Electronic Supplementary Material (ESI) for Lab on a Chip

Supporting info for MS titled:

Nanofracture on fused silica microchannel for Donnan exclusion based electrokinetic stacking of biomolecules

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1. Ring-disk fracture Model

For an electrolyte conductivity cell of parallel square electrodes with an area of A and distance of L, the relation of resistance and the conductivity of the electrolyte is expressed as equation s1, as can be find in any physical chemistry book, .

$$R = \frac{L}{A \cdot k} \qquad \text{s1}$$

If the cell is consisted of two coaxial ring disks with radius *r*, width *w* and small distance d*r* , then the resistance between the two ring disk electrodes can be expressed as equation 2s.

$$dR = \frac{dr}{2\pi rwk} \qquad \text{s2}$$

The resistance of a ring disk fracture can be viewed as the sum of thin ring disk resistors connected in series, hence integration of equation s2 between the inner and outer radius gives the total resistance of the fracture, considering the voltage is applied between inside and outside ring disk electrodes.

$$R_F = \int_{r_i}^{r_o} \frac{dr}{2\pi rwk} \qquad \text{s3}$$

Definite integration of equation s3 give equation s4.

$$R_F = \frac{dr}{2\pi rwk} \ln \frac{r_o}{r_i} \qquad \text{s4}$$

The fracture width can be calculated with equation s5 if the R_F is available.

$$w = \frac{1}{2\pi k R_F} \ln \frac{r_o}{r_i} \qquad \text{s5}$$

2. Measurement of the fracture resistance

The resistance of the fracture was measured by filling the capillary with 1 M KCl solution. First we measure R_{1F}, sum of resistance of R_1 and R_F, by applying a voltage between left end reservoir and that of the middle, and then the R_{2F} in the same manner. The sum of R_1 and R_2 is measured by applying a voltage across the two end reservoirs.

$$R_{1F} = R_1 + R_F, \quad R_{2F} = R_2 + R_F, \quad R_{12} = R_1 + R_2$$

With assumption of the equivalent circuit of the chip system, then R_F can be calculated according to:

$$R_F = \frac{R_{1F} + R_{2F} - R_{12}}{2}$$

According to equation s5, larger fracture resistance resulted in a narrower fracture width.

3. Capillary fractures generated by supersonic generator

Table s1 lists 37 samples generated with supersonic, together with the resistance measurement results. As can be seen that the, R_{1F} and R_{2F} is quite close to each other. The small difference in R_{12} is due to length difference and room temperature changes. Fig.1S is the statistic of the fracture width. The SEM insert clearly shows that the fracture is about 83 nm, which is in agreement with the resistance measurement. As can be seen from the statistics that most fractures has a width of below 250 nm, only one case over 332 nm.

Table 1S. Summary of the resistance / KΩ

No	R_{1F}	R_{2F}	R_{12}	R_F	w/nm

1*	339	345	547	68	208
2*	318	358	547	64	221
3*	388	383	543	114	125
4	403	406	690	59	245
5	440	434	675	99	146
6	414	429	666	88	165
7	402	396	662	68	213
8	1236	1154	696	847	17
9	477	459	694	121	118
10	425	417	688	76	186
11	734	719	701	375	37
12	547	545	695	198	70
13	718	685	722	701	21
14	757	776	711	410	37
15	670	668	625	356	41
16	386	382	635	66	218
17	402	407	622	93	156
18	391	382	616	78	186
19	436	418	658	97	149
20	751	735	658	414	38
21	1116	1113	668	780	21
22	576	578	643	256	62
23	1465	1543	663	1504	11
24	1410	1448	676	1090	15
25	772	789	735	412	37
26	572	564	714	211	73
27	926	1030	746	605	26
28	714	769	718	382	40
29	522	524	735	155	99
30	564	598	729	581	27
31*	308	299	521	43.	332

32*	393	368	535	113	127
33*	318	358	547	64.5	221
34 *	365	361	533	963	156
35	442	436	698	89.8	129
36	403	406	685	62.0	243
37	407	410	633	92.3	157

Note: All capillaries are 5 cm long, except those marked with* that are 4 cm long. 1 M KCl was filled in the chip system, and the resistance measurement was conducted at room temperature. The fractures were generated by supersonic at 40 Hz for 3 sec.

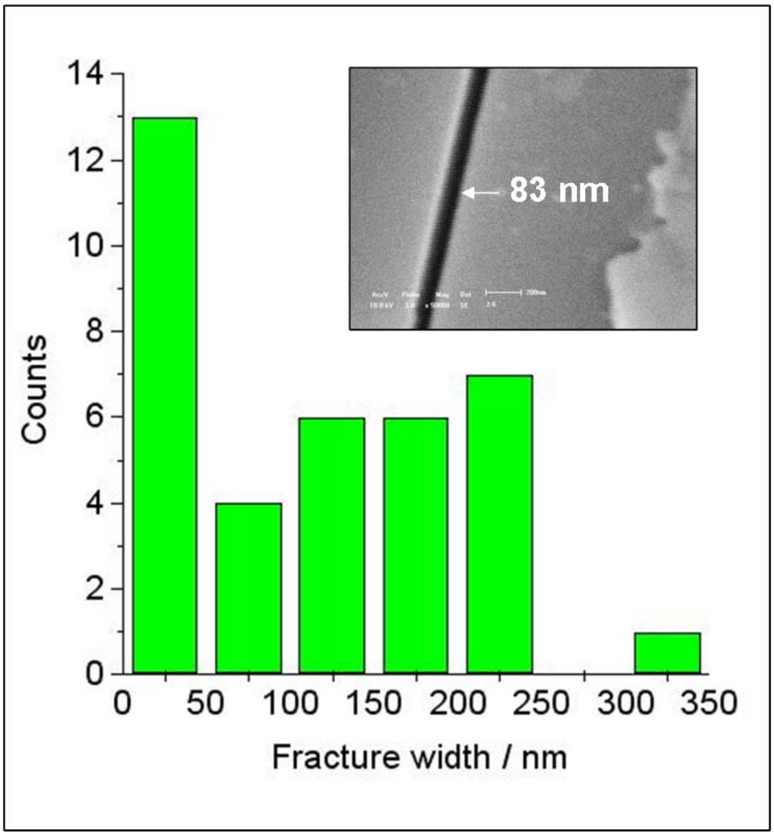

Fig.1S. Statistics of nanofracture generated by ultrasonic, 40 Hz for 3 s. Insert is a SEM of a fracture sample, the scale bar in SEM picture is 200 nm.

4. Current development during stacking

Current development of 2 chips is shown in Fig.2s. As can be seen, that both chip showed current increase by time, and reached the highest level after 1000 s, and a trend of decreasing was noticed for the chip with 118 nm fracture.

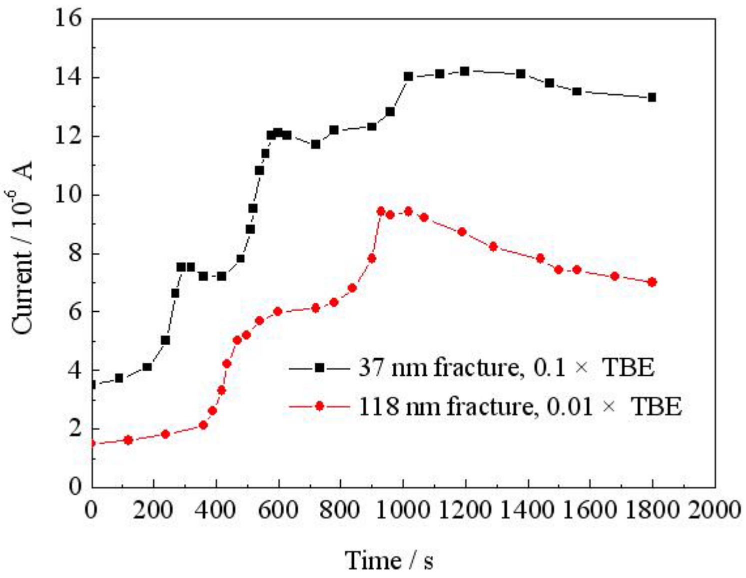

Fig.2s. current development for two chips with different buffer concentrations.

5. Comparison of a capillary fracture interface with and a nanochannel

The ring-disk nanofludic channel formed on a capillary of 100 μm id and 360 μm od, height w, length l = 80 μm; a square nanochannel of the same height h, typically h=5 μm wide, and also 80 μm long. Both filled with the same electrolyte with conductivity of k. According to equation S1 and S3, the ratio of resistance can be expressed as

$$\frac{R_n}{R_F} = \frac{2\pi \cdot l}{h} \ln \frac{r_i}{r_o}$$

The calculated result is about 78.

6. Note on the video clip

A piece of video is provided, which corresponds to 3.2 ng/μL DNA sample in 0.01 M TBE buffer with 0.6×SYBR Green I, 5 cm capillary with 118 nm fracture, voltage 300 V. With blue light excitation, green fluorescence zone was clearly observed inside the capillary at the fracture.