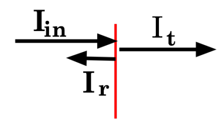
Absorptance of a Solid Measured on the Integrating Sphere



A simple solid has two interfaces (air/solid and solid/air) and the absorbance of the material. At each interface an incoming ray, I_{in} produces a reflected ray, I_r, and a transmitted ray, I_r.

$$I_{in} = I_r + I_t \text{ or } 1 = \frac{I_r}{I_{in}} + \frac{I_t}{I_{in}} = r + t$$

$$\boxed{1 - t = r} \text{ ` } \qquad (1)$$

where r and t are the reflectance and transmittance. For the solid part some of the light is absorbed in the solid and the rest transmitted. If I_{in} is the incoming ray's intensity that enters the solide (after any reflection at the interface) and I_t is the transmitted ray's intensity before interface reflection and I_A is the intensity absorbed by the solid.

$$I_{in} = I_A + I_t \text{ or } 1 = a_s + t_s$$

where a_s is absorptance, i.e. $a_s = I_{in}/I_t$. For the complete sample we measure the intensity of the transmitted beam or the transmittance, T

$$T = t_1 \times t_s \times t_2 \qquad (2)$$

where the subscripts 1 and 2 indicate the front and back air/sample and sample/air interfaces. Thus

$$\boxed{t_s = \frac{T}{t_1 t_2}} \qquad (3)$$

where T transmittance that the integrating sphere measures. If the sample is mounted on the exit port you can measure r_1 and then if you rotate the sample 180º you can measure r_2, which are related to t_1 and t_2 by eq 1. Since the transmittance of the sample is related to the extinction coefficient, ε, or the attenuation length, α,

$$A = -\log(t_s) = \varepsilon[c]l \quad \text{and} \quad \alpha l = -\ln(t_s) \qquad (5)$$

where l is the length of the sample.

Notes:

1) When measuring the reflectance of one interface the second interface must not contribute to the measured reflectance.
2) The reflectance is normally independent of whether you are going from air to solid or solid to air.
3) For a flat surface normal to the surface the reflectance at a particular wavelength is given by $r = (n_1 - n_2)^2 / (n_1 + n_2)^2$ where n is the refractive index at the wavelength.

Material	Refactive index	Wavelength range	Reflectance Air/material	Reflectance Water/material
Air	1.00	all	–	0.02
Water	1.33	Visible to NIR	0.02	–
Silicon	3.96	Visible	0.36	0.25
Quartz	1.46	UV-visible	0.035	0.002
Glass	1.5	Visible	0.04	0.004
TiO_2	2.50	Visible	0.18	0.09

Note that transmittances are multiplicative so while the air/silicon interface reflects 36% of visible light an Si wafer in a water cell only reflects about 26% ((1-0.04)*(1-0.004)*(10.25)) of the light.