

# 실리콘 노즐 기반의 정전기력 잉크젯 액적 토출 시스템

## Drop generation behavior through silicone based nozzle for electrostatic hydrodynamics inkjet system

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Key words : Electrostatic hydrodynamics, EHD, Nozzle, Pin to pin

### 1. Introduction

In recent times, inkjet printing technology was more developed for printed electronics (PE) using piezo, aerosol and thermal types head. Printed electronics are produced by printing the conductive ink nano-metallic particles. Those head technique can be help to make electronics chipper than manufacturing by lithography or using other semiconductor technologies [1,2]. Inkjet has advantages of direct patterning (reducing manufacturing time and cost on the market) and printing on thin substrates (likes paper and plastic films). but the earlier deposition schemes have different disadvantages like clogging of nozzles, complicated structures, physical forces to generate the required droplet and multi step processing. but now a days, to increase the efficiency of the deposition, the focus of the research is changing to electro-hydrodynamics (EHD) inkjet head for the development of printing devices as EHD inkjet head works on electrostatic forces to generate the droplet as per the requirement[3].

In this research, the focus is on the development of EHD inkjet head for reducing droplet size and high aspect ratio pattern line. The paper explains construction of silicone nozzle head, drop on demand (DOD) phenomenon and controlled result patten line on the substrate.

### 2. Experiment setup

#### 2-1 Experiment system setup

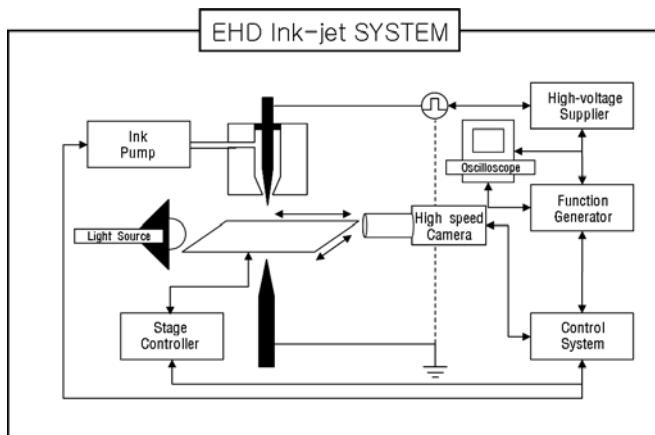


Fig.1 Schematic diagram of EHD inkjet experiment system

The overall schematic diagram setup is shown in the Fig.1. Droplet is generated by electrostatic force for Pin to Pin setup [4]. Firstly, ink charging pin in EHD nozzle is connected positive voltage and ground pin connected to negative voltage from high-voltage supply. High-voltage supplier is controlled by function generator. Function generator can generating AC signals by main control system instructions. Oscilloscope is setup between function generator and high-voltage supplier for comparison of input-signal and output-signal. High speed camera is installed near to EHD inkjet head

for observation of drop generation. Ink pump supply used to transfer the conductive ink to EHD inkjet head using teflon tubing. Substrates fixed on 2-axis stage by holder. 2-axis stage is controlled by main control system signal for stage power controller. Standoffs of all inkjet part (EHD head, substrate and ground pin) is controlled by manual z-axis stages.

#### 2-2 Fabrication of Silicone based Nozzle

Fig.2 shown fabrication sequence for silicone based EHD inkjet nozzle head. at first, the mold of the nozzle head is designed using plastic and metallic pin as shown in the fig.2 (a). then, liquid silicone was poured in the mold as given in the fig.2. (b). then the complete silicone model was cured at 80°C in the thermal oven. the mold is removed after 3 hours to get the final model as shown in fig.2. (c). Fig.2 (d) presents the schematic dimensions of each measured part. where D1 is nozzle orifice dimension, D2 is dimension of electrode holding part, D3 is dimension of ink supplying hole and L1 is length of nozzle orifice channel. Fig.2 (e) shows the holding mechanism of the tungsten electrode. It is used for dual purpose to holder the connector of the electrode and block ink fluidic leakages for using rubber stopper where D4 is diameter of electrode at the holding point. Fig.2 (e) also shows another parameter "Dt" which represent the dimension of tip of electrode. Table 1 shows dimensions of all the parameters of the specifically fabricated nozzle head for this experiment. Fig.3 shows final silicone nozzle head.

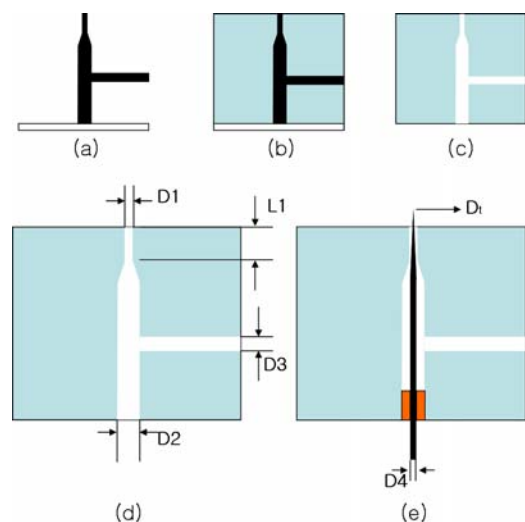


Fig.2 Fabricating sequence of silicone nozzle

Table 1 Measured Data of Nozzle parameters (mm)

D1	D2	D3	D4	L1	Dt
0.28	2.5	1	0.8	3	0.005

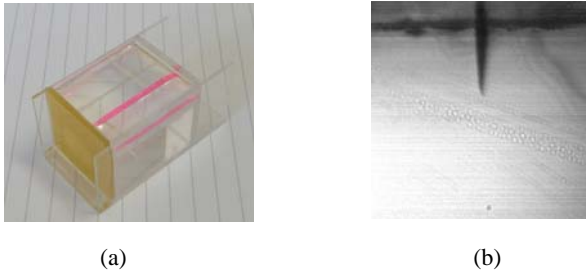


Fig.3 Shows the silicone nozzle head

### 3. Results and Analysis

Fig.4 shows sequence of drop generation cycle captured by high speed camera. Fig.4 (a) and fig.4 (b) shows initial meniscus and stable meniscus respectively. Fig.4 (c) ~ (h) shows the effect of high electrostatic field being generated between electrode and ground and its effect on conductive ink, supplied by pump unit. Fig.4 (c) ~ (h) also shows the effect of change in applied voltage and drop generation phenomena. it can be seen that due to voltage the change of meniscus into the jet shape. Fig.4 (i) ~ (j) shows recoil behavior meniscus of the meniscus. here its important to mention that the power supply being used to provide the extraction voltage has the same rising time and off time ratio. Fig.4 (k) ~ (l) shows again the initial meniscus before the starting of the 2nd droplet generation cycle.

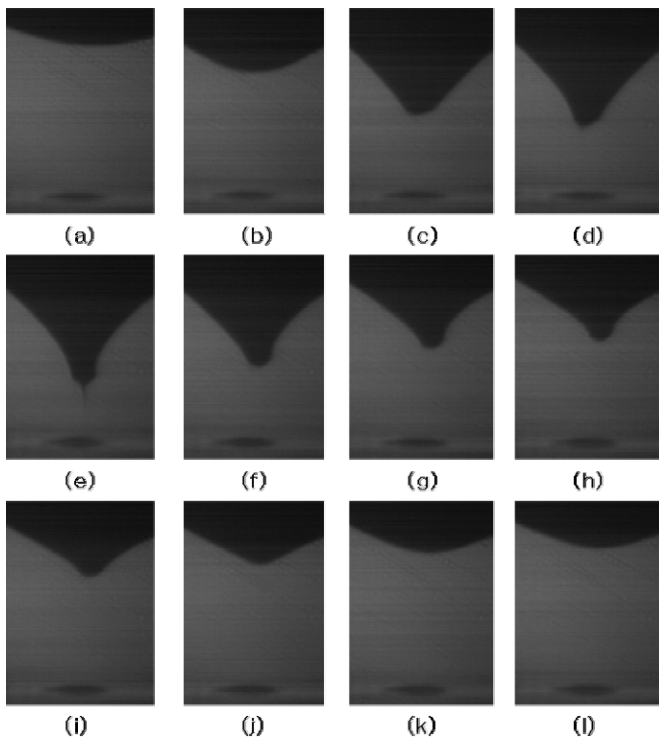


Fig.4 Shows images of one drop generation cycle

Fig.5 shows the microscopic images of resultant pattern line on the substrate. The line width achieved has all other parameters constant like substrate speed, substrate, ink and nozzle size. The only variable parameter is the voltage level. Each patterns printed by only changing voltage levels.

Fig.6 shows graph of line width on the substrate by increasing voltage. At higher applied voltage, reduce droplet size is obtained which in consequences reduce the line width. In this experiment, printing line width of 10um is obtained.

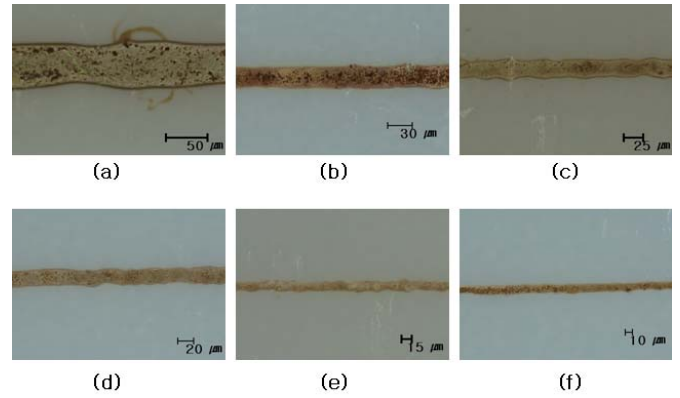


Fig.5 Shows images of the patterns on the substrate by microscope

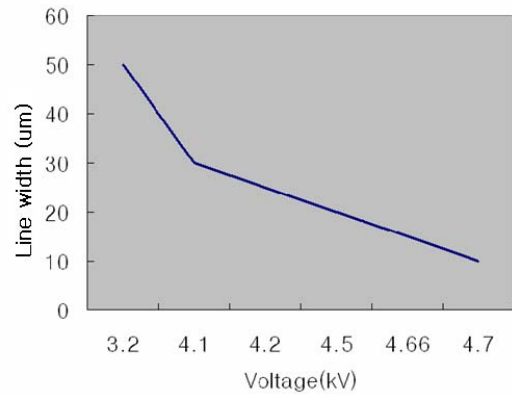


Fig.6 Drop generation behavior by supplied voltage

### 4. Conclusion

In this research, laboratory fabricated silicone nozzle head and the effect of voltage on the generation of the printed line on substrate using metallic ink is studied. By keeping all parameters constant and only taking the voltage as the variable, it is shown that different line width on the substrate can be achieved. This study will help in developing the printed line and will help in developing the electrostatic inkjet head. For future work, effects of different type of materials based nozzle head and different voltage wave form can be studied. This study will also help to facilitate the applications of the inkjet printing technologies.

### Acknowledgement

본 연구는 지식경제부의 전략 기술 개발 사업 연구비 지원으로 수행되었습니다.

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