Electronic Supporting Information (ESI)† for:

Glass-embedded PDMS microfluidic device for enhanced concentration of nanoparticles using an ultrasonic nanosieve

Bryan Ang, [a] Ankush Sookram, [a] Citsabehsan Devendran , [a] Vincent He, [a] Kellie Tuck, [b] Victor Cadarso [a, c] and Adrian Neild [a]

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[a] Department of Mechanical and Aerospace Engineering, Monash University, Clayton 3800, VIC, Australia Address here.
[b] School of Chemistry, Monash University, Clayton 3800, VIC, Australia
[c] Centre to Impact Antimicrobial Resistance, Monash University, Clayton 3800, VIC, Australia

A. Material properties in numerical simulations

Table S1: Parameters used in numerical simulations. Material properties are taken directly from the COMSOL library unless stated otherwise.

Parameter	Symbol	Value	Unit
128° Y-cut Lithium Niobate			
Density	ρ_{LN}	4650	kg/m^3
Speed of sound	C_{LN}	3997	m/s
Polydimethylsiloxane (PDMS, 10:1)			
Density	ρ_{PDMS}	920	kg/m^3
Speed of sound	C_{PDMS}	1076.5	m/s
Attenuation coefficient[1]	α_{PDMS}	2924.2	1/m
Water			
Density	ρ_O	998	kg/m^3
Speed of sound	C_O	1495	m/s
Dynamic viscosity	η	0.89	mPa.s
Bulk viscosity	η_b	2.47	mPa.s
Compressibility	K_O	448	TPa^{-1}

B. Mesh convergence analysis

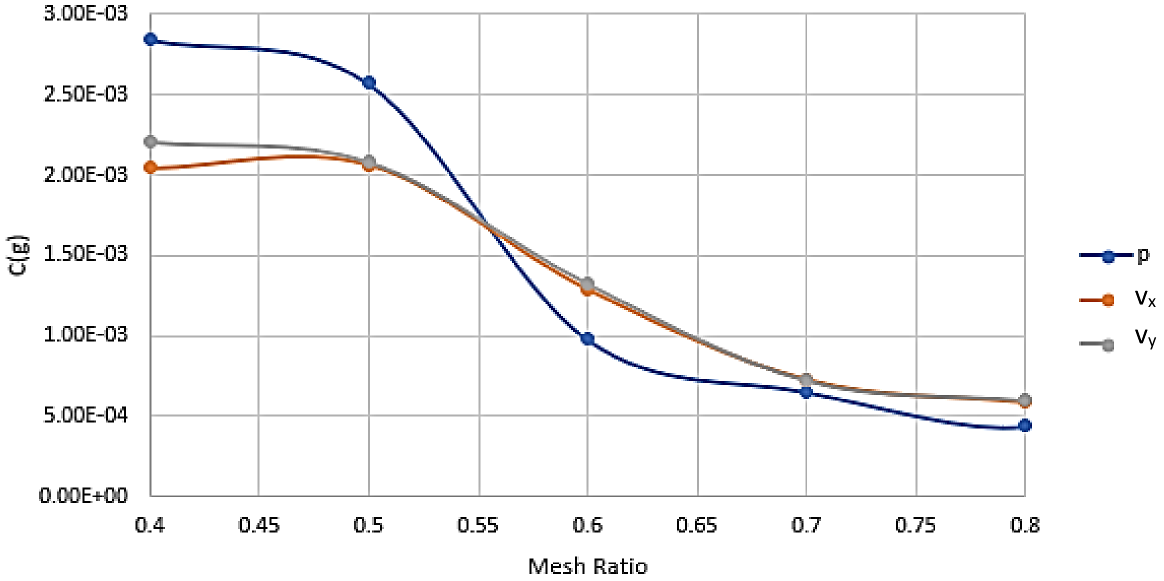

Fig. S2 Mesh convergence of pressure, p and horizontal and vertical velocity field components, v_x and v_y. Convergence is seen at a mesh ratio of 0.6, whereby C(g) is less than 0.002.

A mesh convergence analysis was performed to ensure that adequate spatial resolution was used to efficiently simulate the physics. To quantify convergence, the convergence function C(g) was defined for a solution g with respect to a reference solution, g_{ref} (i.e. finest mesh distribution of element size 0.10 μm) as used by Muller et al.[1]

$$C(g) = \sqrt{\frac{\int (g-g_{ref})^2\, dxdy}{\int (g_{ref})^2\, dxdy}} \qquad \text{(S1)}$$

To ensure that convergence is reached for all parameters below C(g) = 0.002, we used a mesh ratio of 0.6 and element size of 0.167 μm.

C. Analytical model details

The SAW attenuation coefficient through water and PDMS used were α_{water} = 34.35 1/m and α_{PDMS} = 2924.25 1/m.

Equations used were based off work by Keefe et al.[2] The attenuation of energy transmitted through a material or medium can be calculated from Eqn S2.

$$E_{att} = E_0 e^{-\alpha h} \quad \text{(S2)}$$

where E_0 is the input energy, α is the attenuation coefficient and h is the material thickness.

As full reflection is assumed at the glass-PDMS interface, energy attenuation through the glass layer can be assumed negligible. The reflection fractions calculated from the acoustic impedances of each material at each interface can be calculated using Eqn S3. The acoustic impedances used for water and PDMS were Z_{water} = 1.494 × 10^6 Ns/m^3 and Z_{PDMS} = 1.048 × 10^6 Ns/m^3 respectively. The reflection fraction at the PDMS-glass interface was assumed as 1 which is a valid assumption due to the large acoustic impedance mismatch between these two layers. (Z_{glass} = 1.318 ×10^7 Ns/m^3).

$$R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2 \quad \text{(S3)}$$

The transmission fraction at each interface can be calculated from Eqn S4.

$$T = 1 - R \quad \text{(S4)}$$

The energy reflected and transmitted can be calculated from Eqn S5 and Eqn S6.

$$E_{refl} = E_{att}\, R \quad \text{(S5)}$$

$$E_{trans} = E_{att}\, T \quad \text{(S6)}$$

The acoustic energy density within the fluid channel can then be calculated from the sum of energies transmitted and reflected in the fluid, as seen in Eqn S7.

$$E_{total} = E_{refl} + E_{trans} \quad \text{(S7)}$$

D. Imaging region and brightfield image of microparticle packed bed

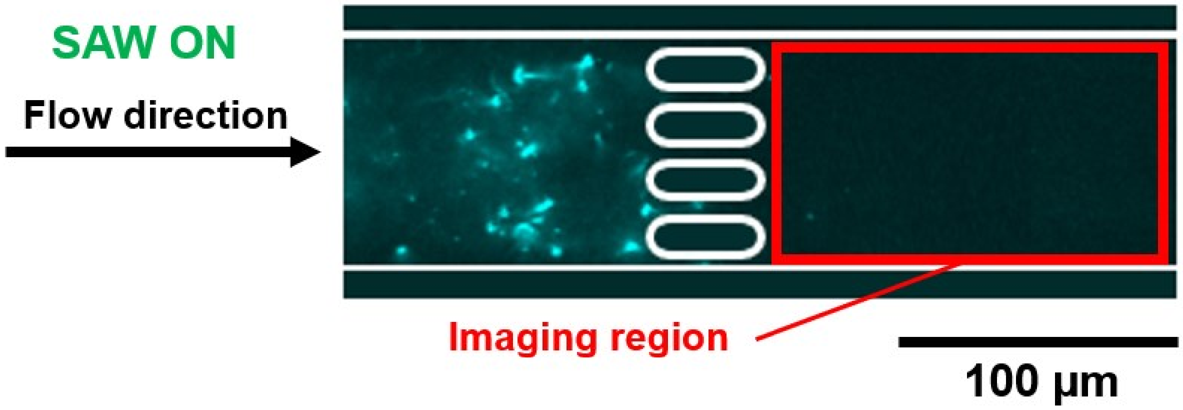

Fig. S4 Fluorescence image at 20x magnification showing imaging region indicated by the red rectangle and the low fluorescence intensity downstream as most of the fluorescent nanoparticles are being captured within the resonating packed bed. The fluorescence intensity was measured in this region during ultrasonic exposure (i.e. SAW on), and this value was normalized between a minimum intensity (background value where no nanoparticles were introduced) and a maximum intensity (nanoparticles flow freely without SAW activation) when calculating the effective capture efficiency.

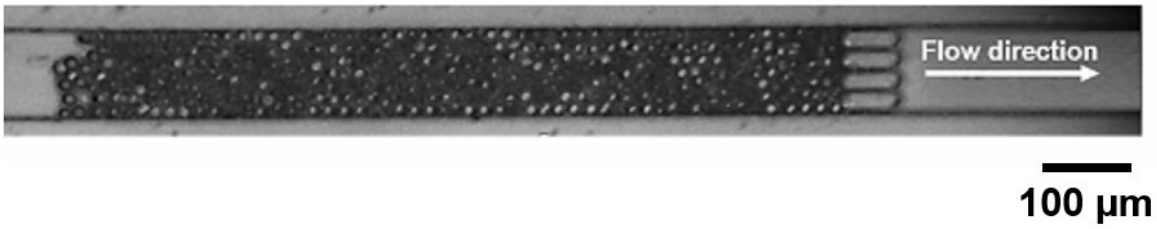

Fig. S5 Brightfield image of the PDMS microchannel at 5X magnification. showing the dense microparticle packed bed structure held by micropillars.

References

1. P. B. Muller, R. Barnkob, M. J. H. Jensen and H. Bruus, *Lab on a Chip*, 2012, **12**, 4617-4627.
2. A. Cafarelli, A. Verbeni, A. Poliziani, P. Dario, A. Menciassi and L. Ricotti, *Acta Biomaterialia*, 2017, **49**, 368-378.
3. D. H. Keefe, R. Ling and J. C. Bulen, *The Journal of the Acoustical Society of America*, 1992, **91**, 470-485.