HORIBA Scientific

JOBIN YVON Technology

Spectroscopic Ellipsometry

Characterization of Organic Light Emitting Diodes (OLED) by Spectroscopic Ellipsometry

Application Note

Flat Panel Display

AN SE-34

OLED technology is playing an important role in display technology since it offers several advantages compared to LCD technology among which its efficiency and high display quality, a high contrast rate, lower energy consumption, etc. Furthermore, this technology has an ecological aspect since it uses organic recyclable materials.

However the improvement of the performances of the devices produced by these technologies requires a precise knowledge of their optical and structural properties that could be provided by spectroscopic ellipsometry. This non destructive and sensitive optical technique is able to characterize layers with thicknesses of some angstroms and provides information regarding the state of the surface, the microstructure of composite materials, etc.

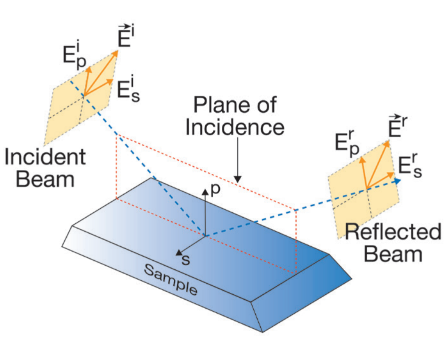
Spectroscopic ellipsometry

Spectroscopic ellipsometry is an optical non destructive technique dedicated to the characterization of the optical and structural properties of thin films. Its principle is based on the analysis of the change of the polarization state of a light beam after it is reflected from the surface of a material. Two observables are measured. The first one (ψ) is related to the change of the amplitude of the incident light beam while the second one (Δ) represents a measure of the change of the polarization state of the light beam after reflection upon the sample's surface. These two observables are given by:

$$\tan(\Psi) = \frac{|r_p|}{|r_s|} \quad ; \quad \Delta = \delta_p - \delta_s$$

Where δ_p and δ_s are the phase shifts undergone respectively by the p-polarized and s-polarized components of the electric field. r_p and r_s represent the Fresnel amplitude reflection coefficients. Phase modulation ellipsometry uses another couple of observables known as (Is,Ic). These observables are deduced from Ψ and Δ as follows:

$$Is = \sin 2\psi . \sin\Delta$$
$$Ic = \sin 2\psi . \cos\Delta$$



Spectroscopic Ellipsometry Measurements

The surface of the OLED sample characterized in this work is shown in figure 1a. Each pixel is 250 µm in length and 80 µm wide and consists of a stack of three layers (ITO, PEDOT, and Polymer-G0) on a 1 mm thick glass substrate (figure 1b). The measurements were carried out using the smallest light beam spot of the Auto-SE ellipsometer (figure 2). The dimensions of this spot are 25 µm x 60 µm. In addition to the small dimensions of the light beam spots provided by the Auto-SE, it has another advantage consisting in its high spatial selectivity.

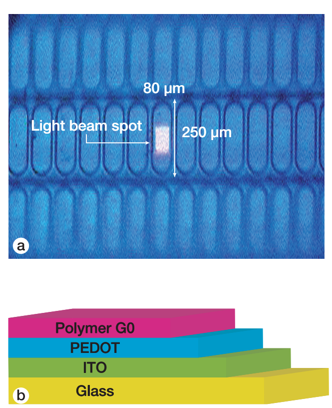


Figure 1

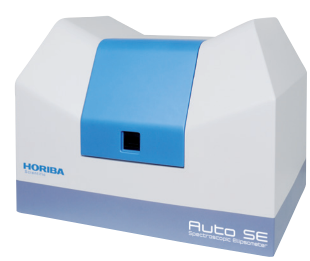


Figure 2

In general when working on glass substrates there is the problem of the light reflected from the backside of the substrate contaminating the experimental data and complicating the calculation. Typically the approach taken is to either account for this backside reflection in the calculations or scratch the rear surface of the substrate in order to eliminate the reflection. These approaches are not ideal, and for the second case destroy the sample. The unique MyAutoView Vision System of the Auto-SE allows the reflections from the top and bottom of the substrate to be separated, thus removing the backside reflection from glass substrates with thicknesses down to 0.4 mm, as well as selecting an ideal measurement position within the pixel.

The measurements have been carried out in the UV-Visible range over three steps. The first measurement has been performed on a sample consisting in an ITO layer on a glass substrate in order to characterize the optical properties of the ITO layer. The second measurement has been undertaken on a sample having the structure PEDOT/ITO/Glass and aimed at the determination of the optical properties of the PEDOT layer and the thicknesses of the two layers.

The final measurement was carried out on one pixel of the sample shown in figure1a. Each pixel consists, as mentioned previously, in the structure Polymer-G0/PEDOT/ITO/Glass. The purpose is to determine the optical properties of the Polymer-G0 layer and the thicknesses of the layers constituting the stack. Figure 3 shows the variation of the experimental (dots) and calculated (full line) observables versus wavelength. Figure 4(a-b-c) shows the wavelength evolution of the optical properties obtained after the fitting procedure for the three layers involved in the OLED structure.

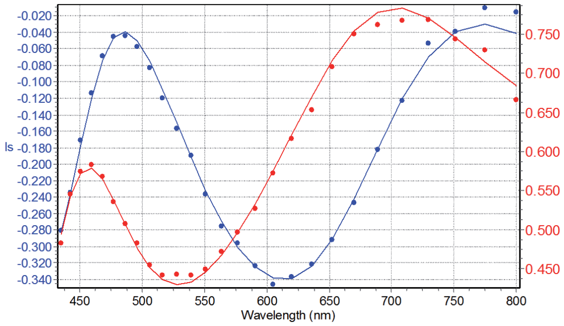
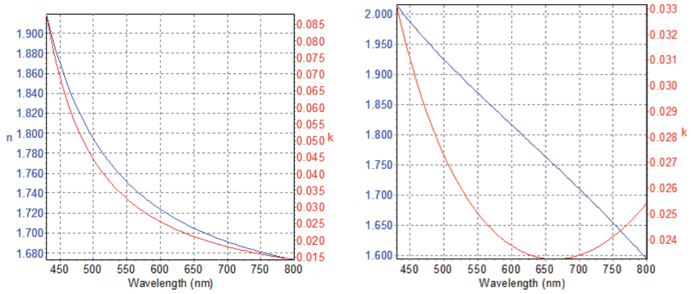
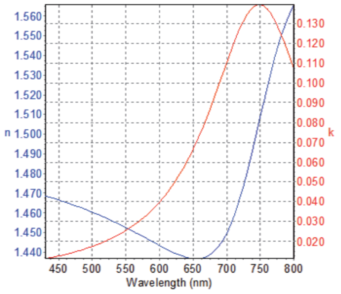


Figure 3





a	b
c	

Figure 4

a: Optical properties of Polymer-GO

b: Optical properties of ITO

c: Optical properties of PEDOT

In order to determine the variation of the thickness of the three layers over different points of the pixel surface, three measurements have been performed as depicted in figure 5. Owing to the sensitivity of the Auto-SE and the power of the Vision System it can be seen that the small light spot of the Auto-SE system allows automatic mapping within the pixels. This allows checking of the homogeneity of the layers through the comparison of the optical properties at the different measurement positions. The thicknesses obtained for the three layers over the different measurement points are reported on table 1.

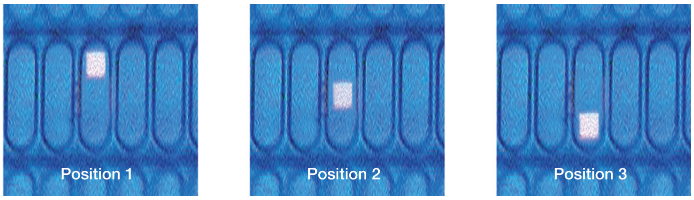


Figure 5: Mapping inside the OLED pixel at 3 different positions

Measurement Point	ITO (nm)	PEDOT (nm)	Polymer-G0 (nm)
Position 1	147	81	89
Position 2	141	72	112
Position 3	151	79	73

Table 1

Conclusion

The aim of this work is to show the capabilities of the Auto-SE ellipsometer to perform localized measurements at short scale thanks to its very small light-beam spots and the unique integrated MyAutoView vision system. Indeed, these features enable to target very small areas and thus, get ride of the averaging effects resulting from using the common large spots. This averaging effect occurs when dealing with thickness variations, patterned, striated and curved surfaces witch complicates considerably data analysis and modelling. In addition, MyAutoView vision system enables to choose the location on which to perform the measurement on the sample's surface and avoid areas having dust particles, impurities, or surface damages.

Furthermore, the Auto-SE system has another advantage consisting in its high spatial selectivity that enables to eliminate the backside reflection for transparent substrates having thicknesses down to 0.4 mm.

info.sci@horiba.com **www.horiba.com/scientific**

HORIBA Scientific

USA: +1 732 494 8660
UK: +44 (0)20 8204 8142
China: +86 (0)21 6289 6060
France: +33 (0)1 69 74 72 00
Italy: +39 2 5760 3050
Brazil: +55 (0)11 5545 1500
Germany: +49 (0)89 4623 17-0
Japan: +81 (0)3 6206 4721
Other: +33 (0)1 69 74 72 00