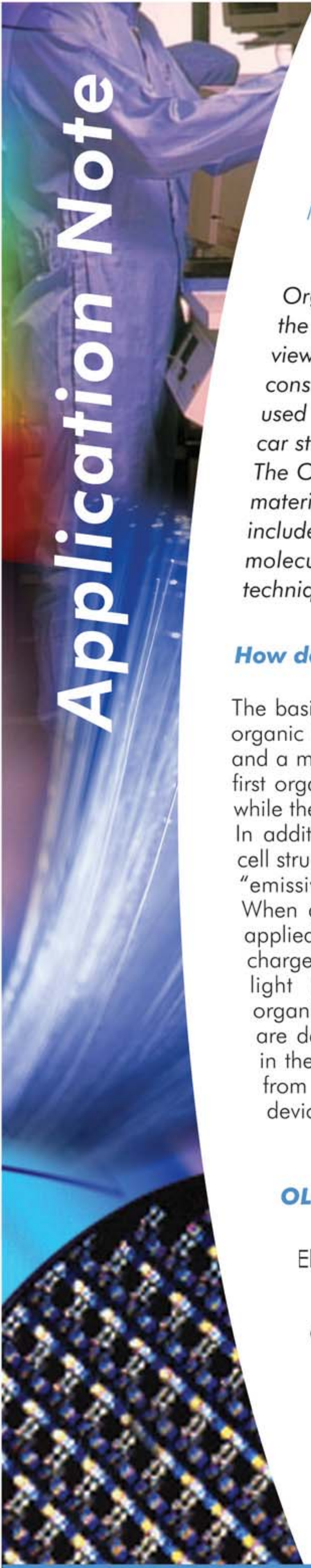
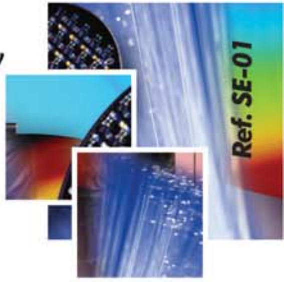




Spectroscopic Ellipsometry

OLED - Organic Light Emitting Diodes

Mélanie Gaillet - Application Engineer - Thin Film Division

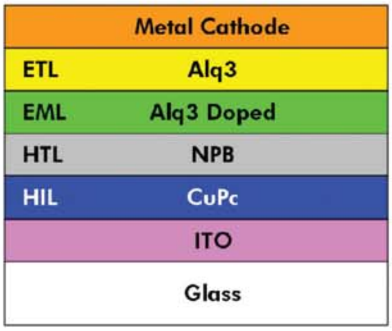
Organic Light Emitting Diodes (OLEDs) are currently under intense investigation for use in the next generation of display technologies. The benefits of this technology include wide viewing angle, high emission efficiencies that result in high brightness with low power consumption and low operating voltage. As OLED devices are very lightweight they may be used in cellular phones, notebooks, digital video cameras, digital versatile disc (DVD) players, car stereos, televisions and many other consumer tools that require colour displays.

The OLED is a display technology based on the use of organic polymers as the semiconductor material in Light-Emitting Diodes (LEDs). The organic materials used in OLED devices may include "small" molecules or "macro" polymers. For OLED displays constructed of "small" molecules vapour sublimation in a vacuum chamber is the most convenient deposition technique. In the case of macro polymers solvent coating techniques are often used.

How does an OLED Work ?

The basic OLED cell structure consists of a stack of thin organic layers sandwiched between a transparent anode and a metallic cathode. The anode injects holes into the first organic layer referred as the "hole injection layer", while the cathode injects electrons into its adjacent layer. In addition to the hole injection layer the basic OLED cell structure also comprises a "hole transport layer", an "emissive layer" and an "electron transport layer". When an appropriate voltage (typically a few volts) is applied to the cell the injected positive and negative charges recombine in the emissive layer to produce light (electroluminescence). The structure of the organic layers and the choice of anode and cathode are designed to maximise the recombination process in the emissive layer, thus maximising the light output from the OLED device. The overall thickness of the device is less than 2000 Angstroms.

Typical OLED Structure

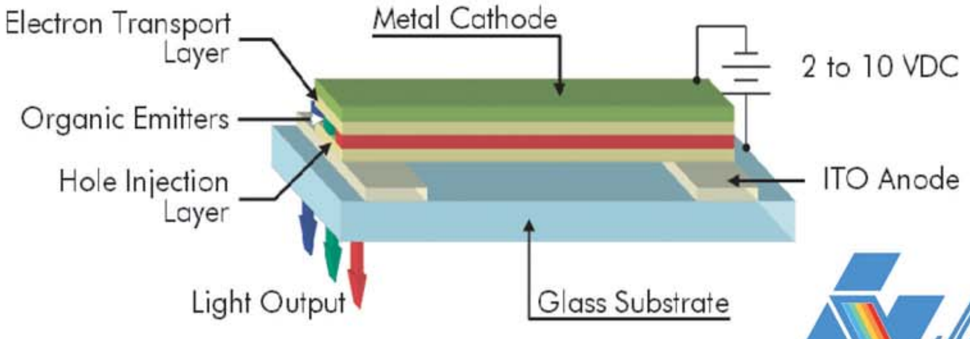


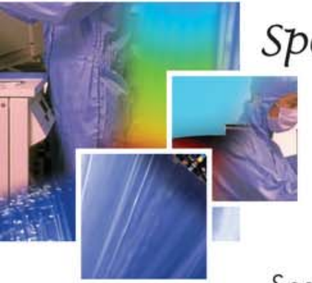
	Metal Cathode
ETL	**Alq3**
EML	**Alq3 Doped**
HTL	**NPB**
HIL	**CuPc**
	ITO
	Glass

HIL : Hole Injection Layer
HTL : Hole Transport Layer
EML : Emissive Layer
ETL : Electron Transport Layer

ITO : Indium Tin Oxide
CuPc : Copper phthalocyanine
NPB : Napthylphenylbiphenyl
Alq3 : Tris-(8-hydroxyquinoline) aluminum

OLED Working Principle





Spectroscopic Ellipsometry

OLED Thin Film Structure Characterisation

Spectroscopic Ellipsometry (SE) allows the non-destructive characterisation of OLED structures with high accuracy and precision. This note describes the successful application of the Jobin Yvon UVISEL phase modulated SE for this application.

Ellipsometric data were acquired at an angle of incidence of 56°, and the spectra represent the Is and Ic variables that are measured by phase modulated ellipsometers. Is and Ic are related to the ellipsometric angles Ψ and Δ defined in the fundamental equation of ellipsometry as follows:

$$r_p/r_s = \tan\Psi\, e^{i\Delta}$$

$$Is = \sin(2\Psi)\sin(\Delta) \text{ and } Ic = \sin(2\Psi)\cos(\Delta).$$

Phase modulated ellipsometry allows accurate determination of Ψ and Δ from 0° – 45° and 0° – 360° respectively with no dead areas.

The refractive index and thickness of each organic layer were extracted from the SE data analysis and are shown along with the optical properties of the ITO layer.

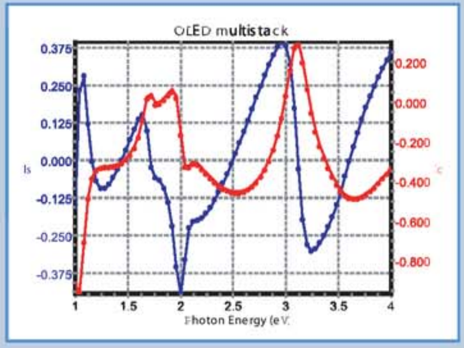
The optical properties of each organic material were calculated using advanced dispersion formulae with multiple oscillators to characterise the materials in the range 310-1240nm.

The ITO layer must be characterised as it is known to be an inhomogeneous material due to the deposition method or post-treatments. The optical properties of ITO represent a variation inside the layer and must be taken into account in the model.

OLED Structure and Modelling Result

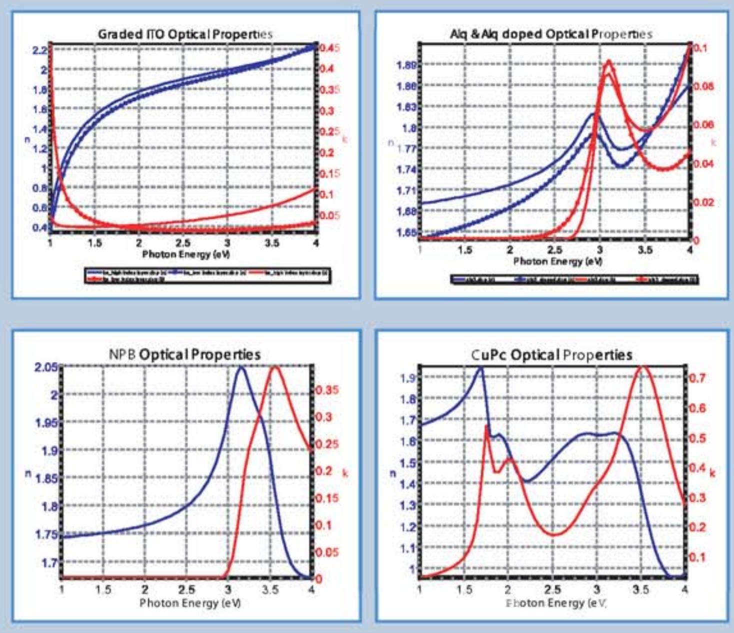
Alq3	338 Å
Alq3 Doped	386 Å
NPB	487 Å
CuPc	141 Å
ITO	1021 Å
Glass	

OLED stack and calculated layer thickness



Modelling result
Adjustment between theoretical model and experimental data

Optical Properties of the OLED Structure



Conclusion

Phase Modulated Spectroscopic Ellipsometry is an excellent technique for the highly accurate characterisation of complete OLED stacks. The technique allows the determination of film thickness, optical properties and the effect of dopants to the active layers.

For very high throughput applications where large area flat panels are to be characterised in a production environment the Jobin Yvon FF-1000 ellipsometer has a fully automated sample stage able to accept samples up to 1000 mm x 1000 mm. This accurate, automated thin film metrology tool delivers both unique performance and proven reliability for on-line quality control of production processes.

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