

Supplementary Information

Two-Photon Polymerization 3D Printed Hydrophobic and Hydrophilic Surface Morphologies for Electrode Micropatterning via Dip Coating Techniques and Enhanced Microchannel Filling

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Mechanical Characterization of 2PP Printed Polymers

Table S1. Nanomechanical properties of IP-Q and IP-S photo resins.

	IP-S (solid)	IP-Q (solid)	IP-Q (scaffold)
Reduced modulus, E_r (GPa)	3.720 ± 0.141	1.633 ± 0.084	1.348 ± 0.081
Young's modulus, E (GPa)*	3.396 ± 0.129	1.488 ± 0.077	1.228 ± 0.074
Indentation Hardness (MPa)	226.6 ± 13.54	43.55 ± 3.99	36.63 ± 3.58

Reported values are mean properties and their standard deviation calculated with a Bessel correction based on five measurements.

* Young's modulus values are obtained using the following expression below, where E , E_r , and ν are Young's modulus, reduced modulus, and Poisson's ratio of the measured sample, respectively, and $E_{in}=1140$ GPa and $\nu_{in}=0.07$ are Young's modulus and Poisson's ratio of Berkovich tip indenter. Poisson's ratio of 0.3 is assumed for IP-S and IP-Q samples when converting their reduced moduli to Young's moduli.

$$\frac{1}{E_r} = \frac{1 - \nu^2}{E} + \frac{1 - \nu_{in}^2}{E_{in}}$$

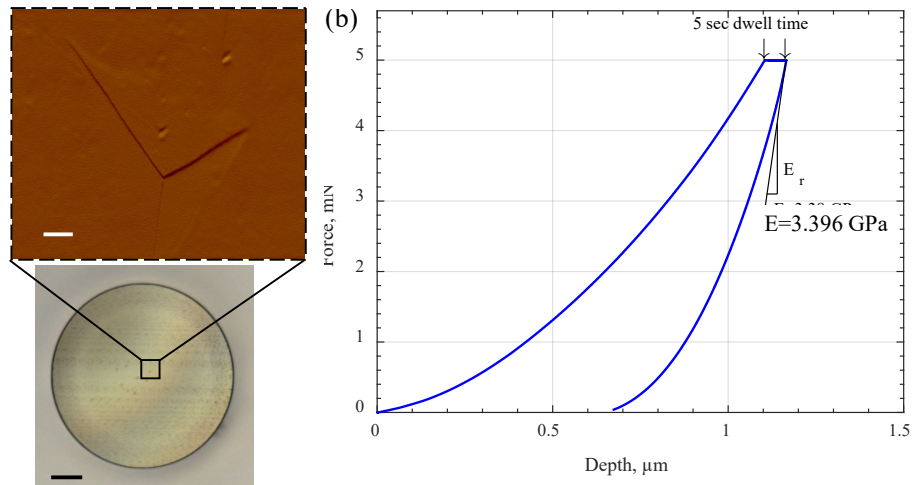


Figure S1. (a) IP-S cylindrical sample on which nanoindentation was performed with the Berkovich tip impression on IP-S sample surface and (b) the obtained force-displacement curve.

Contact Angle Measurement

Knowledge of fluid-solid interaction, particularly contact angle is important for the design and analysis of hydrophobic and hydrophilic microstructures, as well as flow propagation along the channels. Thus, the contact angles of two different PEDOT:PSS aqueous solutions on 2PP printed IP-S and IP-Q surfaces are obtained from the static sessile drop test, as shown in **Figure S2**. **Table S2** lists the measured contact angles.

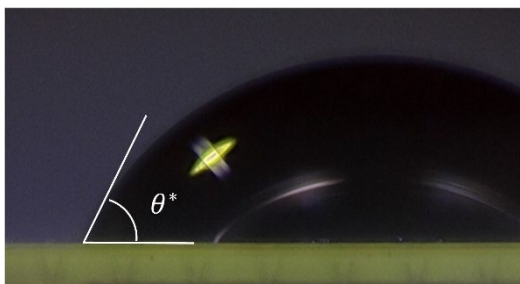


Figure S2. PEDOT:PSS solution droplet on IP-S surface for contact angle testing.

Table S2. Contact angles of different 2PP photopolymers and PEDOT:PSS aqueous solution compositions.

	PEDOT:PSS (wt. %)	Surfactant (wt. %)	Contact Angle
IP-S	1.1	0	58.9°
	1.3	5	44.3°
IP-Q	1.1	0	58.0°

Anti-Wetting Lens Application

Besides 2PP printed microstructured parts for electrode micropatterning and microchannel filling, another application of 2PP for morphologies on flat surface is investigated. A set of anti-wetting lenses are fabricated to demonstrate the capabilities of the microstructure in providing water resistance. The lenses are coated with a simplified version of both the cubic and pyramid microstructures tested previously, as shown in **Figure S3(a1-c1)**. The reduced sizing and complexity of the microstructure increases visual clarity through the lens. The lenses are then compared to a smooth lens for visual clarity, both without and with fluid. The lenses are placed onto a high-resolution camera, and images are taken through the lens before and after being dipped into fluid.

The reduced microstructure behaves slightly different from the original designs. Initially, when the lens is exposed to a small amount of liquid, the microstructure exhibits hydrophobic properties. Functionally, the reduced complexity of the structure lends to many similarities with the hydrophobic mushroom structure at low amounts of liquid. In this state, liquid easily rolls off the lenses, keeping them dry. Once fully exposed to liquid, however, the structure exhibits hydrophilic properties and retains a layer of liquid across the entire lens.

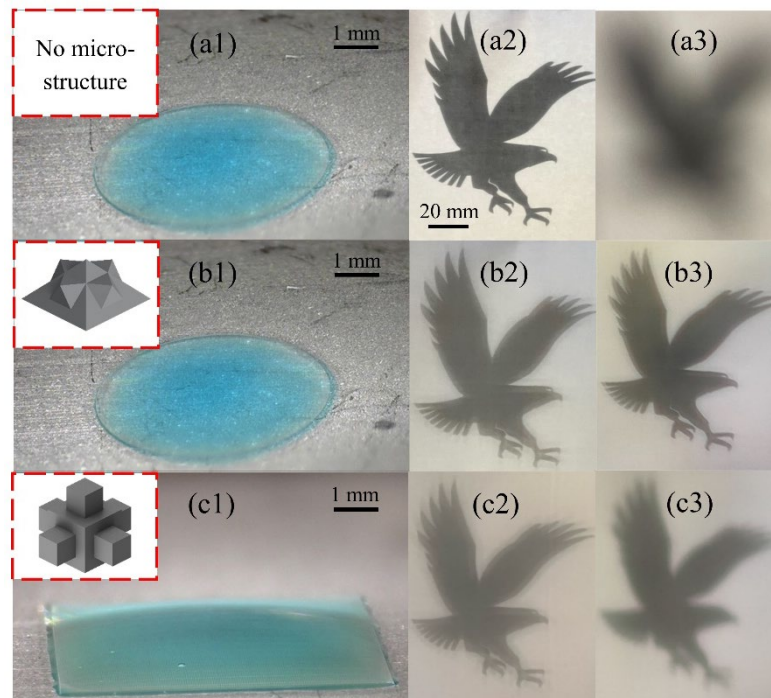


Figure S3. 2PP printed (a1) smooth lens and lenses with (b1) pyramid and (c1) cubic hydrophilic microstructures when fully submerged in liquid with a shown morphology. Performance of the three lenses is demonstrated with the pictures of an eagle logo taken through (a2-c2) dry and (a3-c3) wetted lenses.

Figure S3 shows the effect of the lenses on visual clarity before and after the application of water on entire lens surface. In Figure S3(a2-a3), the smooth lens shows the best visual clarity without liquid, due to the lack of microstructure, but significantly degrades in quality due to the large and uneven droplets of liquid coating the lens. Both the cubic and pyramid structure lenses exhibit small amounts of ghosting and loss of detail without liquid, as shown in Figure S3(b2) and Figure S3(c2), respectively, due to their rougher surface, the presence of overhanging features in cubic microstructures, and possible material optical distortion after 2PP printing. However, Figure S3(b3-c3) demonstrates how microstructured lenses retain a significantly larger amount of visual clarity after liquid is applied. This is primarily due to the even, relatively thin layer of liquid providing little refraction, acting as a pseudo-lens. The pyramid structured lens retains a significantly larger amount of detail and distorts the image less than the cubic structure in wet

state. One potential explanation for this improvement is the lack of overhanging features in the pyramid structure design, which results in light passing through fewer interfaces. The cubic structure contains large pockets caused by overhanging features that increase the wettability, but have a negative effect on visual clarity, causing larger amounts of distortion.