Electronic Supplementary Material (ESI) for RSC Advances

Two General Designs for Fluidic Batteries in Paper-Based Microfluidic Devices That Provide Predictable and Tunable Sources of Power for On-Chip Assays

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Supporting Information

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Materials

Sodium nitrate, aluminum metal, silver metal, silver nitrate, and anhydrous aluminum chloride were purchased commercially and used without further purification. The paper used was Whatman Chromatrography Paper Grade 1, and the tape was Ace Hardware Plastic carpet tape (part # 50106). All solutions were prepared using deionized water. The technicloth used was TechniCloth®11(TX®1109, Wipers (Blend), 45% polyester/55% cellulose, 23 cm × 23 cm). The copper tape (6.3 mm wide, 0.04 mm thick copper, product # 16072) was purchased from TedPella.com.

General Procedure for Fabricating Fluidic Batteries in Paper-Based Microfluidic Devices

Patterning paper. The paper was patterned according to the procedure described by Noh.[1] The only variation made was heating the paper for 105 seconds rather than 120 s after printing wax on the paper using a wax printer.

Patterning tape. The tape was patterned according to the procedure described by Noh.[1]

Fabricating 3D µPADs. The general procedure for assembling the devices is described in Refs. 1 and 2. Specific variations of that procedure are described below as follows: the salt bridges were prepared by spotting 0.375 µL of saturated aqueous $NaNO_3$ solution twice into a designated hydrophilic region of paper, and by drying the wet paper under vacuum for 30 min after each application. The electrolytes, 0.25 µL each of 1 M $AlCl_3$ and 3 M $AgNO_3$, were spotted and allowed to dry under vacuum for 30 min. After each layer was dried, the layers were cut to size using scissors. The holes in the inner layers of tape in the devices were filled with technicloth that had dimensions equal to the size of the holes unless otherwise noted. The assembled 3D µPADs were compressed using a 4.9 kg weight for approximately 15 minutes. The electrode layer contained pieces of aluminum and silver metal (0.25 mm thick) cut to dimensions equal to the size of the holes in the tape. After placing the metal into the holes, the holes were covered using copper tape; the figures indicate whether a single piece of copper tape was used to cover both electrodes, or whether individual pieces of copper tape covered each electrode.

General Procedure for Measuring Open Circuit Voltages and Short Circuit Currents

The short circuit current and open circuit voltage measurements were made using a Commercial Electric Digital Multimeter MAS830B, which can be purchased from a variety of stores, including home improvement centers.

A Single Cell Fluidic Battery That Corresponds to Figure 1

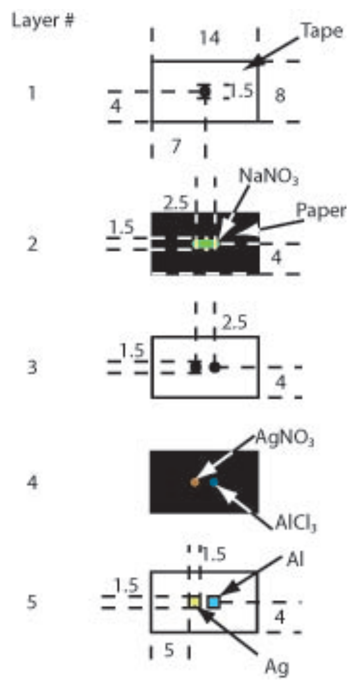

Figure S1. Expanded view of a single cell battery with a 0.99 mm^3 salt bridge. The device is 14-mm wide × 8-mm long. All values listed are in mm.

Fabrication of a single cell battery.
This device was designed as shown in Figure S1, with the salt bridge in layer 2 and the electrolytes in layer 4, which were prepared as described above. Aluminum and silver metal pieces were placed in the holes in layer 5. Copper tape was placed over the pieces of metal to hold them in place. When testing this design, a multimeter was connected (using alligator clips) to the pieces of copper tape, and 5 μL of deionized water was deposited onto the sample input region in layer 1.

Devices and Tabulated Data Used for Fig. 2

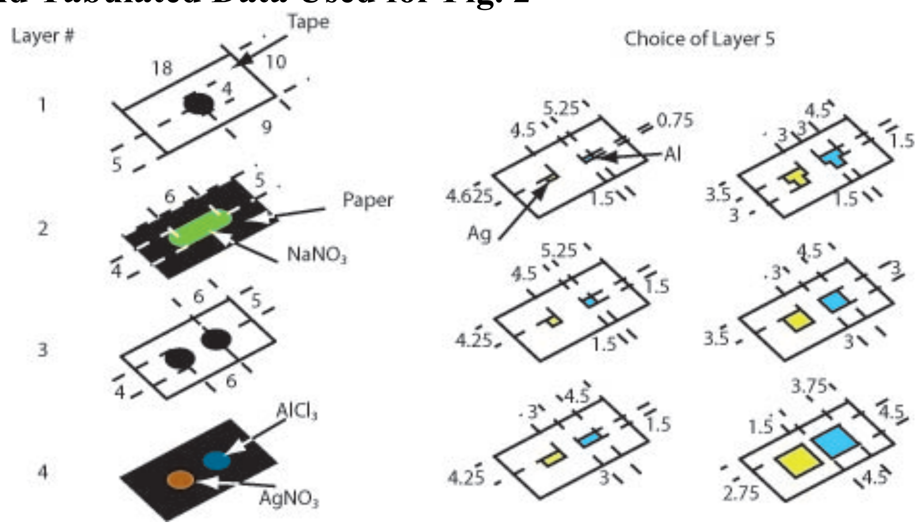

Figure S2. Expanded view of a single cell battery used for testing the batteries with various electrode areas. Layer 5 has several options shown for the different devices tested. The device is 18-mm wide × 10-mm long. All values listed are in mm.

Fabrication of the devices in Figure S2.
These devices were fabricated as described above, with the exception that 5 μL of saturated $NaNO_3$ was spotted onto the salt bridge in layer 2, and 1.75 μL each of 1 M $AlCl_3$ and 3 M $AgNO_3$ were spotted into the electrolyte regions in layer 4. The metal pieces were cut to fit the size of the holes in layer 5 using scissors, and Cu tape was placed over the metal pieces.

Method for testing the effects of the area of the electrodes using the devices in Figure S2. These devices were tested by connecting alligator clips onto the pieces of Cu tape without adding pressure onto the Al and Ag pieces. The device was arranged so that it was not bent, and the alligator clips were attached to the multimeter to monitor the current or potential. The devices were started using by addition of 10 μL deionized water.

Tables of data using the devices shown in Figure S2. This data was used to create the graph in Figure 2:

Table S1. Data collected for 1.125 mm^2 electrodes.

Time	Current (μA)			
(min)	Trial 1	Trial 2	Trial 3	Trial 4
0	0	0	0	0
0.25	-	1480	1370	-
0.5	1550	1350	1360	1310
0.75	1420	1280	1200	1250
1	1270	1210	1120	1200
1.25	1170	1150	950	1160
1.5	1090	1050	880	1070
1.75	1030	1030	-	-
2	970	1000	860	960
2.25	900	950	-	-

Table S1 Continued. Data collected for 1.125 mm^2 electrodes.

Time	Current (μA)			
(min)	Trial 1	Trial 2	Trial 3	Trial 4
2.5	850	970	-	-
2.75	810	-	-	-
3	790	-	-	-
3.25	760	-	-	-
3.5	750	-	-	-
3.75	730	-	-	-
4	680	-	-	-
4.25	670	-	-	-
4.5	650	-	-	-
4.75	-	-	-	-
5	600	-	-	-

Table S2. Data collected for 2.25 mm^2 electrodes.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	1570	1760	1950	1780	1.35	1.31	1.35
0.5	1720	2030	2010	1940	1.34	1.31	1.31
0.75	1650	2110	1830	1920	1.30	1.26	1.26
1	1550	2070	1600	1780	1.25	1.22	1.24
1.25	1460	-	-	1600	1.21	1.20	1.25
1.5	1360	-	-	-	1.19	1.17	1.21
1.75	1220	-	-	-	1.17	1.16	1.20
2	1150	-	-	-	1.17	1.15	1.16
2.25	1080	-	-	-	1.16	1.13	1.10
2.5	1000	-	-	-	1.15	1.13	1.13
2.75	-	-	-	-	1.15	-	1.12
3	-	-	-	-	1.15	1.02	1.12
3.25	-	-	-	-	1.15	1.08	1.11
3.5	-	-	-	-	1.14	1.07	1.10
3.75	-	-	-	-	1.13	1.06	1.11
4	-	-	-	-	1.13	1.05	1.09
4.25	-	-	-	-	1.11	1.04	1.07
4.5	-	-	-	-	1.11	1.04	1.06
4.75	-	-	-	-	1.10	1.03	1.05
5	-	-	-	-	1.10	1.03	1.05

Table S3. Data collected for 4.5 mm^2 electrodes.

Time	Current (μA)			Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
0	0.00	0.00	0.00	0.00	0.00	0.00
0.25	2030	1930	1860	1.33	1.34	1.36

Table S3 Continued. Data collected for 4.5 mm^2 electrodes.

Time	Current (μA)			Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
0.5	2170	2080	1960	1.37	1.31	1.34
0.75	2200	2100	1960	1.34	1.29	1.34
1	2090	2020	1870	1.33	1.28	1.33
1.25	2020	1960	1900	1.31	1.27	1.31
1.5	-	-	-	1.29	1.24	1.29
1.75	-	-	-	1.27	1.23	1.28
2	-	-	-	1.25	1.22	1.25
2.25	-	-	-	1.23	-	1.19
2.5	-	-	-	1.21	1.19	1.20
2.75	-	-	-	1.20	1.16	1.20
3	-	-	-	1.18	1.15	1.17
3.25	-	-	-	1.14	1.18	1.16
3.5	-	-	-	1.14	1.17	1.09
3.75	-	-	-	1.12	1.18	1.13
4	-	-	-	1.11	1.17	1.12
4.25	-	-	-	1.10	1.15	1.11
4.5	-	-	-	1.10	-	1.12
4.75	-	-	-	1.10	1.10	1.12
5	-	-	-	1.09	1.15	1.11

Table S4. Data collected for 6.75 mm^2 electrodes.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0.00	0.00	0.00
0.25	1750	1860	1990	1800	1.36	1.35	1.33
0.5	2000	2240	2000	1910	1.34	1.34	1.33
0.75	2400	2280	1990	1730	1.32	1.33	1.29
1	2350	2140	1930	1930	1.31	1.32	1.26
1.25	2260	2020	1820	1900	1.29	1.30	1.24
1.5	2110	1910	1780	1830	1.27	1.29	1.25
1.75	2040	1850	1690	1750	1.27	1.29	1.22
2	1950	1770	1650	1630	1.24	1.26	1.18
2.25	1890	1770	1580	1580	1.23	1.24	1.19
2.5	1830	1660	1540	1450	1.22	1.23	1.20
2.75	1730	1630	1490	1410	1.20	1.23	1.21
3	1670	1409	1460	1410	1.21	1.20	1.14
3.25	1630	1360	1450	1390	1.20	1.20	1.14
3.5	1550	1300	1420	1350	1.21	1.18	1.13
3.75	1480	1270	1390	1330	1.14	1.18	1.14
4	1430	1220	1350	1280	1.15	1.18	1.12
4.25	1350	1185	1200	1175	1.14	1.17	1.11
4.5	1290	1130	1160	1130	1.08	1.17	1.11

Table S4 Continued. Data collected for 6.75 mm^2 electrodes.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
4.75	1170	1075	1120	1090	1.09	1.116	1.10
5	290	1012	1064	1060	1.09	1.15	1.09
5.25	200	965	978	1020	-	-	-
5.5	175	900	960	945	-	-	-
5.75	162	450	890	915	-	-	-
6	153	162	480	715	-	-	-
6.25	146	130	200	350	-	-	-
6.5	141	110	160	195	-	-	-
6.75	138	101	145	165	-	-	-
7	135	97	129	150	-	-	-
7.25	129	95	120	140	-	-	-
7.5	125	90	117	132	-	-	-

Table S5. Data collected for 9 mm^2 electrodes.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0.00	0.00	0.00
0.25	1880	1730	1870	1900	1.33	1.35	1.36
0.5	2030	1940	2170	2120	1.33	1.34	1.35
0.75	2100	2030	2240	2190	1.32	1.32	1.33
1	2040	1920	2200	2130	1.31	1.31	1.32
1.25	1950	1850	2090	2070	1.29	1.30	1.30
1.5	1850	1780	2000	1980	1.27	1.28	1.28
1.75	1820	1730	1930	1930	1.26	1.26	1.26
2	1760	1670	1860	1870	1.24	1.24	1.24
2.25	1690	1620	1810	1790	1.21	1.24	1.22
2.5	1600	1580	1780	1760	1.22	1.22	1.26
2.75	1580	1530	1720	1720	1.21	1.24	1.26
3	1550	1490	1680	1640	1.21	1.21	1.24
3.25	1460	1460	1610	1610	1.20	1.20	1.23
3.5	1420	1430	1560	1550	1.20	1.20	1.21
3.75	1370	1400	1480	1490	1.19	1.17	1.23
4	1340	1350	1450	1420	1.18	1.20	1.19
4.25	1280	1330	1380	1390	1.18	1.19	1.22
4.5	1210	1270	1360	1340	1.19	1.18	1.22
4.75	1130	1210	1250	1280	1.20	1.18	1.22
5	1100	1150	960	1090	1.19	1.17	1.22
5.25	1030	1060	190	240	-	-	-
5.5	660	700	130	130	-	-	-
5.75	210	190	100	100	-	-	-
6	160	130	90	90	-	-	-
6.25	140	100	80	80	-	-	-

Table S5 Continued. Data collected for 9 mm^2 electrodes.

Time (min)	Current (μA) Trial 1	Trial 2	Trial 3	Trial 4	Potential (V) Trial 1	Trial 2	Trial 3
6.5	130	90	80	70	-	-	-
6.75	120	80	70	60	-	-	-
7	120	80	70	60	-	-	-
7.25	110	70	60	60	-	-	-
7.5	110	70	60	60	-	-	-

Table S6. Data collected for 20.25 mm^2 electrodes.

Time (min)	Current (μA) Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Potential (V) Trial 1	Trial 2	Trial 3
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	1800	2030	1980	1820	1790	1.33	-	1.34
0.5	1960	2120	2050	1930	1870	1.32	1.33	1.32
0.75	1960	2090	2060	1910	1890	1.29	1.31	1.30
1	1930	2040	2010	1880	1920	1.26	1.29	1.28
1.25	1890	1980	1980	1830	1900	1.25	1.27	1.26
1.5	1840	1960	1960	1760	1850	1.25	1.24	1.21
1.75	1800	1900	1850	1720	1780	1.24	1.23	1.18
2	1760	1860	1840	1680	1730	1.23	1.20	1.22
2.25	1730	1810	1790	1620	1680	1.21	1.21	1.19
2.5	1700	1760	1760	1600	1600	1.20	1.18	1.15
2.75	1660	1730	1690	1570	1580	1.18	1.17	1.10
3	1620	1670	1640	1550	1530	1.20	1.16	1.13
3.25	1590	1640	1620	1530	1510	1.17	1.16	1.13
3.5	1550	1570	1590	1510	1490	1.17	1.15	1.12
3.75	1520	1550	1540	1490	1420	1.15	1.15	-
4	1490	1520	1520	1480	1390	1.15	1.15	1.12
4.25	1460	1470	1470	1460	1360	1.14	1.16	1.13
4.5	1450	1440	1450	1450	1340	1.14	1.16	1.13
4.75	1420	1440	1430	1430	1330	1.15	1.15	1.14
5	1400	1300	1390	1420	1330	1.18	1.14	1.13

Four-Cell Battery Corresponding to Figure 3

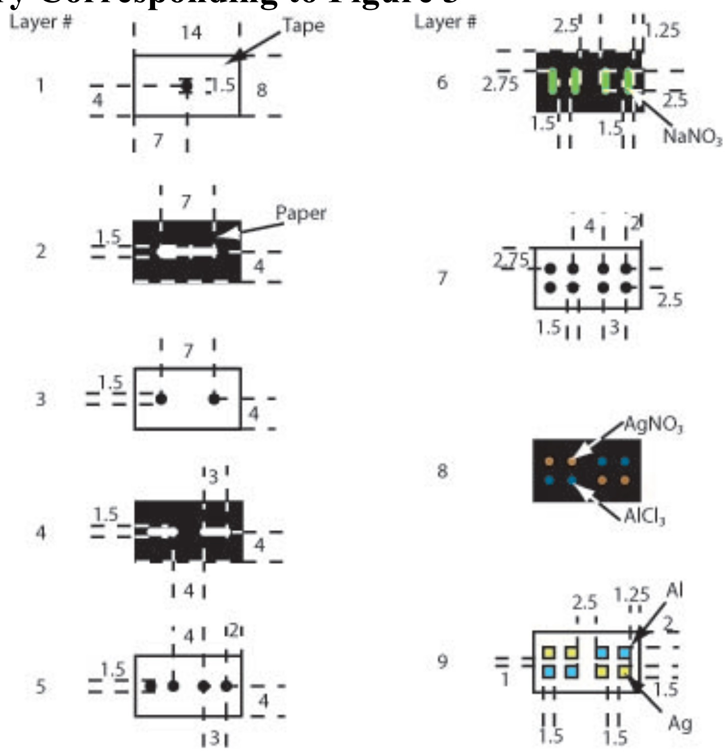

Figure S3. Expanded view of a 4-cell battery. All values shown are in millimeters. The device is 14-mm wide × 8-mm long.

Fabrication of a 4-cell battery.
The four-cell devices were fabricated as described above. The $NaNO_3$ was spotted in the salt bridge in layer 6, and the electrolytes were spotted in layer 8. The metal pieces were placed in the holes in layer 9, and Cu tape was cut and placed over the metal pieces. The alignment of the Cu tape to connect the different cells together can be seen in Figure 3. To test different electrolyte concentrations, the devices were made using 0.5 and 3 M $AgNO_3$ with 0.167 and 1 M $AlCl_3$, respectively.

Method for testing the effects of electrolyte concentration. These devices were tested by connecting alligator clips to the pieces of Cu tape without adding pressure to the Al and Ag pieces. The alligator clips were then connected to the multimeter and either potential or current was monitored. The devices were started using 10 µL deionized water.

Tables of data using the devices shown in Figure S3. This data was used in the section entitled "Quantity of electrolyte per volume of paper".

Table S7. Data collected for four-cell devices made using 0.33 M $AgNO_3$ and 0.11 M $AlCl_3$ (i.e., 44.5 µg of $AgNO_3/mm^3$ of paper).

Time (min)	Current (µA)				Potential (V)
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
0	0	0	0	0	0
0.5	0	0	0	0	0
1	0	0	0	0	0
1.5	0	0	0	0	0
2	0	0	0	0	0
1.5	0	0	0	0	0
3	0	0	0	0	0
3.5	0	0	0	0	0.5
4	0	0	0	0.01	1.3
4.5	0	0.01	0.01	0.02	1.93
5	0.02	0.03	0.02	0.08	2.2
5.5	0.11	0.14	0.06	0.12	2.46
6	0.18	0.24	0.07	0.18	2.48
6.5	0.13	0.21	0.16	0.21	2.45
7	0.12	0.15	0.17	0.15	2.44
7.5	0.10	0.09	0.12	0.12	2.4
8	0.14	0.07	0.10	0.09	2.35
8.5	0.12	0.06	0.08	0.08	2.35
9	0.08	0.05	0.07	0.07	2.3
9.5	0.07	0.04	0.07	0.06	2.26
10	0.06	0.05	0.06	0.06	2.23
11	0.05	0.05	0.04	0.05	2.2
12	0.04	0.04	0.03	0.04	2.19
13	0.04	0.04	0.03	0.03	2.17
14	0.03	0.03	0.03	0.03	2.1
15	0.03	0.03	0.03	0.03	2.09

Table S8. Data collected for four-cell devices made using 3 M $AgNO_3$ and 1 M $AlCl_3$ (i.e., 400 µg of $AgNO_3/mm^3$ of paper)

Time	Current (µA)					Potential (V)			
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 1	Trial 2	Trial 3	Trial 4
0	0	0	0	0	0	0.00	0.00	0.00	0.00
0.5	0	0	0	0	0	0.00	0.00	0.00	0.00
1	0	0	0	0	0	0.00	0.00	0.00	0.00
1.5	0	0	0	0	0	0.00	0.00	0.00	0.00
2	0	0	0	0	0	0.00	0.00	0.00	0.00
2.5	0	0	0	0	0	0.00	0.00	0.00	0.00
3	0	0	0	0	99	0.00	0.00	0.00	0.00
3.5	6	0	102	120	350	0.50	0.99	0.00	1.00

Table S8 Continued. Data collected for four-cell devices made using 3 M $AgNO_3$ and 1 M $AlCl_3$ (i.e., 400 µg of $AgNO_3$/mm^3 of paper).

Time	Current (µA)					Potential (V)			
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 1	Trial 2	Trial 3	Trial 4
4	53	9	180	184	530	2.00	1.79	0.15	2.47
4.5	260	59	290	226	590	2.17	2.16	0.95	2.50
5	302	325	476	262	611	2.28	2.45	1.74	2.49
5.5	360	450	550	300	700	2.40	2.48	2.35	2.47
6	450	520	590	430	730	2.24	2.46	2.39	2.46
6.5	500	545	588	475	756	2.18	2.45	2.38	2.47
7	640	570	600	505	710	2.46	2.45	2.27	2.46
7.5	640	575	595	507	530	2.40	2.44	2.40	2.42
8	660	560	570	515	432	2.40	2.43	2.46	2.43
8.5	590	566	430	510	120	2.20	2.38	2.24	2.42
9	395	550	290	495	100	2.30	2.39	2.45	2.40
9.5	376	510	280	280	80	2.17	2.43	2.35	2.35
10	340	440	220	165	88	2.31	2.44	2.33	2.35
11	178	190	155	107	83	2.33	2.46	2.39	2.33
12	103	130	150	88	79	2.30	2.48	2.37	2.31
13	89	132	120	66	74	2.12	2.44	2.34	2.30
14	81	95	88	61	69	2.30	2.34	2.36	2.25
15	77	65	53	58	65	2.25	2.43	2.32	2.21
16	72	61	47	56	62	2.01	2.38	2.28	2.27
17	67	48	46	54	59	2.07	2.39	2.20	2.26
18	65	47	44	46	56	2.00	2.36	2.20	2.23
19	59	46	42	45	54	1.98	2.32	2.15	2.26
20	57	46	40	45	52	2.07	2.30	2.25	2.23

Effect of the Quantity of Salt in the Salt Bridge on the Conductivity

Procedure for measuring the conductivity of the salt bridge. Conductance was measured using layer 2 (Figure S2). The paper had 5 µL of salt solution spotted onto it and was allowed to dry under vacuum for 30 min. The salt solutions used were 12.56 M KNO_3, 9.39 M KNO_3, 6.33 M KNO_3, 3.07 M KNO_3, 36.47 M $NaNO_3$, 27.35 M $NaNO_3$, 18.24 M $NaNO_3$, and 9.12 M $NaNO_3$. After drying, the paper layers had a solid piece of tape placed across the back. The salt bridge then had 5 µL of deionized water added to it. At 50 s the conductance was measured using a modified Omega CDH-7X conductivity meter. The meter was modified by adding clips to each of the probes and 3" copper wires to the end of the clips. The wires were taped about ½ an inch from the ends to hold them approximately 1 cm apart. The conductivity meter was placed on the center of the salt bridge for 45 s and allowed to come to equilibrium before recording the value at 50 s.

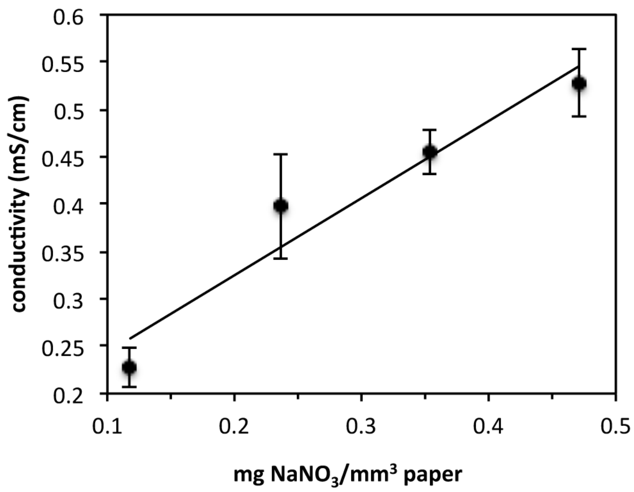

Figure S4. Conductivity of the salt bridge as a function of the quantity of $NaNO_3$ in the bridge. The data are the average of 4 trials.

Table S9. Data collected for the Salt Bridge Conductance measurements. The $NaNO_3$ data is plotted in Figure S4.

Salt	Concentration (mg/mm^3)	Conductivity (mS/cm) Trial 1	Trial2	Trial 3	Trial 4
KNO_3	0.193	0.18	0.17	0.18	0.18
KNO_3	0.144	0.10	0.08	0.13	0.14
KNO_3	0.0972	0.10	0.09	0.09	0.09
KNO_3	0.0471	0.06	0.07	0.06	0.04
$NaNO_3$	0.471	0.51	0.51	0.51	0.58
$NaNO_3$	0.353	0.43	0.44	0.47	0.48
$NaNO_3$	0.236	0.37	0.48	0.37	0.37
$NaNO_3$	0.118	0.25	0.23	0.23	0.20

Effect of the Volume of the Salt Bridge on Short Circuit Current

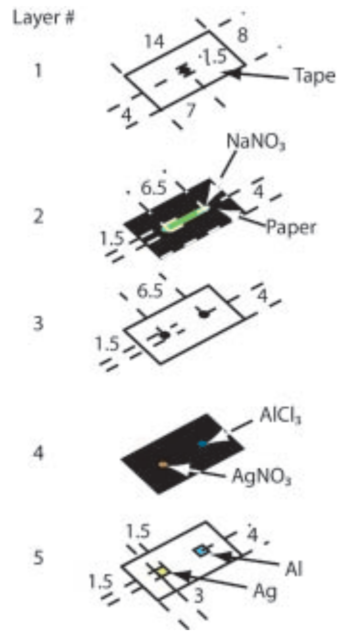

Figure S5. Expanded view of an example single cell battery used for testing devices with a 2.07 mm^3 salt bridge. The salt bridge is 6.5 mm-long. The device is 14-mm wide × 8-mm long. All values listed are in mm.

Figure S6. Side-view of the different salt bridges used in devices with the configuration shown in Figure S5. The only variation in the design between devices is the length of the salt bridge in layer 2. The blue region is the sample input regions (layer 1 in Fig. S5), green is the salt bridge (layer 2 in Fig. S5), and pink is the electrolyte region (layer 3 in Fig. S5). (a) The 2.07 mm^3 salt bridge (6.5 mm-long), (b) the 1.53 mm^3 salt bridge (4.5 mm-long), (c) the 1.23 mm^3 salt bridge (3.5 mm-long), and (d) the 0.99 mm^3 salt bridge (2.5 mm-long).

Method for fabricating the devices. These devices were fabricated as outlined on page S2, with the exception that the volume of saturated $NaNO_3$ spotted in layer 2 was varied according to the salt bridge volume. The 2.07 mm^3 salt bridge required 1.50 µL, the 1.53 mm^3 bridge required 1.16 µL, and the 1.23 mm^3 bridge used 0.92 µL saturated $NaNO_3$. The electrolytes were spotted in layer 4, and the metals were cut and placed in the holes in layer 5. The metal pieces were covered with pieces of Cu tape.

Method for measuring the current and potential. These devices were tested by connecting alligator clips to the pieces of Cu tape without adding pressure to the Al and Ag pieces. The alligator clips were then connected to the multimeter and either potential or current was monitored. The devices were started by addition of deionized water to layer 1 with the volumes varying based on the volume of the salt bridge as follows: 0.99 mm^3 = 1.0 μL, 1.23 mm^3 = 1.2 μL, 1.53 mm^3 = 1.5 μL, and 2.07 mm^3 = 2.0 μL.

Table S10. Current and potential data for the 2.07 mm^3 salt bridge.

Time	Current (μA)				Potential (mV)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0
0.5	175	45	4	58	1250	1261	1181
1	185	125	16	98	1253	1260	1310
1.5	180	138	53	106	1255	1261	1281
2	175	136	82	110	1265	1250	1270
2.5	164	143	96	114	1264	1246	1273
3	164	142	100	113	1265	1260	1277
3.5	160	140	102	112	1263	1257	1264
4	157	135	106	114	1258	1246	1270
4.5	153	133	109	113	1262	1265	1270
5	150	136	106	112	1280	1260	1268
5.5	146	130	107	113	1281	1259	1277
6	143	126	108	113	1286	1240	1278
6.5	138	124	109	115	1265	1265	1275
7	131	132	110	116	1272	1268	1260
7.5	121	129	111	116	1240	1245	1265
8	115	129	110	115	1268	1260	1257
8.5	109	128	110	114	1272	1250	1256
9	98	124	110	115	1271	1250	1270
9.5	88	123	110	114	1276	1245	1260
10	78	124	110	113	1265	1240	1260

Table S11. Current and Potential data for the 1.53 mm^3 salt bridge.

Time	Current (μA)				Potential (mV)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0
0.5	398	325	420	240	1296	1290	1296
1	370	320	419	279	1307	1285	1276
1.5	347	298	402	300	1299	1278	1282
2	322	307	377	300	1299	1280	1270
2.5	312	290	354	298	1298	1270	1274
3	300	275	322	267	1288	1270	1272
3.5	288	260	280	-	1278	1260	1265
4	274	245	170	257	1277	1265	1262
4.5	166	232	51	245	1276	1240	1246
5	41	202	36	222	1260	1217	1244
5.5	32	107	32	65	1259	1215	1237

Table S11 Continued. Data collected for four-cell devices made using 3 M $AgNO_3$ and 1 M $AlCl_3$ (i.e., 400 µg of $AgNO_3/mm^3$ of paper).

Time	Current (µA)				Potential (mV)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
6	29	40	28	44	1225	1250	1235
6.5	25	36	25	40	1238	1250	1234
7	26	33	23	38	1205	1208	1216
7.5	25	31	22	35	1202	1240	1216

Table S12. Current and potential data for the 1.23 mm^3 salt bridge.

Time	Current (µA)				Potential (mV)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0
0.5	558	491	430	417	1270	1290	1280
1	527	437	426	430	1280	1290	1275
1.5	470	415	390	380	1290	1281	1286
2	425	390	367	347	1290	1271	1287
2.5	343	373	352	321	1279	1290	1275
3	230	350	261	305	1286	1285	1283
3.5	70	340	178	298	1279	1291	1269
4	51	139	94	258	1285	1280	1263
4.5	44	38	50	60	1281	1280	1271
5	40	34	37	43	1282	1285	1266
5.5	38	31	33	33	1280	1285	1255
6	36	29	30	31	1270	1278	1271
6.5	34	29	29	30	1273	1282	1266

Table S13. Current and potential data for the 0.99 mm^3 salt bridge.

Time	Current (µA)				Potential (mV)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0
0.5	706	370	606	767	1290	1289	-
1	675	531	636	700	1275	1274	1275
1.5	600	525	600	652	1276	1271	1272
2	488	511	536	599	1303	1300	-
2.5	83	445	490	540	1300	1300	-
3	48	365	53	494	1289	1309	-
3.5	41	59	36	435	1285	1290	-
4	39	43	32	405	1300	1165	-
4.5	35	37	30	360	1280	1281	-
5	32	35	27	280	1273	1272	-

Relationship Between Length of a Salt Bridge and Resistance

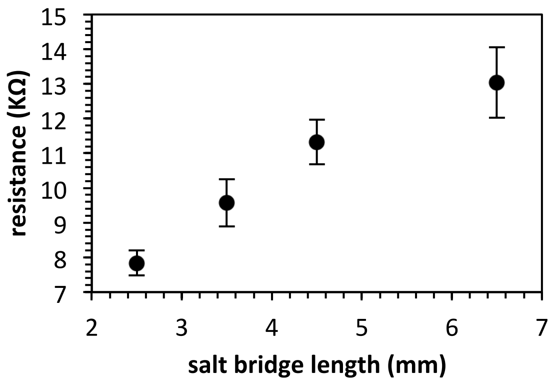

Figure S7. Salt bridge length vs. resistance. These tests were accomplished using layer 2 from the devices shown in Figs. S6 and S6. Each point is the average of 7 trials; the error bars represent the standard deviations from these averages.

Table S14. Data of salt bridge resistance versus length that corresponds to Fig. S7.

Length (mm)	Resistance (KΩ)							
	Trial 1	Trial2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
6.5	-	11.6	13.4	12.4	14.3	12.4	12.9	14.3
4.5	-	10.7	11.3	11.7	12.5	10.8	11.5	10.8
3.5	8.7	10.3	10.4	9.3	10.3	9.3	8.8	9.5
2.5	8.6	8.0	7.5	7.8	8.0	7.6	7.6	7.6

Fluidic batteries Design Type 1 corresponding to Fig. 6

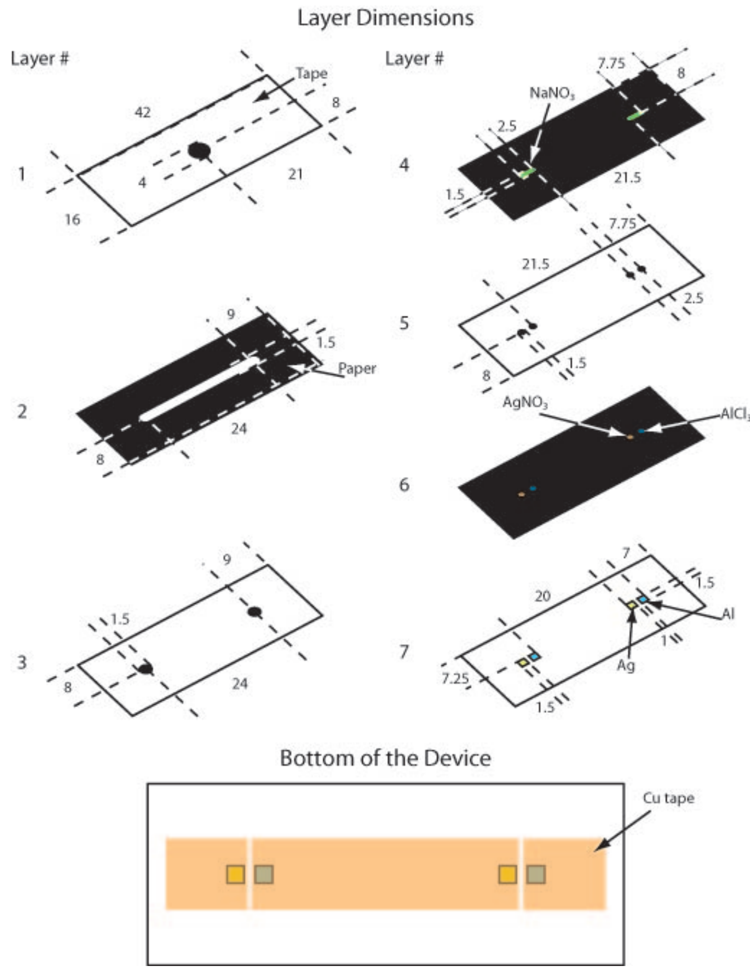

Figure S8. Expanded view of a Type 1 device containing 1 cell in parallel and 2 of those in series. All values listed are in mm.

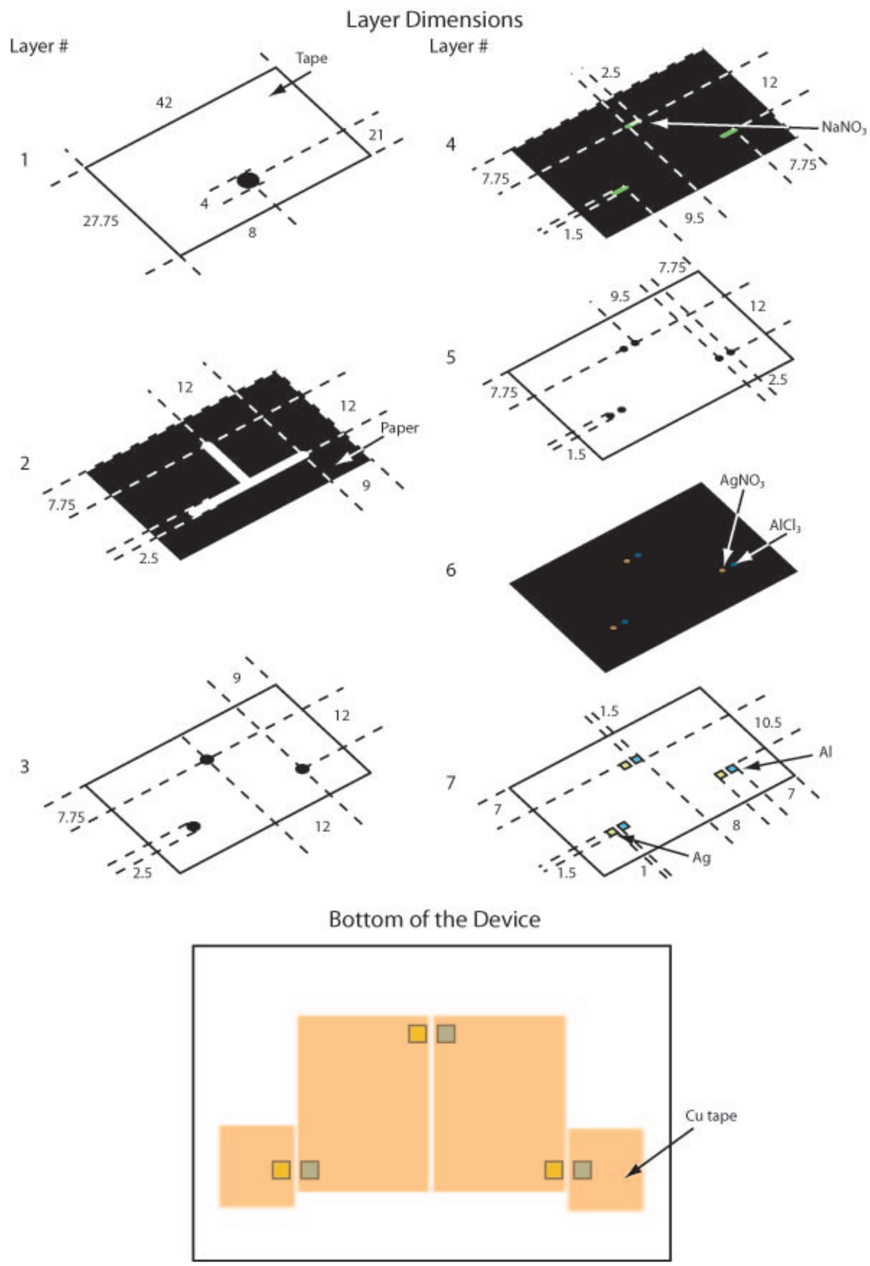

Figure S9. Expanded view of a Type 1 device containing 1 cell in parallel and 3 of those in series. All values listed are in mm.

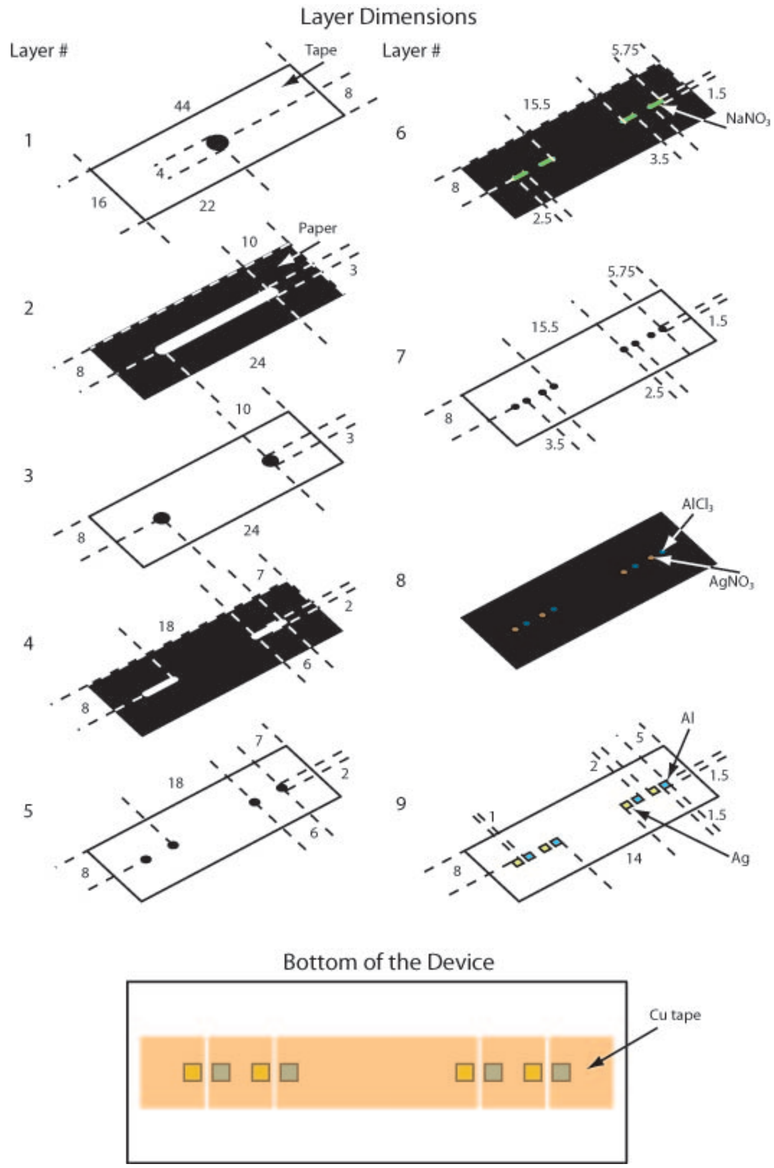

Figure S10. Expanded view of a Type 1 device containing 1 cell in parallel and 4 of those in series. All values listed are in mm.

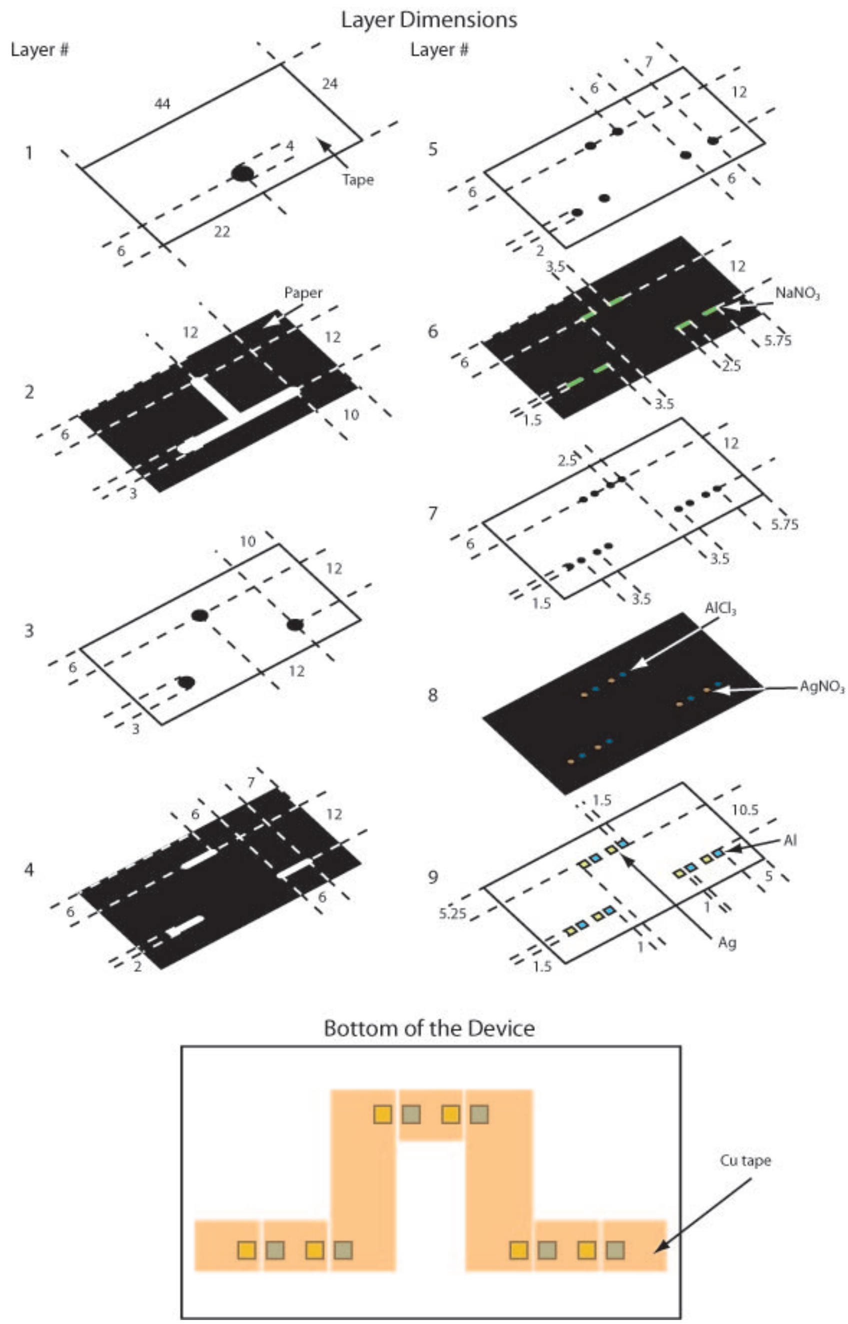

Figure S11. Expanded view of a Type 1 device containing 1 cell in parallel and 6 of those in series. All values listed are in mm.

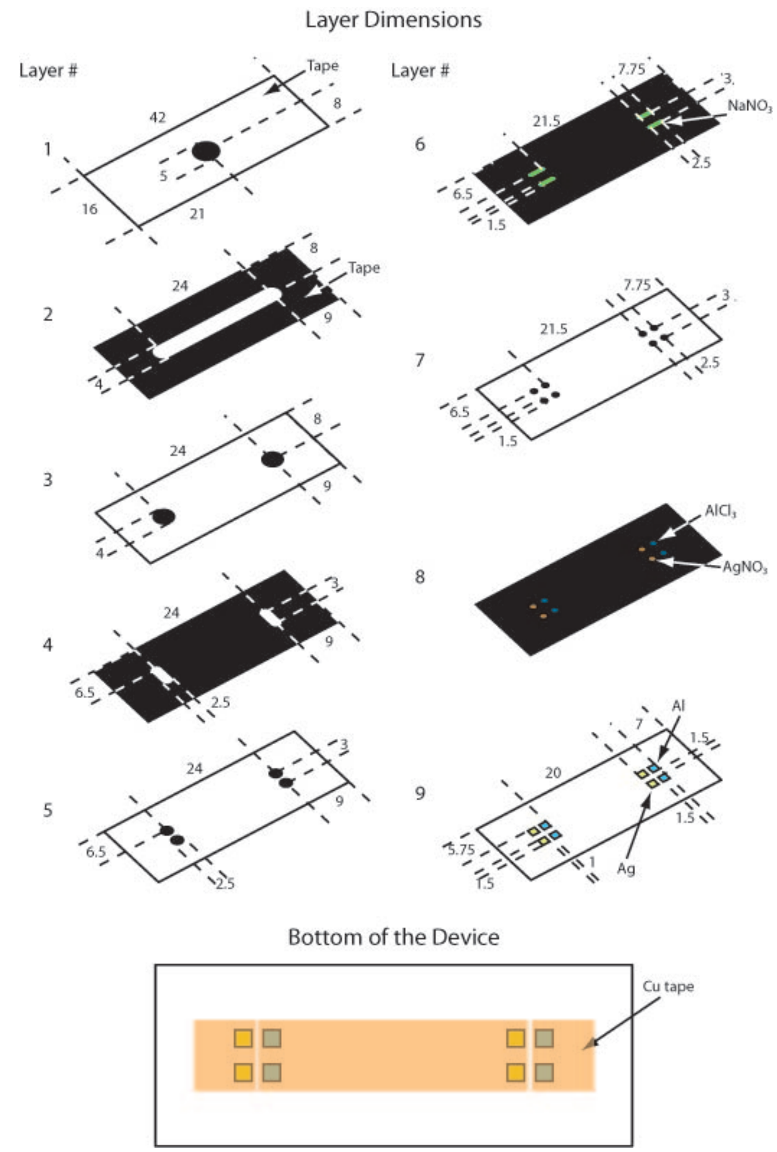

Figure S12. Expanded view of a Type 1 device containing 2 cells in parallel and 2 of those in series. All values listed are in mm.

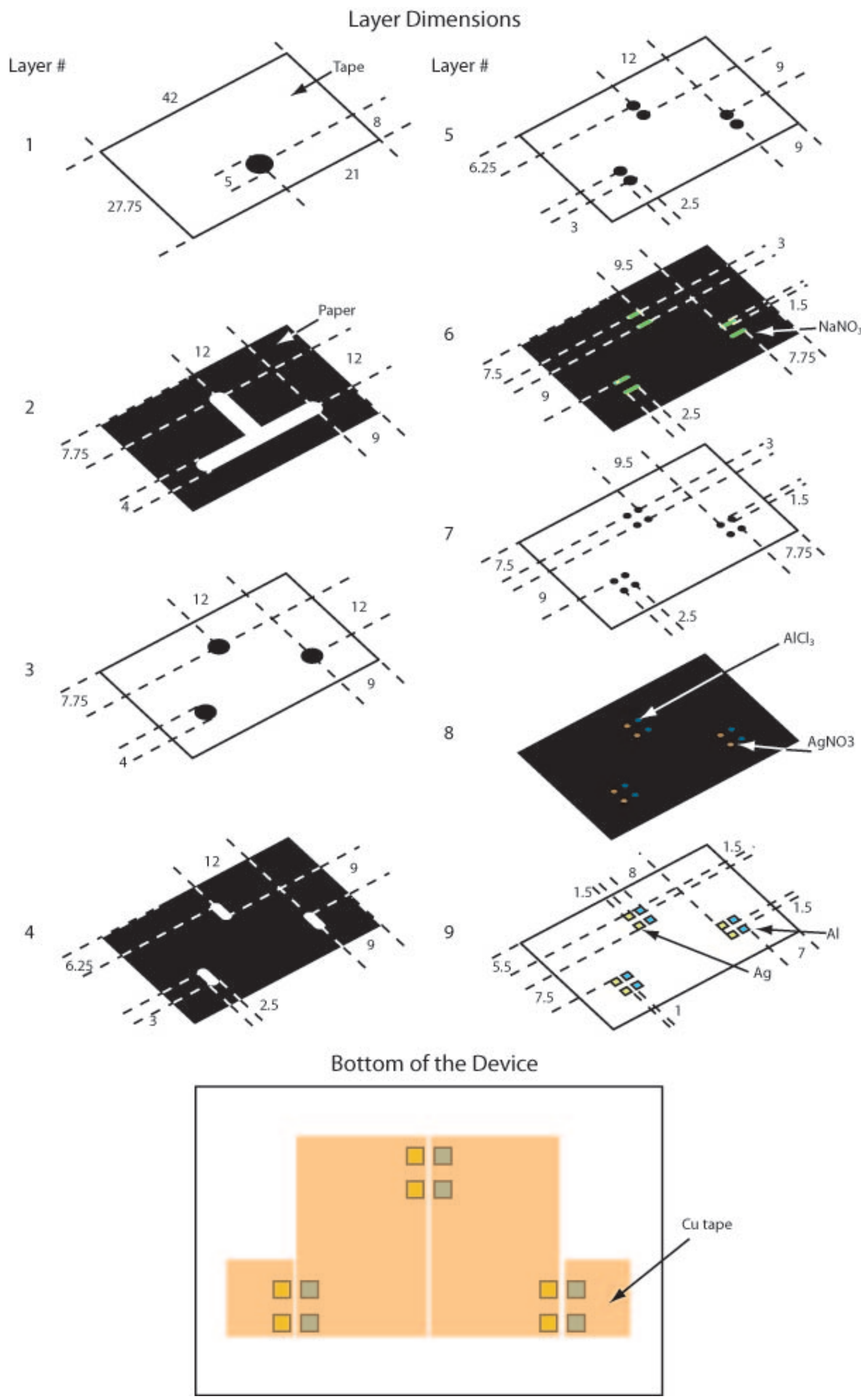

Figure S13. Expanded view of a Type 1 device containing 2 cells in parallel and 3 of those in series. All values listed are in mm.

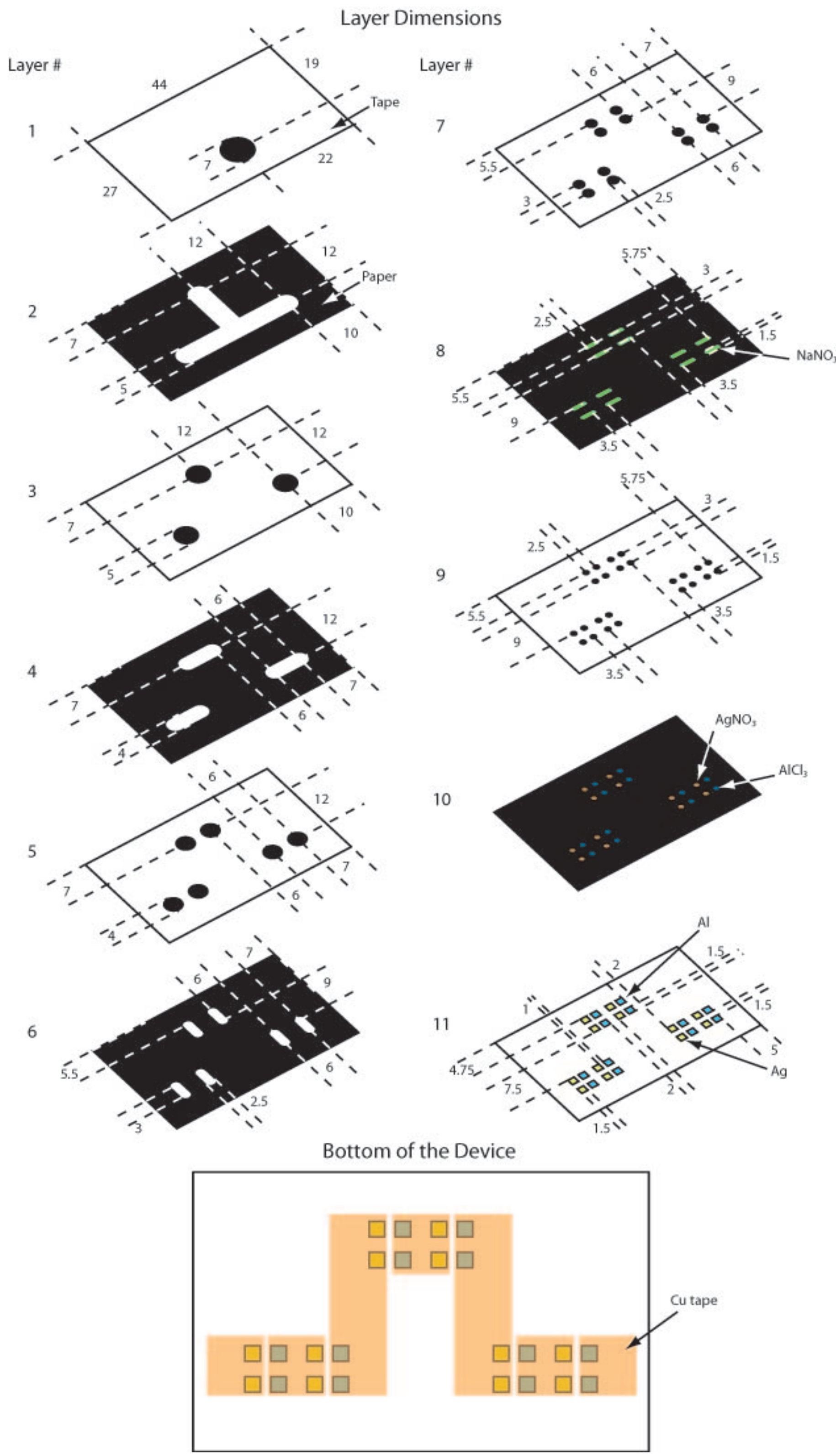

Figure S14. Expanded view of a Type 1 device containing 2 cells in parallel and 6 of those in series. All values listed are in mm.

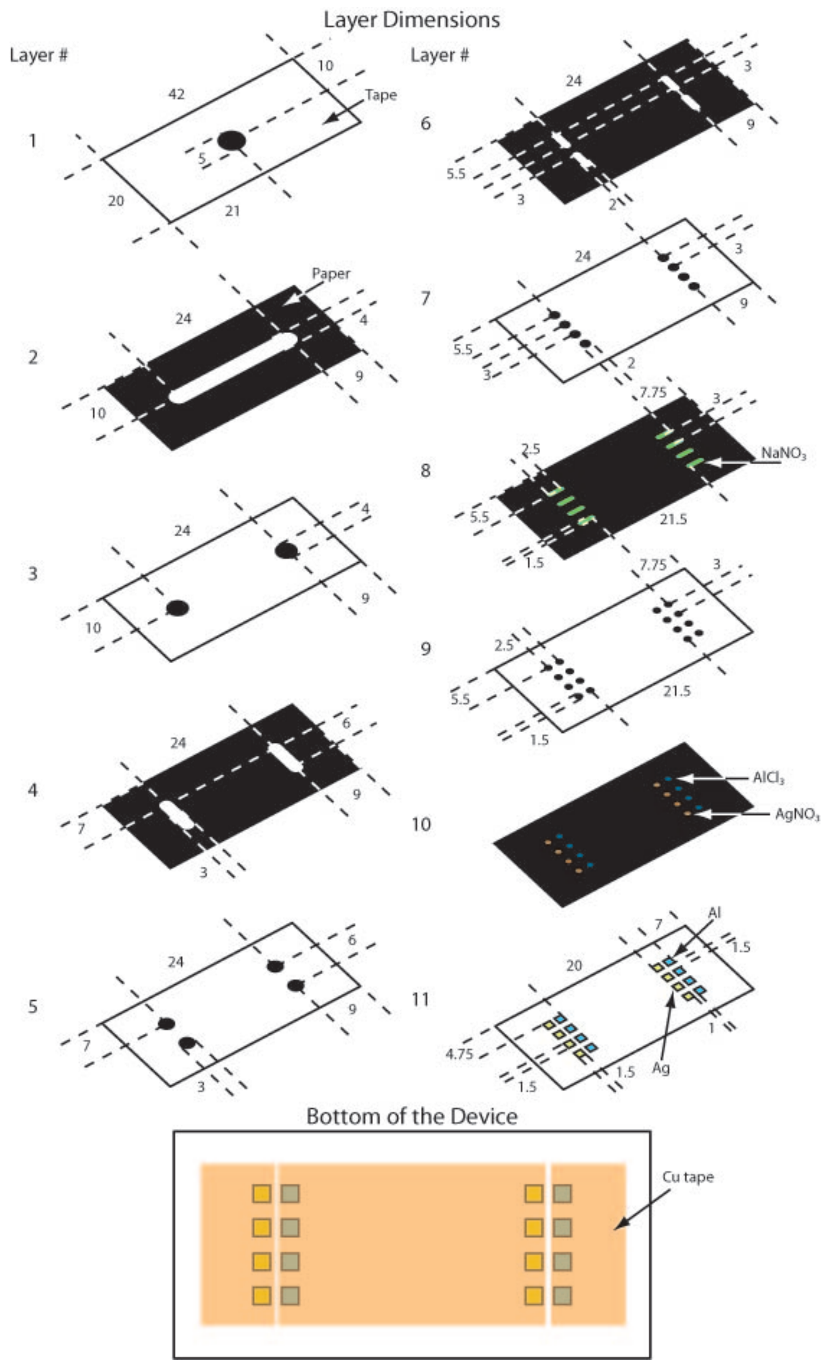

Figure S15. Expanded view of a Type 1 device containing 4 cells in parallel and 2 of those in series. All values listed are in mm.

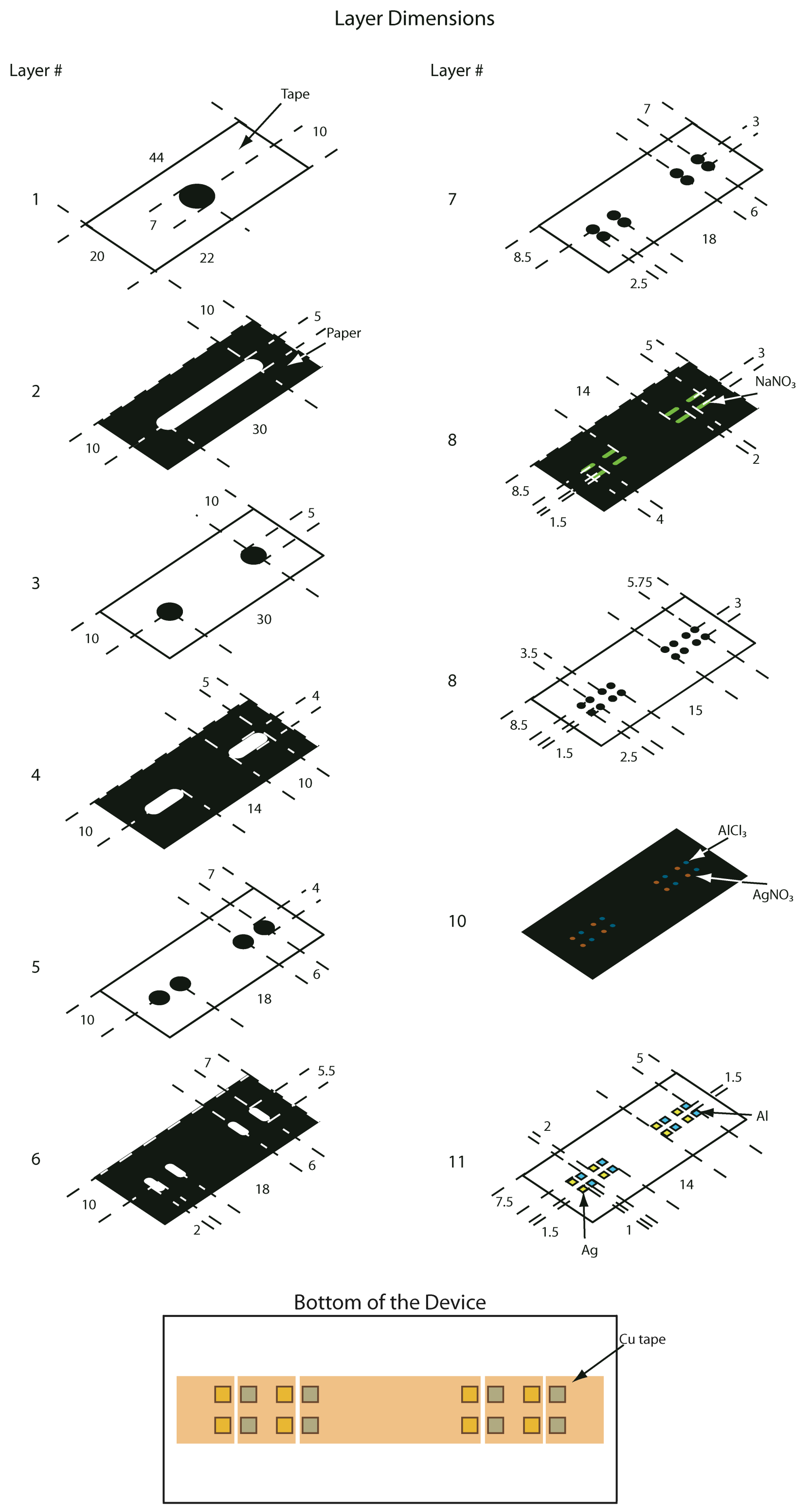

Figure S16. Expanded view of a Type 1 device containing 4 cells in series and 2 of those in parallel. All values listed are in mm.

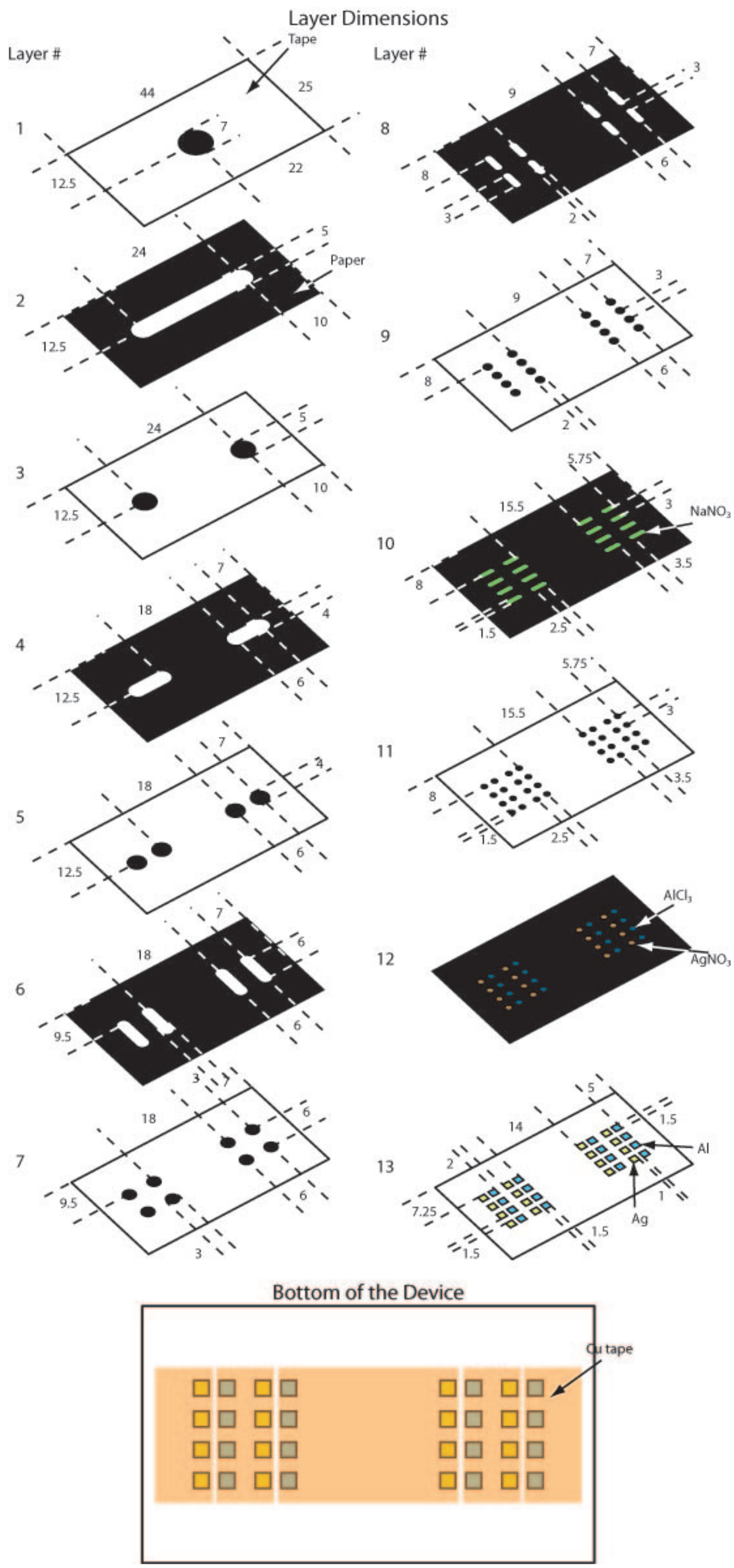

Figure S17. Expanded view of a Type 1 device containing 4 cells in parallel and 4 of those in series. All values are listed in mm.

Table S15. Results from measurements of a Type 1 device containing 1 cell in parallel and 2 of those in series. This data was collected after using 20 µL deionized water to start the battery in Figure S8.

Time	Current (µA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
0	0	0	0	0	0.00
0.5	0	0	0	0	0.00
1	0	0	0	0	0.00
1.5	0	0	0	0	0.00
2	0	20	0	1	0.00
2.5	0	48	58	109	2.27
3	97	86	85	140	2.63
3.5	138	116	107	167	2.70
4	173	151	150	184	2.71
4.5	216	200	179	192	2.74
5	265	225	220	198	2.76
5.5	299	230	242	217	2.76
6	303	242	257	236	2.76
6.5	312	262	283	241	2.75
7	330	290	315	250	2.75
7.5	363	305	340	248	2.76
8	374	315	330	255	2.74

Table S16. Results from measurements of a Type 1 device containing 1 cell in parallel and 3 of those in series. This data was collected after using 30 µL deionized water to start the battery in Figure S9.

Time	Current (µA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
0	0	0	0	0	0.00
0.5	0	0	0	0	0.00
1	0	0	0	0	0.00
1.5	0	0	0	0	0.00
2	0	0	0	50	2.90
2.5	185	4	20	225	3.88
3	271	160	165	310	3.93

Table S16 Continued. Results from measurements of a Type 1 device containing 1 cell in parallel and 3 of those in series. This data was collected after using 30 µL deionized water to start the battery in Figure S9.

Time	Current (µA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
3.5	343	250	225	355	3.94
4	392	290	275	350	3.94
4.5	410	343	320	345	3.92
5	400	395	350	330	3.90
5.5	380	390	330	315	-
6	365	375	320	305	-
6.5	355	365	310	295	-
7	340	355	300	285	-
7.5	315	340	290	280	-
8	255	305	280	260	-
8.5	140	235	270	210	-
9	95	210	245	105	-

Table S17. Results from measurements of a Type 1 device containing 1 cell in parallel and 4 of those in series. This data was collected after using 20 µL deionized water to start the battery in Figure S10.

Time	Current (µA)			Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.00	0.00	0.00
1	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0.00	0.00	0.00
2	0	0	0	0.00	0.00	0.00
2.5	0	0	0	0.00	0.00	0.00
3	0	0	0	0.00	0.00	0.00
3.5	0	0	0	0.00	0.00	0.00
4	0	0	0	0.00	0.00	0.00
4.5	5	0	0	3.07	0.09	0.40
5	176	0	105	5.00	0.13	3.46
5.5	232	25	251	5.16	0.14	4.96
6	265	159	302	5.22	5.15	5.14
6.5	285	218	317	5.19	5.18	5.18
7	292	254	330	5.16	5.21	5.19
7.5	295	280	335	5.14	5.24	4.60
8	285	290	345	5.09	5.21	4.01
8.5	285	290	352	5.05	5.20	4.89
9	277	288	347	5.03	5.18	4.70

Table S17 Continued. Results from measurements of a Type 1 device containing 1 cell in parallel and 4 of those in series. This data was collected after using 20 μL deionized water to start the battery in Figure S10.

Time	Current (μA)			Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
9.5	240	285	340	5.01	5.15	4.50
10	230	275	320	4.98	5.12	4.86
10.5	220	251	290	4.97	5.10	4.94
11	190	225	195	4.92	5.06	4.95
11.5	147	197	161	4.89	5.04	4.51
12	105	158	141	4.90	4.94	4.40
12.5	96	133	101	4.88	4.94	3.22

Table S18. Results from measurements of a Type 1 device containing 1 cell in parallel and 6 of those in series. This data was collected after using 30 μL deionized water to start the battery in Figure S11.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0	0.00	0.00	0.00
2	0	0	0	0	0.00	0.00	0.00
2.5	0	0	0	0	0.00	0.00	0.00
3	0	0	0	0	0.00	0.00	0.00
3.5	0	0	0	0	0.00	0.00	0.00
4	0	0	0	0	0.00	0.15	0.01
4.5	142	4	-	22	0.16	6.00	0.04
5	218	200	130	127	2.90	7.28	6.50
5.5	315	285	190	175	7.40	7.43	7.66
6	345	330	241	220	7.63	7.41	7.73
6.5	367	350	278	260	7.65	6.70	7.68
7	365	357	303	285	7.65	7.07	7.62
7.5	360	360	330	303	7.64	7.32	7.61
8	353	360	355	317	7.57	7.45	7.51
8.5	345	355	365	330	7.53	7.50	7.46
9	320	335	380	336	-	7.36	7.44
9.5	301	320	375	333	7.12	7.37	7.42
10	280	275	350	315	7.31	7.20	7.43
10.5	205	230	290	295	7.41	7.05	7.38
11	100	160	185	266	7.41	6.74	7.35
11.5	55	126	122	235	7.37	6.94	7.32

Table S18 Continued. Results from measurements of a Type 1 device containing 1 cell in parallel and 6 of those in series. This data was collected after using 30 μL deionized water to start the battery in Figure S11.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
12	50	110	65	152	7.11	6.87	7.26

Table S19. Results from measurements of a Type 1 device containing 2 cells in parallel and 2 of those in series. This data was collected after using 30 μL deionized water to start the battery in Figure S12.

Time	Current (μA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
0	0	0	0	0	0.00
0.5	0	0	0	0	0.00
1	0	0	0	0	0.00
1.5	0	0	0	0	0.00
2	0	0	0	0	0.00
2.5	0	0	1	0	0.00
3	0	204	204	67	1.60
3.5	110	365	322	345	2.73
4	320	480	393	420	2.73
4.5	525	524	451	515	2.73
5	580	550	530	598	2.73
5.5	615	570	588	625	2.73
6	633	560	595	611	2.71
6.5	660	570	585	575	2.69
7	660	545	583	615	2.68
7.5	678	540	580	605	-
8	660	545	585	607	-
8.5	635	530	585	607	-
9	610	505	580	600	-
9.5	490	495	560	580	-
10	460	465	480	320	-
10.5	350	335	280	115	-
11	158	250	125	101	-
11.5	145	125	96	97	-

Table S20. Results from measurements of a Type 1 device containing 2 cells in parallel and 3 of those in series. This data was collected after using 30 μL deionized water to start the battery in Figure S13.

Time	Current (μA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
0	0	0	0	0	0.00
0.5	0	0	0	0	0.00
1	0	0	0	0	0.00
1.5	0	0	0	0	0.00
2	0	0	0	0	0.00
2.5	80	220	35	210	3.21
3	405	610	460	435	3.96
3.5	625	815	700	583	3.96
4	740	855	790	630	3.96
4.5	775	827	775	643	3.92
5	785	705	815	609	3.89
5.5	710	723	765	605	-
6	685	655	700	595	-
6.5	625	605	690	540	-
7	620	550	650	522	-
7.5	575	515	625	502	-
8	540	475	540	480	-
8.5	460	400	400	445	-
9	315	280	245	390	-
9.5	215	165	155	260	-
10	187	120	91	250	-

Table S21. Results from measurements of a Type 1 device containing 2 cells in parallel and 6 of those in series. This data was collected after using 100 μL deionized water to start the battery in Figure S14.

Time	Current (μA)			
(min)	Trial 1	Trial 2	Trial 3	Trial 4
0	0	0	0	0
0.5	0	0	0	0
1	0	0	0	0
1.5	0	0	0	0
2	0	0	0	0
2.5	0	0	0	0
3	0	0	0	0
3.5	0	0	0	0
4	2	109	0	0
4.5	7	280	95	4

Table S21 Continued. Results from measurements of a Type 1 device containing 2 cells in parallel and 6 of those in series. This data was collected after using 100 μL deionized water to start the battery in Figure S14.

Time	Current (μA)			
(min)	Trial 1	Trial 2	Trial 3	Trial 4
5	9	330	220	115
5.5	10	370	290	205
6	13	440	340	266
6.5	14	480	372	340
7	15	505	395	390
7.5	22	515	435	490
8	720	525	450	610
8.5	620	545	453	635
9	625	560	467	662
9.5	645	575	458	643
10	650	565	465	615
10.5	610	515	460	545
11	610	450	475	475
11.5	588	390	475	375
12	620	310	473	260
12.5	600	205	450	240
13	445	110	391	227
13.5	335	98	308	187
14	170	96	275	175
14.5	30	93	205	128
15	30	92	140	115

Table S22. Results from measurements of a Type 1 device containing 4 cells in parallel and 2 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S15.

Time	Current (μA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
0	0	0	0	0	0.00
0.5	0	0	0	0	0.00
1	0	0	0	0	0.00
1.5	0	0	0	0	0.00
2	0	0	0	0	0.00
2.5	0	0	0	0	0.00
3	0	0	0	0	0.00
3.5	0	0	0	0	0.50
4	2	3	0	1	1.92
4.5	160	325	0	175	2.59

Table S22 Continued. Results from measurements of a Type 1 device containing 4 cells in parallel and 2 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S15.

Time	Current (μA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
5	700	645	75	635	2.69
5.5	995	785	318	1027	2.71
6	1220	866	645	1250	2.69
6.5	1320	956	825	1416	2.67
7	1390	1015	975	1500	2.66
7.5	1405	1050	1040	1542	2.64
8	1400	1075	1125	1530	2.62
8.5	1375	1080	1220	1495	2.59
9	1360	1068	1230	1440	2.58
9.5	1335	1060	1195	1390	2.59
10	1275	1025	1180	1280	2.58
10.5	1160	1000	1165	915	-
11	820	970	1155	790	-
11.5	615	850	1130	590	-
12	405	785	1100	310	-
12.5	245	550	1015	280	-
13	220	288	810	267	-
13.5	218	188	520	260	-
14	215	183	235	250	-
14.5	210	180	195	245	-
15	208	175	175	240	-

Table S23. Results from measurements of a Type 1 device containing 4 cells in series and 2 of those in parallel. This data was collected after using 40 μL deionized water to start the battery in Figure S16.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0	0.00	0.00	0.00
2	0	0	0	0	0.00	0.00	0.00
2.5	0	0	0	0	0.00	0.00	0.00
3	0	0	0	0	0.00	0.00	0.00
3.5	0	0	0	0	0.00	0.00	0.00
4	2	0	0	0	0.00	0.01	0.00
4.5	161	50	7	188	2.59	4.00	0.00

Table S23 Continued. Results from measurements of a Type 1 device containing 4 cells in parallel and 2 of those in series. This data was collected after using 40 µL deionized water to start the battery in Figure S16.

Time	Current (µA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
5	557	415	312	458	3.57	5.16	0.00
5.5	745	587	600	638	5.28	5.29	0.00
6	820	702	700	740	5.33	5.29	4.36
6.5	837	725	765	800	5.31	5.26	5.18
7	830	745	775	810	5.28	5.22	5.18
7.5	806	700	750	796	5.26	5.23	5.14
8	725	705	770	730	5.22	-	5.12
8.5	645	680	740	600	5.18	-	5.11
9	535	640	680	480	5.15	5.15	5.09
9.5	340	615	567	457	5.13	5.14	5.06
10	300	592	373	380	5.11	5.12	5.05
10.5	275	480	257	275	5.08	5.09	5.03
11	175	385	185	185	5.05	5.05	5.02
11.5	152	150	163	158	5.01	5.03	5.00
12	132	124	122	150	5.00	5.01	4.93
12.5	120	104	104	130	4.99	4.97	4.83
13	121	121	102	120	4.95	4.94	4.88
13.5	130	118	100	115	4.93	4.93	4.79
14	129	116	98	112	4.90	4.89	4.78
14.5	128	114	97	109	4.85	4.86	4.72
15	120	111	90	106	4.81	4.85	4.72

Table S24. Results from measurements of a Type 1 device containing 4 cells in parallel and 4 of those in series. This data was collected after using 80 µL deionized water to start the battery in Figure S17.

Time	Current (µA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
0	0	0	0	0	0.00
0.5	0	0	0	0	0.00
1	0	0	0	0	0.00
1.5	0	0	0	0	0.00
2	0	0	0	0	0.00
2.5	0	0	0	0	0.00
3	0	0	0	0	0.00
3.5	0	0	0	0	0.00
4	0	0	0	0	0.00
4.5	0	0	0	0	0.06

Table S24 Continued. Results from measurements of a Type 1 device containing 4 cells in parallel and 4 of those in series. This data was collected after using 80 µL deionized water to start the battery in Figure S17.

Time	Current (µA)				Potential (V)
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1
5	0	0	0	0	0.06
5.5	0	2	25	175	0.10
6	0	2	167	395	0.12
6.5	0	230	445	1120	0.60
7	1	800	800	1660	2.34
7.5	1	1240	1080	1865	5.18
8	2	1465	1350	1935	5.33
8.5	142	1540	1465	1960	5.33
9	500	1680	1615	1840	5.31
9.5	850	1765	1690	1660	5.30
10	1095	1807	1675	1390	5.30
10.5	1300	1710	1620	1070	5.28
11	1470	1465	1450	770	5.28
11.5	1595	1120	1225	565	5.26
12	1490	770	915	455	5.24
12.5	1490	620	625	415	5.22
13	1450	560	430	405	5.21
13.5	1340	450	360	395	5.20
14	1115	345	317	365	5.17
14.5	920	280	305	335	5.16
15	780	275	295	330	5.13
15.5	620	-	-	-	-
16	480	-	-	-	-
16.5	355	-	-	-	-
17	218	-	-	-	-

Predicting the Maximum Current

For all of the following calculations, A is the maximum current in µA, P is the number of cells in parallel, S is the number of cells in series, m is the slope of the linear regression, and b is the y-intercept of the linear regression.

Design Type 1. The maximum measured current values for Design Type 1 devices containing 1 set of cells in parallel were plotted against the number of cells in series used to obtain the measured current. The linear regression of the maximum current versus the number of cells in series gives the equation $A = m(S) + b$. The slope and y-intercept from the linear regression were recorded. This process was repeated for Design Type 1 devices containing 2 and 4 sets of cells in parallel; the values from the linear regression analyses are recorded in Table S25.

Table S25. Maximum measured current for Design Type 1 devices plotted against the number cells in series for 1, 2, and 4 sets of cells in parallel. The slope and y-intercept are determined from the linear regression of the maximum current plotted against the number of cells in series.

Number of Cells in Parallel	Number of Cells in Series	Max Current (μA)	Slope	Y-intercept
1	2	345	0.40	347.32
	3	378		
	4	312		
	6	361		
2	2	617	-10.82	738.39
	3	775		
	4	792		
	6	608		
4	2	1314	224.38	865.5
	4	1763		

The calculated slopes for each set of cells in series (Table S25) are then plotted against the number of cells in parallel. Likewise, the calculated y-intercepts in Table S25 are plotted against the number of cells in parallel. The linear regression for the plotted slopes versus number of cells in parallel give the equation $A = m_1(P \times S) + b_1(S)$, and the linear regression for the plotted intercepts versus the number of cells in parallel gives the equation $A = m_2(P) + b_2$. The two calculated equations are then combined to provide the final equation $A_1 = 80.8\,(S \times P) + 157.1(P) - 117.2(S) + 283.8$, which is the predicted maximum current for Design Type 1.

Predicting the Current Decay Rates

For all of the following calculations, D is the decay rate in μA/min, P is the number of cells in parallel, S is the number of cells in series, m is the slope of the linear regression, and b is the y-intercept of the linear regression. Decay rates for each device tested are determined by measuring the slope of the linear region of decay directly following the maximum current measured from a plot of current versus time.

Design Type 1. The measured decay rate for Design Type 1 devices containing 3 sets of cells in series were plotted against the number of cells in parallel. The linear regression of the decay rates versus the number of cells in parallel gives the equation $D = m(P) + b$. The linear regression for this plot was then determined and the slope and y-intercept were recorded. This process was repeated for Design Type 1 devices containing 4, and 5 sets of cells in series; the values from the linear regression analyses are recorded in Table S26.

Table S26. Measured decay rate for Design Type 1 devices plotted against the number cells in parallel for 3, 4, and 5 sets of cells in series. The slope and y-intercept are determined from the linear regression of the maximum current plotted against the number of cells in parallel.

Number of Cells in Series	Number of Cells in Parallel	Decay Rate (μA/min)	Slope	Y-Intercept
3	1	-96.1	-45.63	-31.35
	2	-93.97		
	4	-223.4		
4	1	-54.4	-60.94	6.51
	2	-115.4		
5	1	-64.6	-85.07	24.79
	2	-138.8		
	3	-317.6		

The calculated slopes (Table S26) for each set of cells in parallel are then plotted against the number of cells in series, and, in a separate graph, the calculated y-intercepts (Table S26) are plotted against the number of cells in series. The linear regression for the plotted slopes versus number of cells in series give the equation $D = m_1(P \times S) + b_1(P)$, and the linear regression for the plotted intercepts versus the number of cells in series gives the equation $D = m_2(S) + b_2$. The two calculated equations are then combined to provide the final equation $D = -19.7\,(S \times P) - 4.7(P) + 28.1(S) - 84.2$, which is the predicted decay rate for Design Type 1.

Fluidic battery Design Type 2 corresponding to Fig. 8

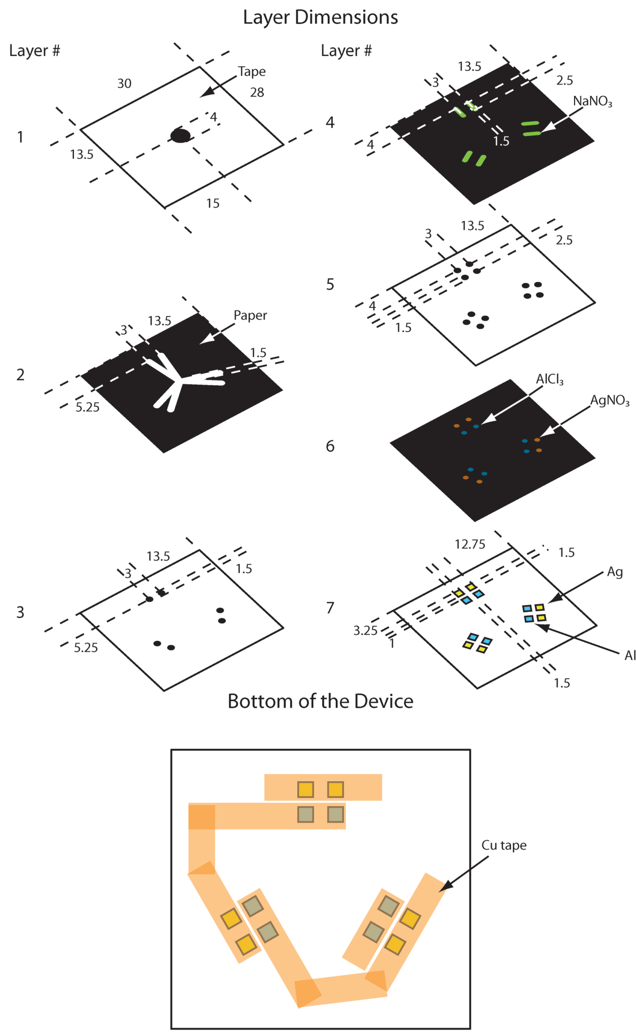

Figure S18. Expanded view of a Type 2 device containing 2 cells in parallel and 3 of those in series. All values are listed in mm. The three sets of features are identical, and are placed at a 120° angle.

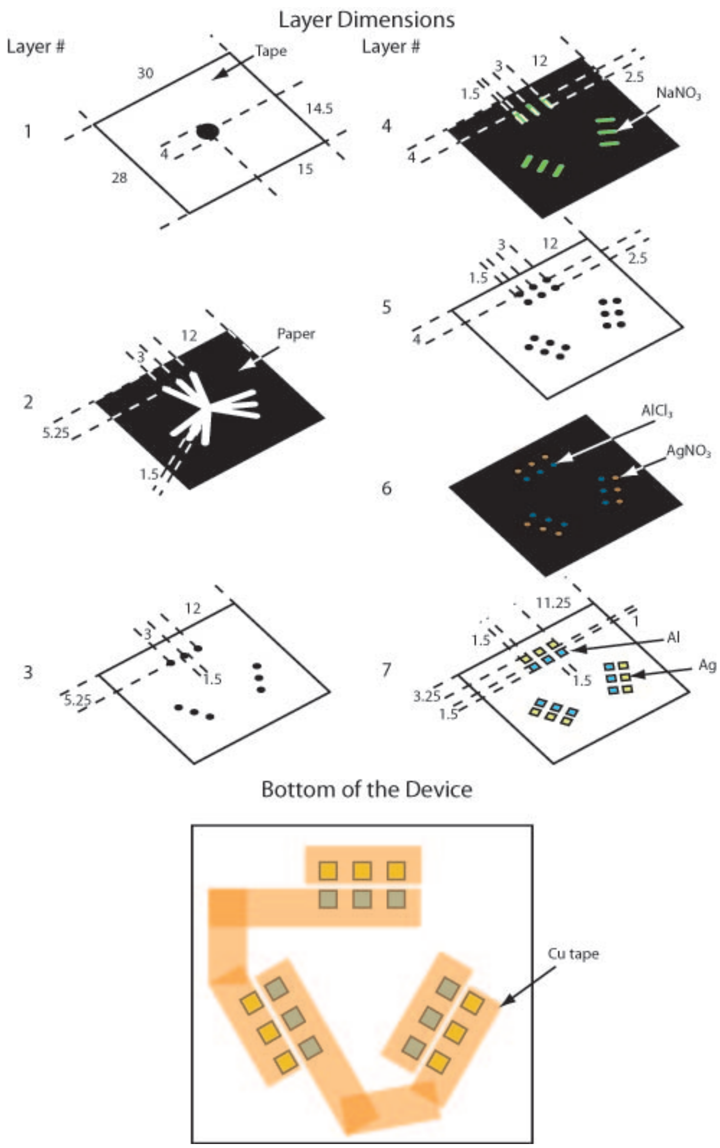

Figure S19. Expanded view of a Type 2 device containing 3 cells in parallel and 3 of those in series. All values are listed in mm. The three sets of features are identical, and at a 120° angle.

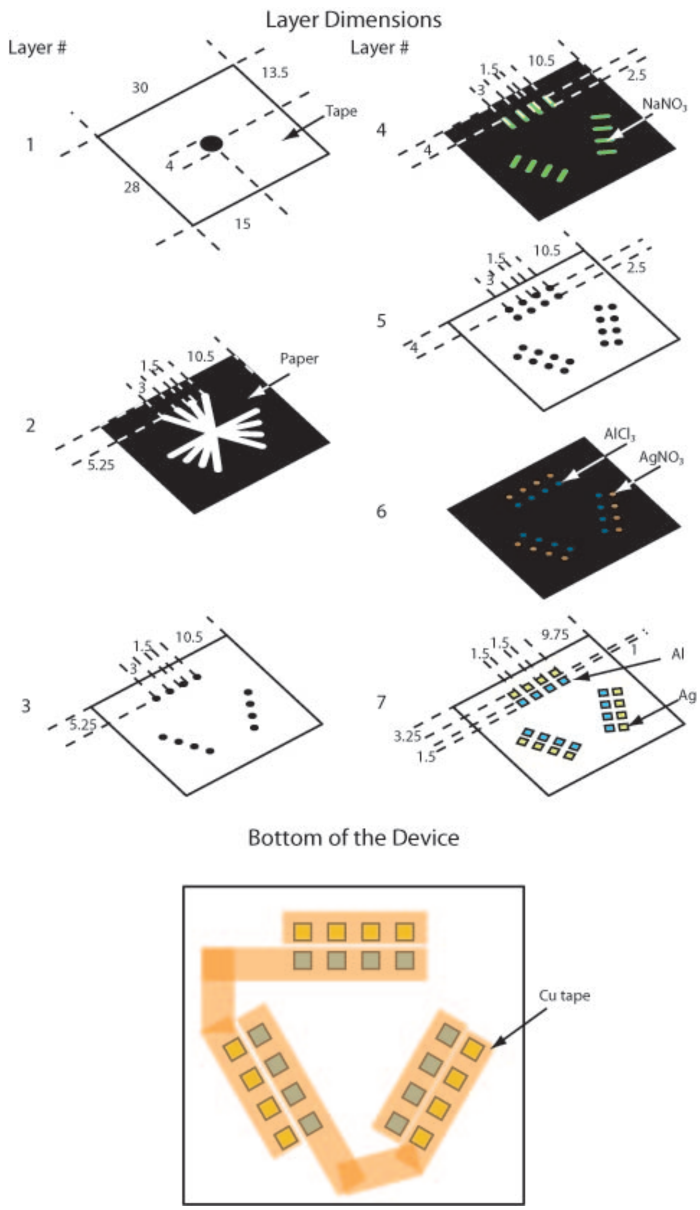

Figure S20. Expanded view of a Type 2 device containing 4 cells in parallel and 3 of those in series. All values are listed in mm. The three sets of features are identical, and at a 120° angle.

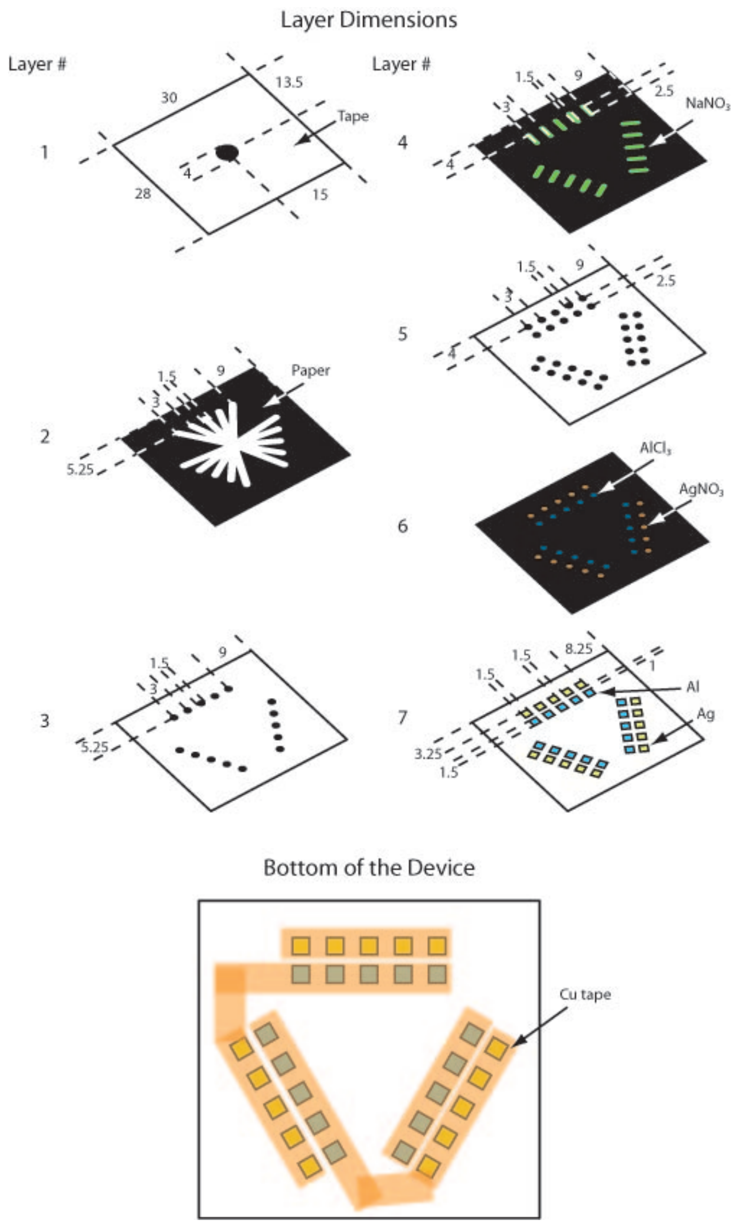

Figure S21. Expanded view of a Type 2 device containing 5 cells in parallel and 3 of those in series. All values are listed in mm. The three sets of features are identical, and at a 120° angle.

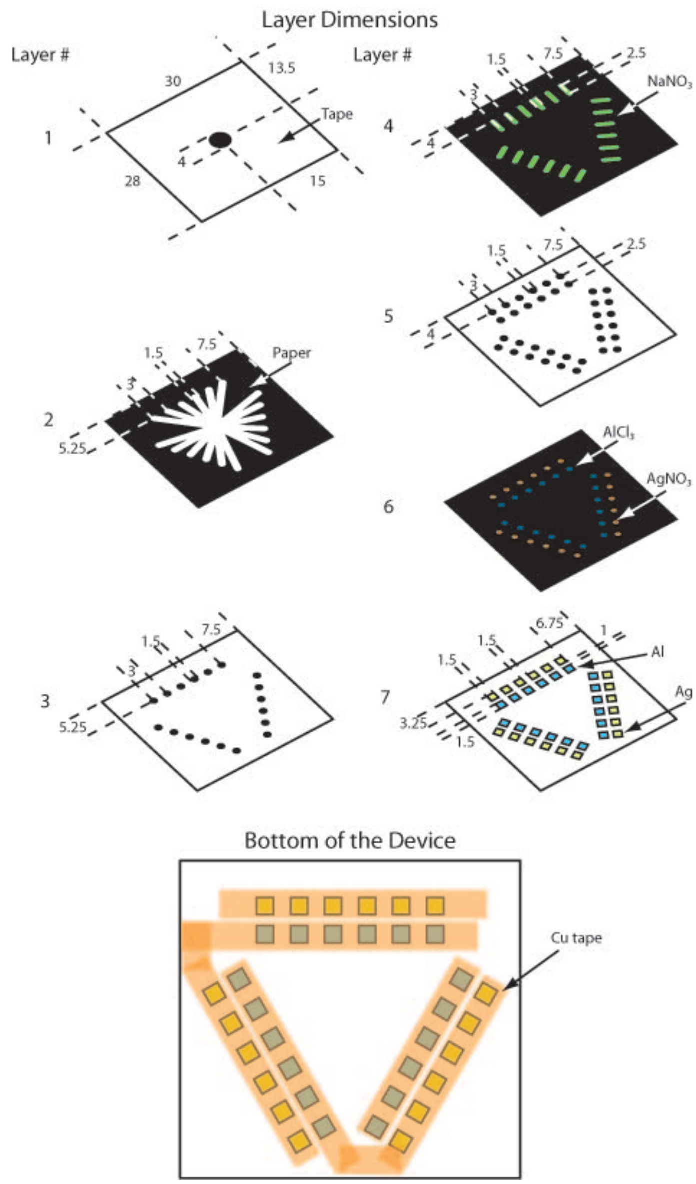

Figure S22. Expanded view of a Type 2 device containing 6 cells in parallel and 3 of those in series. All values are listed in mm. The three sets of features are identical, and at a 120° angle.

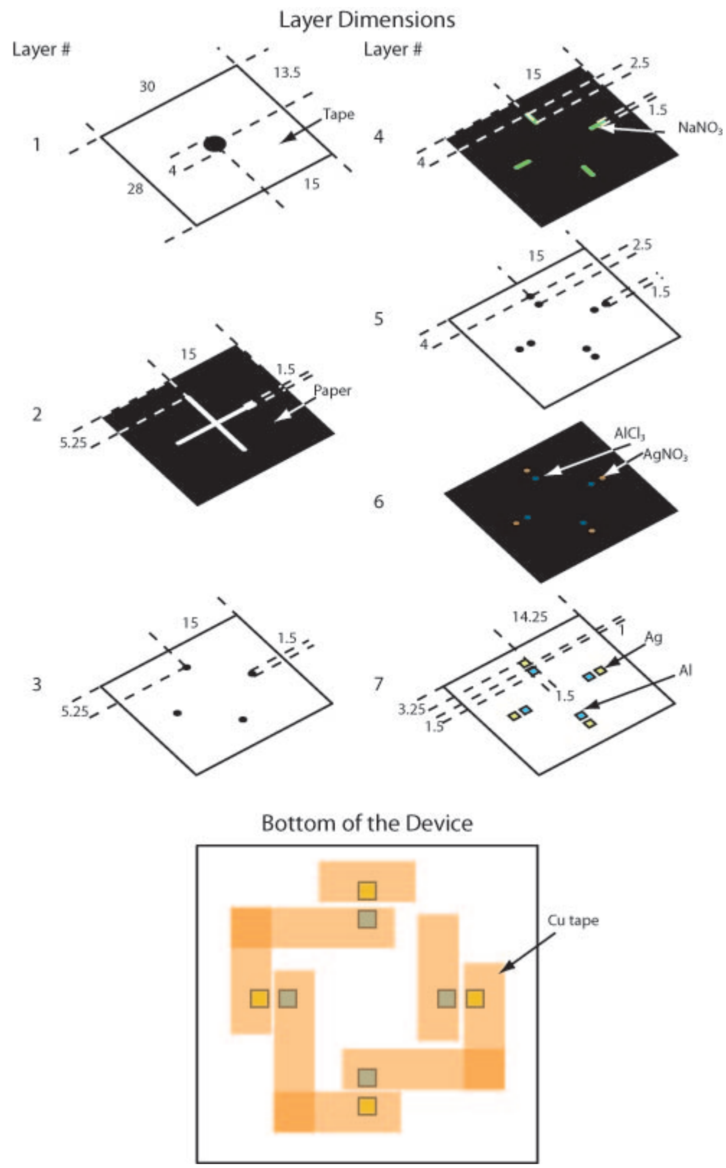

Figure S23. Expanded view of a Type 2 device containing 1 cell in parallel and 4 of those in series. All values are listed in mm. The four sets of features are identical, and at a 90° angle.

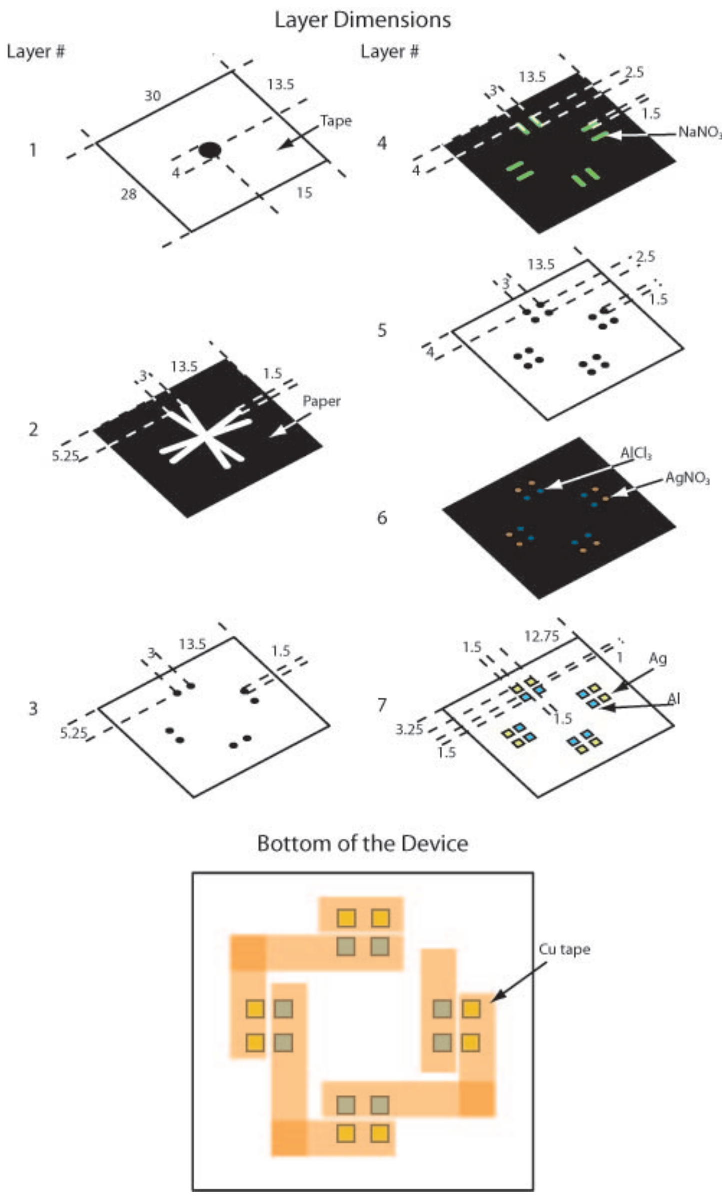

Figure S24. Expanded view of a Type 2 device containing 2 cells in parallel and 4 of those in series. All values are listed in mm. The four sets of features are identical, and at a 90° angle.

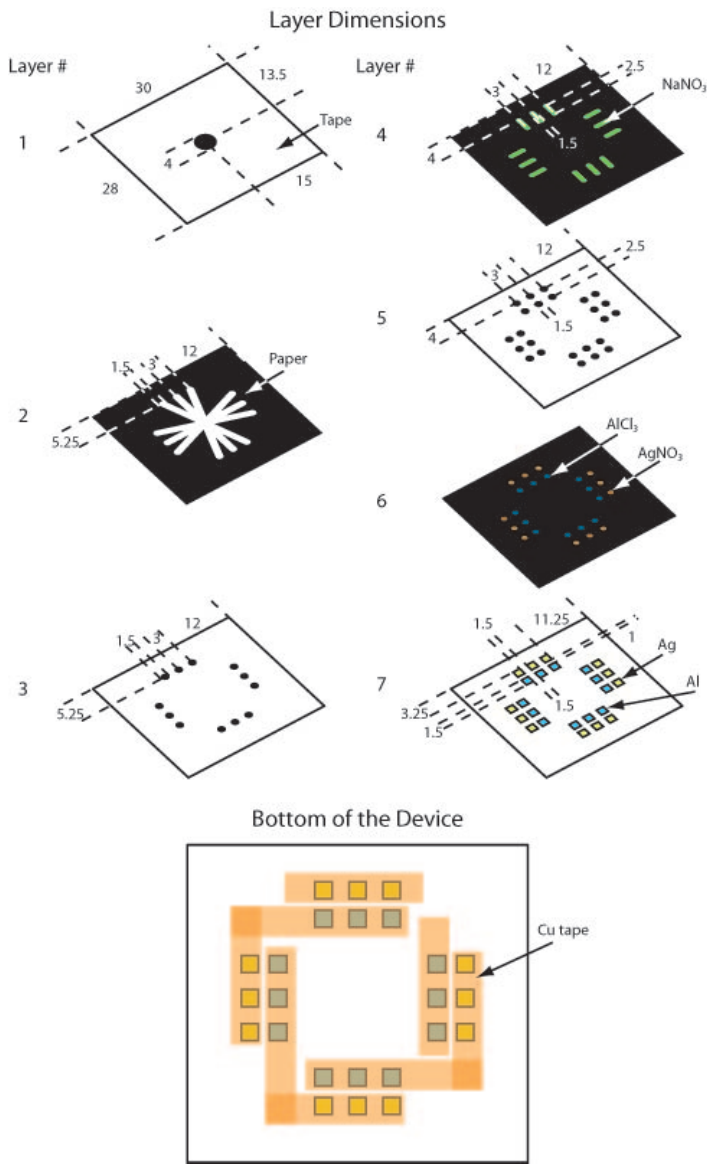

Figure S25. Expanded view of a Type 2 device containing 3 cells in parallel and 4 of those in series. All values are listed in mm. The four sets of features are identical, and at a 90° angle.

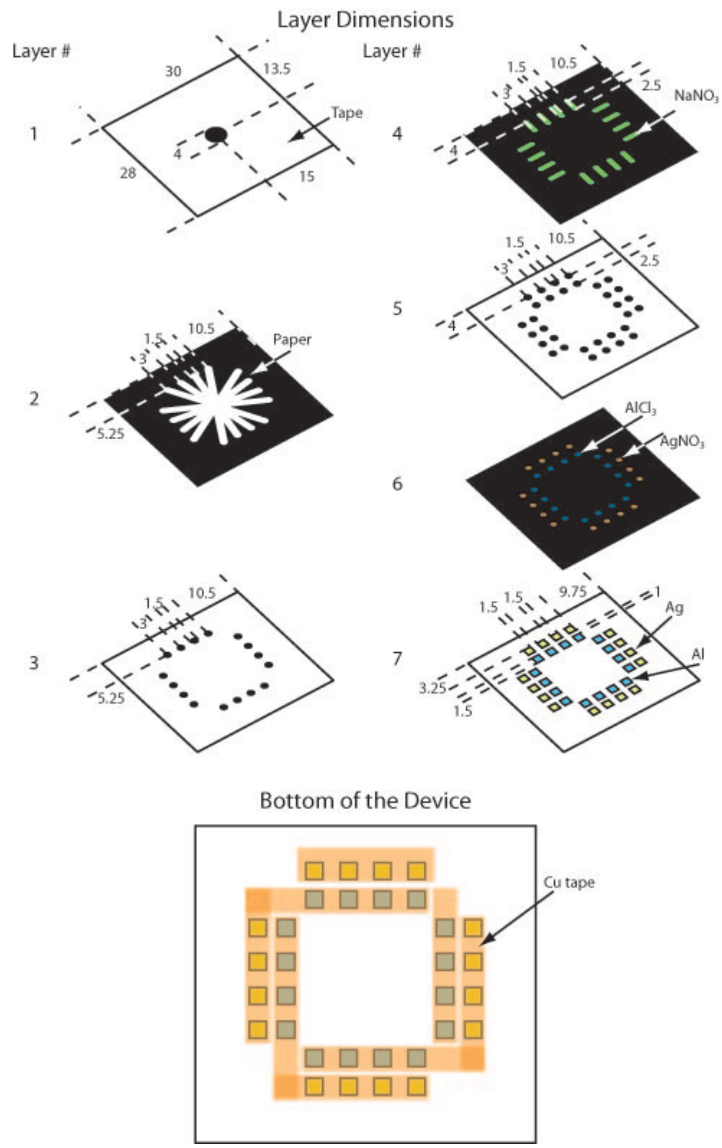

Figure S26. Expanded view of a Type 2 device containing 4 cells in parallel and 4 of those in series. All values are listed in mm. The four sets of features are identical, and at a 90° angle.

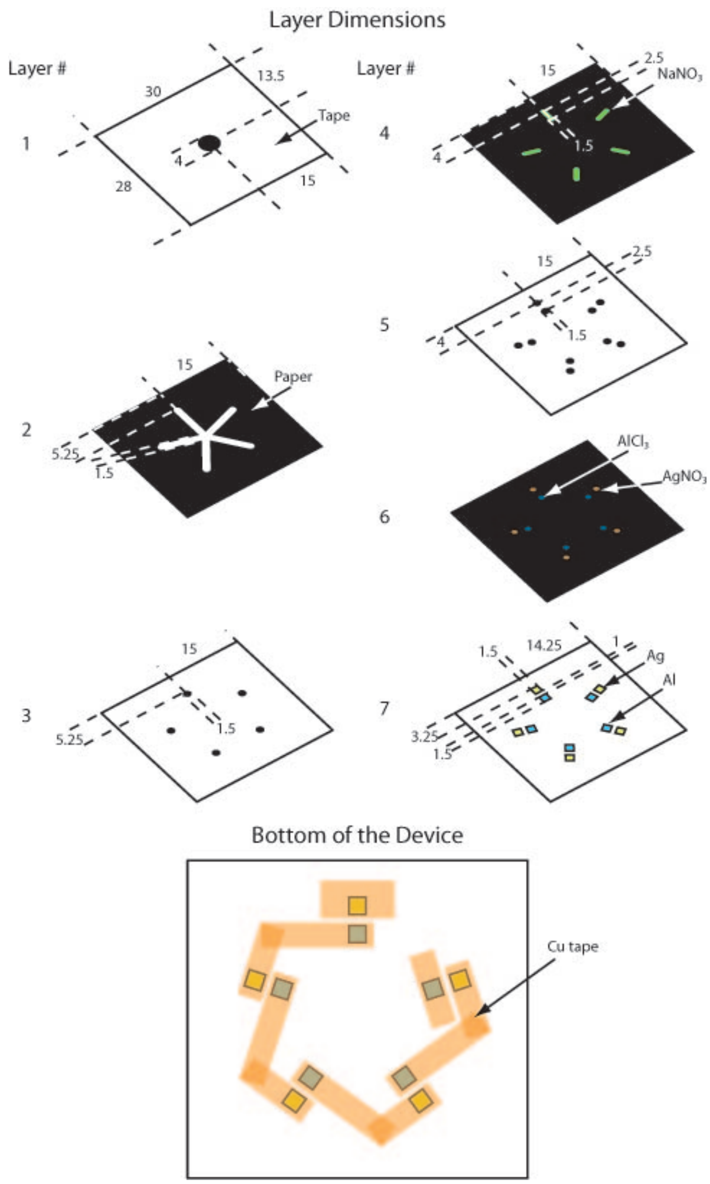

Figure S27. Expanded view of a Type 2 device containing 1 cell in parallel and 5 of those in series. All values are listed in mm. The five sets of features are identical, and at a 72° angle.

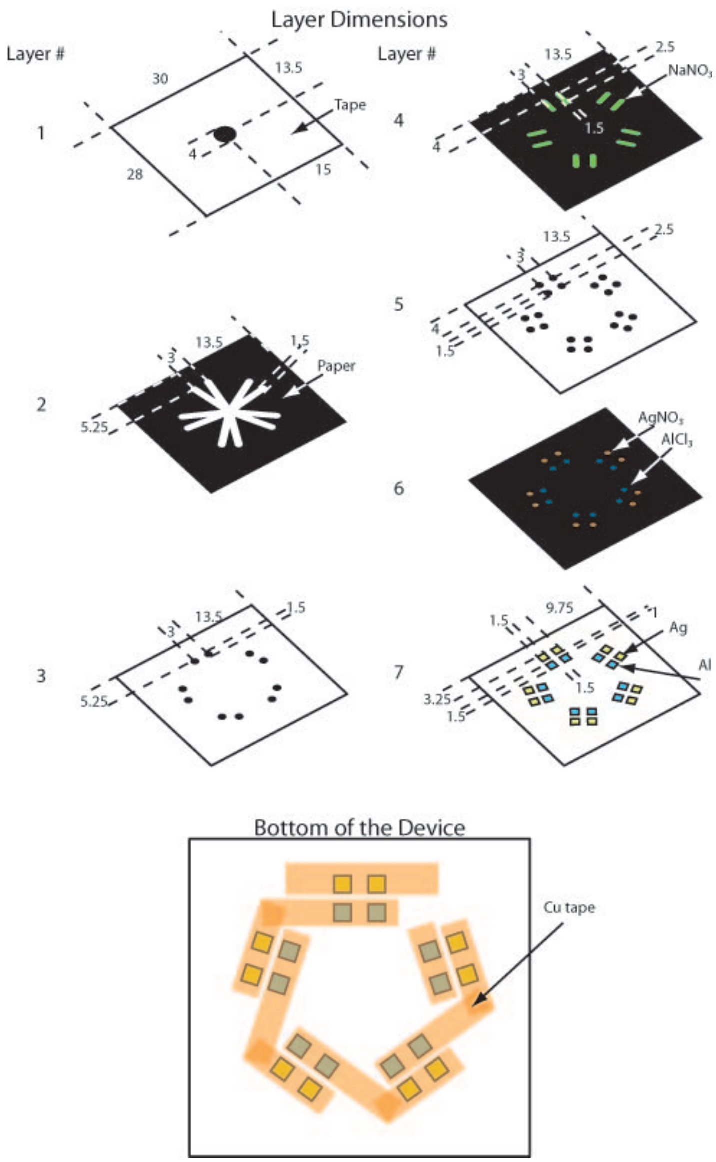

Figure S28. Expanded view of a Type 2 device containing 2 cells in parallel and 5 of those in series. All values are listed in mm. The five sets of features are identical, and at a 72° angle.

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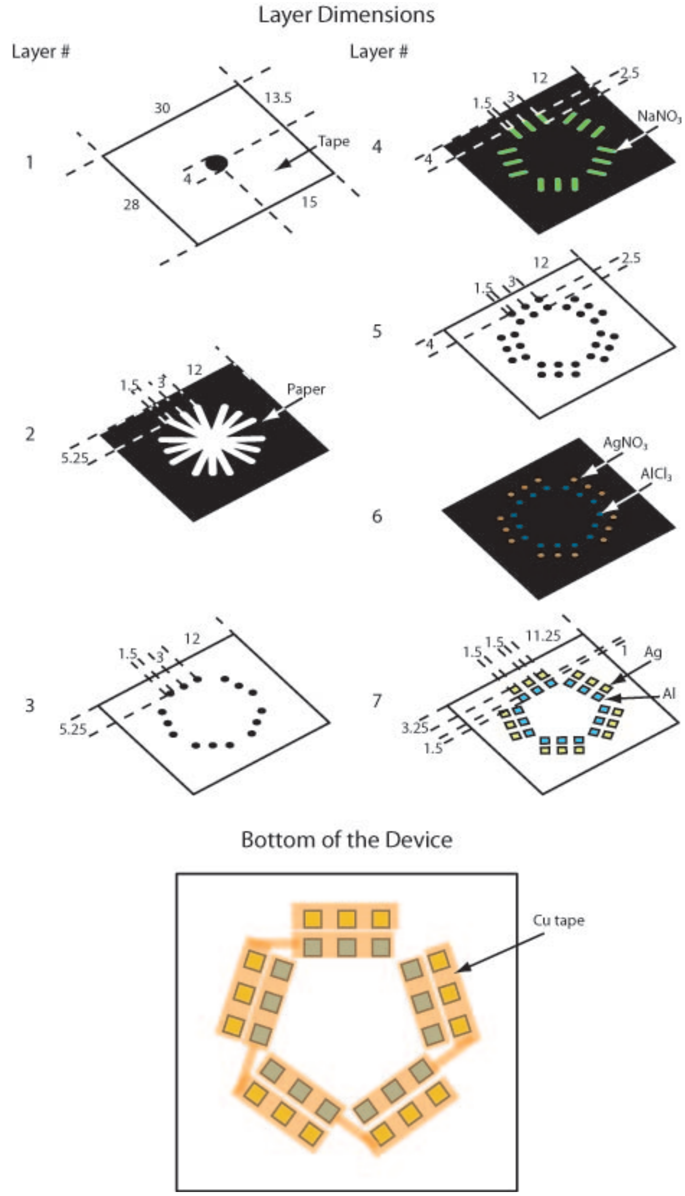

Figure S29. Expanded view of a Type 2 device containing 3 cells in parallel and 5 of those in series. All values are listed in mm. The five sets of features are identical, and at a 72° angle.

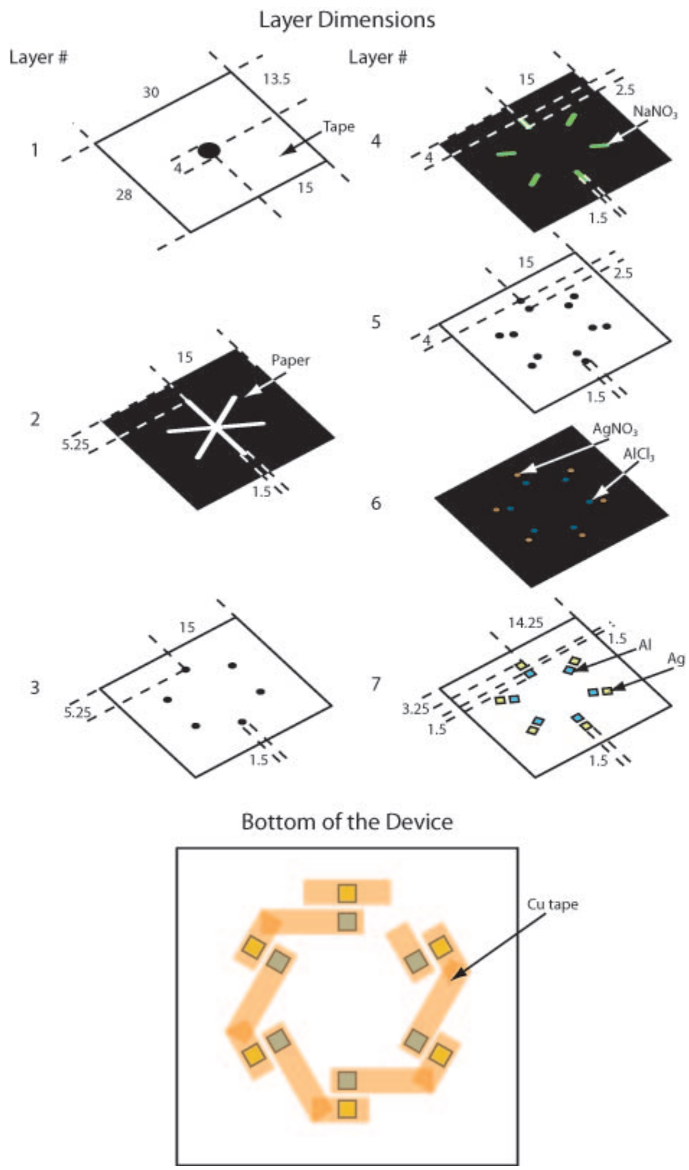

Figure S30. Expanded view of a Type 2 device containing 1 cell in parallel and 6 of those in series. All values are listed in mm. The six sets of features are identical, and at a 60° angle.

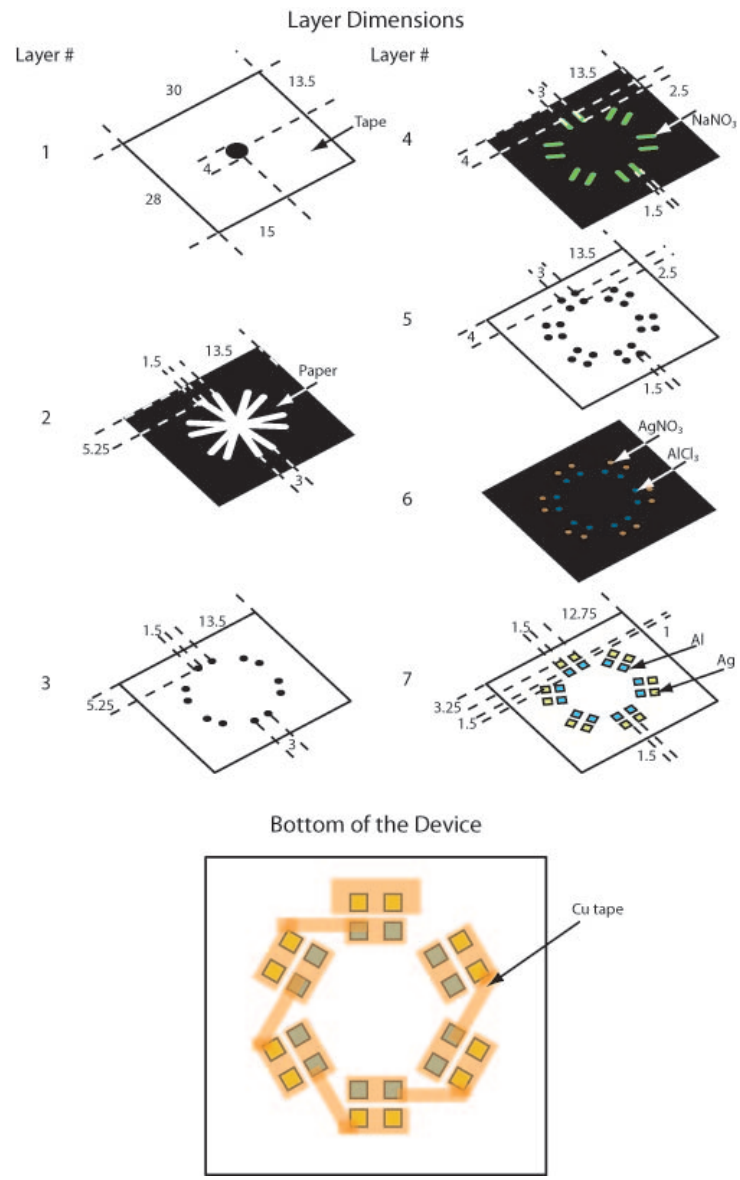

Figure S31. Expanded view of a Type 2 device containing 2 cells in parallel and 6 of those in series. All values are listed in mm. The six sets of features are identical, and at a 60° angle.

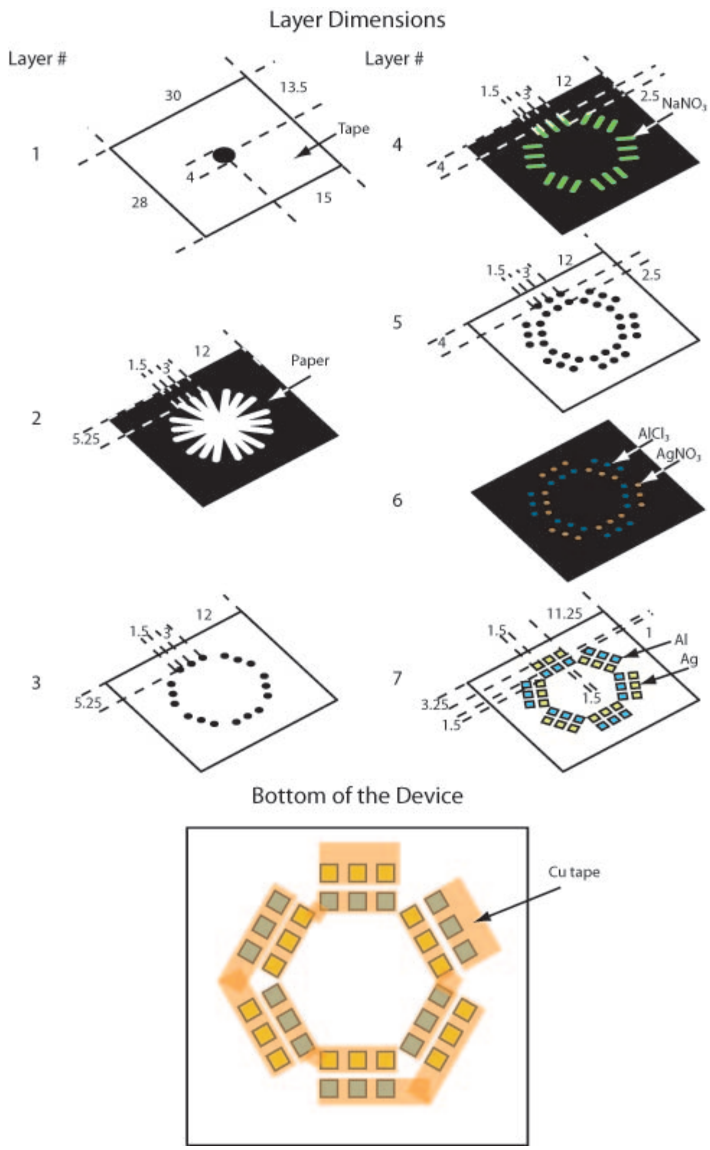

Figure S32. Expanded view of a Type 2 device containing 3 cells in parallel and 6 of those in series. All values are listed in mm. The six sets of features are identical, and at a 60° angle.

Table S27. Results from measurements of a Type 2 device containing 2 cells in parallel and 3 of those in series. This data was collected after using 20 µL deionized water to start the battery in Figure S18.

Time	Current (µA)							Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0	0	0	8	0.00	0.25	0.60
2	50	170	0	175	90	26	195	2.90	1.60	3.30
2.5	400	350	178	333	123	100	325	3.56	3.80	3.98
3	606	490	490	388	235	215	500	4.00	3.94	4.07
3.5	738	400	460	393	320	316	605	3.98	3.95	4.06
4	775	420	480	663	388	425	600	4.01	3.95	4.01
4.5	785	460	463	675	435	500	680	3.98	3.97	4.00
5	770	466	740	755	485	540	697	3.97	3.97	3.99
5.5	730	770	710	695	530	595	693	3.97	3.93	3.98
6	620	710	655	665	570	595	715	3.94	3.94	3.97
6.5	520	580	665	707	585	590	710	3.93	3.91	3.94
7	360	535	580	670	572	590	610	3.89	3.90	3.94
7.5	265	500	500	585	561	585	330	3.87	3.86	3.92
8	240	455	-	505	-	575	173	3.87	3.85	3.90
8.5	200	390	-	320	-	560	96	3.88	3.83	3.88
9	185	390	-	160	500	452	92	3.79	3.82	3.86
9.5	160	300	-	187	430	360	95	3.76	3.79	3.85
10	97	200	-	150	-	295	93	3.76	3.79	3.85

Table S28. Results from measurements of a Type 2 device containing 3 cells in parallel and 3 of those in series. This data was collected after using 40 µL deionized water to start the battery in Figure S19.

Time	Current (µA)			Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.00	0.00	0.00
1	0	0	0	0.08	0.00	0.00
1.5	0	0	0	1.04	0.00	0.06
2	0	1	0	-	0.53	1.59
2.5	5	21	12	2.57	2.52	3.85
3	30	100	95	3.45	3.53	3.98
3.5	115	230	158	3.79	3.86	4.03
4	207	345	235	3.88	3.99	4.07

Table S28 Continued. Results from measurements of a Type 2 device containing 3 cells in parallel and 3 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S19.

Time	Current (μA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
4.5	309	450	290	4.03	4.06	4.07
5	400	560	340	4.12	4.10	4.08
5.5	475	590	630	4.14	4.12	4.08
6	540	675	670	4.15	4.14	4.08
6.5	585	715	730	4.16	4.14	4.08
7	640	720	760	4.16	4.14	4.08
7.5	690	780	740	4.16	4.14	4.06
8	730	800	740	4.14	4.12	4.04
8.5	770	840	720	4.12	4.12	4.03
9	800	900	680	4.14	4.11	4.01
9.5	810	890	500	4.13	4.09	3.99
10	775	860	515	4.13	4.09	3.98
10.5	650	660	520	4.12	4.09	3.97
11	590	490	562	4.10	4.07	3.95
11.5	530	250	480	4.10	4.07	3.93
12	450	230	460	4.06	4.07	3.92

Table S29. Results from measurements of a Type 2 device containing 4 cells in parallel and 3 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S20.

Time	Current (μA)				Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	4	1	2	3
0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0.06	0.04	0.00
1	0	0	0	0	0.77	3.00	0.04
1.5	9	150	8	-	3.99	3.98	2.93
2	495	680	745	875	3.98	3.99	3.97
2.5	845	960	905	1090	3.98	3.95	3.94
3	1008	1045	1040	1160	3.95	3.94	3.93
3.5	1110	1075	1190	1150	3.92	3.92	3.94
4	1128	1075	1250	1110	3.91	3.91	3.91
4.5	1148	1080	1245	1100	3.89	3.91	3.89
5	1162	1000	1148	1200	3.87	3.87	3.86
5.5	1135	888	1075	1200	3.85	3.87	3.83
6	1125	800	1050	1000	3.85	3.83	3.83

Table S29 Continued. Results from measurements of a Type 2 device containing 4 cells in parallel and 3 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S20.

Time (min)	Current (μA) Trial 1	Trial 2	Trial 3	Trial 4	Potential (V) Trial 1	Trial 2	Trial 3
6.5	1050	765	985	790	3.82	3.81	3.83
7	975	719	920	705	3.90	3.77	3.81
7.5	840	600	835	645	3.77	3.76	3.82
8	695	550	840	575	3.77	3.72	3.79
8.5	485	510	730	485	3.76	3.70	3.78
9	420	475	540	397	3.75	3.67	3.78
9.5	325	405	460	302	3.72	3.68	3.75
10	245	385	382	240	3.72	3.68	3.73
10.5	195	310	367	195	3.70	3.64	3.70
11	195	235	320	157	3.69	3.63	3.70

Table S30. Results from measurements of a Type 2 device containing 5 cells in parallel and 3 of those in series. This data was collected after using 50 μL deionized water to start the battery in Figure S21.

Time (min)	Current (μA) Trial 1	Trial 2	Trial 3	Potential (V) Trial 1	Trial 2	Trial 3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.02	0.02	0.04
1	0	0	0	0.10	0.14	0.15
1.5	0	40	160	3.80	2.91	3.53
2	638	708	850	4.06	3.95	4.06
2.5	1095	1030	1140	4.08	4.01	4.06
3	1285	1300	1205	4.08	4.02	4.07
3.5	1398	1390	1340	4.06	4.00	4.03
4	1435	1330	1380	4.03	3.98	3.99
4.5	1435	1520	1385	4.00	3.97	3.95
5	1410	1540	1375	3.96	3.95	3.93
5.5	1365	1427	1330	3.95	3.93	3.91
6	1270	1395	1350	3.93	3.92	3.89
6.5	1130	1450	1230	3.90	3.90	3.86
7	1012	1240	1035	3.89	3.88	3.84
7.5	975	1085	860	3.86	3.88	3.81
8	935	915	735	3.84	3.86	3.78
8.5	875	812	590	3.83	3.84	3.76
9	760	640	725	3.80	3.82	3.73
9.5	620	520	665	3.79	3.81	3.73

Table S30 Continued. Results from measurements of a Type 2 device containing 5 cells in parallel and 3 of those in series. This data was collected after using 50 μL deionized water to start the battery in Figure S21.

Time	Current (μA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
10	520	415	610	3.78	3.79	3.70
10.5	380	340	515	3.77	3.76	3.69
11	312	310	455	3.76	3.76	3.68
11.5	285	309	447	3.74	3.74	3.68
12	275	300	440	3.73	3.72	3.66

Table S31. Results from measurements of a Type 2 device containing 6 cells in parallel and 3 of those in series. This data was collected after using 50 μL deionized water to start the battery in Figure S22.

Time	Current (μA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.01	0.01	0.01
1	0	0	0	0.00	0.01	0.02
1.5	0	0	0	0.05	0.15	0.31
2	5	3	-	1.25	2.36	3.27
2.5	106	32	-	3.50	3.65	3.95
3	234	252	175	3.94	3.93	4.03
3.5	482	420	390	4.04	4.00	4.07
4	775	652	620	4.08	4.06	4.08
4.5	1025	1110	820	4.09	4.05	4.09
5	1245	1265	960	4.10	4.10	4.09
5.5	1370	1355	1060	4.10	4.10	4.08
6	1490	1450	1180	4.07	4.10	4.08
6.5	1580	1550	1230	4.07	4.09	4.07
7	1640	1550	1320	4.09	4.08	4.06
7.5	1710	1650	1330	4.08	4.07	4.05
8	2020	1670	1437	4.07	4.07	4.04
8.5	1900	1630	1500	4.07	4.06	4.02
9	1800	1350	1500	4.05	4.05	4.02
9.5	1350	1150	1490	4.04	4.05	4.00
10	1310	1100	1370	4.02	4.04	3.99
10.5	900	800	1225	4.00	4.02	-
11	750	450	1040	3.99	4.02	-
11.5	500	295	1000	3.98	4.01	-
12	350	255	800	3.98	4.00	-

Table S32. Results from measurements of a Type 2 device containing 1 cell in parallel and 4 of those in series. This data was collected after using 20 μL deionized water to start the battery in Figure S23.

Time (min)	Current (μA) Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Potential (V) Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0	0	0	0	0	0.00	0.00	0.00
2	0	0	0	0	0	2	0	0	0.10	0.00	0.00
2.5	0	0	0	0	0	79	-	0	1.52	0.10	0.00
3	4	0	4	7	76	115	-	124	4.18	1.31	1.88
3.5	12	12	30	19	168	150	-	192	4.18	4.24	3.40
4	29	32	100	40	230	185	230	238	5.30	4.63	4.29
4.5	100	-	145	70	253	205	262	268	5.40	4.66	5.26
5	115	56	178	136	270	-	290	272	5.44	4.63	5.39
5.5	137	61	207	-	285	240	315	275	5.47	5.16	5.45
6	173	82	223	156	291	280	309	270	5.47	5.22	5.47
6.5	225	96	240	182	305	-	313	275	5.47	5.31	5.48
7	246	-	248	210	300	325	312	275	5.46	5.36	5.49
7.5	260	254	260	239	296	311	314	277	5.44	5.40	5.49
8	270	275	273	265	296	327	310	263	5.43	5.31	5.49
8.5	285	180	270	275	288	330	295	240	5.40	5.29	5.47
9	310	291	273	288	280	315	275	224	5.40	5.25	5.46
9.5	290	295	-	311	262	265	240	205	5.38	5.34	5.45
10	303	297	273	321	-	150	153	215	5.36	5.37	5.43
10.5	300	305	265	327	-	-	-	-	5.34	5.44	5.43
11	283	303	230	326	-	-	-	-	5.32	5.45	5.41
11.5	200	297	225	330	-	-	-	-	5.30	5.45	5.40
12	173	305	154	306	-	-	-	-	5.27	5.44	5.37

Table S33. Results from measurements of a Type 2 device containing 2 cells in parallel and 4 of those in series. This data was collected after using 30 μL deionized water to start the battery in Figure S24.

Time (min)	Current (μA) Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Potential (V) Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0	0.05	0.00	0.15
1.5	0	0	0	0	0	4	0	63	0.25	0.01	0.45
2	2	0	0	29	122	195	25	315	0.81	0.61	2.45

Table S33 Continued. Results from measurements of a Type 2 device containing 2 cells in parallel and 4 of those in series. This data was collected after using 30 µL deionized water to start the battery in Figure S24.

Time	Current (µA)								Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 1	Trial 2	Trial 3
2.5	96	1	0	221	295	427	227	480	1.90	4.15	5.08
3	170	42	31	335	460	535	445	-	2.90	5.20	4.86
3.5	212	80	43	410	570	610	625	732	3.62	5.36	4.40
4	237	110	54	465	643	665	675	785	4.95	5.35	5.00
4.5	250	133	68	494	675	685	705	820	4.60	5.34	4.66
5	250	142	79	501	685	700	705	820	5.02	5.33	5.09
5.5	253	157	91	507	680	715	704	815	5.05	5.28	5.15
6	256	170	104	506	695	702	675	760	5.09	5.22	5.26
6.5	253	191	115	501	700	635	635	580	4.96	5.21	5.25
7	253	218	127	504	640	575	550	480	5.10	5.18	4.68
7.5	248	225	139	487	624	425	455	285	5.11	5.14	4.99
8	245	228	168	468	470	342	380	175	5.12	5.14	5.24
8.5	241	235	172	445	390	260	169	100	5.10	5.09	5.15
9	238	244	173	426	250	121	134	103	5.12	5.09	5.00
9.5	237	243	178	390	195	95	130	100	5.17	5.10	5.15
10	230	253	215	316	101	88	90	99	5.11	5.02	5.17
10.5	222	254	220	294	-	-	-	-	5.00	5.01	5.19
11	175	315	231	273	-	-	-	-	5.10	5.00	5.18
11.5	228	313	234	233	-	-	-	-	5.08	5.03	5.17
12	425	301	235	155	-	-	-	-	5.07	5.04	5.15
12.5	415	272	238	140	-	-	-	-	-	-	-
13	390	237	237	135	-	-	-	-	-	-	-
13.5	360	195	233	129	-	-	-	-	-	-	-
14	340	172	190	113	-	-	-	-	-	-	-
14.5	350	188	184	93	-	-	-	-	-	-	-
15	343	187	179	91	-	-	-	-	-	-	-

Table S34. Results from measurements of a Type 2 device containing 3 cells in parallel and 4 of those in series. This data was collected after using 40 µL deionized water to start the battery in Figure S25.

Time	Current (µA)			Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.00	0.00	0.00
1	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0.02	0.00	0.00

Table S34 Continued. Results from measurements of a Type 2 device containing 3 cells in parallel and 4 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S25.

Time	Current (μA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
2	0	0	0	0.55	0.13	1.40
2.5	4	3	23	2.50	1.80	3.90
3	62	28	88	4.40	4.01	4.90
3.5	123	81	168	4.50	4.58	5.29
4	200	148	256	4.95	5.00	5.42
4.5	265	300	345	5.10	5.29	5.47
5	410	343	440	5.23	5.41	5.50
5.5	490	400	515	5.28	5.46	5.52
6	510	450	610	5.40	5.47	5.52
6.5	645	500	590	5.43	5.47	5.52
7	680	515	655	5.43	5.48	5.51
7.5	850	515	675	5.43	5.48	5.50
8	830	550	720	5.44	5.47	5.49
8.5	800	585	730	5.43	5.47	5.48
9	775	615	750	5.41	5.46	5.47
9.5	750	600	750	5.31	5.44	5.46
10	710	605	615	5.24	5.43	5.45
10.5	675	515	580	5.18	5.41	5.43
11	780	520	560	5.26	5.40	5.42
11.5	680	480	560	5.21	5.37	5.40
12	400	490	520	5.20	5.36	5.39

Table S35. Results from measurements of a Type 2 device containing 4 cells in parallel and 4 of those in series. This data was collected after using 50 μL deionized water to start the battery in Figure S26.

Time	Current (μA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.00	0.00	0.00
1	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0.00	0.10	0.01
2	0	2	35	0.40	3.38	3.22
2.5	35	70	105	4.12	5.19	4.93
3	88	171	207	5.12	5.31	5.30
3.5	170	310	325	5.24	5.40	5.40
4	260	425	430	5.39	5.45	5.46

Table S35 Continued. Results from measurements of a Type 2 device containing 4 cells in parallel and 4 of those in series. This data was collected after using 50 µL deionized water to start the battery in Figure S26.

Time	Current (µA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
4.5	317	518	500	5.48	5.48	5.49
5	380	630	555	5.52	5.50	5.50
5.5	407	700	605	5.54	5.50	5.52
6	435	765	645	5.55	5.50	5.52
6.5	590	915	685	5.54	5.49	5.49
7	567	975	700	5.54	5.48	5.49
7.5	665	1005	750	5.54	5.47	5.48
8	690	1045	780	5.53	5.45	5.47
8.5	762	975	790	5.51	5.43	5.46
9	775	970	800	5.22	5.41	5.43
9.5	776	820	915	5.51	5.39	5.43
10	775	870	920	5.42	5.37	5.40
10.5	820	835	820	5.47	5.35	5.40
11	740	800	845	5.46	5.34	5.39
11.5	825	601	750	5.43	5.33	5.38
12	715	490	630	5.42	5.30	5.36

Table S36. Results from measurements of a Type 2 device containing 1 cell in parallel and 5 of those in series. This data was collected after using 30 µL deionized water to start the battery in Figure S27.

Time	Current (µA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.00	0.00	0.00
1	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0.00	0.00	0.00
2	0	0	0	0.00	0.00	0.05
2.5	0	0	0	0.04	0.00	0.14
3	0	4	0	0.45	0.03	0.19
3.5	1	20	5	2.00	1.08	0.21
4	22	66	18	4.28	4.63	0.23
4.5	43	103	45	5.55	5.61	-
5	75	133	72	6.35	6.52	0.51
5.5	120	173	109	6.62	6.72	0.65
6	150	215	145	6.74	6.70	0.79
6.5	201	226	190	6.79	6.84	0.94

Table S36 Continued. Results from measurements of a Type 2 device containing 1 cell in parallel and 5 of those in series. This data was collected after using 30 μL deionized water to start the battery in Figure S27.

Time	Current (μA)			Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
7	218	232	220	6.83	6.66	1.10
7.5	240	239	233	6.84	6.87	6.79
8	245	249	263	6.84	-	6.83
8.5	251	251	274	6.82	-	6.86
9	252	258	280	6.81	-	6.83
9.5	268	257	287	6.79	-	6.80
10	270	255	285	6.78	6.78	6.78
10.5	273	255	274	6.75	6.75	-
11	262	236	250	6.73	6.73	-
11.5	236	215	245	6.72	6.70	-
12	237	160	225	6.70	-	-

Table S37. Results from measurements of a Type 2 device containing 2 cells in parallel and 5 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S28.

Time	Current (μA)						Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 1	Trial 2	Trial 3
0	0	0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0	0	0.00	0.01	0.00
1	0	0	0	0	0	0	0.02	0.02	0.01
1.5	4	0	0	0	0	0	0.53	2.11	1.71
2	280	100	4	21	0	91	6.17	6.47	6.30
2.5	520	337	219	130	104	290	6.55	6.60	6.57
3	675	485	445	360	272	500	6.56	6.58	6.58
3.5	765	545	540	490	350	630	6.54	6.52	6.55
4	760	675	580	570	410	700	6.54	6.51	6.51
4.5	735	665	620	620	414	740	6.52	6.51	6.53
5	675	632	652	630	440	785	6.53	6.48	6.53
5.5	645	575	670	687	460	780	6.51	6.46	6.53
6	585	580	630	685	480	790	6.49	6.44	6.49
6.5	490	535	585	690	470	770	6.47	6.42	6.47
7	405	490	580	655	450	690	6.46	6.41	6.45
7.5	380	420	575	660	800	630	6.44	6.40	6.42
8	335	350	430	590	750	456	6.41	6.39	6.41
8.5	160	300	420	540	662	320	6.39	6.37	6.40
9	155	265	365	430	640	191	6.39	6.35	6.36

Table S37 Continued. Results from measurements of a Type 2 device containing 2 cells in parallel and 5 of those in series. This data was collected after using 40 µL deionized water to start the battery in Figure S28.

Time (min)	Current (µA) Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Potential (V) Trial 1	Trial 2	Trial 3
9.5	147	191	302	202	545	106	6.35	6.36	6.35
10	137	150	215	198	450	101	6.33	6.35	6.32
10.5	128	120	130	160	270	-	6.33	6.30	6.31
11	120	100	122	94	240	-	6.29	6.31	6.29
11.5	108	95	-	78	178	-	3.28	6.29	6.28
12	78	83	-	-	105	-	6.25	6.28	6.27

Table S38. Results from measurements of a Type 2 device containing 3 cells in parallel and 5 of those in series. This data was collected after using 50 µL deionized water to start the battery in Figure S29.

Time (min)	Current (µA) Trial 1	Trial 2	Trial 3	Potential (V) Trial 1	Trial 2	Trial 3
0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0.00	0.00	0.00
1	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0.00	0.00	0.00
2	12	0	1	0.03	0.21	0.55
2.5	35	1	25	3.05	1.80	3.67
3	80	36	175	4.97	5.94	5.70
3.5	140	104	275	6.04	6.47	5.96
4	282	202	360	6.51	6.64	6.68
4.5	500	315	460	6.54	6.67	6.76
5	605	415	506	6.76	6.53	6.81
5.5	659	535	595	6.77	6.79	6.82
6	715	640	670	6.85	6.85	6.81
6.5	745	700	715	6.86	6.85	6.89
7	768	745	750	6.86	6.84	6.90
7.5	800	735	775	6.85	6.83	6.90
8	785	700	700	6.83	6.83	6.89
8.5	675	575	660	6.81	6.80	6.88
9	570	580	660	6.79	6.79	6.50
9.5	510	590	626	6.77	6.58	6.57
10	272	615	575	6.76	6.76	6.45
10.5	176	573	565	6.74	6.73	-
11	164	515	525	6.72	6.71	-
11.5	157	510	400	6.69	6.69	-

Table S38 Continued. Results from measurements of a Type 2 device containing 3 cells in parallel and 5 of those in series. This data was collected after using 50 μL deionized water to start the battery in Figure S29.

Time	Current (μA)			Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	1	2	3
12	153	355	360	6.66	6.66	-

Table S39. Results from measurements of a Type 2 device containing 1 cell in parallel and 6 of those in series. This data was collected after using 30 μL deionized water to start the battery in Figure S30.

Time	Current (μA)				Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	4	1	2	3
0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0.00	0.00	0.00
1.5	0	0	0	0	0.00	0.00	0.00
2	0	0	0	0	0.00	0.00	0.00
2.5	0	0	0	0	-	0.06	0.00
3	0	1	0	0	-	0.16	0.04
3.5	13	6	7	1	6.64	0.40	0.24
4	50	22	21	9	7.39	6.66	0.49
4.5	93	46	45	28	7.77	7.01	2.19
5	146	80	80	75	7.80	7.60	4.98
5.5	229	131	127	112	8.01	7.74	6.72
6	245	164	175	158	8.05	7.81	7.02
6.5	266	180	215	224	8.07	7.82	7.75
7	270	200	230	260	8.11	7.85	7.99
7.5	283	225	245	267	8.12	8.05	7.83
8	290	250	250	272	8.11	8.12	8.13
8.5	300	270	255	278	8.10	8.10	8.16
9	305	275	262	287	8.09	8.08	8.15
9.5	305	275	268	295	8.09	7.32	8.16
10	290	282	279	295	7.70	7.93	8.16
10.5	240	285	283	290	8.05	7.81	8.14
11	195	270	282	255	8.05	7.73	8.13
11.5	180	246	249	225	8.03	8.01	8.12
12	135	207	200	207	8.05	8.01	7.86

Table S40. Results from measurements of a Type 2 device containing 2 cells in parallel and 6 of those in series. This data was collected after using 40 µL deionized water to start the battery in Figure S31.

Time	Current (µA)				Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	4	1	2	3
0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0.06	0.31	0.00
1.5	0	0	0	0	-	6.91	0.34
2	284	0	43	127	0.50	7.52	3.65
2.5	500	100	207	356	0.76	7.55	7.16
3	645	500	365	475	0.77	7.64	7.66
3.5	755	585	495	615	-	7.62	7.70
4	775	685	560	660	7.99	7.60	7.65
4.5	740	742	620	718	7.98	7.61	7.63
5	750	727	660	723	7.95	7.62	7.58
5.5	709	690	675	775	7.90	7.58	7.58
6	660	682	690	768	7.86	7.56	7.56
6.5	580	635	700	733	7.82	7.56	7.52
7	495	552	680	682	7.80	7.51	7.52
7.5	420	500	645	550	7.73	7.48	7.49
8	345	440	580	415	7.70	7.38	7.47
8.5	238	390	405	293	7.69	7.39	7.45
9	215	351	250	190	7.66	7.36	7.45
9.5	285	253	145	122	7.64	7.34	7.43
10	210	145	79	126	7.62	7.32	7.41
10.5	209	99	-	124	-	-	-
11	308	-	-	-	-	-	-
11.5	161	-	-	-	-	-	-
12	232	-	-	-	-	-	-

Table S41. Results from measurements of a Type 2 device containing 3 cells in parallel and 6 of those in series. This data was collected after using 40 µL deionized water to start the battery in Figure S32.

Time	Current (µA)				Potential (V)		
	Trial	Trial	Trial	Trial	Trial	Trial	Trial
(min)	1	2	3	4	1	2	3
0	0	0	0	0	0.00	0.00	0.00
0.5	0	0	0	0	0.00	0.00	0.25
1	0	0	0	0	0.00	0.00	1.28
1.5	0	0	0	-	0.00	0.00	6.26
2	0	0	4	-	1.19	2.53	7.78

Table S41 Continued. Results from measurements of a Type 2 device containing 3 cells in parallel and 6 of those in series. This data was collected after using 40 μL deionized water to start the battery in Figure S32.

Time	Current (μA)				Potential (V)		
(min)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3
2.5	10	13	46	86	5.54	5.68	7.02
3	70	64	160	190	7.27	7.06	6.77
3.5	120	112	262	355	7.82	7.84	6.82
4	195	173	302	535	8.03	8.01	6.83
4.5	260	275	415	607	8.11	8.11	6.70
5	428	350	420	742	8.18	8.16	8.11
5.5	340	410	525	698	8.20	8.19	8.19
6	500	-	575	675	8.21	8.21	8.16
6.5	545	425	640	732	8.21	8.21	8.13
7	560	457	630	630	8.19	8.23	8.12
7.5	620	475	741	600	8.18	8.22	8.09
8	550	475	705	560	8.16	8.22	8.05
8.5	650	440	675	525	8.15	8.22	8.02
9	610	415	640	473	8.13	8.21	7.96
9.5	590	420	630	420	8.11	8.17	7.93
10	520	375	590	410	8.11	8.10	7.91
10.5	500	350	540	393	8.08	8.13	7.87
11	450	330	460	372	8.07	8.12	7.83
11.5	480	315	385	445	8.06	8.05	7.77
12	-	285	300	365	8.04	8.08	7.74

Predicting the Maximum Current

For all of the following calculations, A is the maximum current in μA, P is the number of cells in parallel, S is the number of cells in series, m is the slope of the linear regression, and b is the y-intercept of the linear regression.

Design Type 2. The maximum measured current values for Design Type 2 devices containing 3 sets of cells in series were plotted against the number of cells in parallel used to obtain the measured current. The linear regression of the maximum current versus the number of cells in parallel gives the equation $A = m(P) + b$. The slope and y-intercept determined from the linear regression were recorded. This process was repeated for Design Type 2 devices containing 4, 5, and 6 sets of cells in series; the values from the linear regression analyses are recorded in Table S42.

Table S42. Maximum measured current for Design Type 2 devices plotted against the number cells in parallel for 3, 4, 5, and 6 sets of cells in series. The slope and y-intercept are determined from the linear regression of the maximum current plotted against the number of cells in parallel.

Number of Cells in Series	Number of Cells in Parallel	Maximum Current (μA)	Slope	Y-Intercept
3	2	706	267.71	106.36
	3	823		
	4	1173		
	5	1453		
	6	1730		
4	1	306	205.83	117.19
	2	553		
	3	738		
	4	930		
5	1	273	250.33	91.89
	2	732		
	3	773		
6	1	292	180.00	204.00
	2	748		
	3	652		

The calculated slopes (Table S42) for each set of cells in parallel are then plotted against the number of cells in series, and, in a separate graph, the calculated y-intercepts (Table S42) are plotted against the number of cells in series. The linear regression for the plotted slopes versus number of cells in series give the equation $A = m_1(P\times S) + b_1(P)$, and the linear regression for the plotted intercepts versus the number of cells in parallel gives the equation $A = m_2(S) + b_2$. The two calculated equations are then combined to provide the final equation $A_2 = -21.8\,(S\times P) + 26.8(S) + 324.4(P) + 9.4$, which is the predicted maximum current for Design Type 2.

Predicting Current Decay Rates

For all of the following calculations, *D* is the decay rate in μA/min, *P* is the number of cells in parallel, *S* is the number of cells in series, *m* is the slope of the linear regression, and *b* is the y-intercept of the linear regression. Decay rates for each device tested are determined by measuring the slope of the linear region of decay directly following the maximum current measured from a plot of current versus time.

Design Type 2. The measured decay rate for Design Type 2 devices containing 3 sets of cells in series were plotted against the number of cells in parallel. The linear regression of the decay rates versus the number of cells in parallel gives the equation $D = m(P) + b$. The linear regression for this plot was then determined and the slope and y-intercept were recorded. This process was repeated for Design Type 2 devices containing 4, and 5 sets of cells in series; the values from the linear regression analyses are recorded in Table S43.

Table S43. Measured decay rate for Design Type 2 devices plotted against the number cells in parallel for 3, 4, and 5 sets of cells in series. The slope and y-intercept are determined from the linear regression of the maximum current plotted against the number of cells in parallel.

Number of Cells in Series	Number of Cells in Parallel	Decay Rate (μA/min)	Slope	Y-Intercept
3	1	-138.4	-46.3	-19.3
	2	-172.9		
	4	-162.0		
	5	-189.6		
	6	-361.7		
4	1	-55.3	-33.0	-28.2
	2	-114.1		
	3	-104.7		
	4	-168.4		
5	1	-52.5	-34.2	-35.4
	2	-137.9		
	3	-120.8		

The calculated slopes (Table S43) for each set of cells in parallel are then plotted against the number of cells in series, and, in a separate graph, the calculated y-intercepts (Table S43) are plotted against the number of cells in series. The linear regression for the plotted slopes versus number of cells in series give the equation $D = m_1(P \times S) + b_1(P)$, and the linear regression for the plotted intercepts versus the number of cells in series gives the equation $D = m_2(S) + b_2$. The two calculated equations are then combined to provide the final equation $D = 6.1\,(S \times P) - 62.2(P) - 8.1(S) + 4.6$, which is the predicted decay rate for Design Type 2.

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