Appendix B

Appendix B

Error Analysis

B.1 Refractive Index [n(λ)]

$$n(\lambda) = \left[N + \left(N^2 - n_0 n_1 \right)^{\frac{1}{2}} \right]^{\frac{1}{2}}$$

where;

$$N(\lambda) = \frac{n_0^2 + n_1^2}{2} + 2n_0 n_1 \frac{T_{max}(\lambda) + T_{min}(\lambda)}{T_{max}(\lambda) T_{min}(\lambda)}$$

$$\left[\frac{\Delta T_{max}}{T_{max}} \right] = \left[\frac{\Delta T_{min}}{T_{min}} \right] \approx 10^{-2}$$

$$\left[\frac{\Delta N(\lambda)}{N(\lambda)} \right]^2 = \left[\frac{\Delta T_{max} + \Delta T_{min}}{T_{min}} \right]^2 + \left[\frac{\Delta T_{max}}{T_{max}} \right]^2 + \left[\frac{\Delta T_{min}}{T_{min}} \right]^2$$

$$\left[\frac{\Delta N(\lambda)}{N(\lambda)} \right]^2 = 2.806x10^{-3}$$

$$\left[\frac{\Delta N(\lambda)}{N(\lambda)} \right]^2 = \left[\frac{\Delta n(\lambda)}{n(\lambda)} \right]^2 = 2.806x10^{-3}$$

$$\left[\frac{\Delta n}{n} \right] = 0.05$$

B. 2 Thickness

$$\Delta d = \sqrt{\frac{\sum (d - d^1)}{N(N-1)}}$$

$$\Delta d = \pm 6.0$$

B. 3 Hydrogen Percentage (valence electron model)

The hydrogen in the sample has been obtained from the valence electron model and it is a function of dispersion energy (E_d) and number of free valence electron (n_v). To obtain the error in the hydrogen content, it is a must to obtain the error for E_d and n_v. E_d is obtained from the slope (m) and intercept (c) of the linear portion of the plot of (1 / n^2-1) versus $(h\nu)^2$.

$$E_d = \sqrt{\frac{c}{m}}$$

$$\left[\frac{\Delta c}{c}\right] = 6.21 \text{ x } 10^{-3}$$

$$\left[\frac{\Delta m}{m}\right] = 2.48 \text{ x } 10^{-3}$$

$$\left[\frac{\Delta E_d}{E_d}\right]^2 = \left[\frac{\Delta c}{c}\right]^2 + \left[\frac{\Delta m}{m}\right]^2 = 4.47 \text{ x } 10^{-5}$$

$$\left[\frac{\Delta E_d}{E_d}\right] = 6.69 \text{ x } 10^{-3}$$

$$n_v = 0.0143\frac{E_d^2}{\varepsilon(0)-1}x10^{23}$$

$$\varepsilon_0 = n^2\,(1100)$$

where ;

$$\left[\frac{\Delta n_v}{n_v}\right]^2 = 2\left[\frac{\Delta E_d}{E_d}\right]^2 + 4\left[\frac{\Delta n}{n}\right]^2$$

$$\left[\frac{\Delta n_v}{n_v}\right]^2 = 0.01$$

$$\left[\frac{\Delta n_v}{n_v}\right] = 0.1$$

Hydrogen percentage in the sample,

$$C_H = \frac{1}{3}\frac{n_v}{n_s}\left(4 - \sqrt{\frac{E_d}{2.8}}\right) x100$$

$$\left[\frac{\Delta C_H}{C_H}\right]^2 = \left[\frac{\Delta n_v}{n_v}\right]^2 + \frac{1}{2}\left[\frac{\Delta E_d}{E_d}\right]^2$$

$$\left[\frac{\Delta C_H}{C_H}\right]^2 = 0.01$$

$$\left[\frac{\Delta C_H}{C_H}\right] = 0.1$$

B. 4 Optical Energy Gap (E_g)

From the intercept and slope of the plot of $(\alpha h\nu)^{1/2}$ versus $(h\nu)$, the optical energy gap has been deduced as :

$$E_g = \frac{c}{m}$$

where c is the intercept on y-axis and m is the gradient of the linear portion of the above plot,

$$\left[\frac{\Delta E_g}{E_g}\right]^2 = \left[\frac{\Delta c}{c}\right]^2 + \left[\frac{\Delta m}{m}\right]^2$$

$$\left[\frac{\Delta E_g}{E_g}\right]^2 = (2.329 \times 10^{-4}) + (1.463 \times 10^{-5})$$

$$\left[\frac{\Delta E_g}{E_g}\right] = 0.01$$

B. 5 Width Of The Band Tail (E$_e$)

The error in the width of the band tail has to be obtained by using the following equation;

$$\alpha = \exp\left[\frac{E}{E_e}\right]$$

$$\ln(\alpha) = \left[\frac{E}{E_e}\right]$$

From the equation E_e has to be obtained from the gradient in the linear portion of graph ln(α) versus (hν) and m is the slope of the graph in the linear portion,

$$E_e = \frac{1}{m}$$

$$E_e = m^{-1}$$

$$\left[\frac{\Delta E_e}{E_e}\right]^2 = \left[\frac{\Delta m}{m}\right]^2$$

$$\left[\frac{\Delta E_e}{E_e}\right] = \left[\frac{\Delta m}{m}\right]$$

$$\left[\frac{\Delta E_e}{E_e}\right] = 0.02$$

B. 6 D. C. Conductivity

$$\sigma = \frac{I}{V}\frac{d}{A} = (slope)\frac{d}{wt}$$

$$\left[\frac{\Delta\sigma}{\sigma}\right]^2 = \left[\frac{\Delta slope}{slope}\right]^2 + \left[\frac{\Delta d}{d}\right]^d + \left[\frac{\Delta w}{w}\right]^2 + \left[\frac{\Delta t}{t}\right]^2$$

$$\left[\frac{\Delta\sigma}{\sigma}\right]^2 = 2.46x10^{-5} + 0.0012 + 2.3x10^{-6} + 6.85x10^{-5}$$

$$\left[\frac{\Delta\sigma}{\sigma}\right]^2 = 0.001295$$

$$\left[\frac{\Delta\sigma}{\sigma}\right] = 0.04$$

B. 7 Activation Energy (E_c - E_f)

$$E_c - E_f = k \times S_1$$

where S_1 is the gradient of the first slope,

$$\left[\frac{\Delta(E_c - E_f)}{(E_c - E_f)}\right] = \left[\frac{\Delta S_1}{S_1}\right] = 0.06$$

B. 8 Density Of States At Fermi Level

$$\sigma(\omega) = \frac{\pi}{3} e^2 k [N(E_f)]^2 \alpha^{-5} \omega \left[\ln\left(\frac{\upsilon_{ph}}{\omega}\right)\right]^5 T$$

$$\sigma(\omega) = A\,[N(E_f)]^2 T$$

where A is the constant value,

$$[N(E_f)]^2 = \frac{\sigma(\omega)}{AT}$$

$$[N(E_f)] = \left[\frac{\sigma(\omega)}{AT}\right]^{\frac{1}{2}} = \left[\frac{m}{A}\right]^{\frac{1}{2}}$$

where m is the gradient of the graph $\sigma(\omega)$ versus temperature (T),

$$\left[\frac{\Delta N(E_f)}{N(E_f)}\right]^2 = \frac{1}{2}\left[\frac{\Delta m}{m}\right]^2 = 3.18 \times 10^{-3}$$

$$\left[\frac{\Delta N(E_f)}{N(E_f)}\right] = 0.06$$

B. 9 Hydrogen Percentage from FTIR

To obtain the error in the hydrogen percentage from FTIR calculation, it is a must to obtain the error for integrated intensity (I) and area under the curve (S).

$$\mathrm{I} = \left[\frac{S}{w_0}\right]$$

where w_0 is the peak of the curve.

$$\left[\frac{\Delta I}{i}\right] = \left[\frac{\Delta S}{S}\right]$$

$$\mathrm{S} = \left[\frac{22xA}{7xBB}\right]^{\frac{1}{2}}$$

where A is the intercept of the graph (α versus wavenumber) at y-axis and BB is the gradient of the graph in the linear region.

$$\left[\frac{\Delta S}{S}\right]^2 = \frac{1}{2}\left[\frac{\Delta A}{A}\right]^2 + \frac{1}{2}\left[\frac{\Delta BB}{BB}\right]^2$$

$$\left[\frac{\Delta S}{S}\right]^2 = 9.52 \text{ x } 10^{-9} + 4.84 \text{ x } 10^{-3}$$

$$\left[\frac{\Delta S}{S}\right] = 0.07$$

$$\left[\frac{\Delta I}{I}\right] = \left[\frac{\Delta S}{S}\right] = 0.07$$

Hydrogen Content (C_H) = $1.6 \times 10^{19} \times I$

$$\left[\frac{\Delta C_H}{C_H}\right] = \left[\frac{\Delta I}{I}\right] = 0.07$$

B. 10 Oscillator Strength (Γ)

$$\Gamma = \left[37.6\frac{I_{HS}}{I_{HW}}\right]$$

$$\left[\frac{\Delta\Gamma}{\Gamma}\right]^2 = \left[\frac{\Delta I_{HS}}{I_{HS}}\right]^2 + \left[\frac{\Delta I_{HW}}{I_{HW}}\right]^2$$

$$\left[\frac{\Delta\Gamma}{\Gamma}\right]^2 = 9.8 \times 10^{-3}$$

$$\left[\frac{\Delta\Gamma}{\Gamma}\right] = 0.09$$

B. 11 Parameter R

$$R = \frac{I_{2100}}{(I_{2000} + I_{2100})}$$

$$\left[\frac{\Delta R}{R}\right]^2 = \left[\frac{\Delta I_{2100}}{I_{2100}}\right]^2 + \left[\frac{\Delta I}{I}\right]^2$$

where,

$$\Delta I = \Delta I_{2000} + \Delta I_{2100}$$

$$I = I_{2000} + I_{2100}$$

$$\left[\frac{\Delta R}{R}\right] = 0.09$$

B. 12 Deposition Rate

$$\text{Deposition Rate} = \left[\frac{Thickness(d)}{Deposition Time(t)}\right]$$

$$\left[\frac{\Delta Dep.Rate}{Dep.Rate}\right]^2 = \left(\frac{\Delta d}{d}\right)^2 + \left(\frac{\Delta t}{t}\right)^2$$

$$\left[\frac{\Delta Dep.Rate}{Dep.Rate}\right]^2 = 8.27\text{x}10^{-3} + 3.443\text{x}10^{-10}$$

$$\left[\frac{\Delta Dep.Rate}{Dep.Rate}\right] = 0.09$$

Appendix C

Appendix C

Strong lines: 4.04/X 4.04/X 4.04/X 0.00/1 0.00/1 0.00/1 0.00/1 0.00/1

.97 JCPDS-ICDD Copyright (c) 1995 PDF-2 Sets 1-45 database Quality: i

O
2
licon Oxide

d: CuKa Lambda: 1.5418 Filter: Mono. d-sp: Diff.
toff: Int: Diffractometer I/Icor:
f: Highcock, R., Smith, G., Wood, D., Acta Crystallogr., Sec. C, 41 1391 (1985)

s: Orthorhombic S.G.: Cmc21 (36)
13.836(3) b: 17.415(4) c: 5.042(1) A: 0.7945 C: 0.2895
B: C: Z: 24 mp:
f: Ibid.
: 1.971 Dm: SS/FOM: F28=9(.019,158)

: nwB: ey: Sign: 2V:
f:

own from a gel. SiO2:Al2O3 = 60:1. PSC: oC72. Mwt: 60.08. Volume[CD]:
14.89.

d A	Int.	h k l
10.86	58	1 1 0
8.71	22	0 2 0
6.93	17	2 0 0
5.42	9	2 2 0
4.571	9	1 1 1
4.364	100	0 2 1
3.676	66	2 2 1
3.616	43	3 3 0
3.464	31	4 0 0
3.341	7	3 1 1
3.297	30	0 4 1
2.974	1	2 4 1
2.936	2	3 3 1
2.902	2	0 6 0
2.778	1	3 5 0
2.519	15	0 0 2
2.434	6	3 5 1
[illegible]	[illegible]	3 [illegible] 1
2.365	4	2 6 1
2.283	<1	2 2 2
2.237	<1	5 3 1
2.066	2	3 3 2
2.035	2	4 6 1
1.871	5	7 3 0
1.784	2	3 9 0

d A	Int.	h k l	d A	Int.	h k l	d A	Int.	h k l
6025	4	1 3 3						
4546	2	0 6 3						
3829	2	7 9 0						

trong lines: 4.36/X 3.68/7 10.9/6 3.62/4 3.46/3 3.30/3 8.71/2 6.93/2

27-1402 JCPDS-ICDD Copyright (c) 1995 PDF-2 Sets 1-45 database Quality: *

Si

Silicon

Silicon, syn

Rad: CuKa1 Lambda: 1.540598 Filter: Mono. d-sp: Diff.
Cutoff: Int: Diffractometer I/Icor: 4.70
Ref: Natl. Bur. Stand. (U.S.) Monogr. 25, 13 35 (1976)

Sys: Cubic S.G.: Fd3m (227)
a: 5.43088(4) b: c: A: C:
A: B: C: Z: 8 mp:
Ref: Ibid.

Dx: 2.33 Dm: SS/FOM: F11=409(.002,13)

ea: nwB: ey: Sign: 2V:
Ref:

Color: Gray
Pattern taken at 25(1) C. This sample is NBS Standard Reference Material No. 640. CAS no.: 7440-21-3. Reflections calculated from precision measurement of a0. a0 uncorrected for refraction. C type. Diamond group. W used as internal standard. PSC: cF8. To replace 5-565 and 26-1481. Mwt: 28.09. Volume[CD]: 160.18.

d A	Int.	h k l
3.1355	100	1 1 1
1.9201	55	2 2 0
1.6375	30	3 1 1
1.3577	6	4 0 0
1.2459	11	3 3 1
1.1086	12	4 2 2
1.0452	6	5 1 1
0.9600	3	4 4 0
0.9180	7	5 3 1
0.8587	8	6 2 0
0.8282	3	5 3 3

Strong lines: 3.14/X 1.92/6 1.64/3 1.11/1 1.25/1 0.86/1 0.92/1 1.36/1