Supporting Information

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Laser-Induced Focused Ultrasound for Cavitation Treatment: Toward High-Precision Invisible Sonic Scalpel

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Note 1. Characteristics of laser-generated focused ultrasound

The waveform is measured using a fiber-optic hydrophone. The waveform and its frequency spectrum are shown in Figure S1.

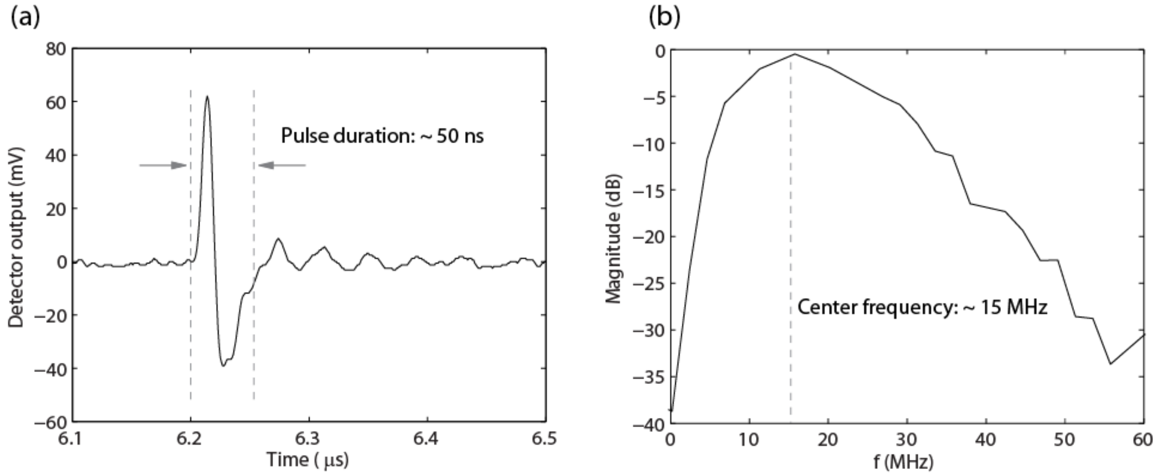

Figure S1. (a) The waveform of PA pulses at the focus. The pulse duration is ~ 50 ns. (b) The frequency spectrum of the PA pulses at the focus in dB scale. The magnitude is normalized to the maximum. The center frequency is ~ 15 MHz.

Note 2. Temperature increase induced by laser-generated focused ultrasound

Although high pressure amplitudes (>30 MPa) are applied, temperature increase by the PA pulses can be minimized, because our approach is based on short-pulse ultrasound (T_d, ~50 ns) and low pulse repetition rate (*PRF*, 10 Hz). The corresponding duty factor is $DF = T_d/(1/PRF)$= 50 ns/(1/10Hz)= 5×10^{-7}. This feature is the key advantage of our approach capable of treating tissue through non-thermal, mechanical effects.

Temperature increase rate induced by ultrasound pulses can be conservatively calculated by neglecting heat dissipation and blood flow, as using the formula:

$$\frac{dT}{dt} = \frac{q}{\rho c_t} = \frac{2\mu I}{\rho c_t}, \quad \text{(S1)}$$

where q is the heat generation rate [W/m^3], ρ is the density, c_t is the heat capacity, μ is the amplitude absorption coefficient, and I is the acoustic intensity [W/m^2].

For typical ultrasound parameters of laser-generated focused ultrasound (p = 30 MPa, fc = 15 MHz, pulse duration = 50 ns, pulse repetition frequency (PRF) = 10 Hz), the temperature increase rate is 2×10^4 [°C/s]. For the estimation, acoustic intensity $I = p^2/2Z$ and $\mu = \alpha f_c/8.7$ are used. Within the single pulse duration (50 ns), the temperature increase at the focus is estimated to be 0.001 °C. For PRF of 10 Hz, the pulse to pulse interval is equal to 1/10Hz = 0.1 sec, which is much larger than the pulse duration and thus the heat due to the short pressure pulse will be quickly dissipated.

Table S1. Tissue properties used for temperature estimation

Properties	**Tissue (e.g. kidney)**
Attenuation coefficient (α)	1 dBcm^{-1}MHz^{-1}
Acoustic impedance (Z)	1.66×10^6 kgm^{-2}s^{-1}
Density (ρ)	1060 kg/m^3
Heat capacity (c_t)	3600 J/kgK