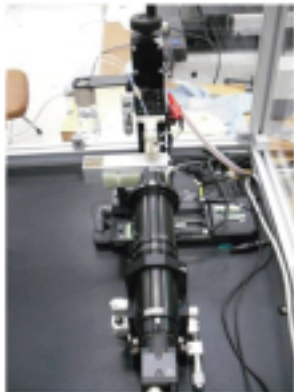


# >> Contact angle measurement system base on piezo inkjet

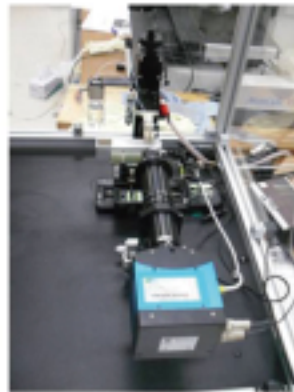
(Micro droplet from pico-liter to micro-liter) [연구 개발을 위한 기관 위의 액적 거동 관찰 시스템]

## Vision Measurement system

CCD camera and high Speed camera can be used to measure micro-droplet on a substrate.

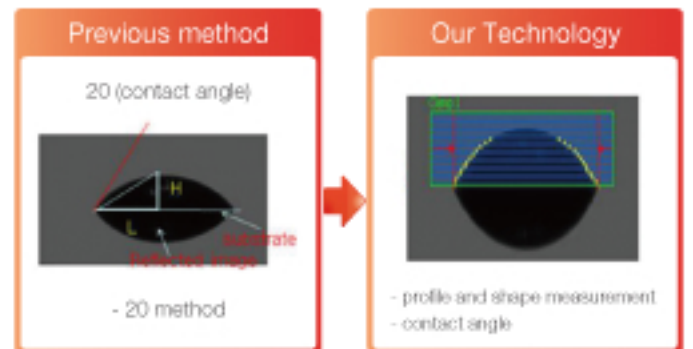


CCD camera



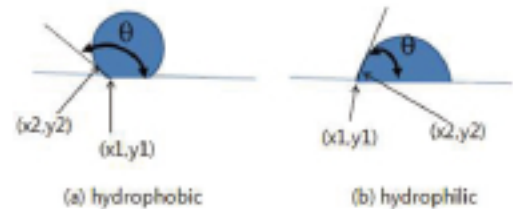
High speed camera

## Vision analysis algorithm



Binary image analysis

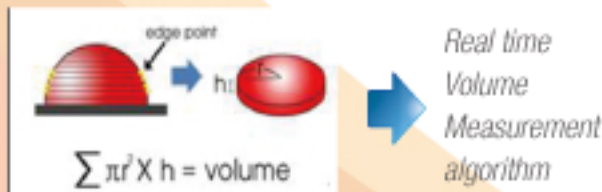
Edge detection technique



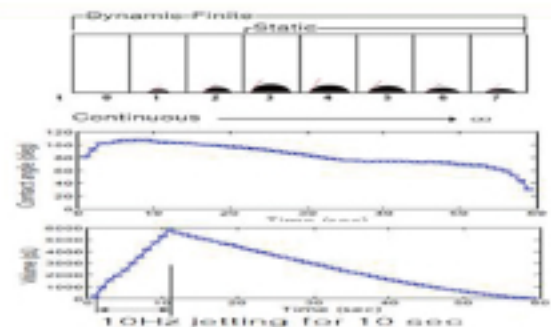
Contact angle calculation

## Droplet analysis

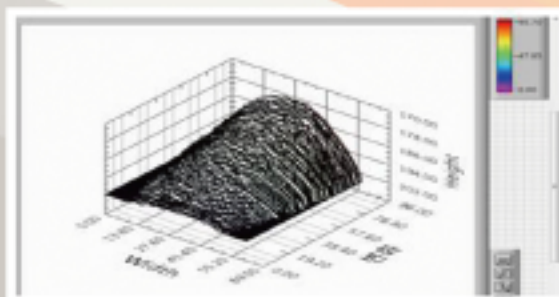
- 1 Real-time contact angle and droplet volume measurement



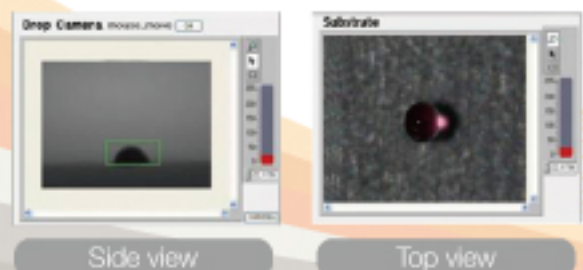
- 2 Dynamic analysis



- 3 Evaluation of penetration and drying of micro-droplet on a substrate



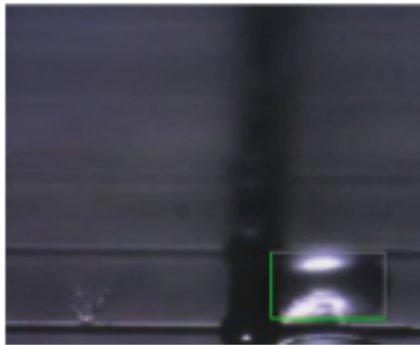
- 4 Top and side view



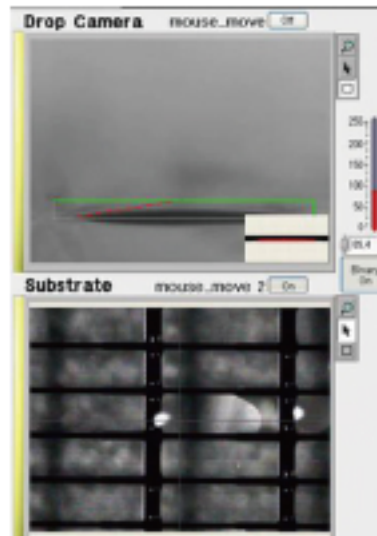
## >> Measurement system for contact angle and wetting condition

(Micro droplet from pico-liter to micro-liter) [연구 개발을 위한 기판 위의 액적 거동 관찰 시스템]

### Evaluation of wetting condition on the cell of display panels



Wetting measured on display panel



- Two cameras are equipped to acquire side and top view images simultaneously
- Droplet can be precisely placed on target location.

### Measurement system specification

Piezo inkjet head	MicroFab Head
Drop Size	Volume 30pL~
Substrate Size	80mm X 26mm (Model : Psjet-100)
Image View	Top and side view
Droplet placement accuracy	3 $\mu$ m
Dynamic and patterned jetting	Yes

### Features

- Accurate droplet placement on target location. (accuracy : 3 $\mu$ m)
- Real time Contact angle and droplet volume measurement.
- Evaluation of penetration and drying of micro-droplet on a substrate.
- Precision control of ink droplet volume.

#### 참고문헌

Publication : 한국정밀공학회지 제 30권 제 4호 pp.414~420) - 미소 액적의 접촉각 및 건조 특성 측정 시스템 개발 (Development of Measurement System for contact Angle and Evaporation Characteristics of a Micro-droplet on a Substrate)

## >> Electrohydrodynamic jet printing system

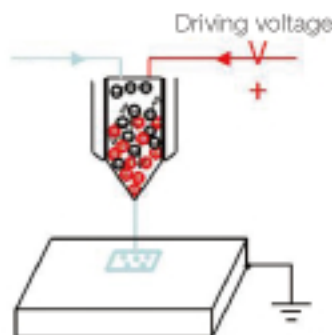
### Electrohydrodynamic jet printing (EHD)

Electrohydrodynamic jet printing uses electric field to create ink jetting from nozzle to deliver ink for high-resolution (less than  $10\mu\text{m}$ ) pattern applications.

### Advantages & jet mode

#### 1 Advantages of using EHD jet printing

1. High resolution printing
2. Wider range of jetting fluid
3. Simple in principle and hardware



#### 2 Jet mode

Jet mode	Electrical field	Hydro-static force	Ink viscosity
Continuous jet	DC	Flow rate control	100–10,000cP
Pulsating jet	DC + pulse	Pressure control	1–100cP

### Two jetting modes for fine printing are available

#### 1 Continuous jet (DC voltage)



Ink Viscosity: more than 100cP  
 - Faster printing (more than 100mm/s)  
 - On-off control for patterning is difficult

#### Jet visualization - Continuous jet

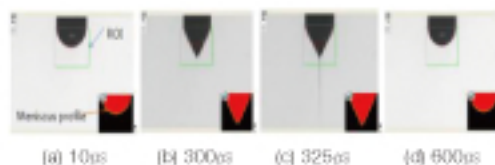


#### 2 Pulsating jet (DC + Pulse voltage)



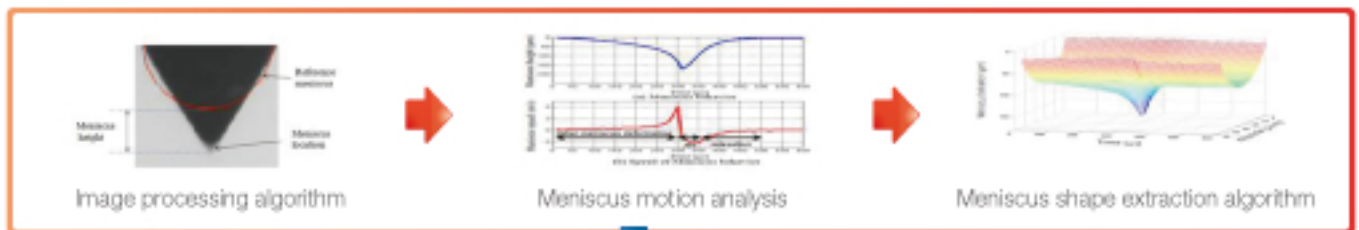
Ink Viscosity: less than 100cP  
 - Drop on demand printing is easier  
 - Slow in printing (about 1kHz jetting)

#### Jet visualization based on strobe LED (using CCD camera) - Pulsating jet

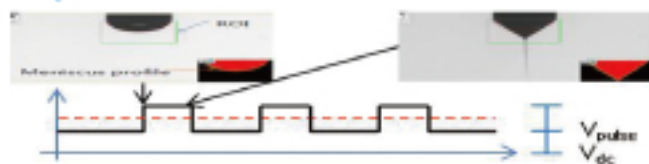


## >> Electrohydrodynamic jet printing system

### EHD jet analysis using strobe LED



Easy to optimize pulse voltage by visualizing EHD jet using low-cost CCD camera



### Printing Software

#### 1 Built in Cad



#### Features

- capable of importing CAD file
- Edit imported CAD information
- Sketch mode on drawing area
- Vector to raster conversion algorithm
- Multi-layer printing
- Various CAD command (line, arc, Block, Array, undo, delete, etc)

#### 2 Printed results of EHD jet

(Nozzle size : 8~15 $\mu\text{m}$ , Ink : nano silver ink)

Raster printing	Vector printing	3D printing
• Dot size : 7 $\mu\text{m}$	• Line width : 7~8 $\mu\text{m}$	- High aspect ratio - Micro 3-D structure

### Specification

Nozzle Size	8, 15, 30 $\mu\text{m}$
Substrate Size	250mm X 200mm (Model : PSjet - 300)
Camera	- Top view camera for printing alignment - Size view camera for real-time jet monitoring
Droplet placement accuracy	Less than 2~3 $\mu\text{m}$
Fluidic system	Air pressure or syringe pump
Optional	- Inkjet and EHD combined system upon request

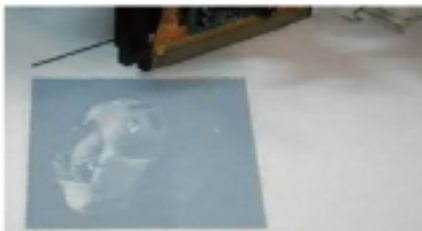
## >> Inkjet printing system

### Main features of PS printing system



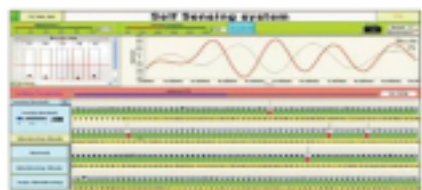
#### Built-in CAD software

- Capable of importing CAD file (dxf file)
- Edit imported CAD information
- Sketch mode
- Image printing (bitmap, png, gif, jpg, etc)
- Vector to raster conversion algorithm
- Various CAD command (Line, Arc, Block, Undo, Delete, etc)



#### User defined print resolution

- Multi-nozzle printing algorithm for head tilting or non-tilting for arbitrary print resolution
- Printing patterns using selected nozzle only
- No need for matching between nozzle spacing and image resolution for printing



#### Jet failure detection by using piezo self-sensing

- zero form factor
- Low cost and high speed scanning (scanning time of less than 1 sec for 256 nozzles)



#### Self-diagnostic algorithm and automatic printing of non-printed area



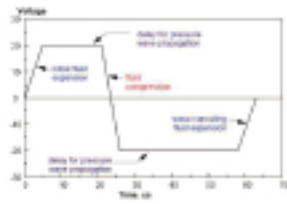

- Real-time detection of faulty nozzles during printing process
- Identifying non-printed (or location) due to faulty nozzles
- Automatic printing of non-printed area

### Specification

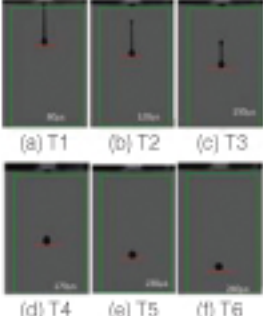
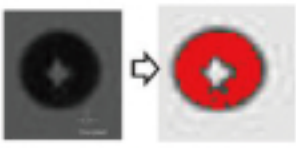

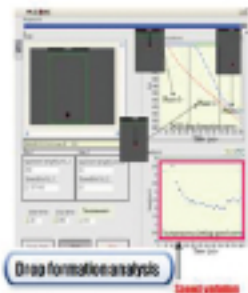
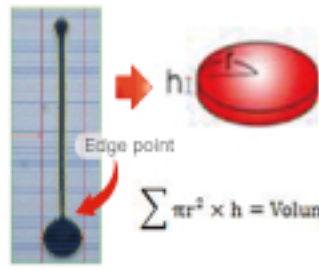
Substrate Size	250mm X 200mm (Model : Psjet - 200)
Print resolution	User defined (not related to nozzle spacing)
Printing mode	- Vector or raster printing - Multi-layer printing
Optional	- Substrate / Head heating - Drop watcher - EHD combined system - Faulty nozzle detection by using piezo self-sensing

## >> Main features of PS Drop watcher system

### Proper measurement of jetting performance is essential in inkjet printing

Various Inks	Various Inkjet Heads	Jetting conditions	PS drop watcher
			 <p><b>Jetting evaluation and measurement items</b></p> <ul style="list-style-type: none"> <li>- Jetting speed</li> <li>- Droplet volume and droplet mass</li> <li>- Jetting frequency characterization</li> <li>- Jet straightness</li> <li>- Drop formation</li> </ul>
Ink optimization	Head selection	<ul style="list-style-type: none"> <li>- Waveform optimization</li> <li>- Head temperature control</li> </ul>	
<p>Jetting evaluation is needed to optimize jetting conditions.</p>			

### Drop watcher system

Conventional Drop watcher system		Our technology									
<p><b>Jetting speed</b></p>  <p>(a) T1 (b) T2 (c) T3 (d) T4 (e) T5 (f) T6</p> <table border="1"> <tr> <td>t1</td> <td>t2</td> <td>speed</td> </tr> <tr> <td>(a)</td> <td>(b)</td> <td>2.2m/s</td> </tr> <tr> <td>(c)</td> <td>(d)</td> <td>1.5m/s</td> </tr> </table> <p>- Jetting speed varies according to drop formation. - Without consideration of drop formation, measured jetting speed can be misleading.</p>	t1	t2	speed	(a)	(b)	2.2m/s	(c)	(d)	1.5m/s	<p><b>Droplet volume</b></p>  <p>Droplet volume can have some errors due to camera resolutions, threshold value, light conditions, etc.</p>  <p>Difficult to calculate droplet volume in presence of long ligament and satellites.</p>	<p><b>Drop formation analysis</b></p>  <p>Drop formation analysis</p>  <p>Edge point <math>\sum \pi r^2 \times h = \text{Volume}</math></p> <p>Droplet volume can be easily calculated in presence of ligament and satellites.</p> <p><b>Drop formation measurement</b></p> <ul style="list-style-type: none"> <li>- Evaluation of ligament and satellite behavior</li> <li>- Measurement of jetting speed variation during drop formation</li> <li>- Relative jetting speed of satellite with respect to main drop</li> </ul>
t1	t2	speed									
(a)	(b)	2.2m/s									
(c)	(d)	1.5m/s									

### Specification for drop watcher

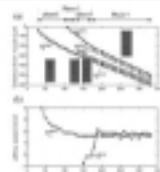
Inkjet head	Various head can be available upon request
Jetting frequency	100 Hz ~
Strobe Delay	0 $\mu$ s to 1 sec (80ns step)
Adjustable zoom lens magnification	1.5x ~ 9x

## >> Inkjet measurement and printing solution

### Drop watcher



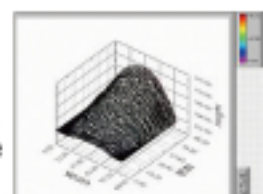
- Jetting performance evaluation (jetting speed, volume, droplet mass)
- Drop formation measurement
- Evaluation of ligament and satellites



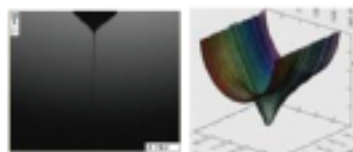
### Contact angle and wetting condition (Micro droplet measurement)



- Pico-liter droplet dispensing
- Real-time measurement of contact angle and volume
- Evaporation rate can be calculated
- Characterization of ink drying and penetration on a substrate
- Wetting condition of ink droplet on display sell



### Electrohydrodynamic (EHD) jet printing



- Patterning size less than 10  $\mu\text{m}$  line width
- Visualization of EHD jet using strobe LED (Using low-cost CCD camera)
- Built in CAD software (Vector to raster print algorithm included)

### Our Inkjet printing system



Raster printing results (Dot size : 5-7 $\mu\text{m}$ )

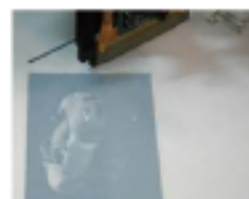
Ultra fine patterning



High aspect ratio  
(3D micro structure print)



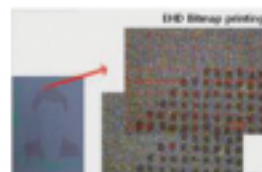
Vector to raster conversion  
(Dxf CAD file to bmp image)



Head tilting  
(User defined print resolution)

### All in one printing system

- Customized software & hardware
- Various printing algorithm
- Inkjet jetting and wetting measurement
- Hybrid printing system (EHD, Inkjet, etc)
- Inkjet health monitoring (jet failure detection system)



## >> PS-jet Model Lineup

All in one printing system

### Model lineup



PSjet-100



PSjet-200



PSjet-300

### Specification

<p><b>PSjet - 100</b> (Low-cost printing system)</p>	<ul style="list-style-type: none"> <li>• Low-cost stepping motor (accuracy : less than 5<math>\mu</math>m)</li> <li>• Printable area : 80 mm X 26 mm</li> <li>• Drop watcher</li> <li>• Contact angle / wetting condition measurement</li> <li>• Hybrid jetting system (Inkjet and EHD)</li> </ul>
<p><b>PSjet - 200</b> (Multi-nozzle printing system)</p>	<ul style="list-style-type: none"> <li>• XY linear motor (accuracy : less than 2<math>\mu</math>m)</li> <li>• Inkjet head (Q-class, S-class, MicroFab, etc)</li> <li>• Printable area : 200 mm X 250 mm</li> <li>• Drop watcher</li> <li>• Head monitoring based on piezo self-sensing</li> <li>• Built in CAD software</li> <li>• Head / Substrate heating</li> </ul>
<p><b>PSjet - 300</b> (Single nozzle printing system)</p>	<ul style="list-style-type: none"> <li>• XYZ linear motor (accuracy : less than 2<math>\mu</math>m)</li> <li>• Printable area : 200 mm X 250 mm</li> <li>• Real-time jetting monitoring (side view camera)</li> <li>• Contact angle / wetting condition measurement</li> <li>• Hybrid jetting system : Inkjet and EHD jet system</li> <li>• Head / Substrate heating</li> <li>• Built in CAD software</li> <li>• Max printing speed : 700 mm/s</li> </ul>

\*We can customize printing systems according to customers' needs and requirement.