900 and 1000°C respectively calculated from $a^{1/2}$ with $h n$. The estimated band gap from Tauc's plot of nc-Si(SiC) thin films are 3.17, 3.11, 3.02 and 2.87 eV respectively. This indicates band gap calculated from both $a^{1/2}$ vs $h n$ and Tauc plot are almost same.

3.7: Composition and electronic environmental analysis

Fig 7 (a) shows the binding energy in the range of 0 to 900 eV of nc-Si(SiC) thin films with the process temperature from 700-1000°C. The binding energy at 0 eV reflects the Fermi level in the nc-Si(SiC) thin films. The elements of Si, C, and O were identified by the core orbital spectra of Si(2p), Si(2s), C(1s) and O(1s) at the binding energy at 99.8 eV, 150.1 eV, 284.9 eV and 532 eV respectively. However, the binding energy of the core orbital spectra varied according to electronic environments and at.% of contamination present in the nc-Si(SiC) thin films. Fig. 7(b) shows the at.% of the Si and C in the nc-Si(SiC) thin films with different process temperatures from 700-1000°C. The atomic percentage of Si and C can be estimated by [30-34]

$$
X \text{ at. %} = \left( \frac{A_i}{S_i} \right) \left/ \sum \left( \frac{A_i}{S_i} \right) \right. \times 100 \text{..................................................(7)}
$$

Where $A_i$ and $S_i$ are the area under the core orbital spectra and surface sensitivity of elements present in the nc-Si(SiC) thin films. The surface sensitivity factor of C(1s) and Si(2p) are 0.25 and 0.66 respectively. The composition of Si and C varied from 53.27 to 59.12 at.% and 46.72 – 40.87 at.% respectively with increasing of process temperature from 700 – 1000°C. This indicates the at.% incorporation of Si more than C, which reflects silicon-rich films in the nc-Si(SiC) thin films, which supports the agglomeration of Si nanoparticles within the SiC network. Fig. 7(c) shows the deconvolution spectra of Si(2p) spectra with
different process temperatures from 700-1000°C in the nc-Si(SiC) thin films. The Si(2p) core orbital can be deconvoluted into three individual Gaussian sub-core orbital according to their coordination number and electron negativity of Si, C, and O associates with nc-Si(SiC) thin films. The binding energy at 97.57, 99.52, 101.67 eV corresponding to Si associate with Si (Si-Si), Si associate with C (Si-C) and Si associate with O (Si-O) respectively at the 700°C process temperature. However, the binding energy of Si-Si, Si-C and Si-O is at 97.15, 99.37, and 101.56 eV respectively for the nc-Si(SiC) thin films deposit at 1000°C. This indicates decreasing of binding with increasing of process temperature by incorporation of Si with increasing of process temperature to 1000°C. The FWHM of Si-Si, Si-C and Si-O varied from 2.4486 to 2.1991 eV, 2.5200 to 2.8568 eV and 2.0172 to 2.6579 eV respectively with increasing of process temperature from 700 to 1000°C. The decreasing of FWHM of Si-Si sub-core orbital indicates decreasing of bonding coordinate distribution, however for increasing of bonding co-ordination number of Si-C and Si-O sub-orbital increased with increasing of the process temperature. Fig. 7(d) shows C(1s) deconvolution of two individual Gaussian peaks. The binding energy at 282.39 eV and 284.51 eV, can be assigned as carbon associate with Si atom, (C-Si) and carbon associate with carbon (C-C / C=C) respectively for 700°C process temperature. The binding energy varied from 282.39 to 279.82 eV and 284.51 to 282.95 eV C-Si and C-C/C=C respectively. The shifting of binding energy towards lower binding energy indicated the incorporation of silicon content in the nc-Si(SiC) thin films. The FWHM of C-Si and C-C/C=C varied from 3.5012 to 1.1715 eV and 3.5048 to 4.1661 eV with increasing process temperature from 700-1000°C. Fig. 7(e) shows O(1s) core orbital spectra varied from 528 to 536 eV from 700 to 1000°C respectively. The peak position of O(1s) is invariant 532.2 eV for all nc-Si(SiC) indicates the oxygen contamination is associate with the handling of samples or atmospheric expose [34-39].

4. Conclusions

In this work, the fractal dimension and lattice strain of SEM images of nc-Si(SiC) thin films were increased from Williamson-Hall and Scherer formula was varied from 0.00227 to 0.00469 and 0.000855 to 0.00574 respectively deposited on p-type Si substrate. The SEM images reveal the Si particles are embedded with SiC thin films. The Raman signature at the 1346.19 cm$^{-1}$, 1491.78 cm$^{-1}$ and 1570.94 cm$^{-1}$ bonding corresponds D, G-Si and G peaks respectively. The estimated band gap from Tauc's plot of nc-Si(SiC) thin films are 3.17 to 2.87 eV respectively with increasing of process temperature. The observed crystalline size of nc-Si in nc-Si(SiC) is from 21 nm to 27 nm from 700 to 1000 oC respectively. The possible bonding network of core-orbital of Si(2p), C(1s), and O(1s) in the C: ZnO thin films have been discussed by deconvolution with the Origin 2018.

Declarations

Acknowledgment

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Conflict of Interest: Author has no conflict of interest

Author contributions: The author has taken full responsibility for this manuscript.

Availability of data and material: Data generated during the study are subject to a data sharing mandate and available in a public repository that does not issue datasets with DOIs

Compliance with ethical standards: To ensure objectivity and transparency in research and to ensure that accepted principles of ethical and professional conduct have been followed.

Consent to participate: The participant has consented to the submission of the case report to the journal.

Consent for Publication: All authors consent to the publication of the manuscript.

References


**Tables**

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</tbody>
</table>
Figures

Figure 1

SEM images of nc-Si(SiC) deposited at 700, 800, 900, and 1000°C process temperature.
Figure 2

(a) power spectral density function (PSDF), (b) partition function, (c) triangular and (d) cube counting of SEM images deposited with different process temperature varied from 700-1000°C.
Figure 3

(a) XRD of nc-Si(SiC) with different process temperature from 700-1000oC, (b) microstrain calculated from Williamson –Hall formula, (c) microstrain calculated from Scherer formula, and (d) Crystallite size, I(311)/I(111), and I(220)/I(111) with different processing temperature from 700-1000oC.
Figure 4

FTIR spectra of nc-Si(SiC) thin films with different process temperatures from 700-1000°C.

Figure 5

Raman spectra of nc-Si(SiC) thin films with different process temperatures from 700-1000°C.
Figure 6

Optical band gap estimated from $a^{1/2}v$, $h_n$ and $(a_n h)^{1/2}$ vs, $h_n$ with different process temperature from 700-1000$^\circ$C.
Figure 7

(a) XPS spectra of nc-Si(SiC) with different processing temperature 700-1000°C, (b) Atomic percentage of silicon and carbon present in nc-Si(SiC), (c) deconvolution of Si(2p) binding energy of nc-Si(SiC) thin films, (d) deconvolution binding energy of C(1s) of nc-Si(SiC) thin films, (e) Binding energy of O(1s) with different process temperature varied from 700-1000°C.