잉크젯 헤드의 공진주파수에 따른 구동파형을 이용한 개별노즐 제어

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Driving Per Nozzle By Various Waveform Depending On Resonance Frequency In Piezoelectric Inkjet Head

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Abstract - This paper presents the effect of driving waveform for piezoelectric bend mode inkjet printhead with optimized mechanical design. Experimental and theoretical studies on the applied driving waveform versus jetting characteristics were performed. The inkjet head has been designed to maximize the droplet velocity, minimize voltage response of the actuator and optimize the firing frequency to eject ink droplet. The head design was carried out by using mechanical simulation. The printhead has been fabricated with Si(100) and SOI wafers by MEMS process and silicon direct bonding method. To investigate how performance of the piezoelectric ceramic actuator influences on droplet diameter and droplet velocity, the method of stroboscopy was used. Using the water based ink of viscosity of 11.8 cps and surface tension of 0.025N/m, it is possible to eject stable droplets through 64 nozzles average velocity of 4.05 m/s with standard deviation of 0.06 m/s and average diameter of 29.2 ㎛ with standard variation of 0.5 ㎛.

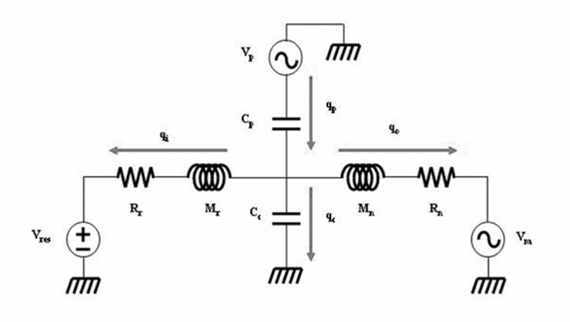
1. Introduction

Today the inkjet printing technologies are increasingly demanded for such as LCD, color filter and biochemistry such as DNA printing [1]. The trend in inkjet printer technology is to increase printing quality and speed by: 1) reducing droplet size; 2) increasing the number of channels per head; 3) increasing ejection rates; and 4) reducing problems such as crosstalk between channels and satellite droplets [2], [3]. In most situations, it is desirable to reduce droplet size and variation, improve droplet consistency, and eliminate satellite droplets[4]. In this paper, we investigated the piezoelectric inkjet actuator with both computer simulation and experimental observations. The effects of driving waveform changes in piezoelectric actuator on ejected droplet velocity and diameter were examined

2. Results and Discussion

2.1 Design

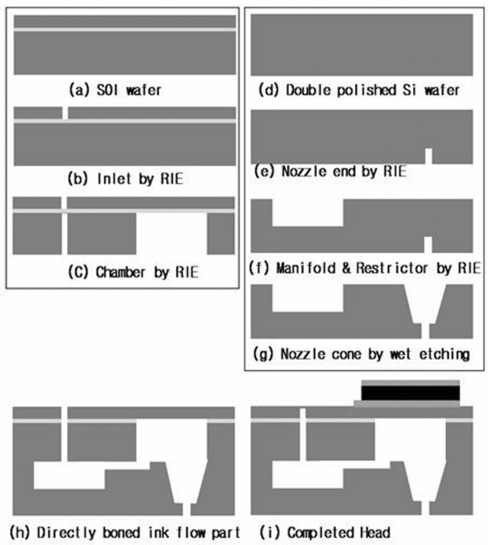
The displacement of a piezoelectric vibrator on a pressurization chamber, and the resulting ink stream, may be analogized to an electric circuit as shown in Fig. 1 C, M, and R illustrate the compliance, inertance and resistance of the lumped elements respectively. Fluid compressibility in pressurization chamber is represented by C, compliance. Also, elastic deformation of vibratory plate acts as compliance. When accelerated ink flows through a thin passage, the mass of the ink acts as inertance. Under this analysis, the ink jet printing head is like a series circuit as shown in Fig. 1.



<Fig. 1> Equivalent circuit representing a piezoelectric inkjet system.

2.2 Fabrication

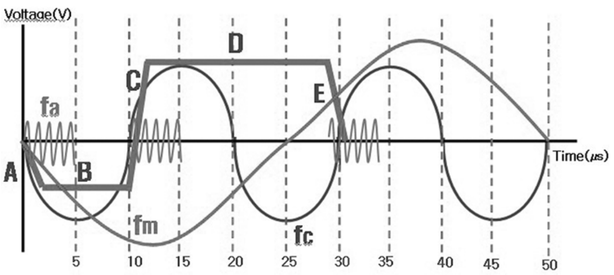
The fabrication processes are shown in Fig. 2. Upper plate is made by SOI (Silicon On Insulator) wafer that is consisted of Si, SiO_2 and Si layers with 40㎛, 2㎛ and 280㎛ thickness. (Fig. 2(a)) Following dry etching of silicon to 40㎛ depth for ink inlet, the backside silicon is etched to 280㎛ depth for chamber using ICP-RIE (Fig. 2.(b) (c)). Fabrication of lower plate begins with a Si(100) wafer and the nozzle is formed with depth of 30㎛ and diameter of 30mm. And cone shape is finally formed by silicon wet etching in TMAH. The liquid flowing part is completed by silicon direct bonding of these two plates.(Fig. 2.(h))



<Fig. 2> Equivalent circuit representing a piezoelectric inkjet system

2.3. Basics of DPN

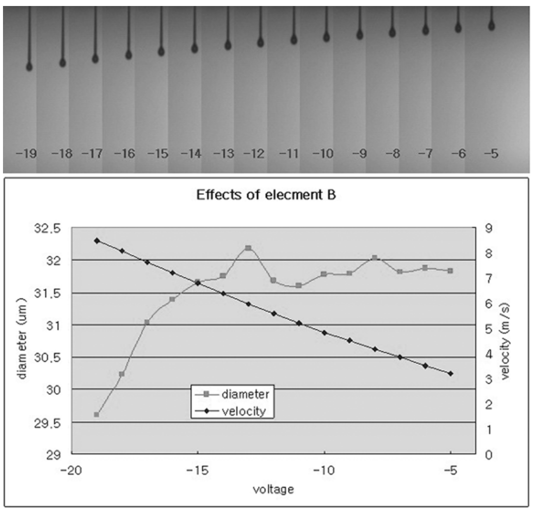
It is very important to control both droplet velocity and droplet diameter simultaneously for industrial application of inkjet technology. Droplet velocity and diameter are determined by applied driving waveform depending on resonance frequency of actuator, meniscus and chamber calculated by C, M and R. (Fig. 1) Especially, resonance frequency of chamber is important to determine both jetting time and the length of basic waveform as shown in Fig. 3.



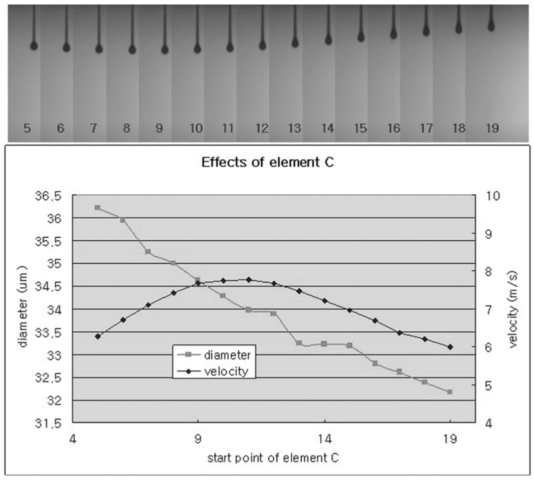
<Fig. 3> **Basic pull-push waveform depend on resonance frequency of actuator(f_a), meniscus(fm) and chamber(f_c).**

2.4. Experiments

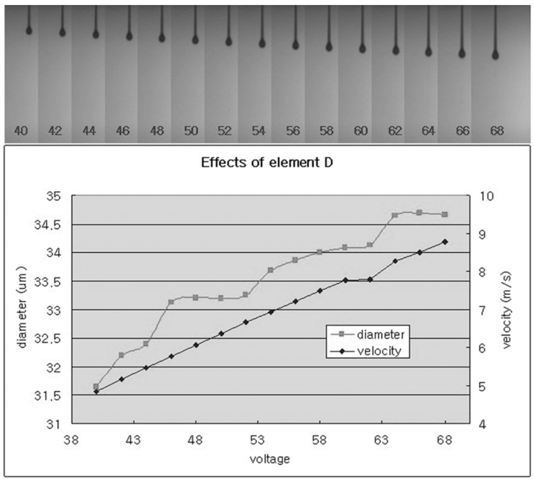
As shown in Fig. 4, 5, 6 droplet velocity and diameter were changed by different waveform. When element B is −13V , droplets have maximum diameter. According to increasing of the element B, droplet velocity increased largely. When the start point of element C is 10μs, the element C is matched well with f_c and the vibration of chamber is reinforced droplet velocity and droplet has maximum velocity of 7.8m/s. According to increasing of the element C, droplet diameter decreased because of displacement reduction. When the element D is increasing, both droplet velocity and diameter increased simultaneously.



<Fig. 4> Graph of drop velocity and diameter vs element B



<Fig. 5> Graph of drop velocity and diameter vs start point of element C



<Fig. 6> Graph of drop velocity and diameter vs element D

3. Conclusions

Using the water based ink of viscosity of 11.8 cps and surface tension of 0.025N/m, it is possible to eject stable droplets through 64 nozzles average velocity of 4.05 m/s with standard deviation of 0.06 m/s and average diameter of 29.2 ㎛ with standard variation of 0.5 ㎛ at jetting frequency of 1kHz using above mentioned driving per nozzle technology.

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