The Effects of Force on Contact Width of a Stamped Surface by a Wrinkled Specimen

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Abstract

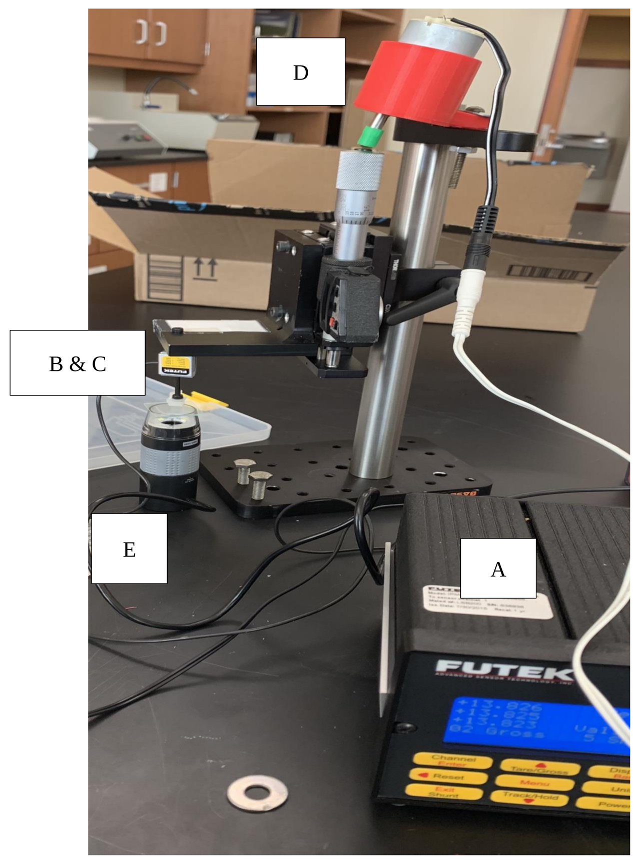
The purpose of this research was to identify the effect that force had on contact width of a stamped surface using wrinkled surface. An initial analysis was done using a wrinkled surface of only silicone. Then, the silicone specimen was soaked in a chemical solution which changed the surface properties of the glass that was being stamped. The solution will change the surface of the glass slide to display hydrophilic properties rather than hydrophobic ones. The contact width of these separate regions would have then been measured and associated to the force.

Introduction

Soft Lithography is a group of patterning methods that utilize an elastomeric stamp to deposit a solution, most commonly an ink, onto a substrate [1]. In this experiment, the first part is ensuring that there is a linear relationship between force and contact width of the wrinkled surface. Once this was verified, the next part was to introduce the ink solution. In this research, the ink solution used was a mixture of Toluene and Octadecyltrichlorosilane (OTS). The reason that this solution was used is because when OTS encounters glass, the surface being used in this research, it changes the surface properties. Usually, glass is hydrophilic which means water adheres to the surface. When the OTS is introduced to the surface, it changes the glass from hydrophilic to hydrophobic, disrupting the adhesion of water to glass. This was originally going to be measured by stamping the wrinkled surface and then introducing condensation so see how the water droplets formed in the different regions – where the wrinkle encountered the surface and where it didn't. Due to the unforeseen circumstances that prohibited students from being able to get into the lab for research, the final part of the research dealing with the Toluene and OTC was not able to be completed. Therefore, the initial part of the research will be discussed as well as what results would have been expected based on the contact angles of water and OTS.

Method

I. Testing Research Apparatus
   - I. The first part of the actual process was testing the research apparatus – it hadn't been used for a few years since the last student worked on the research
   - II. This required a new 3D printed apparatus to hold the motor as well as debugging of the Futek load cell reading system
   - III. The system is shown below with labels:

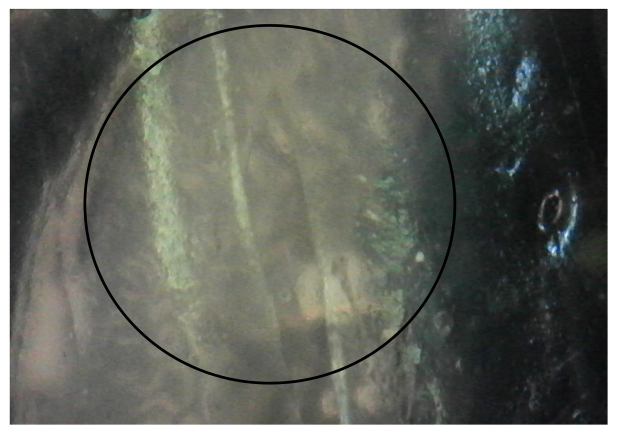


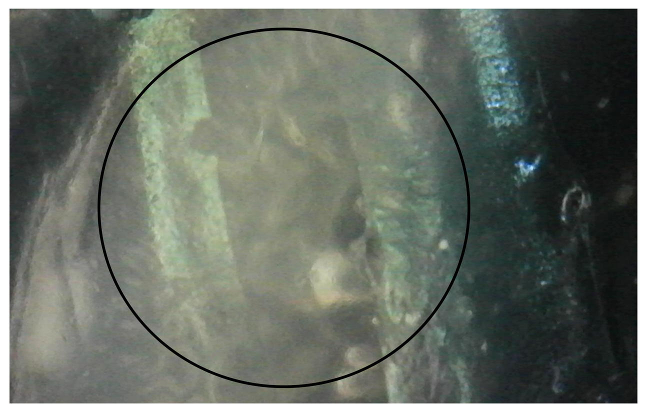
A – Futek power source
B – Futek load cell to read force data
C – Mounted sample
D – Motor and linear actuator system to make very small movements lowering the sample to the camera
E – Camera to capture images of the contact between the sample and the glass slide

II. Making Samples
   - I. There were some samples left from the previous student research (labeled P1 and P2 on results chart)
   - II. Fresh samples were made using Ecoflex
     - I. Ecoflex is a type of silicone with a very low viscosity which sures to a strong, stretchy rubber like material
   - III. There were premade molds from the previous student so those were labeled and used to make new samples
   - IV. The Ecoflex was made by mixing two versions of the material together – this gave desired softness and strength
     - I. This mixture was then put into a vacuum in an attempt to get as many air bubbles out as possible
   - V. This mixture was then poured over the molds and placed into a furnace for 30 minutes at 90 degrees Celsius
   - VI. Once pulled out, the samples are mounted to a cut glass slide attached to a screw – the sample is now ready for testing

Method continued

IIII. Testing Samples
   - I. Each sample was tested at various forces
   - II. At force increments, pictures of the samples were taken like the ones shown below:

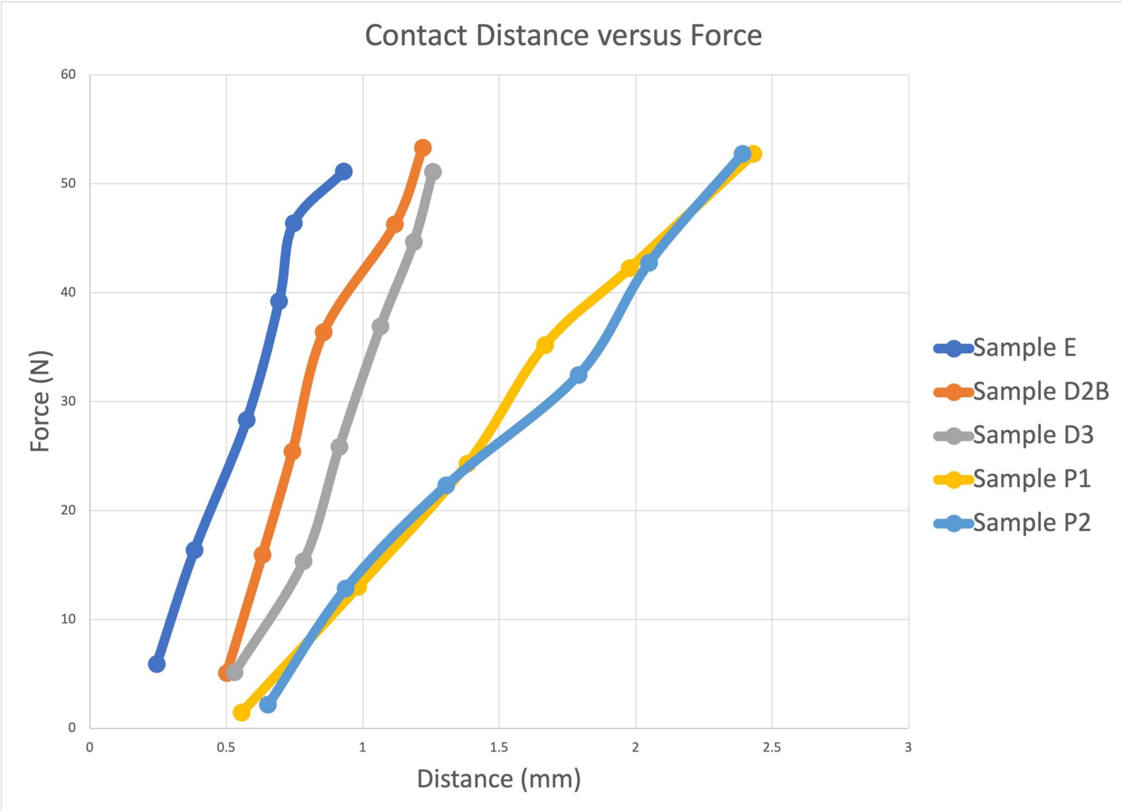




   - III. Once the images were taken, the width was measured by the number of pixels and then converted to millimeters

Results

Once there were pictures of each sample at various forces, the data was put into an excel sheet and a graph was produced showing the relationship between force and contact width for all samples:



As shown above, there relationship was not exactly linear, but that could be due to any measuring error with measuring the number of pixels an area takes up. Multiple width measurements were taken along the length of the wrinkle and the widths were averaged, but there was still room for some error.

Discussion

Overall, the initial part of the experiment went well considering the relationship between contact width and force was close to linear which is what we expected. The final part of the experiment could not be completed but for that, the theoretical contact angles can be compared. As stated previously, glass is usually hydrophilic which means there is an easy adhesion of water to glass. The OTS in the solution was meant to change the surface property of glass from hydrophilic to hydrophobic changing the adhesion of water to the glass. Rather than being able to see this adhesion, the contact angles are an indication of whether something is hydrophilic or hydrophobic. The contact angle of water on a glass slide is ~55 degrees [2] whereas the contact angle of OTS on a glass slide is ~ 113-116 degrees [3]. The picture below shows a visual of differing contact angles [4]:

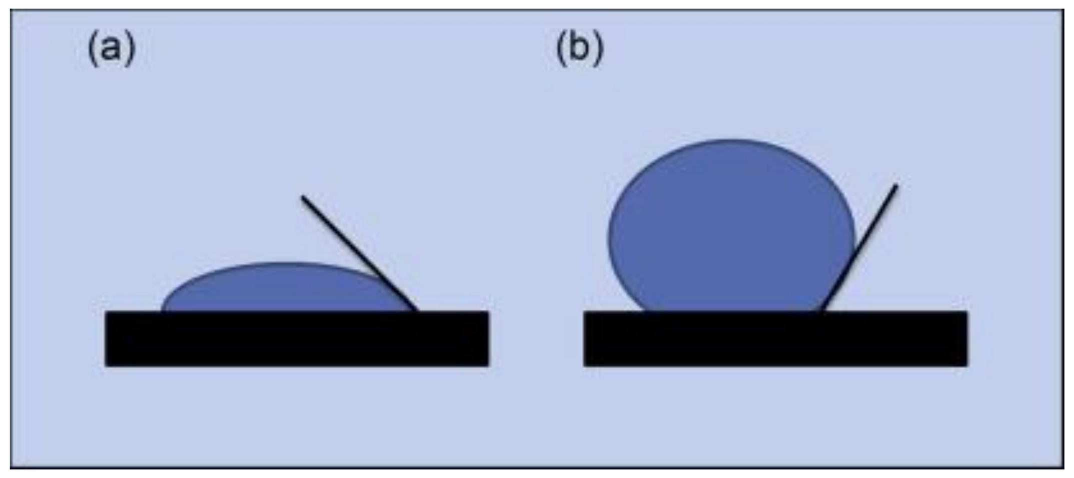


Image (a) shows a contact angle of under 90 degrees and image (b) shows a contact angle of over 90 degrees. Image (a) depicts was water would do on a glass slide normally whereas image (b) depicts was the water would do on a slide coated with OTS. The droplet in image (a) spreads over the slide more showing more adhesion. The droplet in image (b) shows much less of the liquid in contact with the surface which is what the OTS would do the water.

References

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[3] Carson, G., & Granick, S. (n.d.). Self-Assembly of Octadecyltrichlorosilane Films on Mica. Retrieved April 28, 2021, from http://groups.mrl.uiuc.edu/granick/Publications/PDF%20files/1989/Granick%20group%20-%2021%20-%20self-assembly%20of%20OTS%20on%20mica.pdf

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