Supplementary information

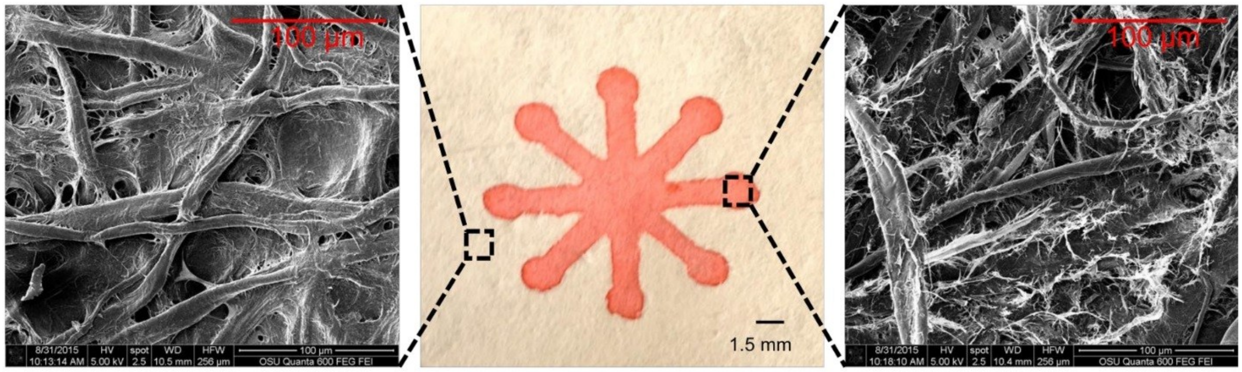


Fig. S1 A Whatman no 1 CHR µPAD developed with red dye to aid in visualization of hydrophilic and hydrophobic regions. The left panel shows an SEM image of a portion of the device that was PCL treated (hydrophobic), the center panel is the device as developed, and the right panel shows an SEM image of a portion of the device that was masked (hydrophilic).

Table S1 Laser cutter optimization study.

Laser Cutter Settings				Result
Power (%)	Speed (%)	PPI	Z-Axis (mm)	
1	50	1000	0.4	Does not cut through tape
5	50	1000	0.4	Cuts through tape on straight sections, but not curved
1	25	1000	0.4	Does not cut through tape
2	25	1000	0.4	Cuts through tape, but difficult to cleanly remove masking material
3	25	1000	0.4	Cuts cleanly, can remove masking material easily
4	25	1000	0.4	Cuts cleanly, can remove masking material easily
5	25	1000	0.4	Cuts cleanly, some paper damage

The power and speed settings, both of which have the most control over cutting depth, were varied while pulses-per-inch (PPI) and Z-axis (material thickness) settings remained the same. Increasing power leads to deeper cuts while sacrificing control over fine detail, lower speeds likewise yield deeper cuts with a sacrifice in detail. Higher PPI values lead to finer detail with little to no effect on cut depth.

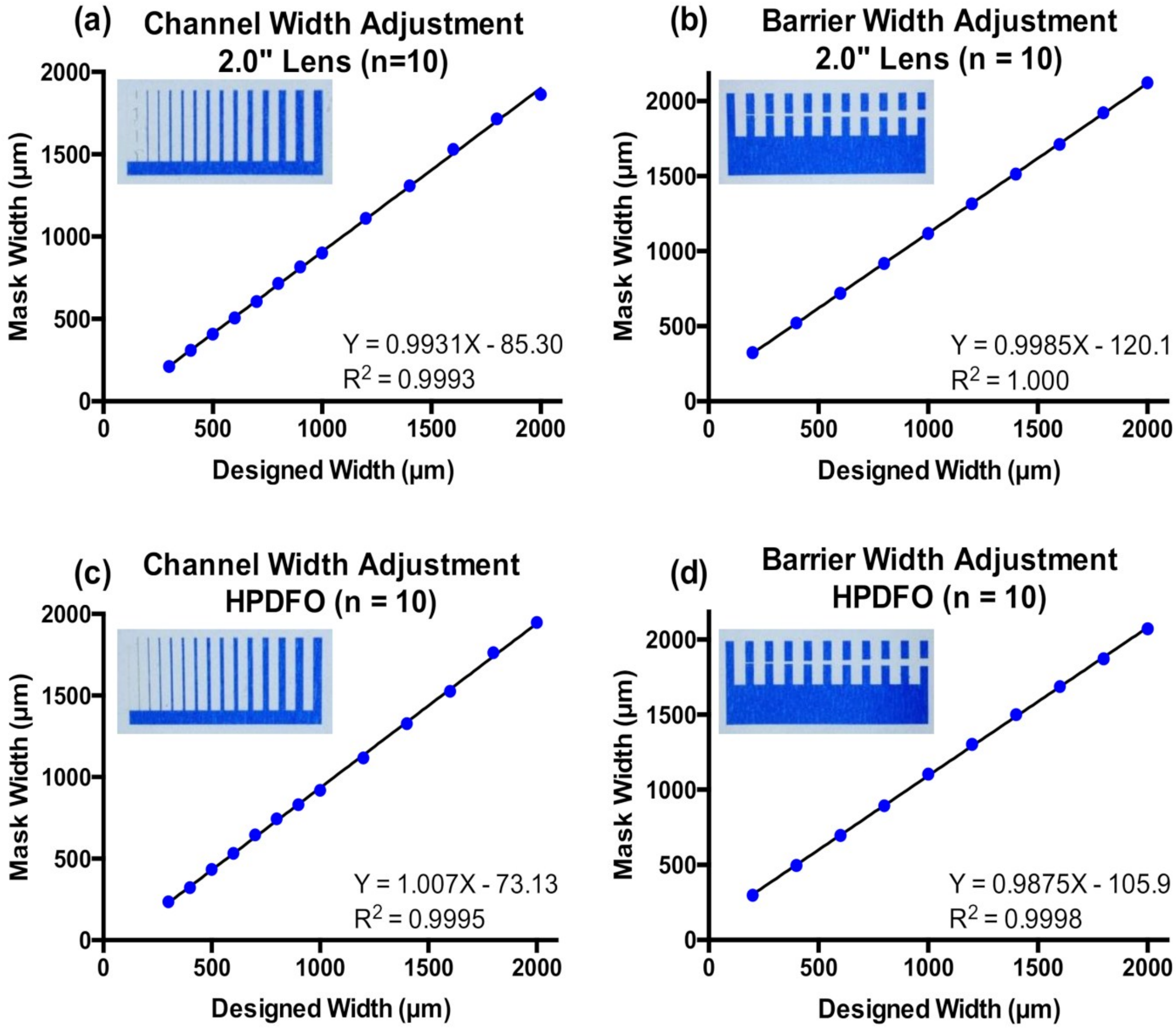


Fig. S2 Laser cutter calibration results. A quantitative comparison between the designed width programmed in Solidworks and the resulting width of the mask for channels (a) and barriers (b) using a 2.0" lens and for channels (c) and barriers (d) using High Power Density Focusing Optics (HPDFO). A linear trend following the equation WM = 0.9931WD – 85.30 (r^2 = 0.9993; WM is with masked, WD is width developed) can be established when using the standard 2.0" lens for channel mask fabrication (a). Inset images show examples of resulting masking material on Whatman no. 1 CHR following laser cutting. Following the optimization of the laser cutter, the average percent difference between the designed width and actual width was 1.02% for channels and 1.25% for barrier masks. It was experimentally determined that the smallest mask that could be reliably created was 105.10 µm ± 0.01 for channels, while a single line drawn in SolidWorks allowed for a barrier with a width of approximately 50 µm.

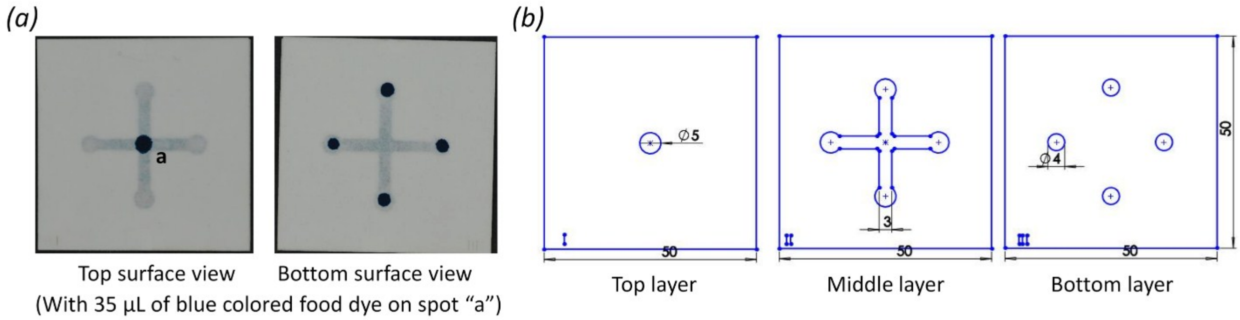


Fig. S3 3D fluid flow device fabrication by thermal lamination of different layers. (a) The tested device consists of 3 individual layers with different patterns. (b) The mask patterns for individual layers (unit dimensions are in mm).

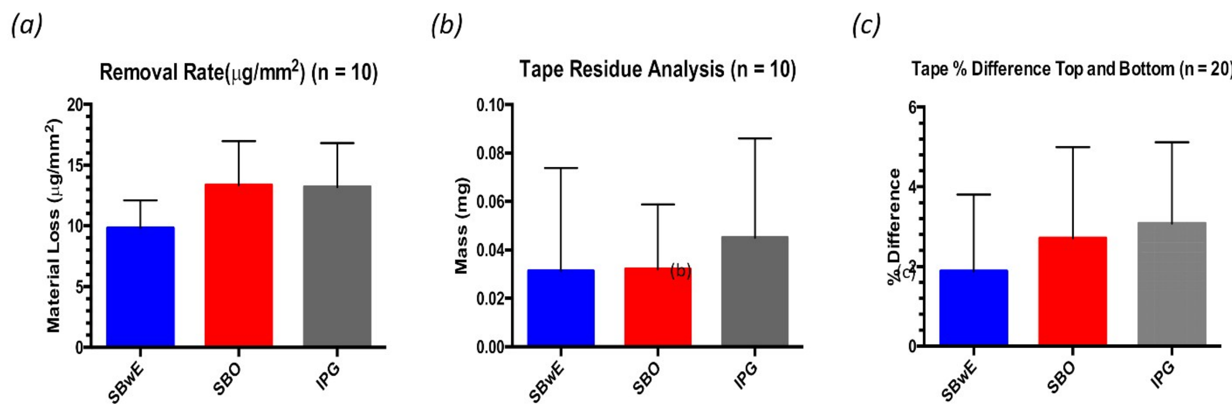


Fig. S4 Results of masking material selection. Scotch Blue with Edge Lock for delicate surfaces (SBwE) caused the least amount of surface disturbance with a material removal rate of 9.82 µg/mm2, while Scotch Blue Original (SBO) and Intertape Polymer Group masking tape (IPG) had rates of 13.34 µg/mm2 and 13.19 µg/mm2 respectively (a). Residue analysis indicated SBwE had left the lowest amount of residue at 31 µg, SBO left 32, and IPG resulted in 45 µg of residue (b). SBwE was the most effective at masking with an average difference in diameter from top to bottom of 1.88%, SBO and IPG had larger differences at 2.72% and 3.08% (c).

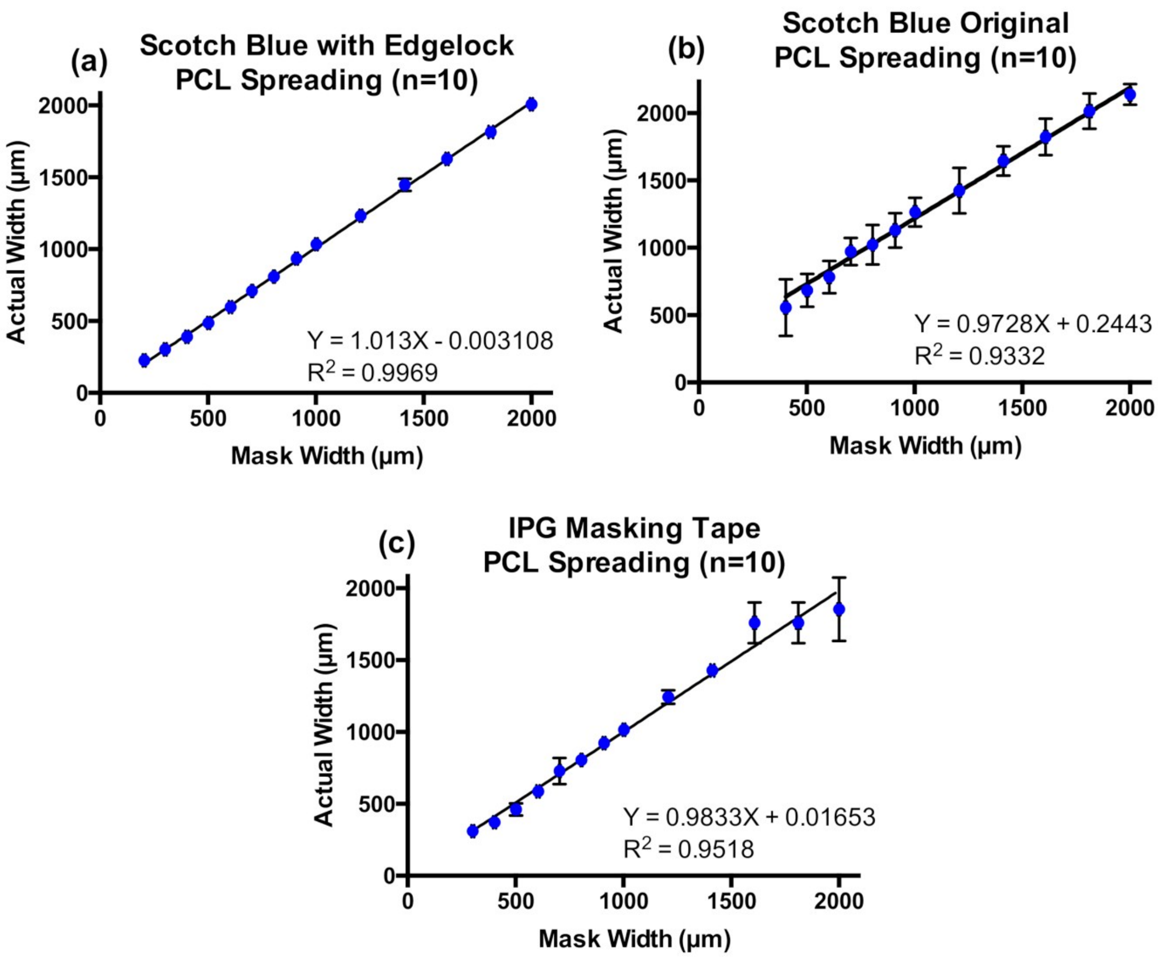
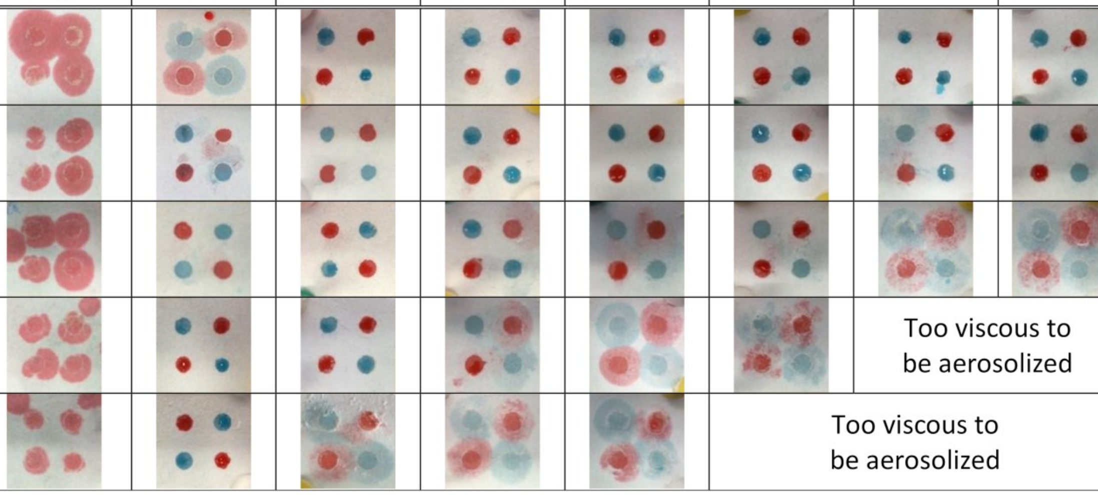


Fig. S5 Results of PCL spreading study. The extent of PCL spreading underneath the mask was determined by comparing the actual mask width in µm and the resulting width in µm after the application of PCL. Masks consisting of Scotch Blue with Edgelock (a) resulted in a linear trend with the equation WA = 1.013WM – 0.003108 (r2 = 0.9969). Scotch Blue Original (b), and IPG masking tape (c) also produced linear trends, although the results were much less consistent.



% W/V	CAPA 7201A MW 2K	CAPA 6100 MW 10K	CAPA 6200 MW 20K	CAPA 6250 MW 25K	CAPA 6400 MW 37K	CAPA 6506 MW 50K	CAPA 6800 MW 80K	SIGMA MW 80K
5%								
7.5%								
10%								
15%							Too viscous to be aerosolized	
20%						Too viscous to be aerosolized		

Fig. S6 Effect of molecular weight and weight percent (%) of PCL solution on the aerosolized deposition fabrication method. Increasing molecular weight and weight % results in decreased penetration into the paper leading to increased sample spreading under the layer of PCL on the top surface. Solutions become increasingly difficult to spray at higher weight % and molecular weight as clogging of the airbrush nozzle occurs resulting uneven PCL application.

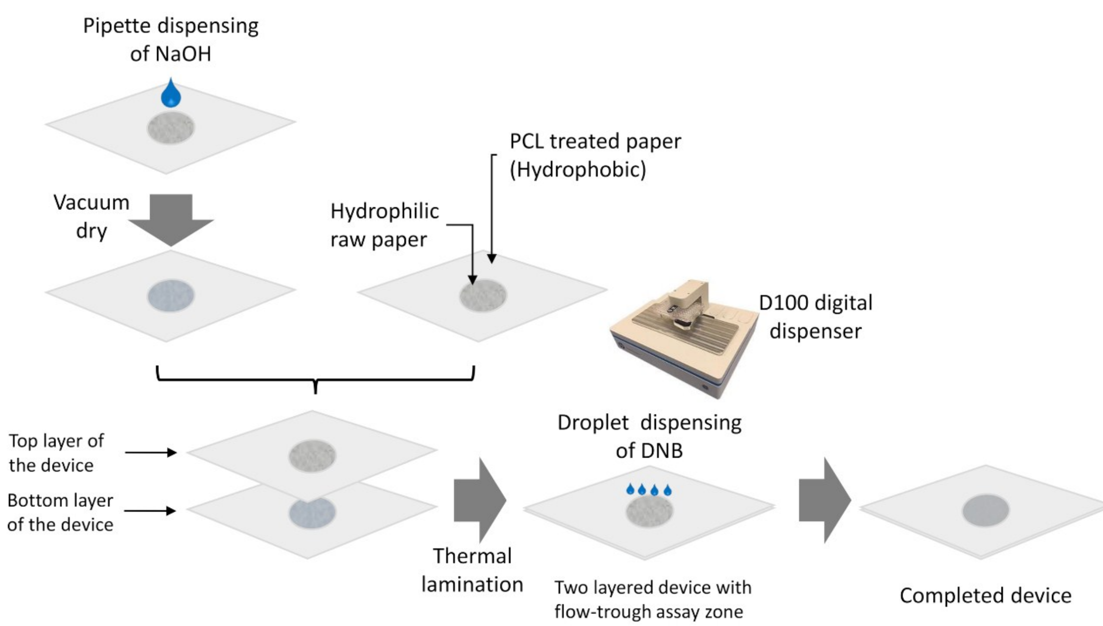


Fig. S7 Steps of the fabrication process for creatinine detection device

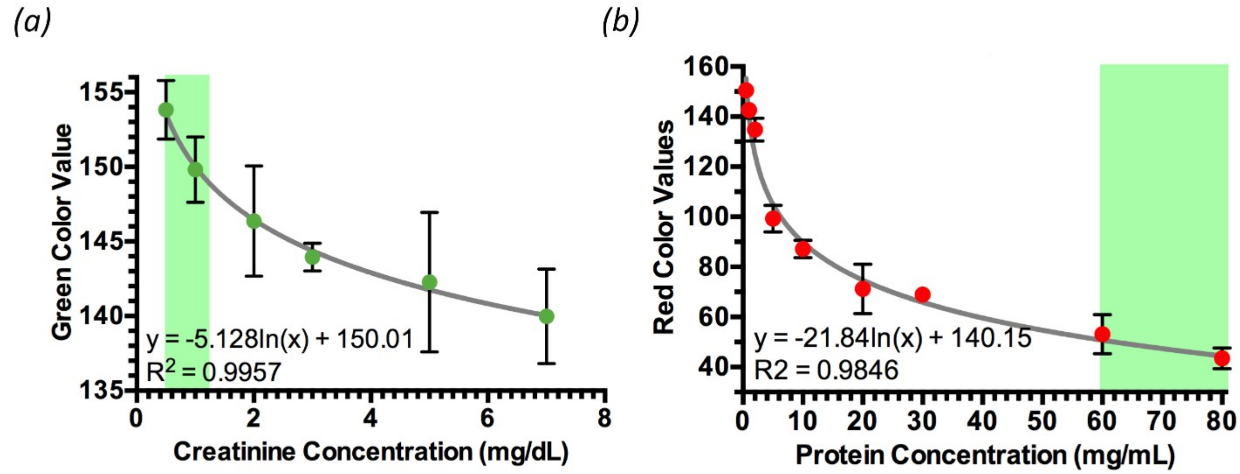


Fig. S8 Calibration plots using color values in the RGB color space and normal intervals: (a) creatinine assay, (b) protein assay. The normal concentration range (in human serum) for each analyte is indicated by the green shaded region in each plot.