

Description of Additional Supplementary Files

Supplementary Video 1. The working principle of 3D-DAT with the slit's opening and closing precisely controlled by a motorized stage. This animation was created using Fusion 360 (Autodesk).

Supplementary Video 2. k-Wave simulation of ultrasound wave propagation from two photoacoustic point sources through the diffractive slit. As the elevational focus of the linear-array transducer is co-localized with the slit opening, a point source from anywhere in the far-field can be effectively detected by the transducer through the slit's diffraction.

Supplementary Video 3. A cross-hair phantom was imaged by DPAT with various slit widths. As the slit width decreases, the elevational target becomes more clear.

Supplementary Video 4. A cross-hair phantom was imaged by DUST with various slit widths. As the slit width decreases, the elevational target becomes more clear.

Supplementary Video 5. A bolus of blood flowing through a silicone tubing inside optically scattering medium.

Supplementary Video 6. Time-lapse DPAT images of a bolus of blood flowing through the tube embedded in optically scattering medium.

Supplementary Video 7. Volumetric rendering of DPAT (green) and DUST (magenta) images of a glassfrog *in vivo*. The DPAT image was acquired at 670 nm, showing primarily the BBS concentrated in the frog skin.

Supplementary Video 8. Time-lapse DPAT images of a tumor-bearing mouse, acquired every 6 minutes following the cGNS injection. A gradual accumulation of cGNS was observed in the tumor region.

Supplementary Video 9. Time-lapse PS-DPAT images of a blood sample (left) and a BphP1-expressing tumor cells sample (right) during a photoswitching cycle. The signal decrease in the tumor cells was due to the switching of BphP1 from the Pfr state (ON state) to the Pr state (OFF state).

Supplementary Video 10. Time-lapse PS-DPAT images of a mouse BphP1-expressing tumor *in-vivo* during a photoswitching cycle. The tumor signal decreased in the first two seconds due to the photoswitching of BphP1 from the Pfr state (or ON state) to the Pr state (or OFF state).

Supplementary Video 11. DPAT images of a cross-hair phantom with 0.8-mm slit width, reconstructed with various synthetic aperture widths.

Supplementary Video 12. DUST images of a cross-hair phantom with 0.8-mm slit width, reconstructed with various synthetic aperture widths.