Supplementary materials

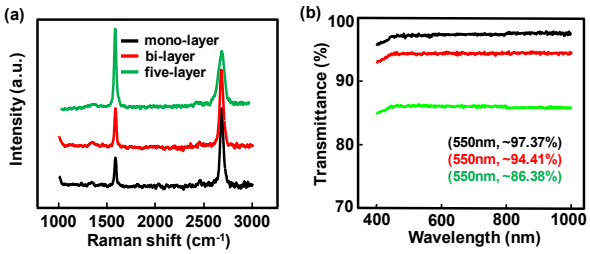

Figure. S1 Raman spectra (a) and optical transmittance (b) of the graphene film with different layers.

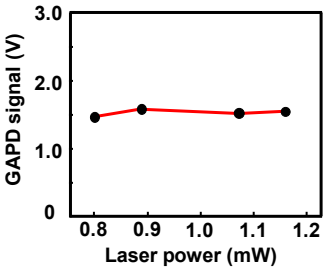

Figure. S2 The effect of the interrogation light power on the ultrasonic detection for the GPAD with ten-layer graphene film.

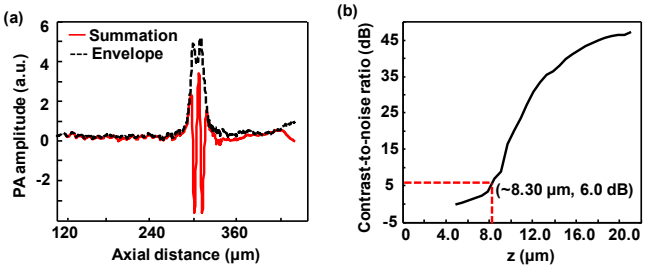

Figure. S3 Axial resolution determined by numerical shift-and-sum simulation. (a) Time-shifted photoacoustic signal and its envelop when the axial distance of the two point sources is set at 10.5 μm. (b) Contrast-to-noise ratio with respect to the axial separation.

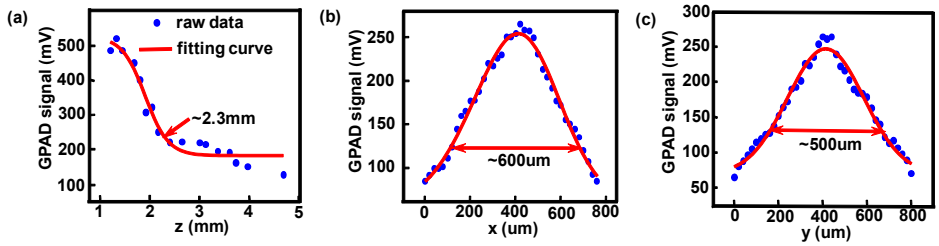

Figure. S4 Determination of the photoacoustic detection sensitivity in depth (a) and transverse (b, c) directions. The arrow in (a) indicates the depth at which the photoacoustic point source was placed to examine the transverse position-dependence detection sensitivity of the GPAD.

We examined the position-dependence detection sensitivity of our GPAD in the depth and transverse directions. In Figure S1a, a photoacoustic (PA) point source is created by tightly focusing the PA excitation onto an optically-absorbing black tape immersed in the deionized water. The induced PA signals were recorded by linearly translating the black tape along the detection axis of the stationary GPAD while maintaining the focal spot of the PA excitation on the tape. The depth position is derived from the time of flight of the PA waves and the velocity of the acoustic waves in water. Similarly, the PA point source is translated horizontally across the detection axis of the stationary GPAD, and the corresponding PA signals were captured at each location (see Figure S1b and c). We intentionally placed the PA point source ~2.3 mm away from the GPAD surface (indicated by an arrow in Figure S1a), where a moderate detection sensitivity is possible.

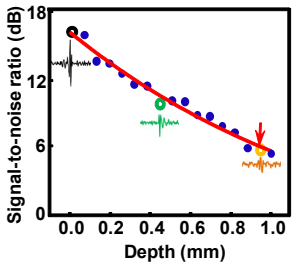

Figure. S5 Determination of the GPAD's imaging depth. Inset represents three photoacoustic A-lines at different depths.

We fabricated a tissue-mimicking phantom by inserting a human hair obliquely into a mixture made from a 1.6% Intralipid solution and 1% agar gel (reduced scattering coefficient of around 1.3 mm^{-1}). Photoacoustic signals at different depths were acquired using the GPAD. The imaging depth is defined when the signal-to-noise ratio of the photoacoustic signal decreases to be ~ 6 dB.

Media 1 PAM volumetric rending of two hairs from different view angles.

Media 2 PAM volumetric rending of *in vivo* vasculatures from different view angles.