Characterisation of OLED Films using the Aquila nkd Spectrophotometer

Aquila
Instruments

This application notedemonstrates the principle of measuring andcharacterising typical OLEDthin films ontheAquila nkd Spectrophotometer.

One of the main advantages of the nkd spectrophotometer is its ability to analyse, not just single films and substrates, but multiple layers of thin films and coatings. Such layer systems are often devices in themselves and the thickness and properties of each layerarecriticaltotheiroperation.

Onesuchdevice typeofincreasing importance, in the billiondollar flat panel display market, is Organic Light Emitting Diodes or OLEDs.

OLEDtechnology enablesfullcolour,full-motionflatpaneldisplays to be produced with a level of brightness and sharpness not possiblewithothertechnologiessuchasliquidcrystaldisplays. OLEDs areself-luminescent— that istheyglowwhenanelectrical field is applied to them and do not require a back light, diffuser, polarizer, or any of the other systemsrequired for LCDs . This fact allowsthemtobethinner,lighter,andmoreenergyefficientoverall. They can be produced in a variety of formats to suit the application. These include flexible OLEDs (FOLEDs), stacked, high-resolution OLEDs (SOLEDs), and transparent OLEDs (TOLEDs).

OLEDs are robust enough to beused in portable devices such as mobile phones, digital video cameras, DVD players, car audio equipment and can be viewed at high incidence angles, providing a clear distinct image even in bright light. Because OLEDs can be made paper thin and produced on a variety of surfacestheyhaveanalmostlimitlessrangeofapplications.

Although they have been introduced commercially for mobile phones and car audio equipment, there are many production obstacles to overcome before OLEDs become commonplace in modernelectronicequipment.Colouruniformityandlifetimeissues as well as water solubility are all hurdles to be overcome in their development.

The ability to characteriseand measurethe thin films that makeup these devices is a distinct advantage to the developers and manufacturers of this technology and we shall demonstrate here therolethatthenkdspectrophotometercanplayinthisprocess.

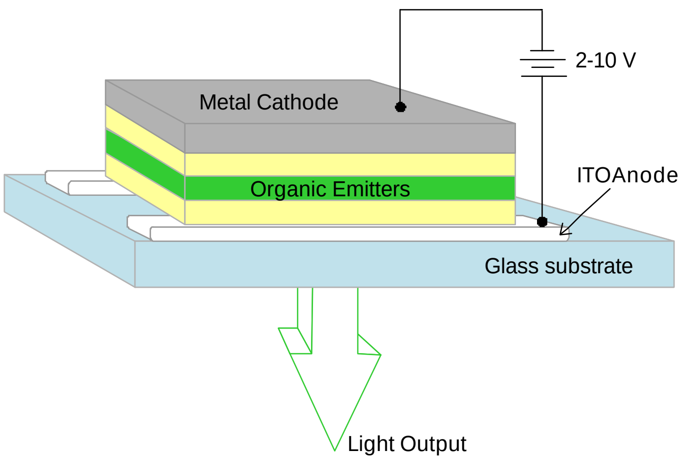

Figure 1. Typical OLED

The basic OLED cell structure consists of a stack of thin organic polymer layers sandwiched between a transparent anode (such asITO) andametalliccathode (often CuorAl).Theorganiclayers comprisea hole-injection layer, a hole-transport layer,anemissive layerandanelectron-transport layer.Whenanappropriatevoltage (typicallybetween2and10volts)isappliedtothecell,theinjected positive and negative charges recombine in the emissive layer to produce light (electro luminescence). Thestructure oftheorganic layers and the choice of anode and cathode are designed to maximize the recombination process in the emissive layer, thus maximizingthelightoutputfromtheOLEDdevice.

To the nkd spectrophotometer, characterising the layers of the OLED device is a simple process. In the following example, a simple OLED structure of glass/ITO/Light emitting polymer(LEP) wasanalysed.Threesamples wererequiredforthe measurement process-glassonly,glass/ITOand glass/ITO/LEP.

The first step in evaluating the device wastofully characterise the substrate orglasslayer. Most commonglass materials are known to Pro-Optix, simplifying the analysis process greatly. Figure 2 below showsthemeasuredtransmittanceandreflectancespectra for the greenplate glass used for in this particular OLED. Transmittanceandreflectancemeasurementsforbothpolarisation statesareshown aswellasthefitteddispersionmodeloverlaidon the plot. The resulting optical properties are plotted in Figure 3 overleaf.

The upper curves in Figure 2 for T and R are the s- polarisation measurements. The ability to achieve a model fit for both polarisationmeasurements,helpstoeliminateanyambiguityinthe results.

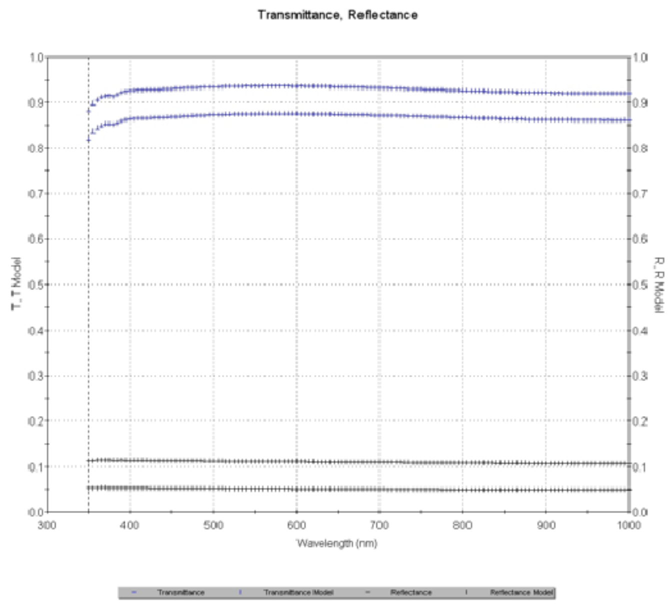

Figure2.TandRspectraforthegreenplateglasssamplewith fitted model

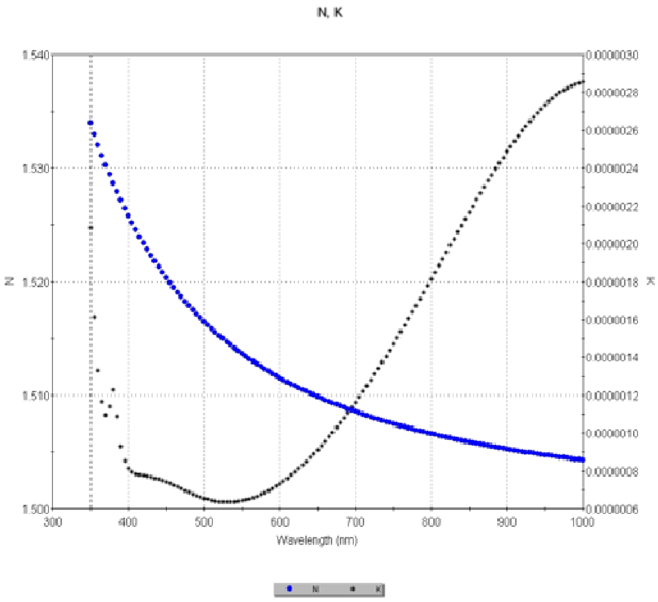

Figure 3. Optical properties for the Greenplate glass.

ITO is a common material though its optical properties can vary considerably from one sample to another. It was important to establish the optical properties of this particular ITO layer rather than assume that it is the same as the Pro-Optix™ database ITO.

Measurement of T and R for both polarisations were taken and can be seen, plotted together in Figure 4.

With the glass layer already known to Pro-Optix™ and added to the materials database, it is now a simple process of fitting the spectra for the ITO layer . The layer thickness and refractive index of the ITO are the only two unknowns. The fitted plot is shown overlaid on the measured spectra in Figure 4 and the resulting dispersion profile for the ITO given in Figure 5. The properties of the ITO layer were then added to the database for use in the analysis of the glass/ITO/LEP layer sample.

Figure 6 shows the measured T and R spectra for the three layer structure. The properties of the glass and ITO have been loaded from the Pro-Optix™ materials database, leaving only the properties and thickness of the polymer layer to be determined.

The Drude-Lorentz model was used to fit a theoretical model to the measured spectra and extract the optical properties of the LEP layer as shown below. Values of 171nm and 80nm have been determined from the fit for the ITO and LEP layers respectively.

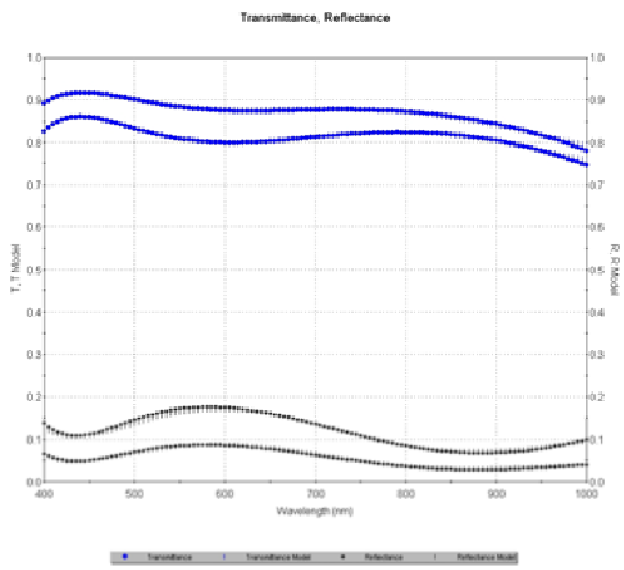

Figure 4. Combined s- and p polarisation plots of T & R for glass/ITO overlaid with fitted spectra.

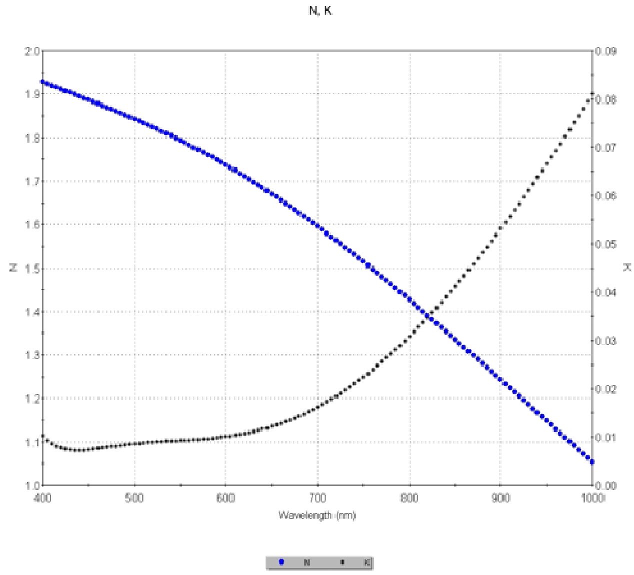

Figure 5. n and k for ITO layer

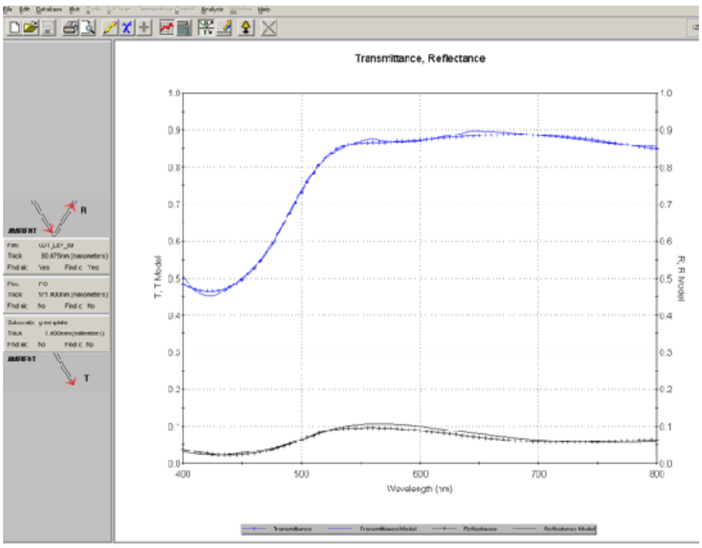

Figure 6. T and R with layer thickness for the glass/ITO/LEP device

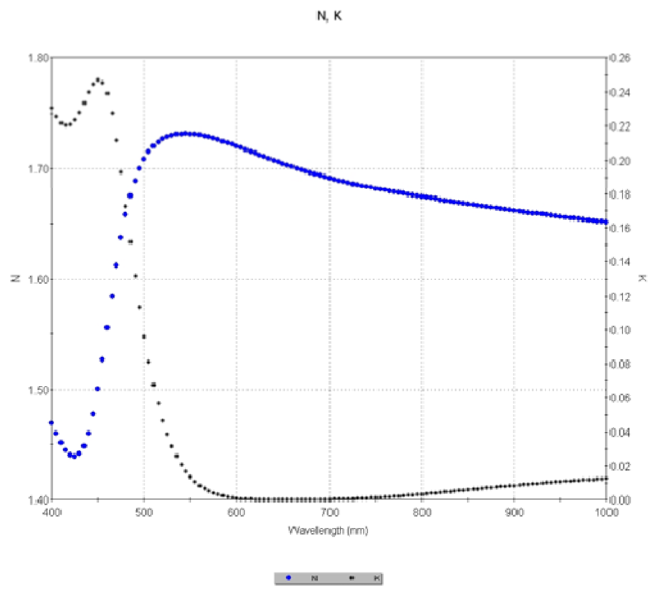

Figure 7. n and k for light emitting polymer layer

It can be seen then that the nkd spectrophotometer is capable of determining the optical properties and layer thickness of the individual films which constitute a typical OLED device with accuracy and ease. Its functionality and precision make it an ideal instrument for both production control and process development.