Additive Manufacturing of Microlens Arrays on the Voltera V-One platform

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Contents

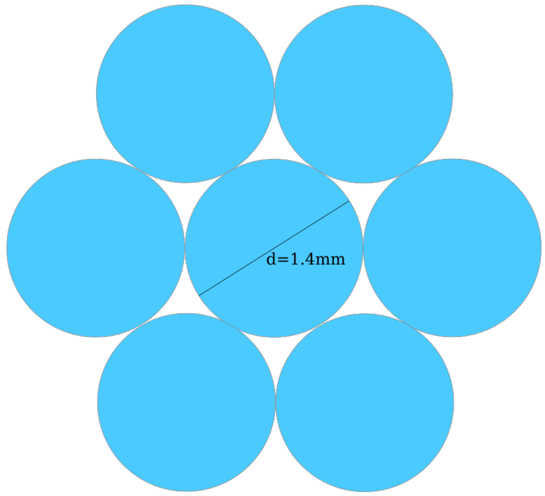


Figure 1: Sketch of the intended microlens array. It consists of seven microlenses with a diameter of 1.4 mm in a hexagonal lattice.

1 Introduction

The purpose of this experiment is to determine suitable parameters for creating custom microlens arrays on the Voltera V-One platform[3]. The desired microlens array consists of seven mirolenses arranged on a hexagonal lattice in a concentric manner. Each microlens should have a diameter of 1.4 mm. The microlens array is shown in figure 1.

2 Experimental procedure

The Voltera V-One operates by printing a substance on a substrate. It accepts Gerber printed circuit board design format. A python script was used to generate a KiCad[1] project which contained the microlens geometry in the first copper layer. The project was then manually exported to the Gerber format and printed with the Voltera V-One according to the instructions of the Voltera V-One software.

The employed substrate was a standard microscope slide. The printed substance was Loctite AA 3525[2], a clear, light cure adhesive. It was stored in a cool and dark environment to prevent premature curing. The settings for the ink in the Voltera V-One software are shown in table 1. They are mostly the standard parameters of the *TrickyTanuki* conductive ink preset, but with a lowered feedrate.

The microlenses were printed sequentially, i.e. after printing one microlens, the dispensing nozzle returned to the homing position. Before printing the next one, the already printed lens was illuminated by a handheld UV laser source for about 10 s. This causes the adhesive to harden and prevents droplets from joining other droplets as well as deformation due to running of the liquid.

Tunable parameters in the generating python script were the distances of the microlenses to each other, the thickness of the lines and the kind of shape of the path approximating the lens. The latter could either be a continuous spiral or a series of concentric circles. Both of these shapes have a minimum starting radius and a maximum radius. The concentric circles can also consist of a variable number of circles.

Table 1: Custom ink settings in the Voltera V-One software.

Parameter name	Value
Probe pitch	5.0 mm
Pass spacing	0.15 mm
Anti-stringing distance	0.1 mm
Dispense height	0.10 mm
Kick	0.35 mm
Trim length	50 mm
Soft start ratio	0.10
Trace penetration	0.15 mm
Rheological setpoint	0.16
Soft stop ratio	0.15
Feedrate	100 mm/s

3 Results

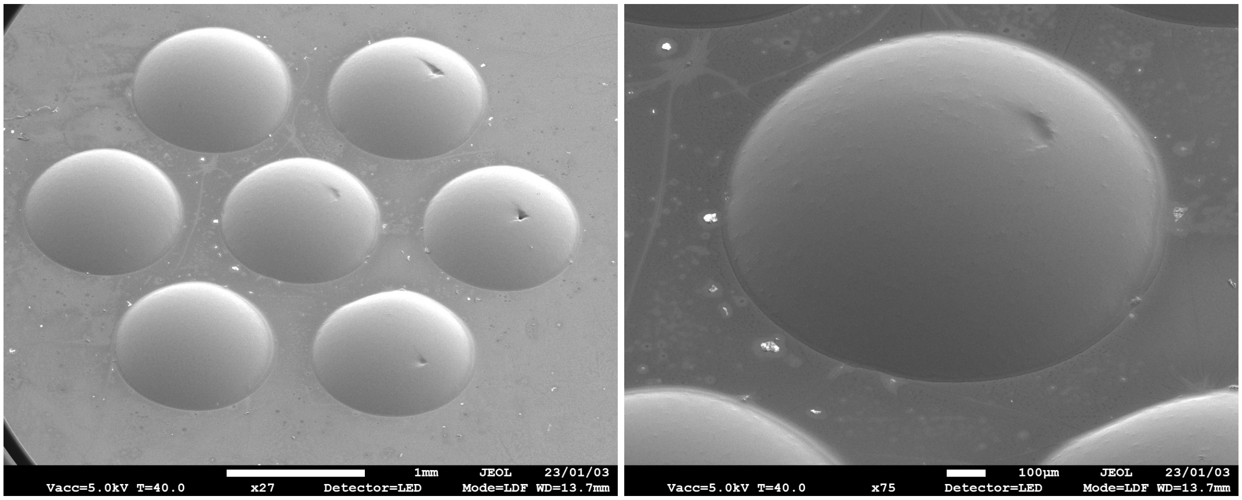
In the final version of the generating python script, the concentric circles are chosen as lens shape approximators. The linewidth is $w_l = 0.05\,\mathrm{mm}$, the minimal radius is 0.01 mm, the end radius is $r_{\mathrm{end}} = 0.5\,\mathrm{mm}$, the number of circles is 5 and the number of linear segments that are used to approximate a circle is 5. REM images of the microlenses are shown in figure 2. The diameter of the microlenses can be measured from these images to be $(1.143 \pm 0.036)\,\mathrm{mm}$. The expected diameter is

$$d = 2 \cdot r_{\mathrm{end}} + w_l = 1.05\,\mathrm{mm},$$

which is smaller than the measured radius.

4 Discussion and Conclusions

The Voltera V-One platform is suitable for manufacturing feasible microlenses via the described technique. The diameter of the microlenses is smaller than desired. This is because the diameter measurement was not available during testing and a smaller diameter was chosen as a precaution for running fluid. The diameter of the microlenses is bigger than expected from the input geometry. This is probably due to the nozzle of the printer dragging the droplet around and the running of the liquid before curing.



(a) View of the full microlens array.

(b) View of a single microlens.

Figure 2: REM images of the manufactured microlenses.

By choosing a larger end radius and possibly a bigger number of concentric circles approximating the shape of the lens, microlens arrays that match the desired parameters better could be produced.

References

[1] KiCad EDA – Schematic Capture & PCB Design Software. `https://www.kicad.org/`. Accessed: 2023-01-04.

[2] Loctite AA 3525 Datasheet. `https://tds.henkel.com/tds5/Studio/ShowPDF/?pid=AA%203525&format=MTR&subformat=REAC&language=EN&plant=WERCS&authorization=2`. Accessed: 2023-01-04.

[3] V-One – Voltera. `https://www.voltera.io/v-one`. Accessed: 2023-01-04.

A Raw data

Table 2: Diameter measurements from figure 2. The first measurement is from the single microlens in figure 2(b), the other measurements are from figure 2(a), excluding the already mesured lens.

Microlens	Diameter in mm
Figure 2(b)	1.125
1	1.138
2	1.179
3	1.134
4	1.145
5	1.131
6	1.151

B A physica macro

This physica macro was used to generate the plot of as well as to fit xxx xxxxx xxxxx xxx xxxx xxxx xxxxx xxxxx xxxx xxxxx xxxx xxxxxxxxx xxx xxxxx xxxxx xxx xxxx xxxx xxxxx xxxxx xxxx xxxxx xxxx xxxxxxxxx

```
! exp_3.pcm
clear

! read in the data
read\format\noerror exp_3.dat (*) x,y,dy

! plot the data
label\x ‘Voltage, V’
label\y ‘Power, W’
set colour 1 1
set pchar -4
graph x,y,dy

! fit and plot the curve
scalar\vary A,T,w,phi
! initial values for parameters
A=2.3
w=6.5
phi=0
T=10.

fit y=A*cos(w*x+phi)*exp(-x**2/T)
fit\update f
set colour 2 2
set pchar 0
graph\noaxes x,f
```