

Supporting information for:

Paper and Toner Three-dimensional Fluidic Devices:

Programming Fluid Flow to Improve Point-of-Care Diagnostics

Kevin M. Schilling⁺, Daisy Jauregui⁺ and Andres W. Martinez *

Department of Chemistry & Biochemistry, California Polytechnic State University, San Luis
Obispo, CA 93401

⁺ These authors contributed equally to this work

* Corresponding author E-mail: awmartin@calpoly.edu

Fabrication of 3D microPADs.

Sheets of Watman 1 CHR Chromatography paper (20 cm × 20 cm) were patterned by wax printing. Patterns were designed in Adobe® Illustrator® and printed using a Xerox Phaser 8560 printer. The wax was then melted at 195 °C for one minute in an MTI Corporation Compact Forced Air Convection Oven. Four toner layers were printed on the patterned paper using a Samsung CLP-620ND printer waiting five minutes between each print cycle. The devices were folded manually and then fed through a Purple Cows laminator (model 3015C) set to the 5 mil setting. Finally, the devices were cut using scissors.

Braided Device (Figure 1).

Fifteen microliters of 1-mM Eriogalucine (blue), 25-mM Allura red, 25-mM Tartrazine (yellow) and a mixture of 0.5-mM Erioglucine and 12.5-mM Tartrazine (green) were added to the fluid inlets and allowed to wick across the channels. The fluids filled the channels in under 2 min. The device was dried under ambient conditions and scanned using an Epson V300 scanner. The image of the cross-section of the device was obtained by cutting the device in half using a razor blade and imaging the cross-section through an AmScope trinocular stereo microscope using a Nikon D5100 camera with a microscope adapter.

Distribution Devices (Figure 2).

Fifteen microliters of the four aqueous dyes described previously were added to the fluid inlets at the top of the 3D distribution devices. The solutions wicked through the channels in the devices into the test zones on the bottom of the devices. The devices were dried under ambient conditions and scanned.

Devices with Patterned Results (Figure 3).

We prepared a glucose reagent solution containing 0.6-M potassium iodide, 0.3-M trehalose, 67,000-U/L glucose oxidase and 67,000-U/L horseradish peroxidase in 1X PBS (phosphate buffered saline, pH 7.4). For the devices shown in Figure 3 C-F, we spotted 0.5 μ L of the glucose reagent solution in each test zone in the desired pattern, and dried the reagents under ambient conditions. To operate the device, we added 20 μ L of a 100-mM glucose solution in 1X PBS to the sample inlet at the top of the device. The sample wicked into the test zones where the colorimetric reaction took place. The devices were dried under ambient conditions and scanned after 30 min. For the devices shown in Figure 3 G and H, we spotted 2 μ L of 100-mM glucose solution in 1X PBS in the second to last layer of the device as shown in Figure S3. The solution was dried under ambient conditions and the device was folded and laminated. We then spotted 0.5 μ L of the glucose reagent solution in each test zone in the desired pattern, and dried the reagents under ambient conditions. To operate the device, we added 20 μ L of either a 10-mM (Figure 3G) or a 2-mM (Figure 3H) glucose solution in 1X PBS to the sample inlet at the top of the device. The sample wicked through the device, dissolving the glucose and carrying it into the test zones where the colorimetric reactions took place. The devices were dried under ambient conditions and scanned after 30 min.

Figure S1

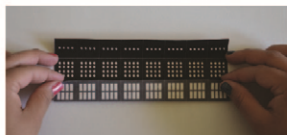
1. Pattern paper (7 min)



2. Print Toner (20 min)



3. Fold (10 min)



4. Laminate (5 min)



5. Cut (6 min)

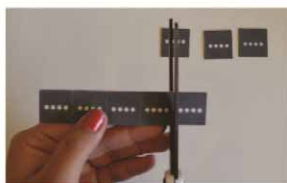


Figure S1. Demonstration of rapid manufacturing of 3D devices. A total of 160 devices (ten sheets of paper) were prepared in under 50 minutes. The times shown above each image indicate the time required to process all 160 devices.

Figure S2

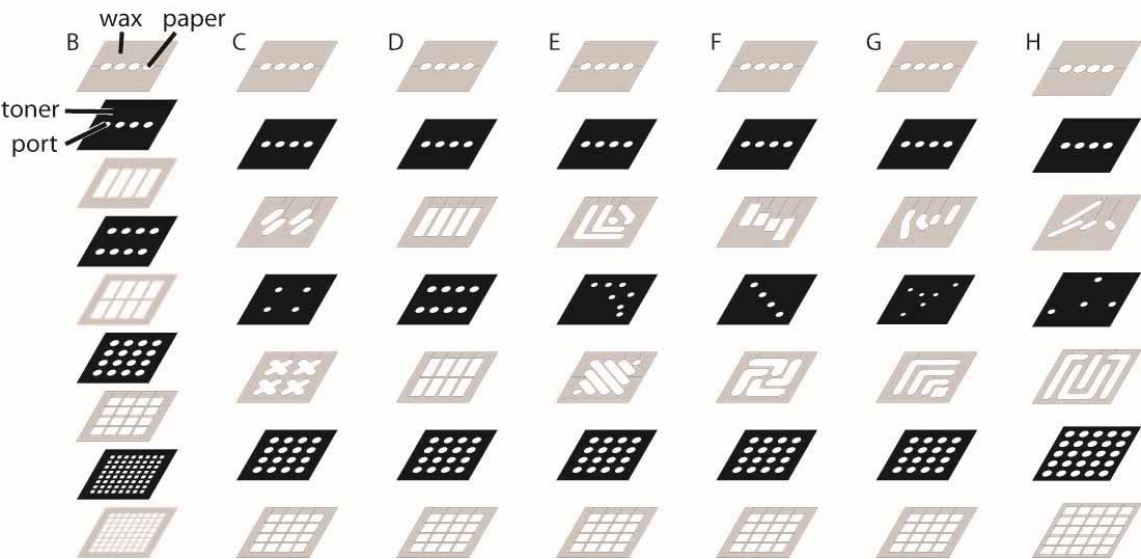


Figure S2. Patterns of the layers of paper and toner for the devices shown in Figure 2.

Figure S3

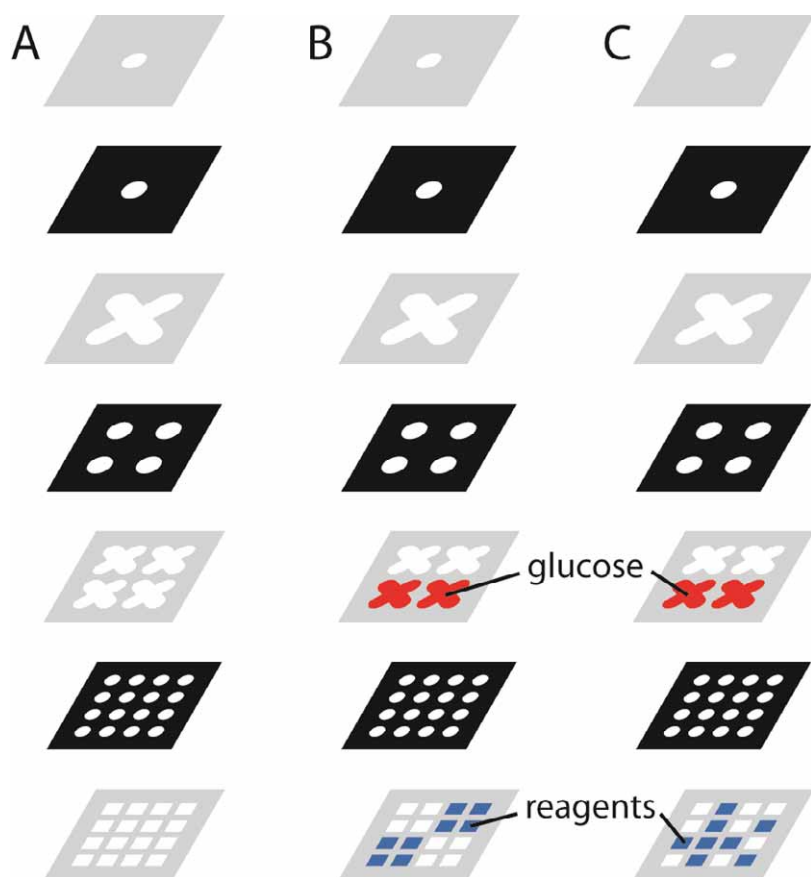


Figure S3. Patterns for glucose assay devices. (A) Layers of patterned paper and toner that make up the device. (B) Device shown in Figure 3G. The glucose solution was spotted and dried in the indicated zones before the device was laminated. The reagents were spotted after the device was laminated. (C) Device shown in Figure 3H.