

Precision Industrial Ink Jet Printing Technology for Full Color PLED Display Manufacturing

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1. Abstract

Litrex Ink Jet equipment offers prospect for reliable and low cost manufacturing process for PLED technology. The design concept of 140P system that we are developing meets requirement of process/equipment for PLED manufacturing line in terms of higher mechanical accuracy, in-line monitoring system of print head, high precision of process capability, reasonable through-put, high reliability/easier maintenance and no particle generation.

2. Introduction

PLED (Polymer Light Emitting Display) technology provide a new alternative to TFT-LCD for many display applications, and are particularly attractive because of brightness, wide viewing angle, fast response time and low power consumption. At SID 2002, Boston, and this year ^{[1][2][3]}, several companies such as CDT, Philips, Dupont, Seiko-Epson, TM (Toshiba-Matsushita) Display, Samsung SDI and Delta are developing AM-PLED and PM-PLED technology and have already demonstrated PLED devices.

The forecast for market size of OLED/PLED display presented by Stanford Resource is expected to reach \$1.5 billion in 2007 ^[4], which demonstrates the need for industrial production and research equipment for process development. To achieve successful volume production of PLED technology, two items are required. First, the need to develop and improve PLED material in terms of lifetime, efficiency and color coordinate is required, and second, a low cost manufacturing technology such as ink jet technology. To establishment this PLED infrastructure, Litrex, CDT and Covion has teamed together to deliver a total package of ink jet technology.

3. Ink Jet Technology

The ink jet process offers prospect for reliable and low cost manufacturing of PLED technology. Table 1 below shows the comparison between OLED (Small Molecular Type) and PLED (Polymer Type) display manufacturing:

Table 1. PLED vs. OLED Display Manufacturing

	OLED	PLED
1. Process	Complicated	Simple
2. Material Usage	More	Less
3. Equipment Cost	High	Low
4. Manufacturing Cost	High	Low
5. Product (Higher Resolution and Larger Screen)	Difficult	Achievable

3.1 Design Concept of 140P System

Litrex 140P system will handle glass substrates up to 400x500mm (Generation 2.5). The machine's total mechanical accuracy is less than 5.5 microns tolerance; this takes into account the stage alignment, thermal and vibration conditions. The system includes in-line monitoring with a two-camera system of the print head to make sure all ink jet head nozzles are firing correctly before printing on the substrate.

The system's footprint is compact measuring 52.6" W x 47.5" D x 98.3" H (133.6 x 120.7 x 250 cm), which allows for smaller in-line configurations and a lower cost clean room facility. The 140P is a modular design allowing for ease of maintenance and high reliability. This system has a high precision process capability. Drop placement accuracy is around 12 microns with good drop uniformity of less than 5% and its mechanical features do not generate particles potentially contaminating the substrates during printing. Substrate throughput will be discussed later in this paper.

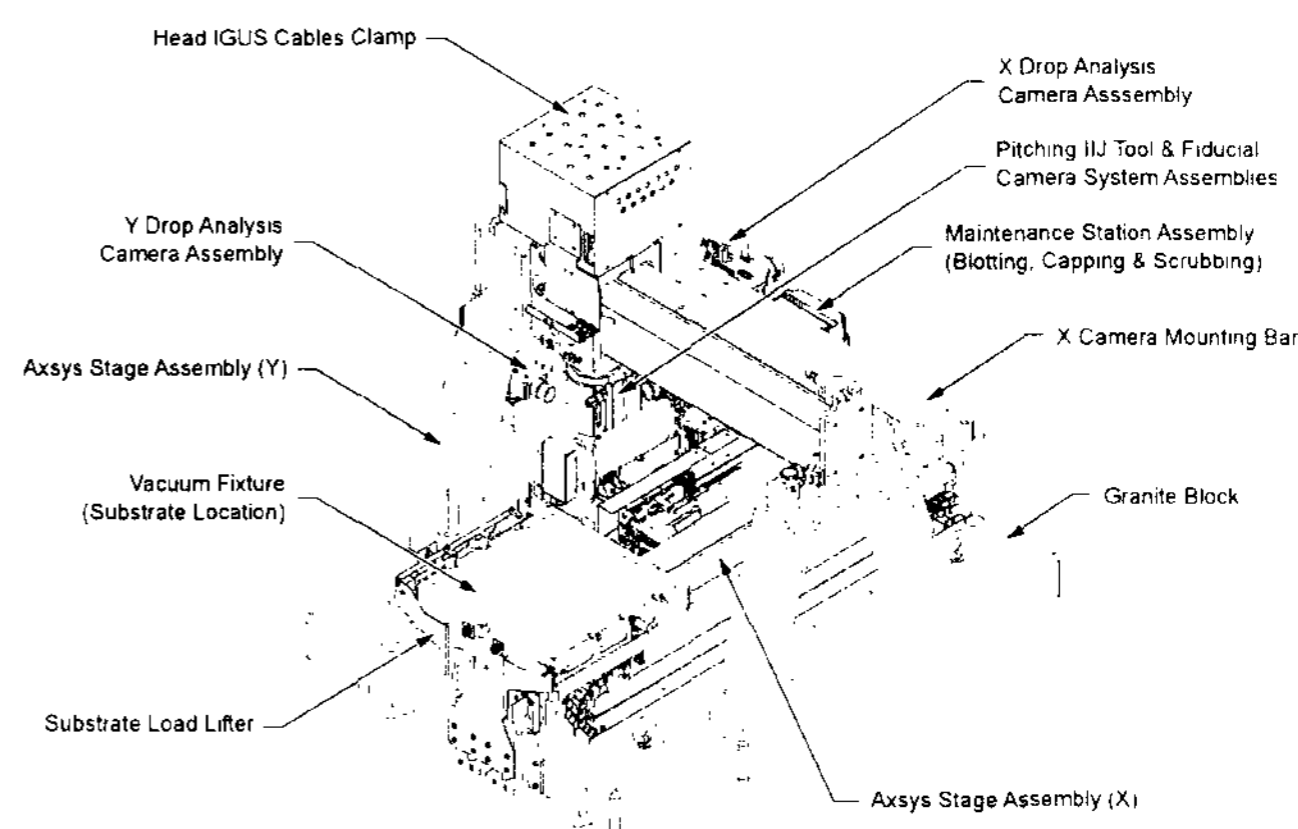


Figure 1. 140P Print Engine

3.2 Drop Analysis System

The 140P Drop Analysis system consists of a two-camera and strobe LED system and works in conjunction with the system software to allow rapid verification of each nozzle, checking for drop volume, drop velocity and angle deviation and any other defects such as misfiring nozzles before substrate printing. This system is used to calibrate Litrex IJJ systems (80L and 140P) and improve the device yield. It is also very useful for material development and process development of PLED devices as well as other applications (TFT-LCD).

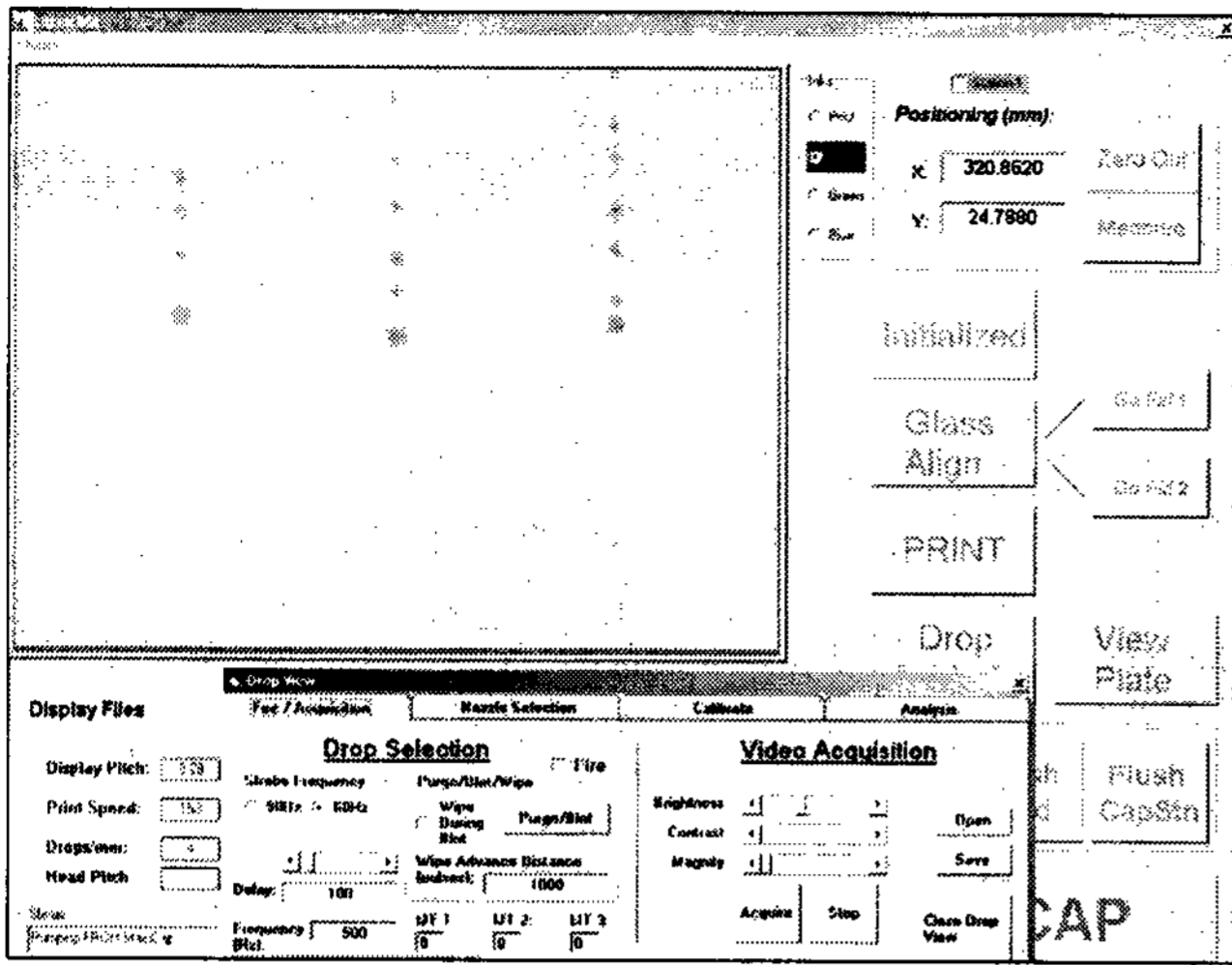


Figure 2. Screen Capture of the Drop Analysis System from the Litrex System Software Main Screen

3.3 LCL Patterning Flexibility (Direct Patterning Environment)

Litrex IJ Systems are controlled by the LCL (Litrex Control Language) printer system software, which is used for driving separate XY positional stages of the printer and other hardware components, automatic optical alignment of the print head and substrate, nozzle failure inspection, print head maintenance, nozzle drop image analysis (volume, placement, and correction), and graphical user interface for printer operation.

Below is a screen capture from a Litrex system showing the print head drops in flight. It enables users to produce their own print pattern and change the process design without the need for software rewrites. Unlike a fixed photolithography mask, the print pattern is a digital file that can be easily changed. The optional LCL environment permits the user to customize applications.

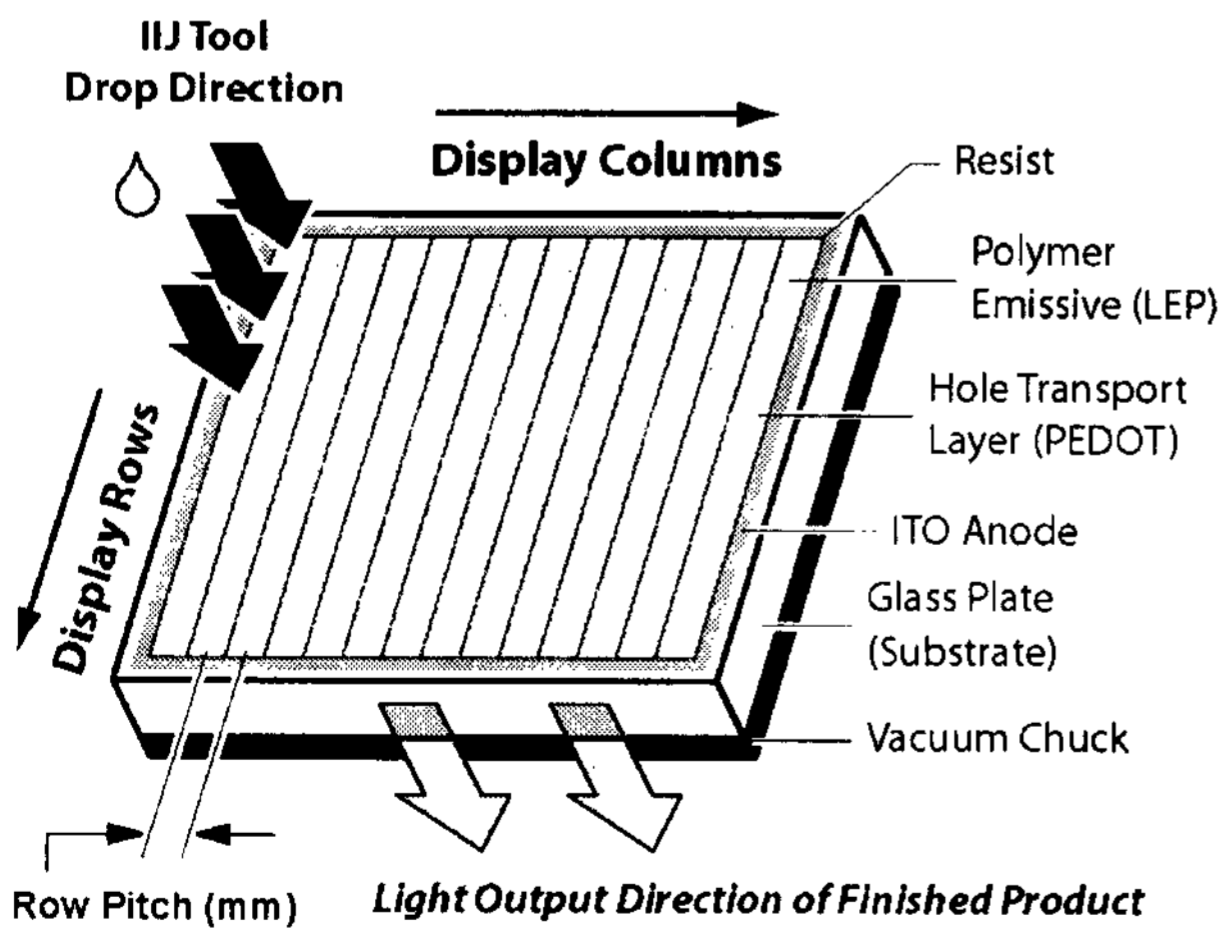


Figure 3a. Row Printing

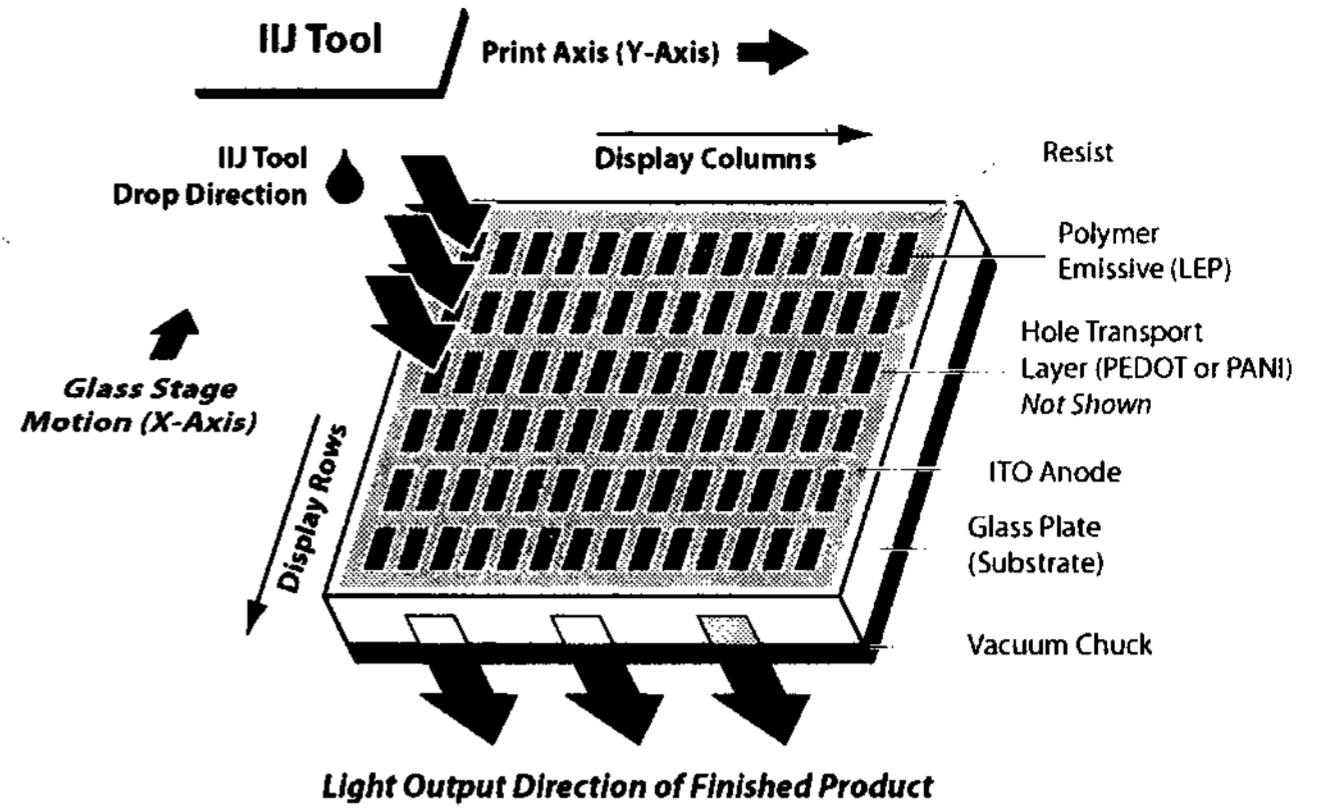


Figure 3b. Well Printing

3.4 Ink Jet Patterning Accuracy Directionality

According to the design concept of our 140P system, the drop placement accuracy on substrate is around 12 microns. The figure below shows a schematic diagram of the drop placement accuracy while making a PLED device.

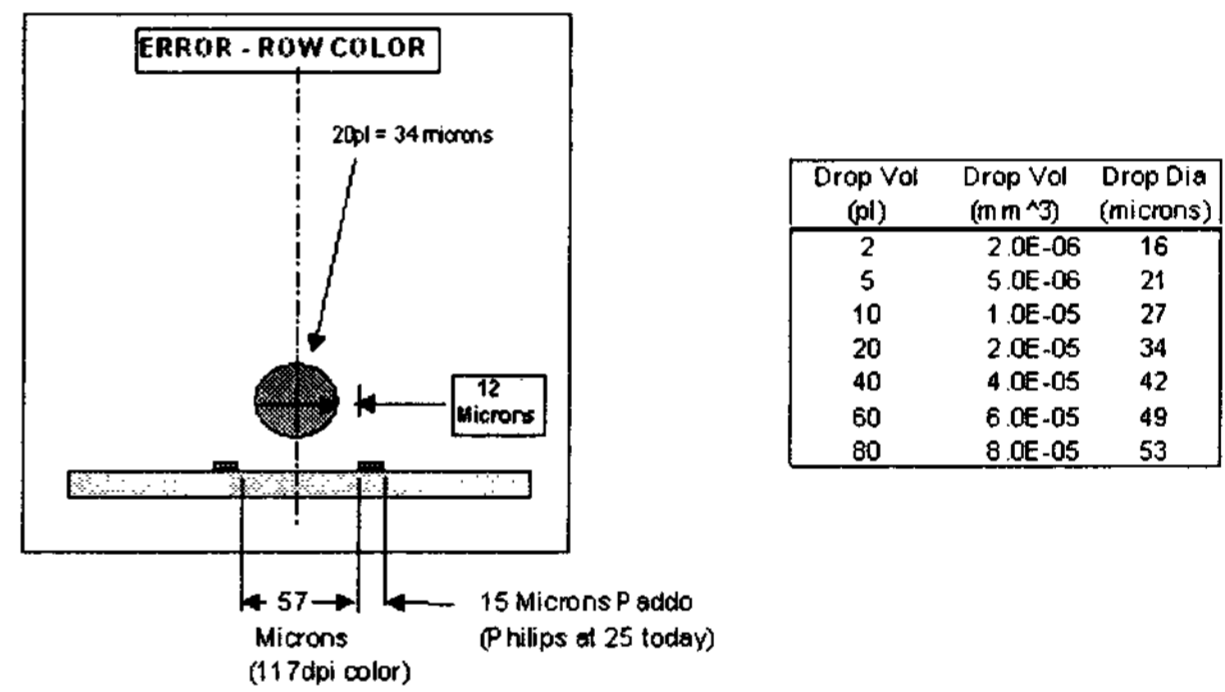


Figure 4. Drop Placement Accuracy & Drop Volume

To make a PLED device, for example, assuming a resolution of 117 ppi (57 micron pixel width) and a 20 picoliter (pl) print head, the ink jet process has about 12 micron process margin on both sides of the well structure considering the substrate positional accuracy, glass alignment accuracy, print head mount/pitch accuracy, drop directionality, glass flatness and other sources such as a patterning bank structure.

Litrex is collaborating with other developers in developing a smaller drop volume print head to get more process margin of ink jet process and to make high-resolution PLED devices. Another important thing to remember is that drop placement accuracy will be dramatically improved by surface treatment of the substrate such as wetting and non-wetting. The combination of ink jet equipment accuracy, including new print head and surface treatment, gives better drop placement accuracy enabling higher resolution PLED devices of up to 200ppi.

3.5 Through-put Analysis

Figure 5 below shows the printing time of the 140P System for Generation 2.5 glass size. Printing time is for print time only not including glass loading/unloading and glass alignment. The figure assumes a print cycle efficiency of 70% (where 30% is in acceleration of the linear motor, positioning and turnaround). The printing time depends on performance of the print head and resolution of the device. With a print head containing 256 nozzles running at a frequency of 2KHz, the printing time for each device with a resolution of 200ppi will take about 100 seconds to print.

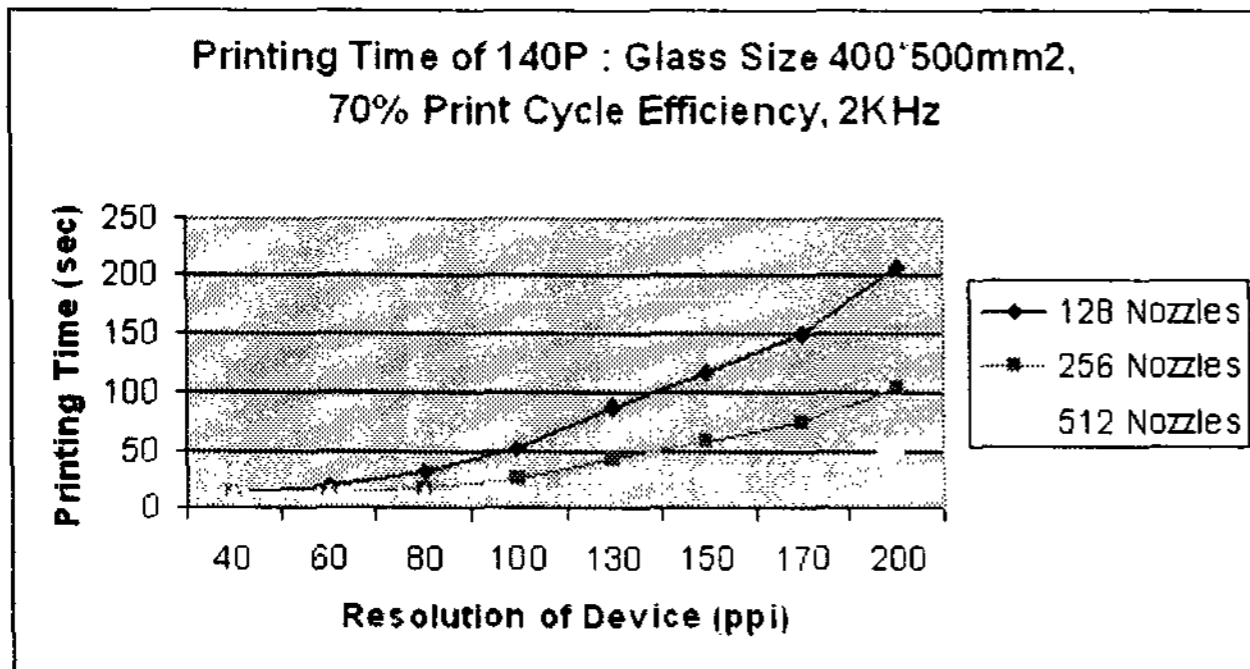


Figure 5. 140P Printing Time in 400x500mm² Glass Size

3.6 The Breakthrough of Ink Jet Technology for Volume Production

We are continuing to develop our 140P System and ink jet technology to improve the performance in terms of patterning resolution, ink jet process reliability and throughput.

4. Conclusion

Ink jet technology offers prospects for reliable and low cost manufacturing processes of PLED technology. The 140P System design is very reliable and accurate in achieving the manufacture of PLED devices using ink jet technology. Ink jet technology can also be useful in reducing the manufacturing costs, such as the color filter process, in the TFT-LCD industry.

5. Acknowledgement

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6. Reference

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