Supplementary information

Plate vibration mode. The speed of transversal shear wave in glass was calculated from the Newton-Laplace equation: $c = \sqrt{\frac{K}{\rho}}$, where K is the shear modulus of the glass (28.5 GPa) and ρ is the density of glass (2.44 g/cm^2), resulting in a shear wave velocity of 3,417 m/s.

The wavelength of the shear wave at 74.3 kHz is hence 3,417 m/s divided by 74,300 s^{-1}, equaling 4.59 cm, which is far larger than the plate thickness (1 mm). Hence the vibration of the plate is mainly dominated by the flexural lamb wave mode.

Calculation of the vibration amplitude. Along the long axis of symmetry of the plate (the x-axis) the out-of-plane displacement in the standing wave is given by $U_z = Acos(kx)e^{i\omega\omega}$, where k is the wave vector, ω is the frequency of the acoustic wave, and x is the coordinate along axis of symmetry. The surface slope is therefore the first derivative of the displacement over x $S_x = \frac{\partial U_z}{\partial x} = -kAsin(kx)e^{iwt}$. As the wavelength λ of the standing flexural wave is approximately 13 mm based on the scanning of the surface profile along the x-axis, then the wave vector k is obtained from $k = \frac{2\pi}{\lambda}$. The maximum value of slope S_{max} is reached when $sin(kx)=1$ with the relation $S_{max} = -kA$. Therefore, the maximum of the displacement U_{max} is reached at the location where cos(kx)=1 and has the value of A while from above $U_{max} = A = \frac{S_{max}}{-k}$. By inserting the values of k and S_{max} from the measurement, we obtained an amplitude of 1.18 μm for the empty plate and 0.24 μm for the PDMS bonded plate at 30 V of driving voltage.

Acoustic pressure and cavitation threshold. Acoustic pressure, p can be calculated by $p = \rho cu$,[2] where ρ is the density of the material, c is the speed of sound, and u is the particle velocity.

If we consider that at the glass/liquid interface, liquid molecules are vibrating at the same

amplitude and frequency as the glass surface, the particle velocity u can be calculated as $u = \xi\omega$, where ξ stands for the particle displacement and ω for the angular frequency.

Since the transducer was operating within its linear range and assuming linear deformation of brittle material like glass, the maximum plate displacement at 300 V can be estimated to be up to 10-fold of the measured displacement at 30 V, resulting in ξ = 2.4×10-6 m. With the density of water being 1,000 kg/m3, the speed of sound in water being 1,497 m/s,3 the frequency f being 74×103 s-1 and the angular frequency being 2πf, the acoustic pressure was approximately 16.5 bar.

Because the cavitation threshold for water in ambient condition was reported to be around 1 to 10 bar,4 the acoustic pressure inside our microfluidic channel should already exceed the cavitation threshold.

(Movie S1.avi)

Movie S1

Cavitation bubble dynamics at 300 V and 74.3 kHz. 1 sec in the movie corresponds to 85.75 μs in real time.

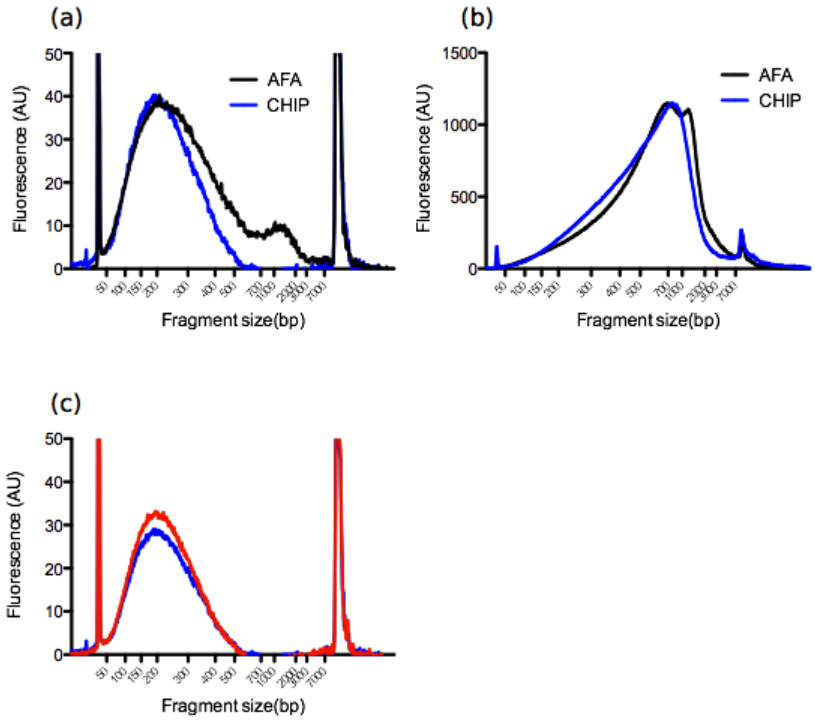

Figure S1

DNA fragmentation performance. (a) and (b), Comparison of the size distribution of DNA fragments generated either by sonication on-chip (blue lines) or using a Covaris AFATM sonicator (black lines) aiming at average sizes of 200 bp and 1000 bp, respectively. (c) Reproducibility of the microfluidic sonication experiments as obtained for two independent experiments (blue and red lines) using the same shearing conditions. For the generation of 200 bp fragments, 7 µL of 10 ng/µL lambda phage DNA was sonicated at 300 V for 10 min using the microfluidic sonicator while 50 µL of 10 ng/µL lambda phage DNA were sonicated when using the Covaris AFATM adjusted to an intensity of 5, 10% duty cycle and a burst of 200 per cycle for 120 sec. For the generation of 1000 bp fragments, the same DNA samples were sonicated at 150 V for 10 min using the microfluidic device, and the Covaris AFATM was adjusted to an intensity of 5, 2% duty cycle and a burst of 200 per cycle for 45 sec.

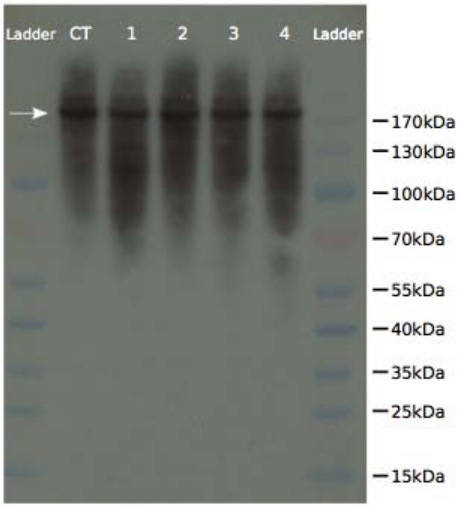

Figure S2

Western blot analysis of covalently cross-linked chromatin after shearing in the microfluidic device. Samples were treated using different sonication conditions (CT: no sonication; 1: 300 V 10 min; 2: 300 V 6 min; 3: 300 V 3 min; 4: 300 V 1 min) and assayed by immunoblot using antibodies against RNA polymerase II (Pol II). The arrow indicates the band of the Pol II complex; Pre-stained protein ladder (PageRuler, Fermentas) was used as marker.

References

1 Y. Ghavi-Helm and E. E. M. Furlong, in Methods in Molecular Biology, eds. B. Deplancke, N. Gheldof, Human Press, 2012, vol. 786, pp. 229–245.

2 T. D. Rossing and N. H. Fletcher, in Principles of Vibration and Sound, Springer, 2004.

3 J. Lubbers and R. Graaff, Ultrasound Med. Biol., 1998, 24, 1065–1068.

4 J. E. Barger, *J. Acoust. Soc. Am.*, 1964, 36, 1008–1009.