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Leader in thin film meterology

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Application note AP4

Study of blue OLED layer on 0.7mm glass substrate

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Coloured sample

Normal incidence transmission measurements showed a transparent region in the blue between approximately 400nm and 550nm, with relatively strong absorbtion in the red. The refractive index (n,k) will vary with wavelength.

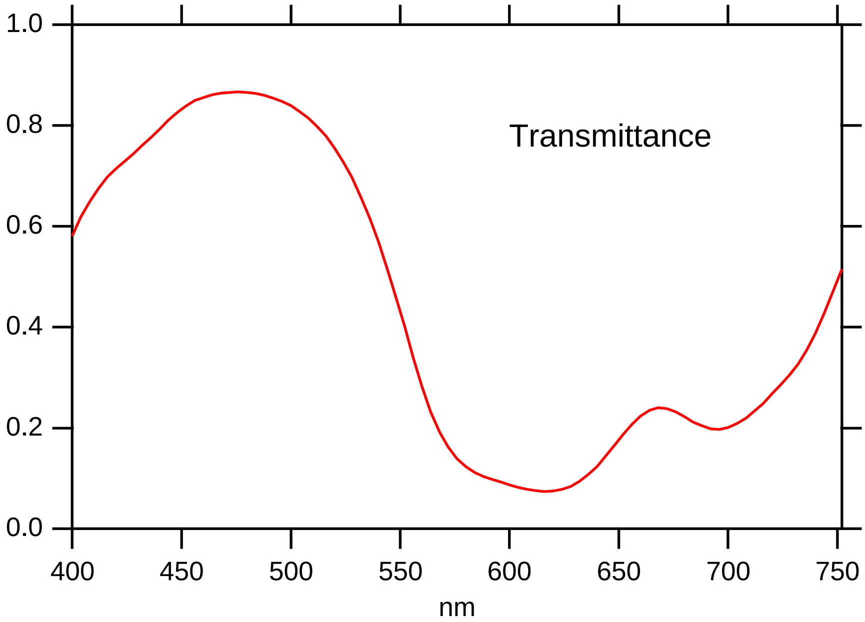

Figure 1: Transmission of the sample as a function of wavelength

Our standard Picometer ellipsometer is not suitable for this type of sample since it uses a red laser source and red absorbing wavelengths will be insensitive to layer thickness.

We have used the visible Spectroscopic Picometer ellipsometer in this study of this sample. The ellipsometer has a monochromator to select a wavelength in the visible region. (A less expensive version using a filter wheel is available, with interference filters chosen to match the sample under study.) We have made measurements as a function of angle of incidence at each of a few wavelengths in the transparent region and also in the red. From these variable angle spectroscopic measurements we have deduced a thickness and refractive indices for the OLED layer.

The glass substrate

The glass substrate which is relatively thin causes some minor difficulties. There is interference between light reflected from the front and back surfaces, which produces fringes (periodic variations) in the ellipticity which vary as a function of the angle of incidence, with a periodicity of less than 1/100 of a degree.

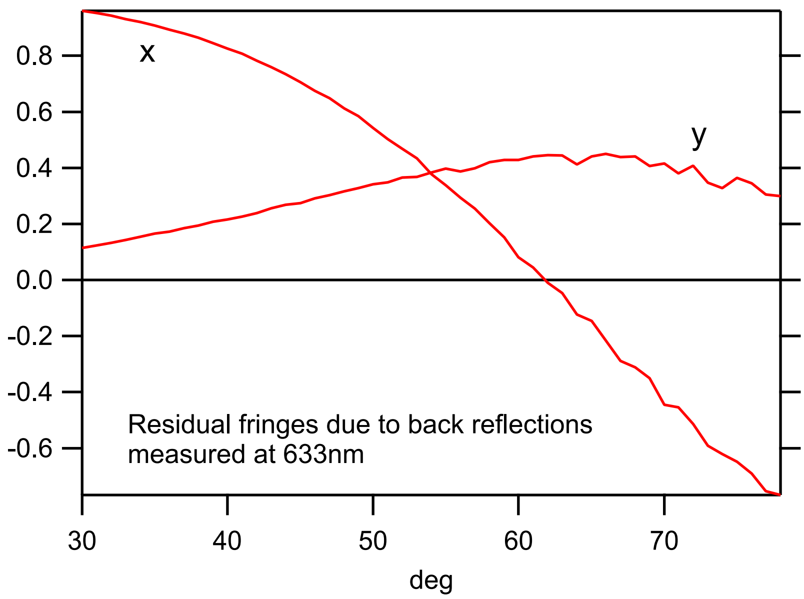

Figure 2 Residual fringes at 630nm (absorbing region)

These fringes can be eliminated in various ways:
(i) It is possible to separate the light beams reflected from the front and back surfaces. This is best done using a focused beam. We have focused the laser beam to a microspot to help with this separation, with an aperture placed infront of the detector.

(ii) One can average the interference pattern, by using a range of wavelengths and/or a range of angles of incidence, or by smoothing the angle variation of the data. One needs to take into account the incoherent net reflection from the back surface.

(iii) One can reduce the back surface reflection using ‘index-matched’ black tape or other backing. In this method the incoherent back reflection is eliminated.

We have tested each of these and find consistent results. We report data using (iii) since the method is easy, the back reflection is eliminated and the analysis can be performed as usual.

Thickness, and refractive index in the transparent region
The following Figures 3, 4 show the independent determination of the thickness and refractive index as a function of wavelength. Of course the thickness should be a constant, but we show the independent determinations to demonstrate the accuracy. The averaged thickness is 135 ± 4nm. It appears to vary systematically with wavelength, so the variation is probably due to limitations in the single uniform layer assumption.

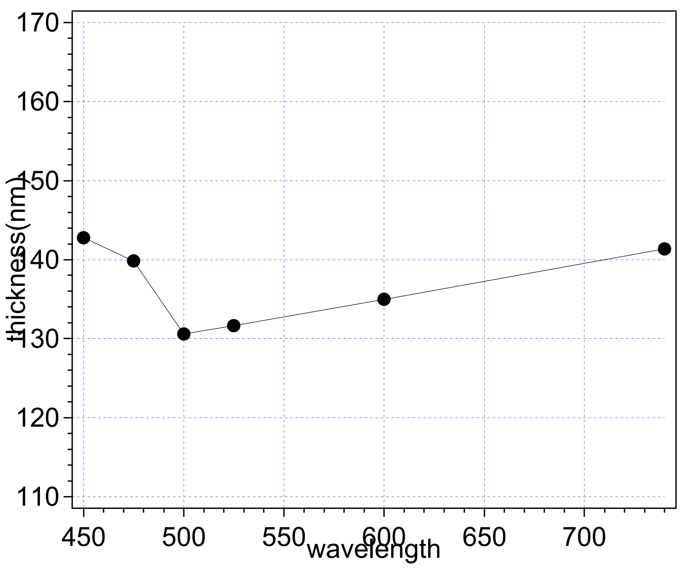

Figure 3 Independent determinations of the sample thickness. Average value 135± 4nm.

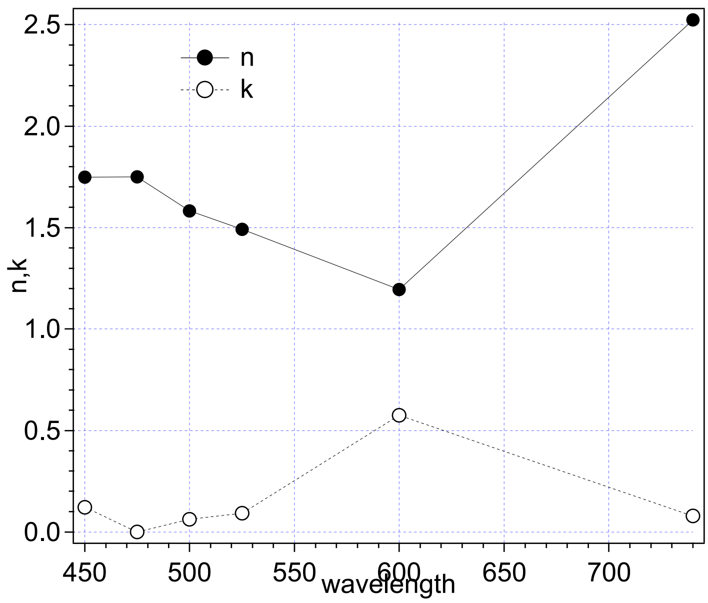

Figure 4 Refractive index versus wavelength.

Sample uniformity

Our instruments can be provided with a motorised XY sample translation stage, with software to scan the sample by moving the sample under the light beam. The standard range of motion is 25mm in each direction, but this can also be changed as required by the user.

We have made measurements at 480nm, 60 degrees angle of incidence, along a line in the center of the sample. The variation in the measured parameters is shown in Figure 5. The changes are consistent with changes in refractive index less than ~ 0.02, and changes smaller than ~ 0.1nm in thickness.

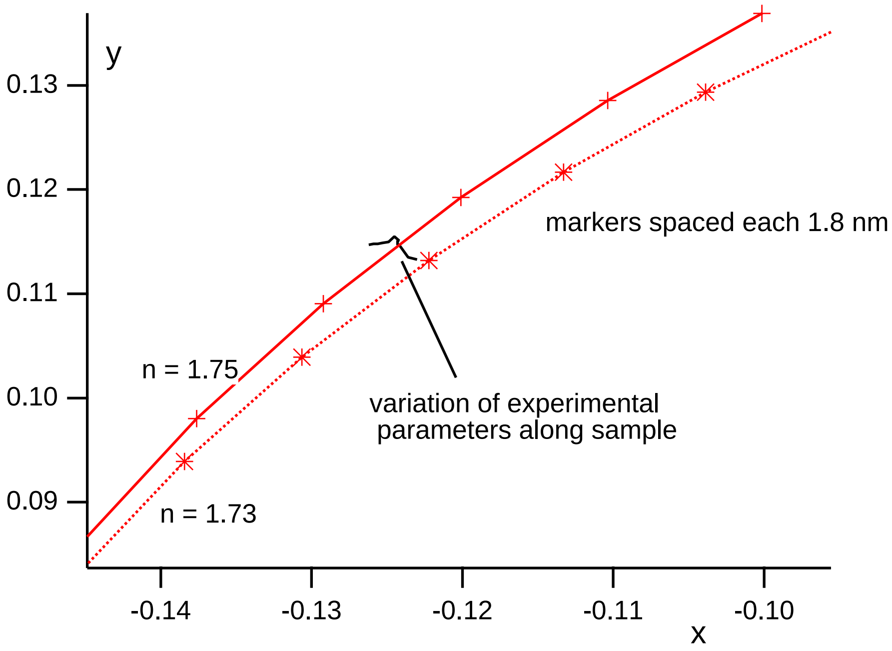

Figure 5 Measured sample variation, and theoretical curves of the locus of the experimental parameters with varying thickness, for two values of refractive index.

Summary

A spectroscopic ellipsometer using either a monochromator or selected filters is essential for the study of this and similar samples. The accuracy of the thickness determination using a single uniform layer model is a few percent. The precision, which is useful for uniformity measurement, is better than 0.1nm. Back surface reflections can be averaged or eliminated using index-matching black tape at the back surface.