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Research Article

Investigation of Surface Profile Characteristics in Polymer Substrates Printed Using Woven Labels

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Abstract

Printing on polymer clothing are textile industry major requirement. Woven label print machines are used in this study. Printing obtained on polymer substrate should be accessible and cost effective method. Design from free hand sketch in app and Computer Aided Design (CAD) direct use in polymer print machines are studied. The integration of polymer, clothing, paper analytical devices, stick paper devices, digital, electronic equipments, apps and surface characterization machines that are surface profilometer are needed. In this paper we develop woven label printing on the polymer. We draw using app. The design is printed on paper, stick paper and polymer. We have to perform scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) on the paper and stick paper. In this study we use the woven label machines. We print 100 prints on the woven label. We study the surface characteristics of the printed design on the cloth/polymer using surface profilometer. We obtain the vertical height features. Here we consider six random regions on the polymer that has the print. We understand from the surface characterization the polymer print features are coil. The vertical heights of the coils in various regions does vary from 50 μm to 400 μm. The details of the polymer need further study. We have to perform scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) on the cloth with and without woven label print on the polymer cloth. The key results need numerical formula for the polymer. That is scope for the future. The details of the woven label equipment are needed for the development and progress of the methodology. There is research gap in this section. Here, we provide the shop details of the woven label equipment. The woven label printer prints at once 2000 to 10,000 same prints on each cloth. The cloth is square shape. The details of the printed woven label are given. We have to input the designs of our free hand sketch, apps and CAD. The printing is safe handling and cost effective. This is the novelty of the printer. We have placed the woven label image printed on the cloth on another substrate cloth. We repeat the study varying the number of woven label cloth from 1 to 100. The print on polymer from software can find applications for color drawings to print, sensors and digital polymer electronics applications.

Keywords

Polymers, Free Hand Sketch and CAD, Woven Label Machines and Printing, Surface Characterization

1. Introduction

In the current status of cloth print literature the efficient use of machine to print numbers and mathematical formula in regularized flow chart to algebra is the big research gap. The add on features can be understood in the print polymer using label machines. The installation requirements need thorough logic in the flow of equipment and details. The place of

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camera, phone, lab on apps, phone apps, software, computer, keyboard, mouse, monitors, knowledge of number of equipments, woven label machines, microscope, surface profilometer, raw material textile, polymers, clothing, membranes, output print on cloth. The polymer surface printing technologies include woven label machines. Figure 1. shows the woven label machines [1]. The equipment is big in size. The big size of the equipment made in India is to print many pieces of square woven label. The design of the image is feeded to the polymer label machines. The designs are pre feeded in the digital electronics feeder as shown in the Figure 1. The machine in shop ensures print and pack methodology. The number of printed pieces are 2000 to 10,000. The method is cost effective.

Figure 1. *Woven label machines to print images on the woven label polymer cloth.*

The other polymer surface printing technologies are different from the woven label machines. The raw material we discuss now are going to be polymer resin. The raw material are injected to the bed of stereolithography [2]. The lithography known principles convert the liquid resin to solid. The lithography tool tip creates the 3D lithography print on the polymer cloth. The input of the print is image. The printing technology is new to polymers. Woven label is a method to print images on polymers. Computational methods are recently delved to know woven fabric measurements [3]. Polymers are light weight materials that are finding deep interest to explore for thermodynamic, mechanical and printing properties [4-6]. Surface characterization of polymers are available in the literature to understand the mechanical and fiber properties. Surface characterization of polymers are carried out using x - ray photoelectron spectroscopy, (XPS), and static secondary ion mass spectrometry, (SSIMS) [7]. Polymer surfaces are studied for understanding the chemical composition. The chemical elements establish the pitch to describe the cloth. The surface study includes morphology. They describe relate the material of the cloth and new parameters on the surface of the cloth fibre, coil, length, stroke length, chain orientation, viscosity, roughness, wedge height features, distance between the wedge, contact, contactless detailing of surface, asymmetry and polymer topology physics related surfaces. The mathematics of the continuum bulk geometry of surfaces are needed. The other physical properties are contact ratio, skewness dependent topology physical parameter, uncertainty arising parameter physics in control, solid-solid interaction stiffness, solid-gap interaction physics, nematic crystal imaging, polymer physics, coil tight binding stress and print physics [8]. The infrared (IR) and Raman spectroscopy (RS), nuclear magnetic resonance (NMR) spectroscopy provide the details of the intensity of the absorption (I) is proportional to the square of the change in dipole moment and the wavelength. The light, vibration, normal mode and visible mode of deformation on the printed cloth relates the image physics. The inverse methodology from the variables provides complete equation of the polymer physics. However, the surface profile is tough. The characterization is not known to many. The application of surface characterization can help in printing new chips for mechatronics and membrane electronics applications [9, 10]. Laser based print methods are widely used in research [11]. Paper based analytical devices are applicable for printing [12]. Atomic layer deposition (ALD) is a popular method for manufacture of polymers. The substrates with polymers and silicon are popular in many applications that includes packaging industry [13, 14]. There are certain polymers that can be prepared and manufactured using chemical vapor deposition (CVD) [15]. CVD methods increase the capability of designing polymer surfaces. In CVD technique the monomers are coated on the surface during the vapor phase in the machine. The thin film is formed along with polymerization to obtain the desired polymer. CVD coating to prepare polymer film is a single coating step. CVD technique to prepare polymer films are used as functional thin films for surface handling in sensors and packaging industry. The printing using combination of 3D printing and woven textiles are used to print weft knitted structures [16, 17]. Warp and weft are two components to understand the polymer to manufacture into coil and printed images in the textile industry. Knitting is a method where the coil of the polymer is interlaced to produce the design feature in the textile. Fused deposition modelling (FDM) is a printing method for some polymers. Here the position of the model used to create the polymer should be taken in account during the print. FDM method is used to print layer by layer structure on the polymers.

There are many research gaps in polymer science. Firstly improved targeting precision of print on cloth for designs are missing [18]. Long term safe use of machine to printing is needed. Safe handling of the machines are essential. Bio development with the scope to polymer machine tools are needed [19]. The knowledge of field specific combination of target assembly in the piping of the lab from the chip, cloth, phone, app, electronics, digitization, machine scale printer, microscope, characterization to bio, department, temporal environment, with clean bio drug assembly needs to be formula possible means in polymer, chain polymerization, from CAD included principles. The substrate properties of the polymer coil and fiber are not easy to determine. The reason is that we have slow characterize using the scanning electron microscopy technique. We have to thorough document the periodic table elements from most electron microscopy techniques. In our work we print with target precision on the cloth for the first time. That is the first problem we address to solve in this paper.

2. Methodology

Figure 2. shows the image drawn using the app on phone. We used Draw app on the phone to create the free hand sketch of the image. The AutoDesk CAD images are available in the module.

Figure 2. *Drawing app on the phone to create the free hand sketch of the image. CAD drawing is also possible here.*

The first Instrument 1 is the woven label machine to print the design on the polymer material. The design is obtained as a free hand sketch using app discussed before. We use CAD software. Figure 1. shows the woven label machine. The printed material was obtained from Sj Woven Labels, India. The number of prints are 100.

The second instrument 2 are paper and stick paper xerox color machines. The design is obtained as a free hand sketch using app discussed before. We use CAD software. The image is feeded using pen drive to the xerox color machine to print on paper and stick paper. Figure 3. shows the image obtained from the free hand sketch drawing app. Figure 4. shows the image printed on the stick paper. Figure 5 (a) shows the woven label image printed on the cloth. Figure 5 (b) shows the back side of the cloth. We need to parameter understand the polymer physics available on the back side of the cloth. The back side of the cloth has the polymer coil, fiber, weft and knit color threads. Table 1 shows the woven label some properties and parameters. They are obtainable in the shop floor of label machines. The details of the printing procedure and use of label machines are the scope for the future work.

Figure 3. *Free hand sketch of the image from the phone app methods.*

Figure 4. *The drawing is printed on stick paper.*

(a) (b)

Figure 5. *(a) Woven label image printed on the cloth. The image is generated from the free hand sketch drawing app (b) back side of the cloth containing polymer coil, fiber, weft and knit color threads.*

Table 1. *Parameters and some properties of the woven label printed on the cloth.*

Usage/Application	Garments
Color	MUlticolour
Packaging Type	Packet
Folding	Top and bottom Fold
Type	Garment Label
Is It Water Resistance	Water Resistance
Pattern	Embroidered
Shape	Square
Country of Origin	Made in India
Minimum order machine handle possible	100

We use IITM facility for surface characterization using surface profilometer. The resolution we use is 1 μm. We perform only surface profiling. The surface profilometer instrument is provided in the Figure 6. We analyse vertical feature height. The movement of the tip of the profilometer provides the opportunity to measure different regions. We measure the regions that have the woven label print on the cloth along with no print region. The instrument is non contact optical based to measure the vertical features. Surface profilometers are based according to standards like ISO, DIN, ANSI, and JIS [20]. The optical based surface profilometer are compact, stand-alone and portable machines. The are in built sensors with high speed. The machine scans large surface in precision accuracy. Using the instrument we obtain the 3D waviness, roughness, step height, film thickness and fractals of nematic and normal modes from prints. We are learning the advanced surface characterization to build particle and equivalent mathematical models. The repeatability of surface characterization are available in the machine.

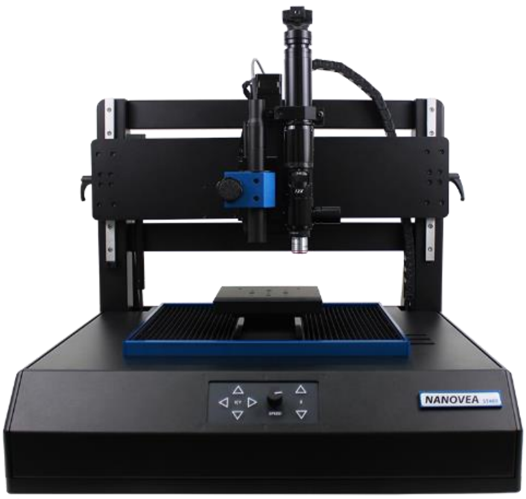


Figure 6. *Surface profilometer machine to characterize the surface of the woven label print on the cloth. Our image is given.*

3. Results and Discussion

Figure 7 (a) shows the surface characterization on the front side of the polymer that has the printed image. We found the surface profile is irregular. The printed polymer surface is difficult to characterize because of the coil design. We analyzed six random regions on the polymer that has the printed image. In order to understand the polymer thin film fiber print we considered in each of the six random regions both the image component and the no image component during surface characterization. We could see there are vertical features of the image on the polymer. Figure 7 (b) shows the 3D contour surface profile measurements of the printed polymer. Figure 7 (c) shows the vertical feature is irregular with feature height up to 300 µm. The variations in the vertical height is found to be due to the polymer fiber print with varying thickness. The design lead to the print. To our knowledge this result is new. To understand the printed image on the polymer we do sensitivity analysis using the surface profilometer. We consider on different regions of the polymer having the print image. Here we consider a second region. We perform the surface profiling on the image side of the polymer. Figure 8 (a) shows the surface profilometer 2D contour. The area of the map is 10 mm × 10 mm. The same size and different area was picked by the profilometer in the Figure 2. However in Figure 8 (a) the legend shows the thickness of the image printed on the polymer. We note significant difference in the 2D contour in Figure 2 and Figure 3, respectively. Figure 8 (b) shows the 3D contour. The roughness peaks we call vertical feature is clearly visible in the 3D map. Figure 8 (c) shows the selected 6 mm region of the polymer with vertical feature of the print height being 400 µm. Here we distinguish the image layer and the no image layer on the front side of the polymer. Figure 9 (a) shows the contour map. The vertical height of the feature is 1 mm. Figure 9 (b) shows the 3D contour to reveal the thickness of the feature. The thickness in this region is 376.9 µm. In order to know the edge of the print feature we profile the thickness to show the vertical height can be 50 µm as shown in Figure 9 (c). We continue to analyze the printed image. Figure 10 (a) shows both the no image and image region in the picked 10 mm × 10 mm. Figure 10 (b) shows the 3D contour re focuses on the empty region along with the thicker profile region. Figure 10 (c) shows the profilometer capability to profile the thin flat no image and thick image region on the printed polymer for the first time. The vertical height with edges of the print coil are 40 µm. Figure 11 (a) shows the capability of the profilometer to move back and forth to the picked regions. We name the region 5. The surface characterization shows the contour map. Figure 11 (b) shows the 3D contour of wider print vertical feature height 567.2 µm. Figure 11 (c) shows the edge feature height with no flat region meaning no image region is not available. The vertical feature maximum height is 90 µm. Here we focus on the need to show the step difference between the printed image and no image on the polymer. We show the thickness of the woven label method handles prints for 1.2 mm. Figure 12 (a) shows the contour map region 6. Figure 12 (b) shows the region 6 has different thickness region part of the same printed image. The vertical thickness is 1.19 mm. The edge feature is irregular to 60 µm as shown in Figure 12 (c).

Figures

Figure 13 shows the placing of the printed polymer on another substrate polymer. The sensitivity of the study includes print placing on the substrate polymer for numbers 1, 4 and 100.

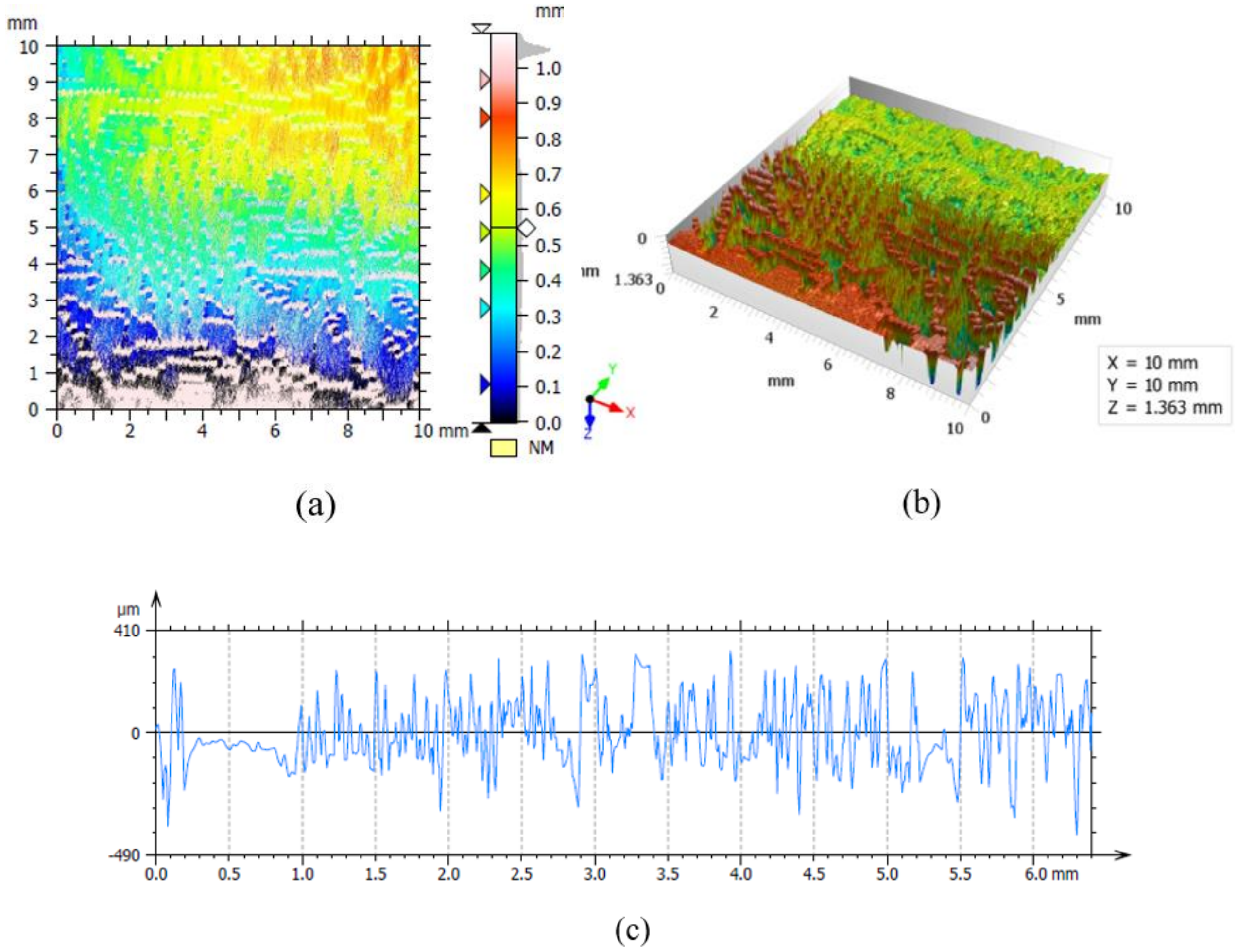
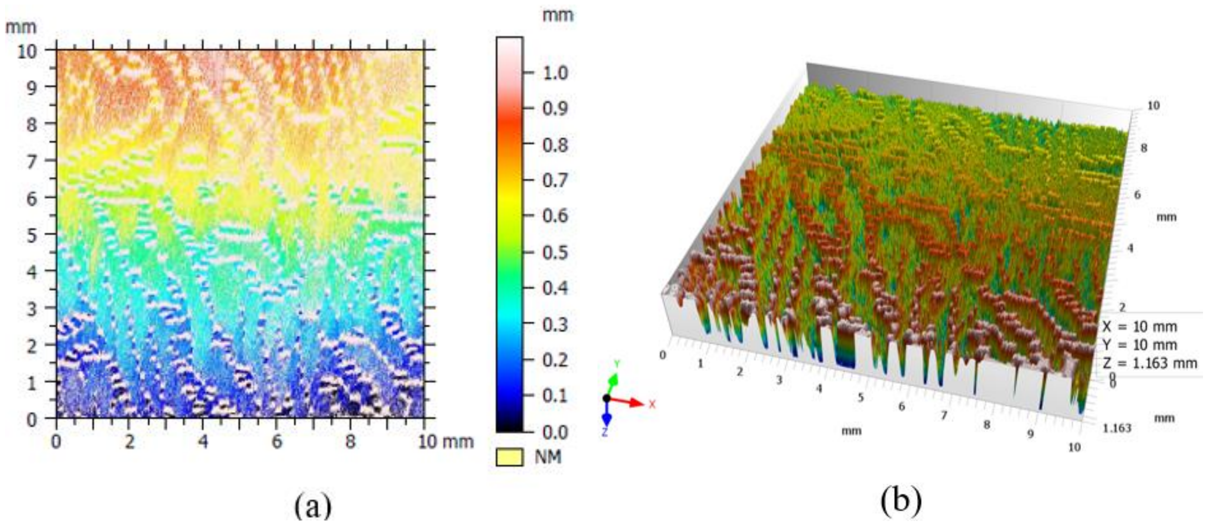
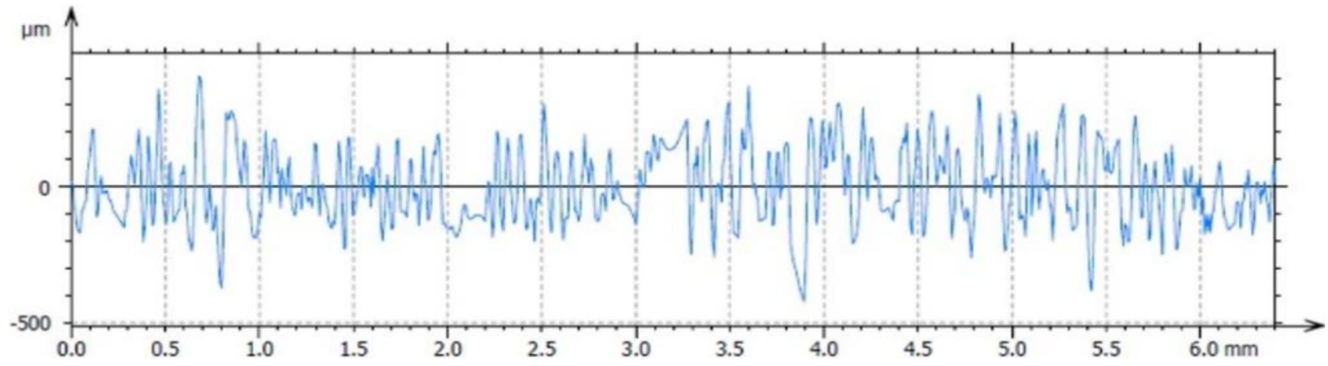


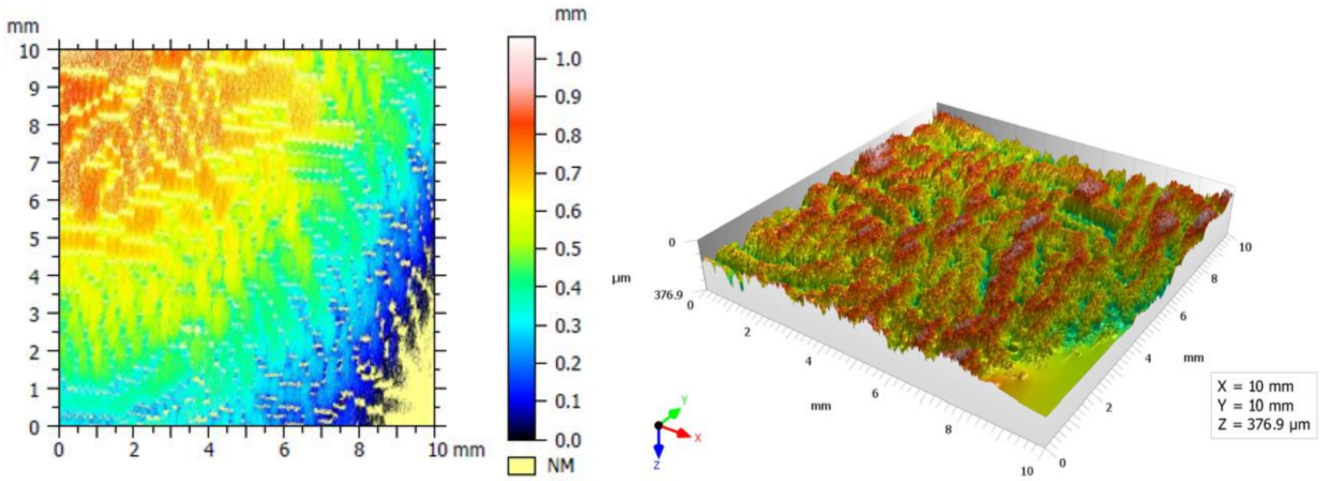
Figure 7. On the region 1 (a) surface characterization on the front side of the polymer that has the printed image. (b) surface profile of the printed polymer (c) vertical feature is irregular with feature height up to 300 μm.



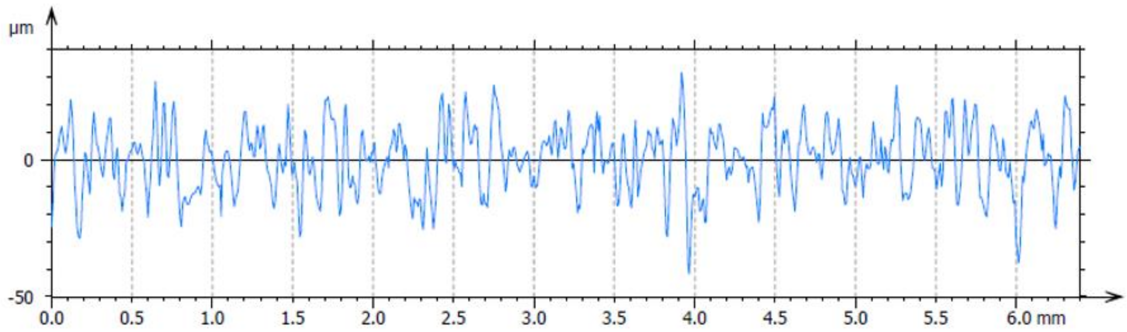


(c)

Figure 8. *On the region 2 (a) surface characterization on the print side of the polymer (b) 3D surface profiling on the given region. (c) vertical feature height is 400 µm.*



(a) (b)



(c)

Figure 9. *On the region 3 (a) surface characterization to show the 2D contour. (b) 3D surface profiling (c) vertical is 50 µm.*

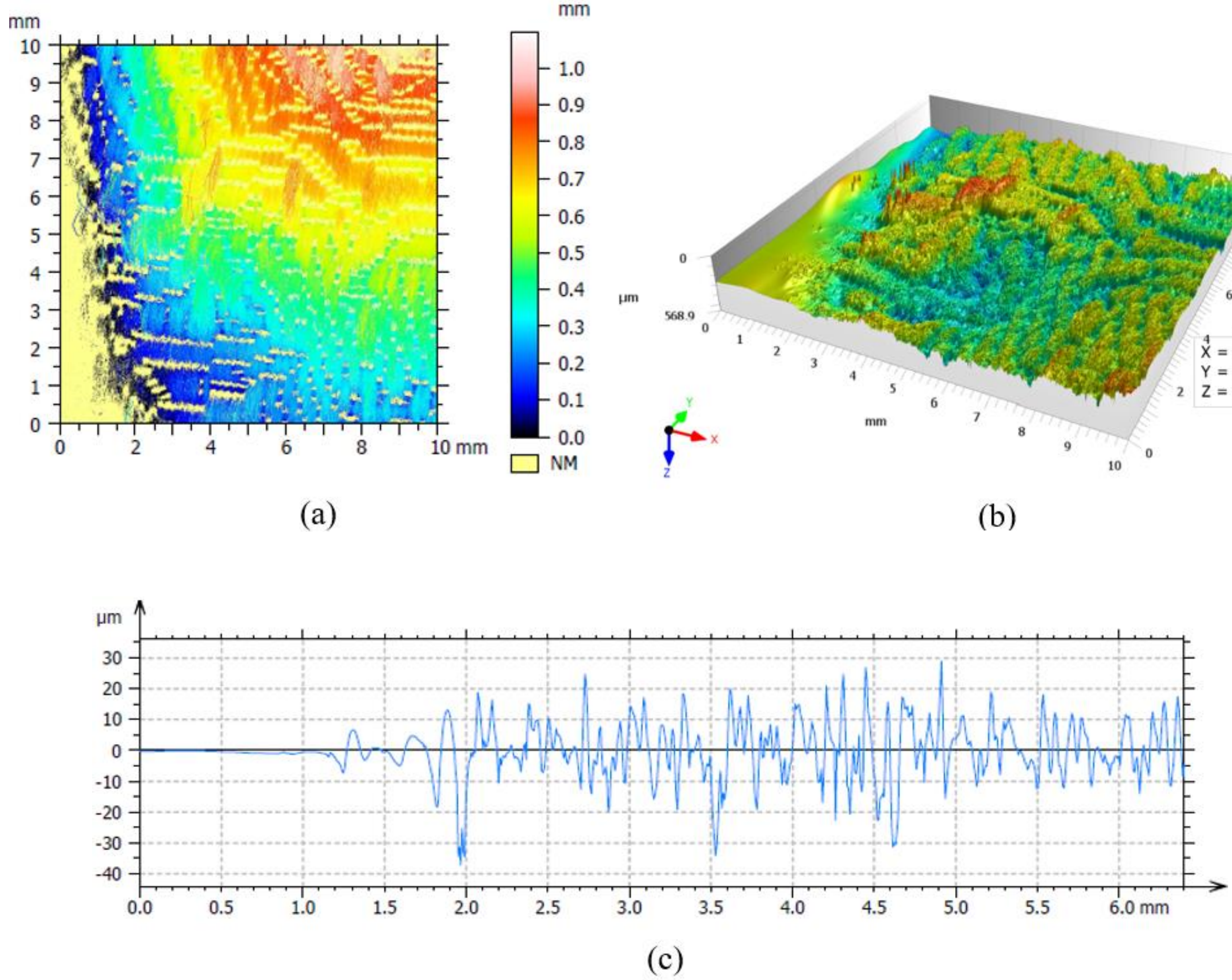
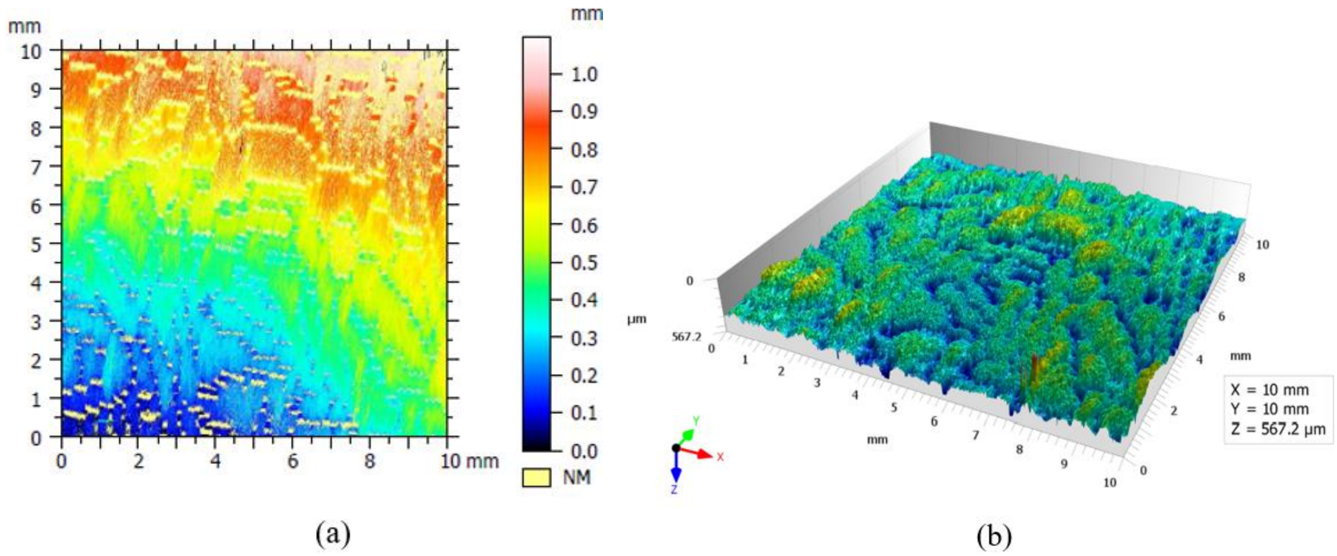
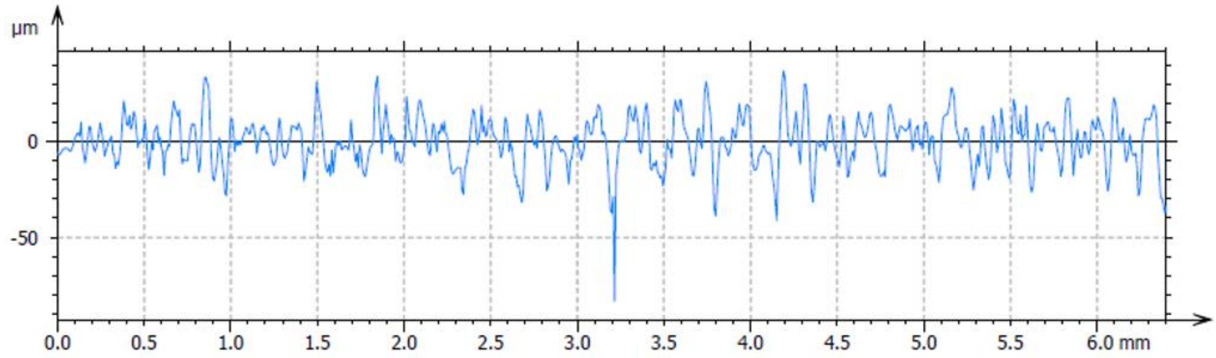


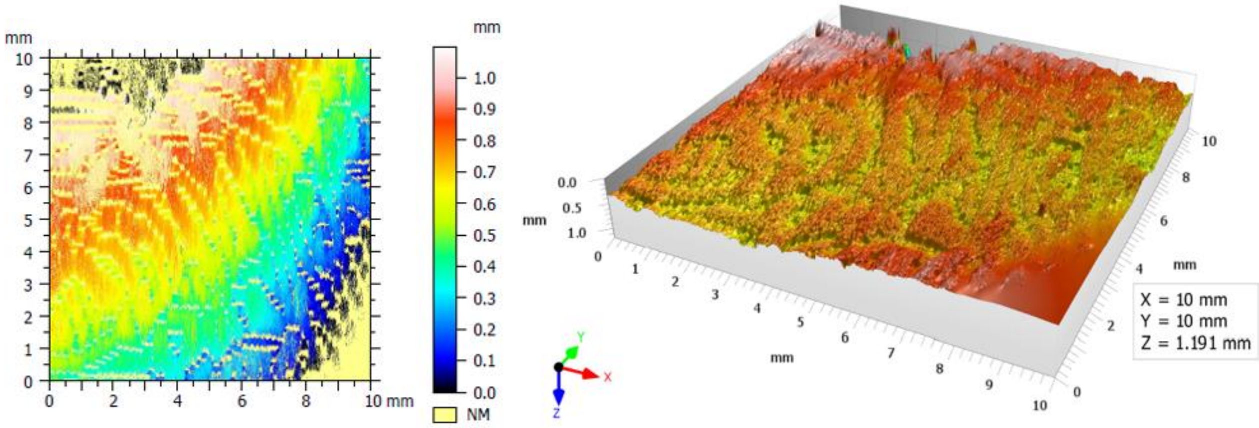
Figure 10. On the region 4 (a) 10 mm × 10 mm 2D contour (b) surface profiling (c) vertical feature height is 40 μm.



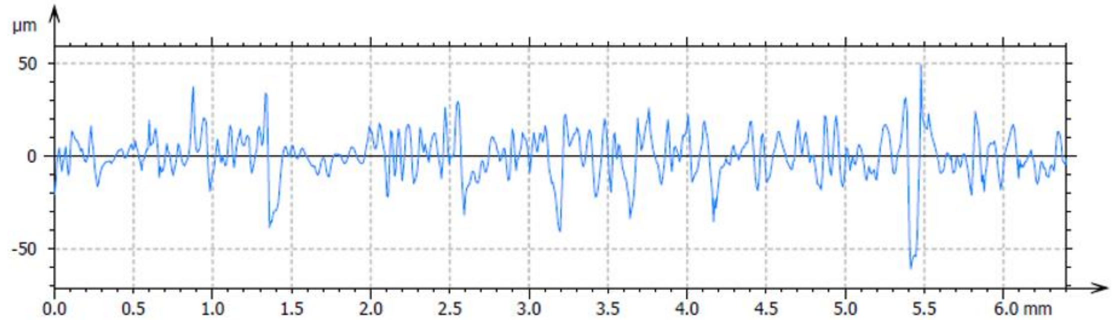


(c)

Figure 11. *On the region 5 (a) surface characterization to show 2D contour. (b) 3D surface profiling with contour region 10 mm ×10 mm × 567.2 µm (c) vertical feature height is 90 µm.*



(a) (b)



(c)

Figure 12. *On the region 6 (a) surface characterization is on thicker printed polymer (b) 3D surface profiling with thickness 1.19 mm (c) vertical feature height is 60 µm.*

(a) (b) (c)

Figure 13. *Printed image (a) one (b) four and (c) hundred are placed on second substrate polymer.*

4. Conclusions

To conclude we printed the drawing on the polymer using woven label. We performed surface profiling on the image to understand the vertical height of the image printed on the polymer. We printed the drawing on the paper based analytical devices. In this study the printed polymer is placed on substrate polymer. We used app to create our drawing. The print process can find applications in polymer mechatronics, wearable electronics and flexible sensors. We need to characterize the polymer, cloth, print polymer cloth region for further inclusion of nematics and polymer physics.

Abbreviations

SEM	Scanning Electron Microscopy
EDS	Energy Dispersive Spectroscopy
CAD	Computer Aided Design
XPS	X-ray Photoelectron Spectroscopy
SSIMS	Static Secondary Ion Mass Spectrometry
IR	Infrared Spectroscopy
RS	Raman Spectroscopy
ALD	Atomic Layer Deposition
CVD	Chemical Vapor Deposition
FDM	Fused Deposition Modelling

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Author Contributions

Vishal Venkata Raghavendra Nandigana is the sole author. The author read and approved the final manuscript.

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Field

Vishal Venkata Raghavendra Nandigana: Micro-nanofluidic Integrated Systems, Polymers, Membranes, Artificial Intelligence.