SUPPLEMENTARY INFORMATION for

Integrating microfluidics and biosensing on a single flexible acoustic device using hybrid modes

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	ZnO
Piezoelectric coefficient d ₃₃ (pC/N)	12
Dielectric constant	8.66-8.91
Acoustic velocity (longitudinal) (m/s)	6336
Acoustic velocity (transverse) (m/s)	2720
Young's modulus (GPa)	110-140
Poisson's ratio	0.36
Effective coupling coefficient, k^2 (%)	1.5-1.7

Table SI1. Piezoelectric properties of ZnO thin film¹.



Fig. SI1 (a) Images of acoustic devices with hybrid wave modes on 1.5 mm-thick (bulk) and 200 μ m-thick (flexible) Al substrates. (b) Microscope image of IDTs.



Fig. SI2 (a) Scheme of the 3D model used in the simulation. (b) Meshing of the 3D model.

	ZnO	Au	Al	H_2O
Density (g/cm ³)	5.68	19.3	2.7	1
Young's modulus (GPa)		79	70	
Poisson's ratio		0.42	0.35	
Coupling matrix (C/m ²)	$e_{31} = -0.51 \pm 0.04 C/m^2$			
	$e_{33} = 1.22 \pm 0.04 C/m^2$			
	$e_{15} = -0.45 \pm 0.02 C/m^2_2$			
Elasticity matrix (GPa)	$C_{11} = 209.7GPa, C_{12} = 121.1GPa,$			
	$C_{13} = 105.1GPa, C_{33} = 210.9GPa,$			
	$C_{44} = 42.47GPa_{,C_{66}} = 44.29GPa_{,3}$			
Relative permittivity	$\kappa_{11} = 7.77$, $\kappa_{33} = 8.91$ ₄			
Speed of sound (m/s)				1498

Table SI2. Material properties used in FEA simulations.



Fig. SI3 Fundamental resonant frequencies of A-TSM obtained from FEA simulations with different domain sizes.



Fig. SI4 1 μ L distilled water droplet (2 mm diameter) moves along the surface to the red arrow direction, driven by LFE-TSM wave (at a power of 10 W) at different times (a) t = 0 s (before actuation), (b) t = 2 s and (c) t = 4 s. Droplet transport was achieved using the LFE-TSM waves, however, this required high input powers and yielded much lower velocities than those generated from the SAWs and Lamb waves.



Fig. SI5 We conducted the same Imatinib sensing experiments as shown in Fig. 5b of the main text, with a higher order of LFE-TSM wave at a resonant frequency of 46 MHz. The results confirmed the working principle of LFE-TSM based on sensing the mass change due to the loss of the 'Aptamer-Imatinib' complex. The sensitivity was calculated as $1.9 \text{ kHz/(cm^2 \cdot \mu M)}$.

References

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