Appendix A

Error Analysis

A1. Refractive Index [n(λ)]

Refer to section 4.4.4 for details on the formulas.

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

where

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

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

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

$$= 6 \times 10^{-4}$$

$$\left[\frac{\Delta n(\lambda)}{n(\lambda)} \right]^2 = \left[\frac{\Delta N(\lambda)}{N(\lambda)} \right]^2 = 6 \times 10^{-4}$$

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

A2. Hydrogen Percentage (Valence Electron Model)

Refer to Section 6.3.2 for details on the formula.

E_d is obtained from the relationship

$$\left(n^2 - 1 \right) = \frac{E_d E_0}{\left[E_d^2 - (\hbar\omega)^2 \right]}$$

From the plot of $[1/n^2-1]$ versus $(\hbar\omega)^2$

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

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

$$\left[\frac{\Delta c}{c}\right] = 4 \times 10^{-3}$$

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

$$\left[\frac{\Delta E_d}{E_d}\right]^2 = \left[\frac{\Delta c}{c}\right]^2 + \left[\frac{\Delta m}{m}\right]^2 = 4.16 \times 10^{-4}$$

$$\left|\frac{\Delta E_d}{E_d}\right| = 0.02$$

$$n_v = 0.0143\frac{Ed^2}{\varepsilon(0)-1} \times 10^{23}$$

where $\varepsilon(0) = n^2$ (1100 nm)

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

$$= 2.4 \times 10^{-3}$$

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

$$\text{Hydrogen Percentage} = C_H = \frac{1}{3}\frac{n_v}{n_s}\left(4 - \sqrt{\frac{E_d}{2.8}}\right) \times 100$$

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

$$= 2.7 \times 10^{-3}$$

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

Thus, resolution for the hydrogen content determined by this technique is 5%.

A3. Hydrogen Percentage (Chemical Bonding infra-red Model)

Refer to Section 6.3.4 for details on the formulas.

$$N_H = \text{Hydrogen Concentration}$$
$$= A_S \int \frac{\alpha(\omega)}{\omega} d\omega = A_S \times A$$

where $\int \frac{\alpha(\omega)}{\omega} d\omega$ is the area under the absorption peak of Si-H_x stretch and Si-H wagging mode.

$$\left[\frac{\Delta A}{A}\right] = 0.11$$ Since the resolution for the endpoints are ~ 10 cm^{-1}.

$$\left[\frac{\Delta N_H}{N_H}\right]^2 = \left[\frac{\Delta A}{A}\right]^2$$

$$\left|\frac{\Delta N_H}{N_H}\right| = 0.11$$

Thus, the resolution for the hydrogen content determined by this technique is 11 %.

A4. Optical Energy Gap (E_g)

Refer to Secton 4.4.4 for details on the formula.

E_g is determine from the intercept on the plot of $(\alpha h\omega)^{1/2}$ versus $(h\omega)$.

Thus,

$$E_g = \frac{Int}{Slope}$$

where (Int) is the intercept on the y-axis and (Slope) is the gradient of the linear portion of the plot above.

$$\left[\frac{\Delta E_g}{E_g}\right]^2 = \left[\frac{\Delta Int}{Int}\right] + \left[\frac{\Delta Slope}{Slope}\right]$$

$$= (10^{-2})^2 + (4 \times 10^{-3})^2$$

$$= 1.16 \times 10^{-4}$$

$$\left|\frac{\Delta E_g}{E_g}\right| = 0.01$$

A5. Conductivity (σ)

Refer to Section 4.3 for details on the formulas.

$$\sigma = \frac{I}{V}\frac{d}{A} = (Slope)\frac{d}{t \times w}$$

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

$$= [0.03]^2 + [7 \times 10^{-3}]^2 + [0.01]^2 + [4 \times 10^{-4}]$$

$$= 9 \times 10^{-4} + 4.9 \times 10^{-5} + 1 \times 10^{-4} + 1.6 \times 10^{-7}$$

$$= 1 \times 10^{-3}$$

$$\left[\frac{\Delta\sigma}{\sigma}\right] = 0.03$$

A6. Activation Energy [(E_c-E_f) and (E_c-E_f)]

Refer to Section 4.3.1 for details on the formulas.

[E_c-E_f] and [E_c-E_f] are obtained from the gradient of the first and second linear portion of the plot of ln[Current (I)] versus inverse temperature (1/T) respectively.

$$E_c - E_f = k \text{ [gradient of first slope]}$$

$$= k \times S1$$

$$E_c - E_f = k; \text{ [gradient of second slope]}$$

$$= k \times S2$$

$$\left[\frac{\Delta(E_c - E_f)}{E_c - E_f}\right] = \left[\frac{\Delta S1}{S1}\right] = 0.04$$

$$\left[\frac{\Delta(E_a - E_f)}{E_a - E_f}\right] = \left[\frac{\Delta S2}{S2}\right] = 0.08$$

A7. Density of States at the Fermi Level [$N(E_f)$]

Refer to Section 4.3.1 for details on the formulas.

$$N(E_f) = \left[J\frac{k^{\frac{3}{2}}}{e^3}\right]^2$$

$$= \left[2\frac{k(\text{Slope})(n)^3}{e^3}\right]^2$$

$$\left[\frac{\Delta N(E_f)}{N(E_f)}\right]^2 = 2\left[\frac{\Delta \text{Slope}}{\text{Slope}}\right]^2 + 6\left[\frac{\Delta n}{n}\right]^2$$

$$= 2[0.05]^2 + 6[0.02]^2 = 5 \times 10^{-3} + 2 \times 10^{-3}$$

$$= 7.4 \times 10^{-3}$$

$$\left[\frac{\Delta N(E_f)}{N(E_f)}\right] = 0.09$$