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An Investigation on The Master Printing Plates Development Attending to Micron Sizes Employing a Flexographic Micro Scalar Printing Technique

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Abstract: Master printing plates play a major part in the flexographic micro scalar printing technique. In the industry, there is no substantial use on master printing plates developed for micron sizes using a flexographic micro scalar printing technology. Therefore, an investigation on the potential types of master plate produced used in the process of flexographic micro scalar printing technique was conducted. A step-by-step approach by designing the master mould, printing of the master mould plates and printing of multiple fine lines needs to be carried out in advance to help comprehend this process that is influenced by many interacting parameters. The characteristics of the printing plates are among the number of parameters that plays a big role in this study. Printing trials of the master mould plates using different printers were carried out to compare the compatibility and the accuracy of the developed fine solid lines on the mould plates.

Keywords: Master Mould, Master Printing Plates, Flexographic Micro Scalar Printing

1. Introduction

It is proven that micro scalar flexographic printing technique is a vast advance in technology in the printing industry according to past research about this printing technique from around the world. Micro-contact printing (μ CP) provides a simple and low-cost surface patterning procedure. After its invention, the method has undergone a remarkable evolution to enhance its ability to create sub-100nm Self-Assembled Monolayer (SAM) patterns of different polar and polar materials and biomolecules over macroscopic regions.[1] Firstly, a Polydimethylsiloxane (PDMS) stamp is coated with a thin and uniform layer of organic polymer sensitive to ultraviolet light and then the organic polymer is transferred by conformal contact from the stamp surface to a substrate.[2] Polydimethylsiloxane (PDMS) was essentially used as a medium to make the stamps in the Micro-Contact system, as it can be shaped using a master mould where when the ink is applied it will become soft.[3] However, the deformation of the stamp during the removal of the stamp from the template and during the touch of

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the substrate limits the patterning resolution.[4]In summary in flexography printing, the pattern, usually from a photopolymer is turned into plates. A roll is then attached to the plates.

Meanwhile, a method of printing nanometre scale patterns is flexographic micro scalar printing. The main component of flexography micro scalar printing process consists of four main components which are fountain roll, ink metering (anilox) roll, plate cylinder and impression cylinder.[5] Meanwhile, the printing parameters are ink, printing plate and substrate. This process uses the mechanism of high-speed roll to roll printing technique since it is an easy operation. It produces patterns of imprint resistance and subsequent processes by mechanical deformation.

Current research shows that in the micro scalar flexographic technique, there are no wide ranges of substrates that can be used. The types of substrates used would most certainly impact the printing technique's solid line pattern width and gap precision outcome. Therefore, it is important to use the most suitable rubber like material (silicon, polyethylene, PDMS etc.) to accurately produce a solid line pattern of width and gap of 50 μm , 20 μm and 10 μm for the master mould plates. The goal of this research is to generate a low-cost printing plate mold for micro-flexographic printing machines using 3-dimensional (3D) printers to print solid fine lines associated to flexographic micro scalar printing technique.

2. Materials and Methods

This section outlines the appropriate approach for achieving the research's goal, which is to develop a low-cost printing plate mould for a micro-flexographic printing machine that can create fine line features smaller than 50 micrometers. The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study. The formation of master mould printing plates using the 3-dimensional (3D) printing technology was tested and completely exploited. The study of microstructure and fine line characteristics, on the other hand, was done with an optical microscope (OM). The smallest tiny lines on the printing plate mould were examined and rated. All of the findings were documented in order to be analyzed and used in the future.

The virtual design of the printing plate mould structure was created before the master mould was prepared. It was accomplished using SolidWorks software. SolidWorks software was used to transfer the exact design from the first draught. Spiral square and straight-line patterns were chosen as the pattern to testify the compatibility of the 3D printers to print multiple solid fine lines for the master mould printing plates. The construction of a model in SolidWorks software usually begins with a two-dimensional (2D) drawing. Geometries such as points, lines, arcs, conics, and splines were included in the sketch. In addition, measurements were added to the drawing to specify the size and placement of the geometries. Furthermore, characteristics such as tangency, perpendicularity, parallelism, and concentricity were defined using relations.

The first design was a square spiral shape with a 50 μm of width and gap. The gap between each line was 20 μm and the length of line increased by 0.02 mm in each spiral. The depth of each line was 50 μm . The master mould was constructed to measure 20 mm \times 20 mm in size. Figure 1 depicts the square spiral mold's design.

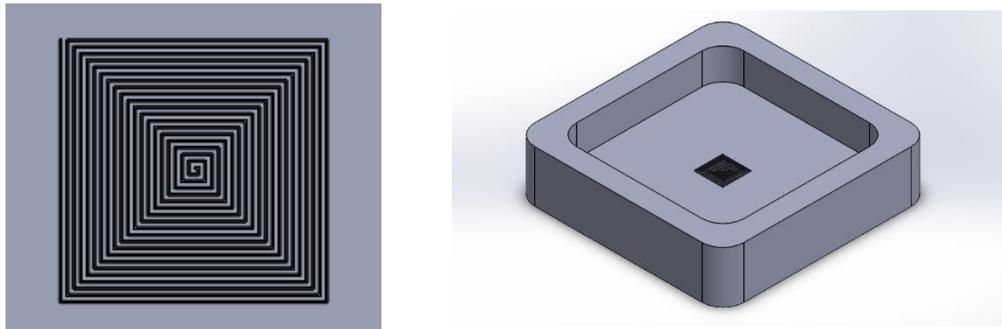


Figure 1: Spiral square design

The dimension of the mold is 20 mm x 20 mm. The exterior thickness of the mould block is 5mm and the interior is 2 mm. The second design was 50 micrometer, 20 micrometer and 10 micrometer patterns of straight lines. The gap between each line is 20 micrometers. The gap between each set of lines is 2mm. The thickness of each line is 50 micrometer and it is 10 mm in length. 20mm x 20 mm is designed to be the size of the master mold.

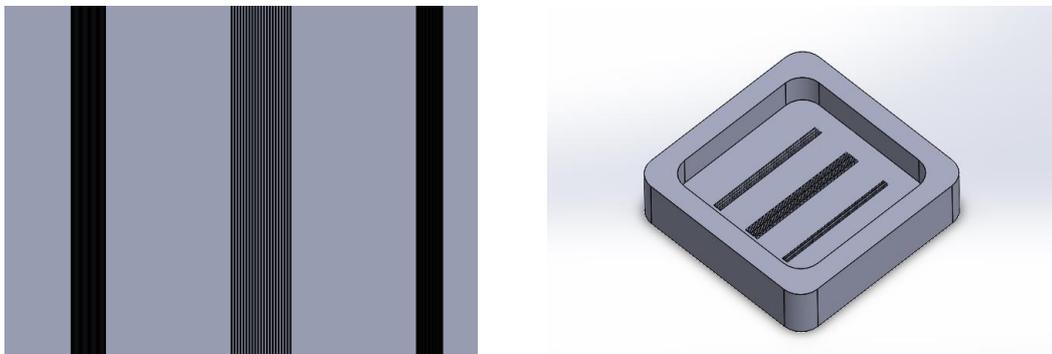


Figure 2: Straight-line design

The master mould was created when the design was completed. The master mould was created with the help of 3 various types of 3D printers. Cubicon Single 3DP-110F, Raise Pro N2 plus, and MyVista Cube 200 3D printers were utilized in the experiment. The produced item measured 240 mm x 190 mm x 200 mm, according to the Cubicon Single 3DP-110F's specs. The layer height was adjusted between 150 and 300 micrometers, with a minimum of 50 micrometers, and the filament diameter was 1.75 millimeters (mm). Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA) fibers were used (PLA). This 3D printer has a nozzle diameter of 0.4 mm.

As for the Raise Pro N2 plus, it was able to print a 305 mm x 305 mm x 300 mm printed item. The filament diameter was 1.75 mm, and the layer height was adjusted to 10 to 250 micrometers. HIPS (High Impact Polystyrene), PLA (Polylactic Acid), and TPU (Thermoplastic Polyurethane) were the filament types used (TPU). This 3D printer has a typical nozzle diameter of 0.2 to 0.8 mm. The MyVista Cube 200, on the other hand, could print objects that were 200 mm x 200 mm x 200 mm in dimension. The filament diameter was 1.75 millimeter, and the layer height was adjusted at 0.1 to 0.4 mm. ABS (acrylonitrile butadiene styrene), PLA (polylactic acid), and TPU (thermoplastic polyurethane (TPU) filament. This 3D printer has a nozzle diameter of 0.4 mm.

3. Results and Discussion

The goal of this experiment was to see if those 3-Dimensional (3D) printers could create the smallest micro size master mould pattern for the printing plate. Furthermore, the experiment was carried out to

see if the dimensions of the printed master mould were the same or does it vary from the designed values as the designed master mould in the SolidWorks software. An optical microscope was utilized to evaluate the micro scale design on the master mould in this experiment.

The 3D printing of the spiral square design on the mould plate was the first step in the experiment. The structure's breadth, gap, and height were all less than 100 micrometers. Several prerequisites have to be met in order to print exceedingly thin lines. First, a suitable filament was selected based on the 3D printer's specifications. Cubicon Single 3DP-110F printer uses 1.75 mm ABS filament. ABS filament was found to be a material that was extremely flexible, robust, and durable. The 3D printer was filled with a spool of ABS filament. Once the nozzle had reached working temperature, the filament was supplied to the extrusion head and melted in the nozzle. The material that came out of the extruder was very hot. The material was malleable and easy to shape while it is still hot. However, when it cooled, it solidified fast and held its form.[14]

The precise measurements of tiny lines on master mould created by 3-Dimensional(3D) printers were determined using an optical microscope (OM) in this study. Figures 3 to 5 show the image findings acquired with the Optical Microscope. The actual line width results for the spiral square model and straight-line model generated by the Cubicon Single 3DP-110F printer are shown in Figure 3. The actual width obtained vary slightly from the expected width.

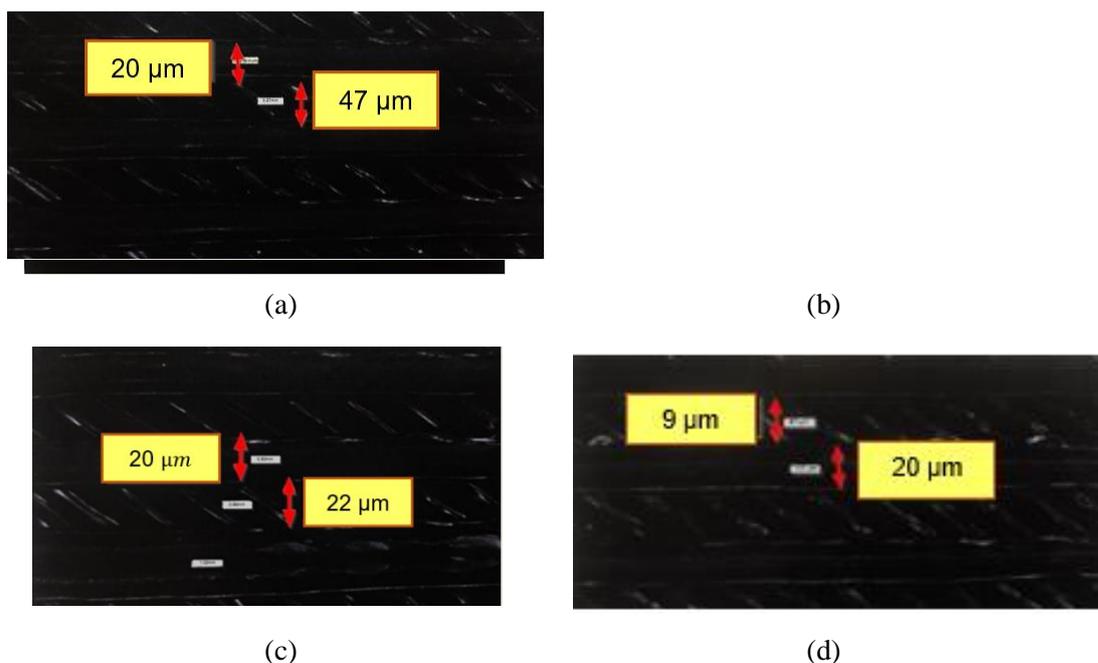


Figure 3: Actual lines width results produced by Cubicon Single 3DP-110F printer: (a) square spiral shape with a 50 μm width and gap, (b) straight-lines pattern of 500 μm width and gap, (c) straight-lines pattern of 20 μm width and gap, and (d) straight-lines pattern of 10 μm width and gap

Figure 4 illustrates the actual line width results generated by Raise Pro N2 Plus for the spiral square and straight-line designs. The actual width attained, however, differed somewhat from the predicted width.

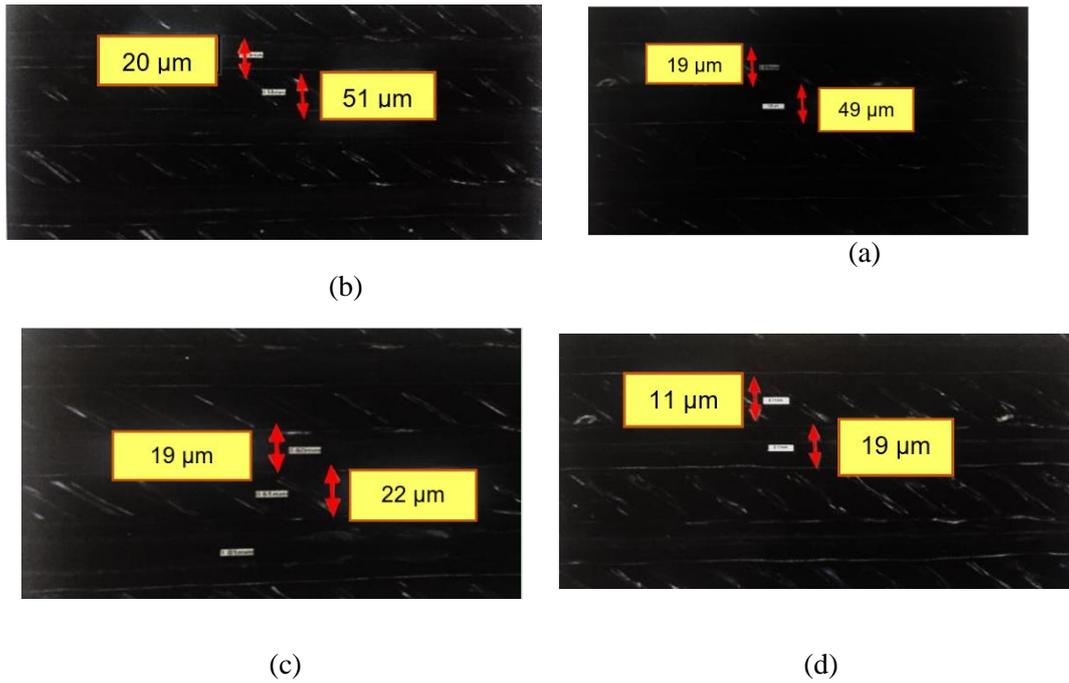


Figure 4: Actual lines width results produced by Raise Pro N2 Plus printer: (a) square spiral shape with a 50 μm width and gap, (b) straight-lines pattern of 50 μm width and gap, (c) straight-lines pattern of 20 μm width and gap, and (d) straight-lines pattern of 10 μm width and gap.

The actual line width results for the spiral square model and straight-line model generated by the MyVista Cube 200 printer are shown in Figure 5. The actual width achieved differed somewhat from the predicted width.

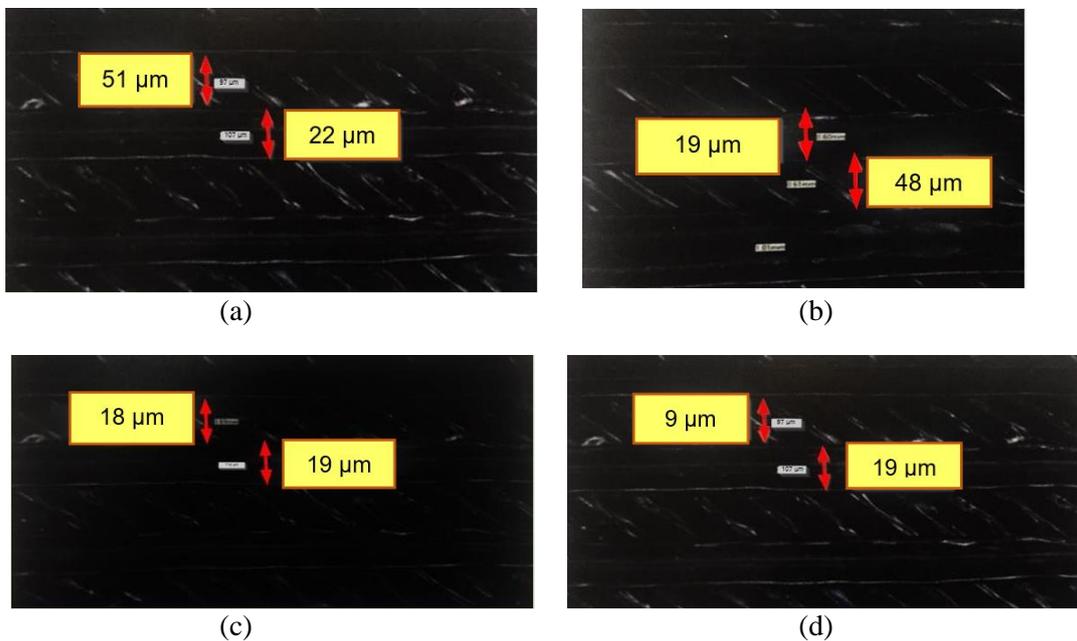


Figure 5: Actual lines width results produced by Myvista Cube 200 printer: (a) square spiral shape with a 50 μm width and gap, (b) straight-lines pattern of 50 μm width and gap, (c) straight-lines pattern of 20 μm width and gap, and (d) straight-lines pattern of 10 μm width and gap

Figures 6–8 shows a comparison of the results of the actual width of lines generated by the printing plate mould with the design width in micrometers (μm). The actual widths of tiny lines produced on the master mould were somewhat different from the design width, as seen in the images. This variation in breadth might be attributable to a variety of circumstances encountered throughout the experiment.

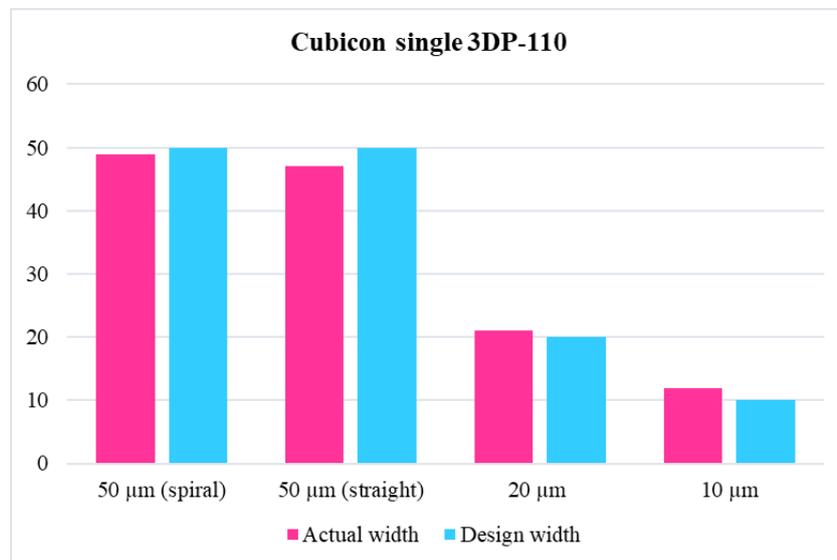


Figure 6: Microstructure analysis result for Cubicon single 3DP-110F

During the experimental testing, four distinct sorts of line designs were employed. The first design was a square spiral design form, while the second design was a straight-lines pattern with varying widths. The Cubicon Single 3DP-110F printer was used in the first experiment. As seen in Figure 6, the actual line width was reduced in comparison to the planned width.

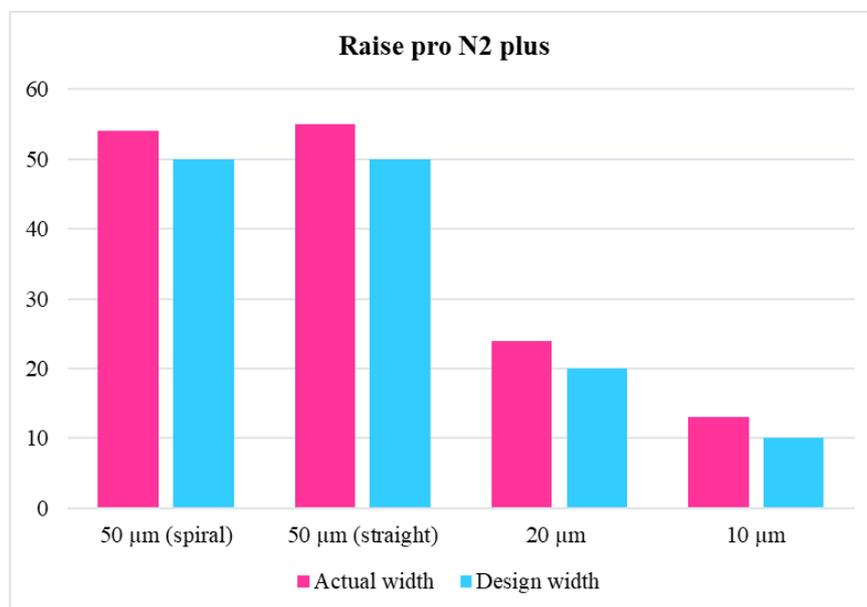


Figure 7: Microstructure analysis result for Raise pro N2 plus

The second experiment, as shown in Figure 7, revealed that the actual line width exceeds the intended original design value for the width using The Raise Pro N2 Plus. Straight lines with a width of 50 m had the greatest increase in line width.

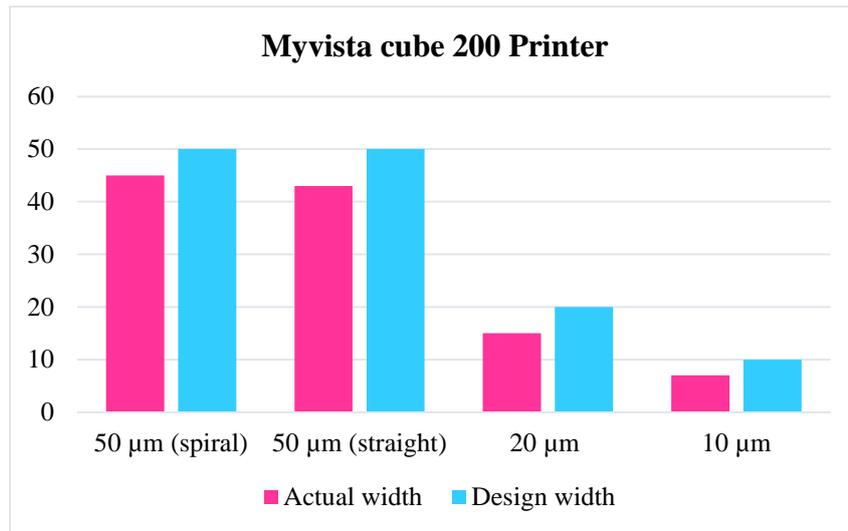


Figure 8: Microstructure analysis result for Myvista cube 200 Printer

The most recent experiment was conducted using a Myvista Cube 200 printer. Figure 8 shows that the width of the printed lines was reduced when compared to the design width created with SolidWorks software. This experiment revealed the same pattern of decreasing line width as the previous one which is good.

In summary, the lines created by the experiment are more or less consistent in all locations of the solid lines, according to micro-structure analysis for Optical Microscope. This is due to a variety of variables that might influence the lines that were developed. One of the factors was the unevenness of the ABS material that extruded into very thin filaments from the 3D printer's nozzle. Because the normal nozzle diameter was 400 µm (0.4mm) and the lines were 50 µm, 20 µm, and 10 µm, they were slightly different from the design. The shaking of the 3D printer's nozzle as it moved might possibly have produced the uneven width of the mould lines.

4. Conclusion

The actual line width and gap generated on the master mould are the outcomes of the experiment. The line width and gap of the master mould influences the fine line width and gap of the printing plate. Several findings may be drawn from this study, which are as follows:

- i. The lowest fine line width for spiral square shape is 49 µm, produced from MyVista Cube 200 printer.
- ii. The lowest fine line width for straight-line pattern is 9 µm, produced from Cubicon Single 3DP-110F printer and Myvista cube 200 Printer.
- iii. The micro-flexographic printing technology, which combines two printing techniques, proved effective in generating the smallest line width and gap. Using graphene as the printing ink medium, this novel printing technology was able to print thin solid lines with a width of 9 µm and a spacing of 20 µm on BOPP substrate.
- iv. This printing approach eliminated the need for batteries and cable connections, resulting in a smaller biomedical equipment. Cell culture might be printed at a cheap cost and with a better throughput in biomedical applications.

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