Electronic Supplementary Information (ESI)

Large-Scale Acoustic Single Cell Trapping and Selective Releasing

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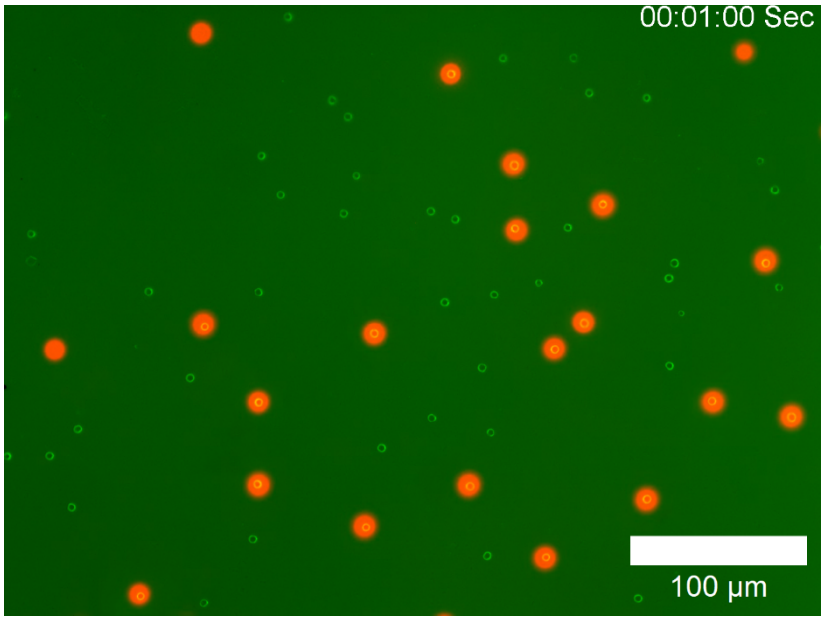
This ESI file includes:

Captions for movies S1 to S6

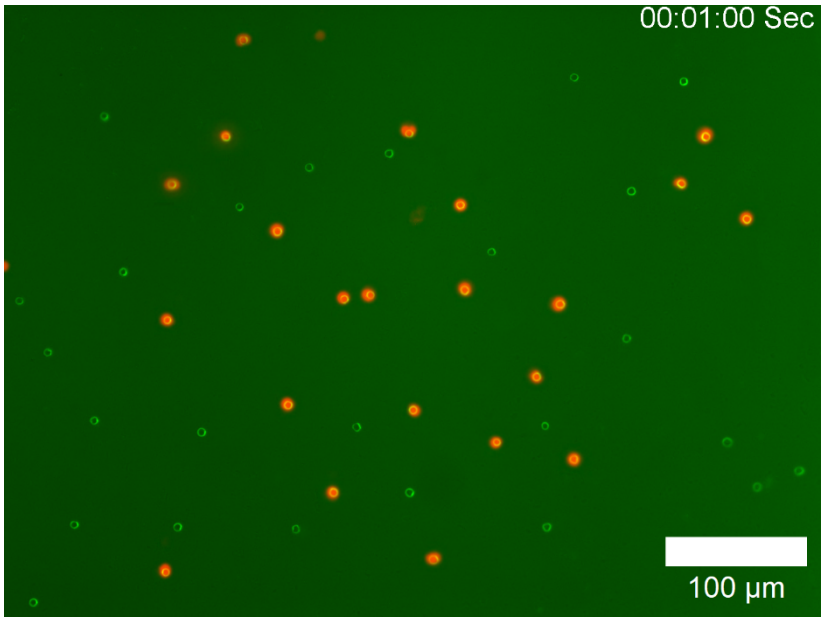
Figs. S7 to S10

Other supplementary materials for this manuscript include the following:

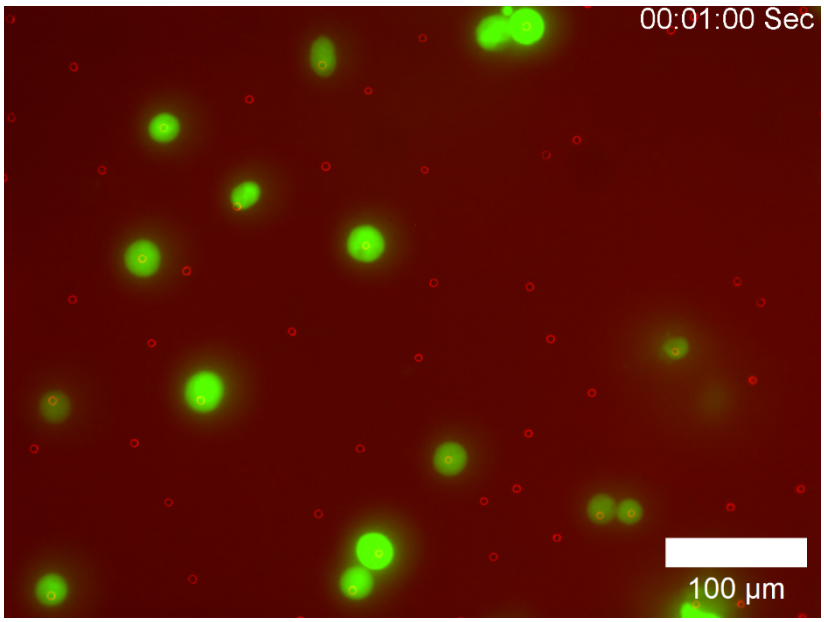
Movies S1 to S6



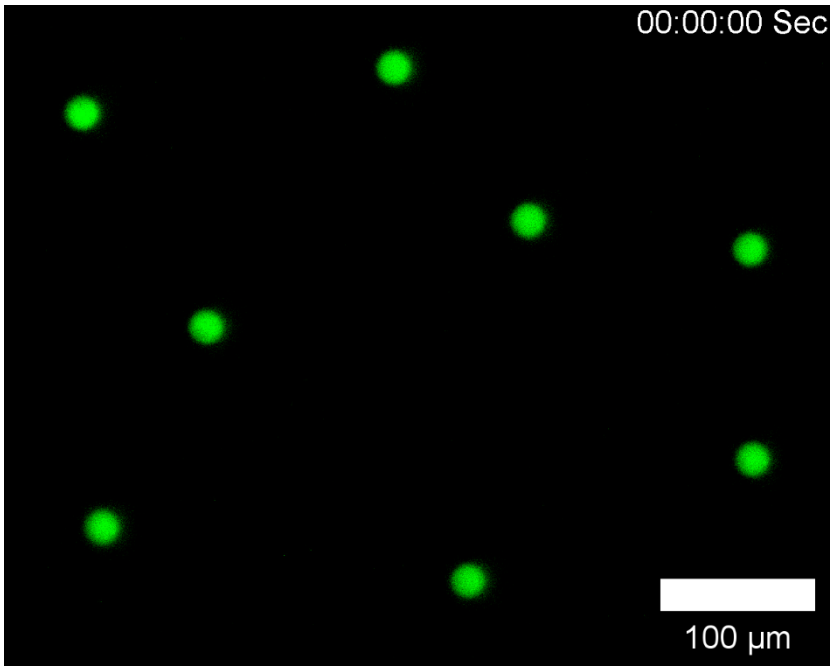
Movie S1. *10 µm red fluorescent polystyrene beads in water are trapped by 5 µm air cavities at the acoustic excitation of 3 MHz and 17 Vpp.*



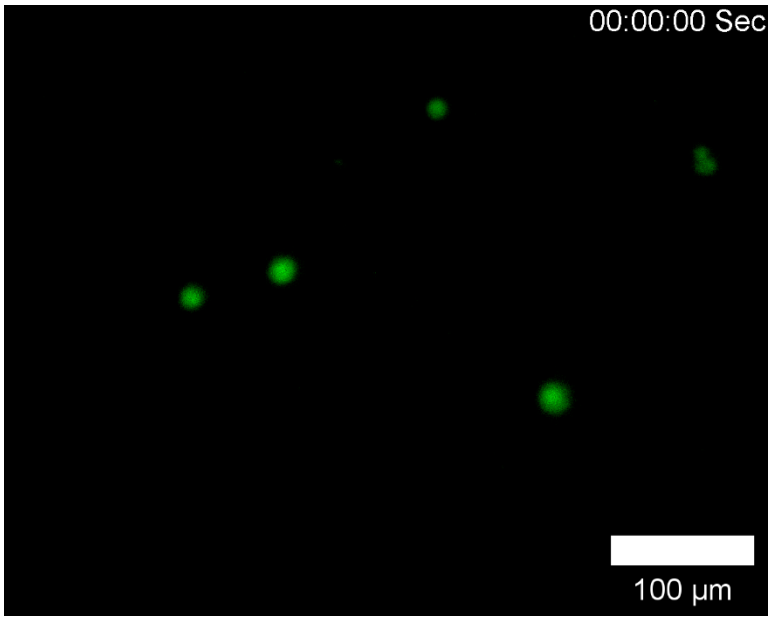
Movie S2. *A20 lymphoma cells in culture medium are trapped by 5 µm air cavities at the acoustic excitation of 3 MHz and 17 Vpp. The size of the cells ranges from 8 to 15 µm.*



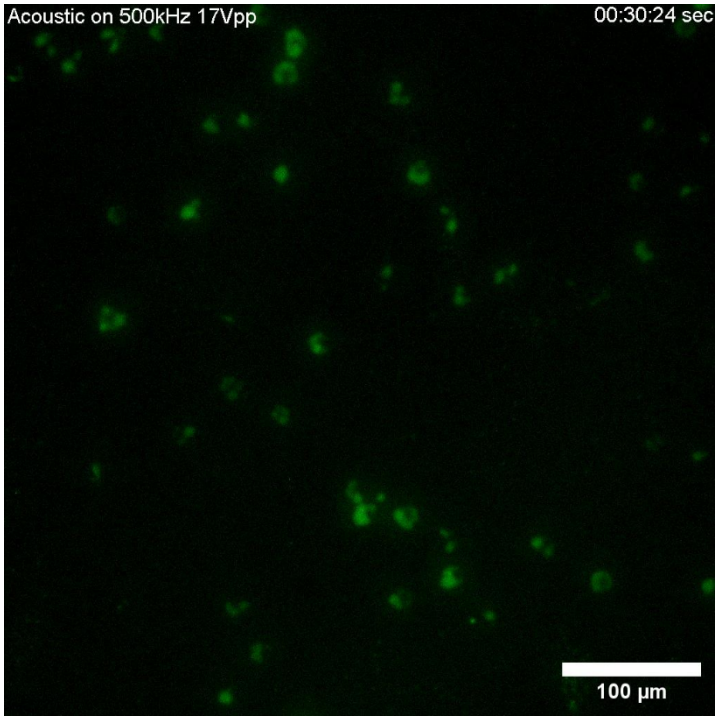
Movie S3. *LNCap cells in culture medium are trapped by 5 µm air cavities at the acoustic excitation of 3 MHz and 17 Vpp. The size of the cells ranges from 20 to 30 µm.*



Movie S4. *10 µm green fluorescent polystyrene microspheres initially trapped by 5 µm air cavities at the acoustic excitation of 3 MHz and 17 Vpp. Upon laser activation, the air cavities are selectively disrupted, releasing the microspheres one by one. The released particles are then flushed downstream by the background flow.*



Movie S5. *Green fluorescent A20 lymphoma cells are trapped in place by 5 µm air cavities at the acoustic excitation of 3 MHz and 17 Vpp. When the air cavities are selectively disrupted by the laser, the cells are released one by one and subsequently flushed downstream.*



Movie S6. *1 µm green fluorescent polystyrene microspheres are trapped at the acoustic excitation of 500 kHz and 17 Vpp. Under this excitation, the microspheres circulate in vortices around the 5 µm air cavities, highlighting strong acoustic streaming flow near the cavity region. When the frequency is switched to 3 MHz at the same voltage (17 Vpp), the acoustic streaming effect is almost completely suppressed, as evidenced by the minimal movement of the tracer beads.*

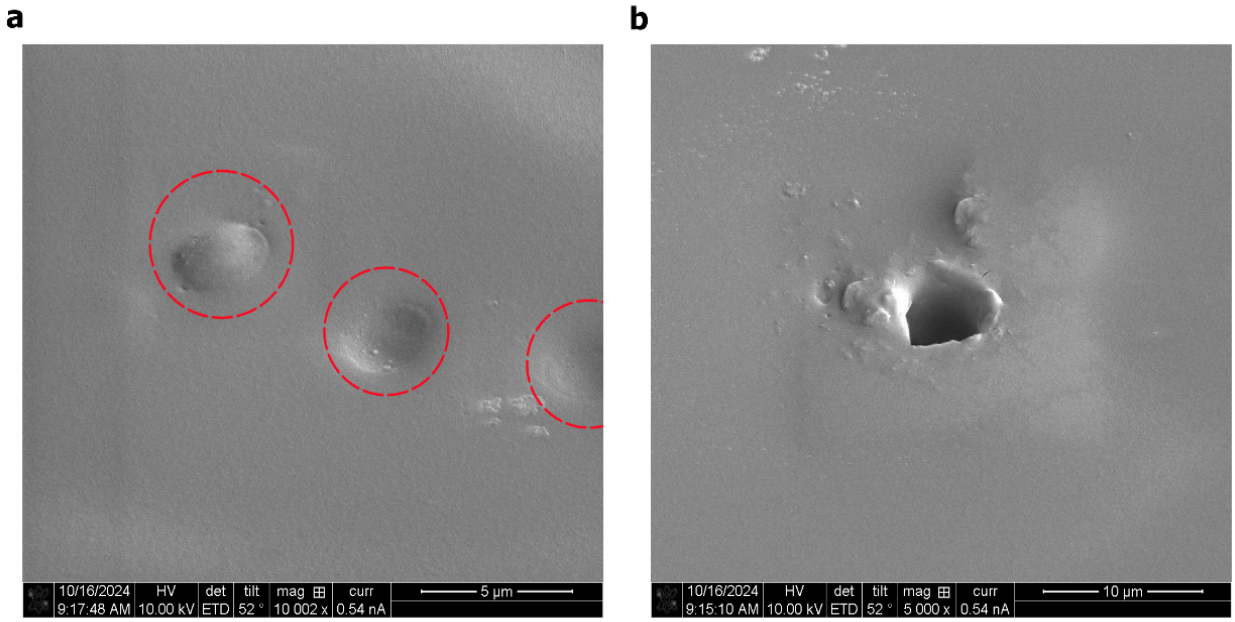
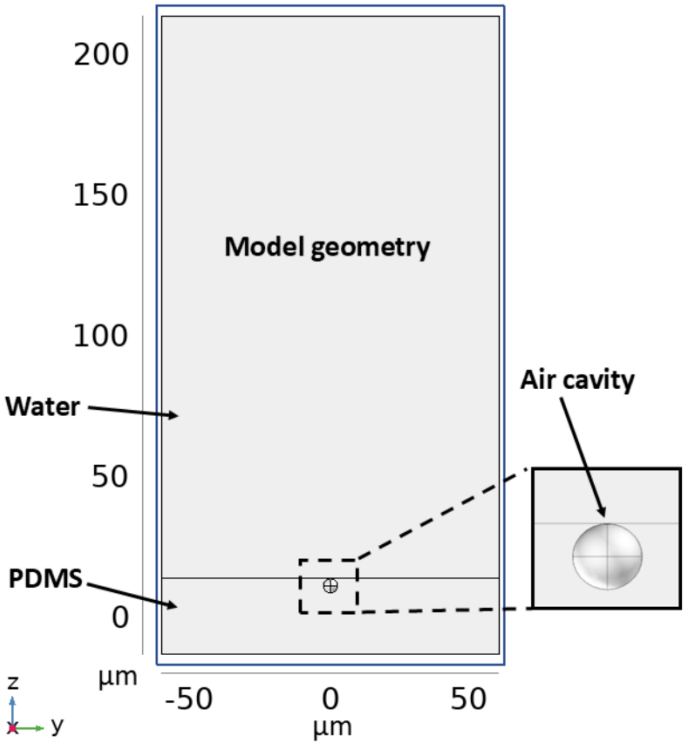


Fig. S7: *SEM images of air cavities before and after laser-induced destruction.* ***(a)*** *Three intact air cavities with thin membranes, highlighted by red dashed circles. The average membrane diameter is approximately 2 µm.* ***(b)*** *An air cavity after exposure to a 1030 nm near-infrared laser, showing the membrane destroyed with an average hole diameter of around 4 µm.*



Study Frequency	3MHz
Isotropic Loss Factor	0.2
Storage Modulus	0.1MPa
Dynamic Modulus	StorageM + i*tan(Iso_Loss)*StorageM
Density of Polystyrene Beads	1050 kg/m^3
Density of Water	1000 kg/m^3
Density of PDMS	965 kg/m^3
Polystyrene Beads Isentropic Compressibility	2.38×10^{-10} Pa^{-1}
Water Isentropic Compressibility	4.45×10^{-10} Pa^{-1}

Fig. S8: *Cross-sectional view of the 3D model geometry for the acoustic-structural interaction module. The model includes water (top region) and PDMS (bottom region), with an embedded air cavity within the PDMS layer to simulate acoustic trapping effects. The dashed box highlights the air cavity used to examine acoustic-structural interactions. Key parameters used for the simulation are shown in the table.*

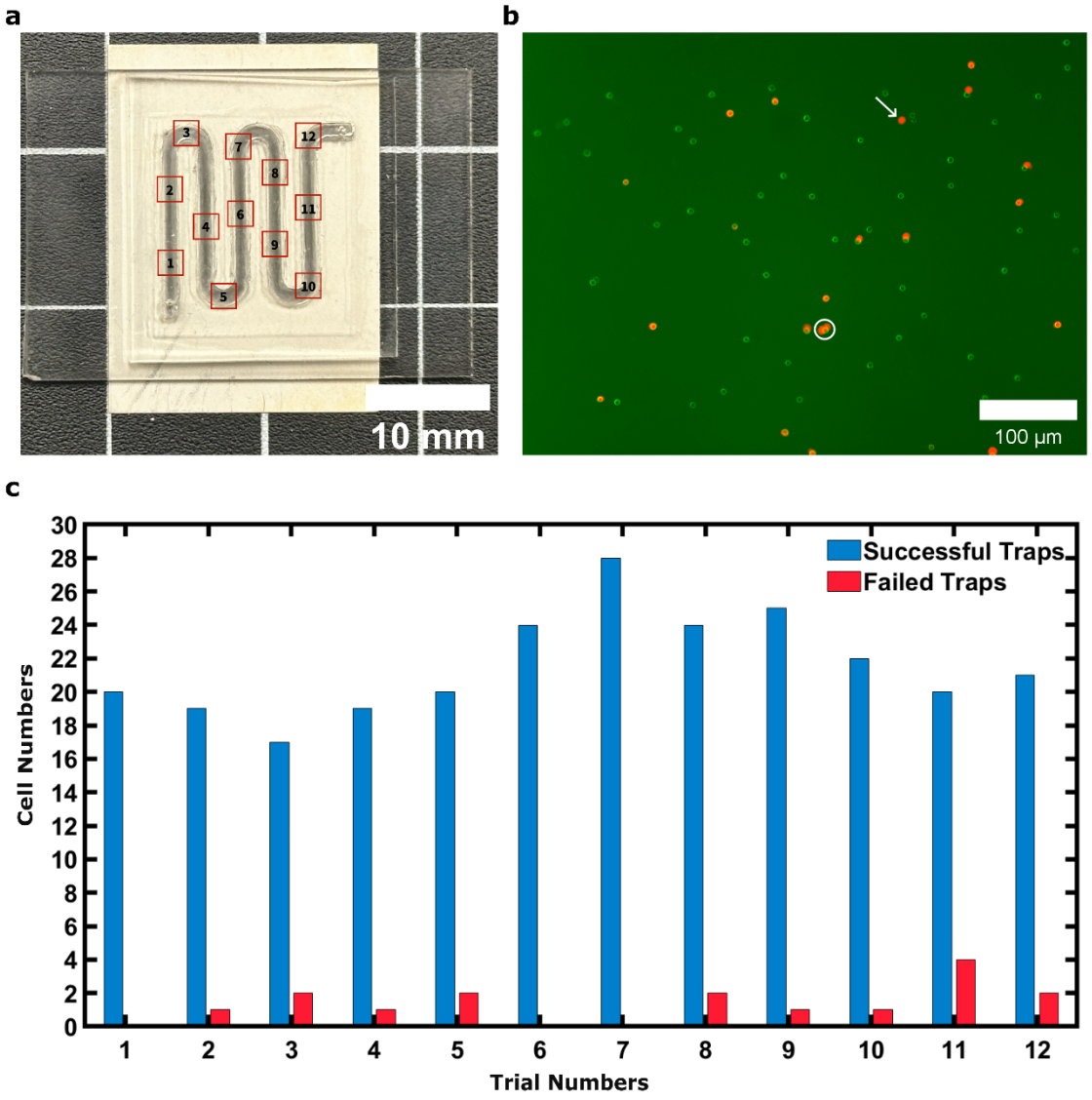


***Fig. 9S**: **(a)** The 12 examination areas sampled along the fluid channel. **(b)** An example image illustrating failed single-cell traps, either due to cell adhesion to the device surface or cell clustering. **(c)** A summary of the cell counts in the 12 examination areas. Of the 275 cells introduced into the observed regions, 259 single cells were successfully trapped, resulting in a single-cell trapping efficiency of 94.09% with a standard deviation of ±4.75%.*

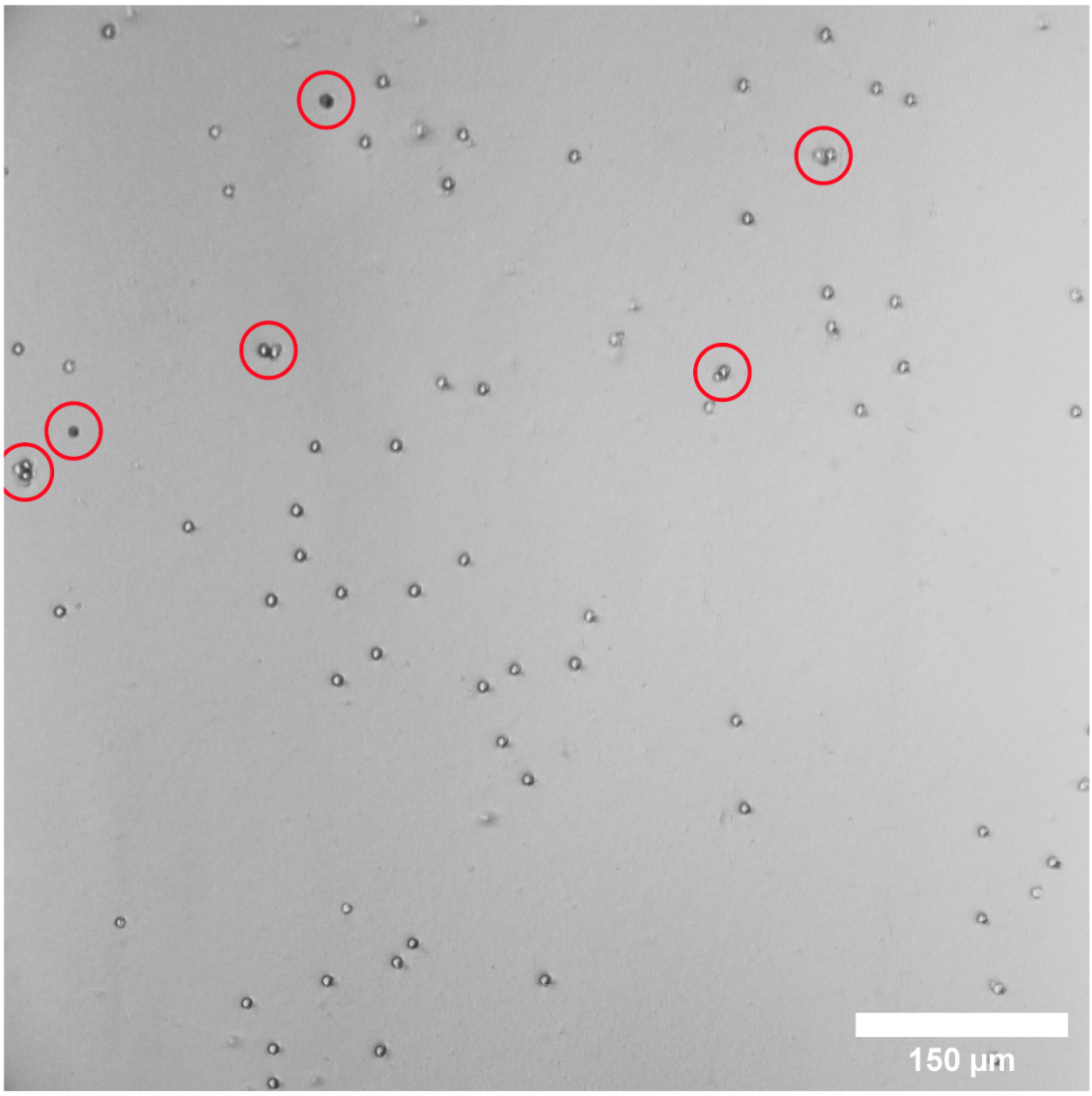


Fig. S10: *Bright-field microscope image of air cavities on the device. Non-functional air cavities, such as those with defects (solid black circles) or cases where two cavities are stuck together, are highlighted with red circles. The functional air cavities account for approximately 90% of the total fabricated air cavities.*