Technical Note #2

Overlayer Thickness Determination Using the Thickogram

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Background

During his time at the National Physical Laboratory (NPL), Peter Cumpson published the so-called ‘Thickogram’ method for calculation of overlayer thickness where the chemistry of overlayer film and substrate are different (for example Rh on a Si substrate) [1].

The advantage of the Thickogram method is:

- Any uniform surface contamination is not important (*i.e.* advantageous carbon can be neglected)
- Instrumental factors (which may be unknown), would be common to overlayer and substrate and so cancel out
- Works over a range of film thicknesses, from small to large
- Applicable to a wide range of kinetic energies above *ca.*500 eV
- Simple equation and graphical method with error of ±10% based on accuracy of attenuation lengths obtained by calculation

The Thickogram

The Thickogram itself is a graphical method, with minimal calculations required, however the emission angle for analysis must be between 0^o and 60^o (i.e. Take-off angle of 90^o to 30^o), with emission angles around 45^o considered to be the most accurate.

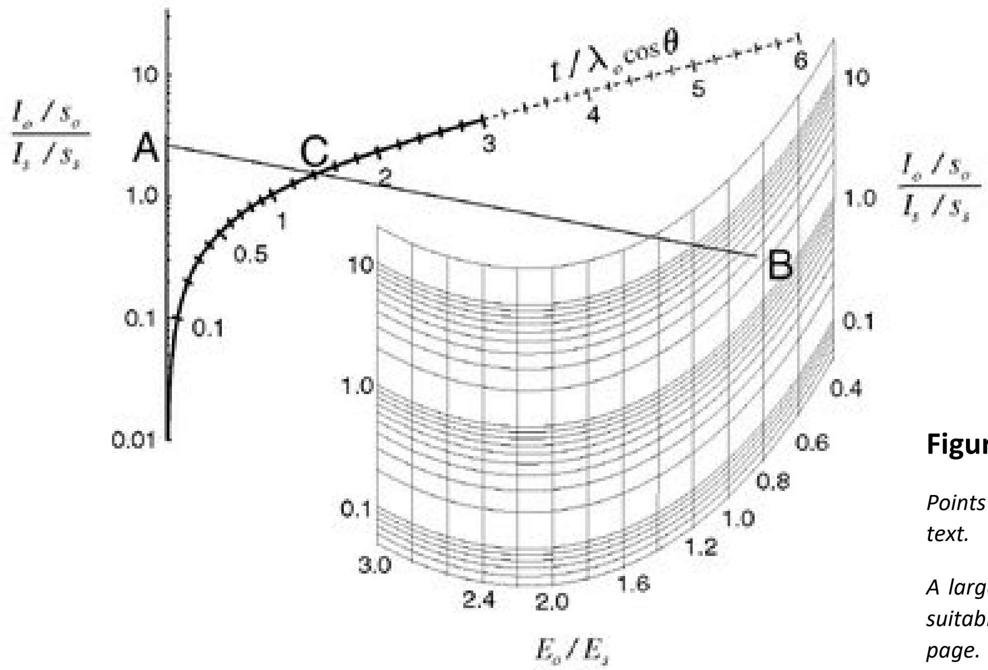

Figure 1. The Thickogram

Points A, B & C are described in the text.

A larger version of the Thickogram suitable for use is given on the last page.

Figure 1 shows the graphical Thickogram together with the values A, B and C values required to plot to calculate the film thickness (t), where:

I_o and I_s	Integrated peak area, where o = overlayer and s = substrate
S_o and S_s	Relative Sensitivity Factor (RSF) of peak
E_x	Kinetic Energy peak
θ	Emission angle (Zero for a 90º take off angle, so COS(θ) = 1)
λ_o	Attenuation length of photoelectrons (from the overlayer) in the overlayer

Using the Thickogram

Obtaining the data to plot the Thickogram is straightforward:

1) Calculate A and add point to Thickogram $$A = \left(\frac{I_o}{S_o}\right) \bigg/ \left(\frac{I_s}{S_s}\right)$$

2) Calculate B and add point to Thickogram $$B = \left(E_o / E_s\right)$$

3) Draw a line from A to B; point C is found at the crossover on the curve.

4) Thickness (t) is calculated as: $$t = C(\lambda_o \cos\theta)$$

'Topofactors' – An Extension to the Thickogram

The standard Thickogram equation assumes that the surfaces studied with are flat. Whilst most XPS quantification takes this simplistic view and with reasonable accuracy, Shard has sought to improve such quantification through introducing correction factors to provide overlayer thicknesses on topographic samples of known geometry, such as spherical or cylindrical particles [2].

Their concept is simple; analysis is performed with the sample normal directed towards the XPS analyser, the equivalent planar thickness is calculated from the Thickogram and the Topofactor applied to the result to provide the actual thickness.

References

[1] P.J. Cumpson, *Surf. Interface Anal.*, 29, 403-406 (2000)

[2] A.G. Shard, J. Wang, S.J. Spencer, *Surf. Interface Anal.*, 41 (7) 541-548 (2009)

Printable Thickogram Work Sheet