**Supplementary Information**

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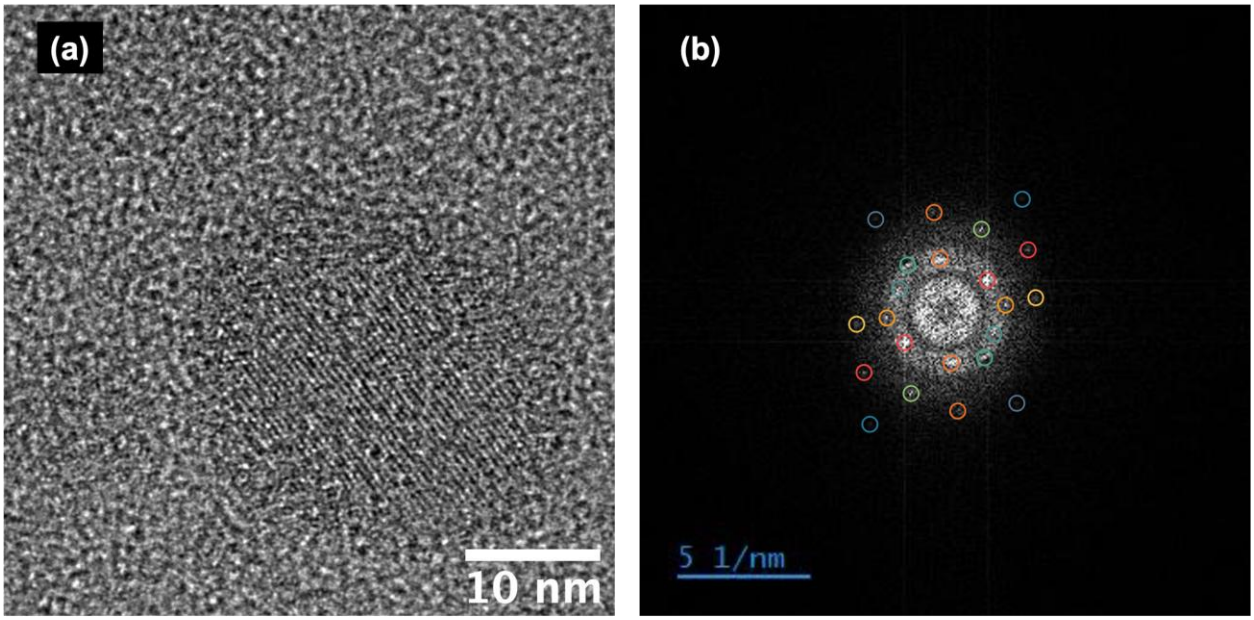


**Fig. S1.** (a) HRTEM image of a QD and (b) its corresponding fast Fourier transform (FFT) pattern calculated from the 15 nm × 15 nm area. In (b), the diffraction spots are grouped by color-coded rings according to their crystallographic orientation, indicating the polycrystalline nature of the QD.

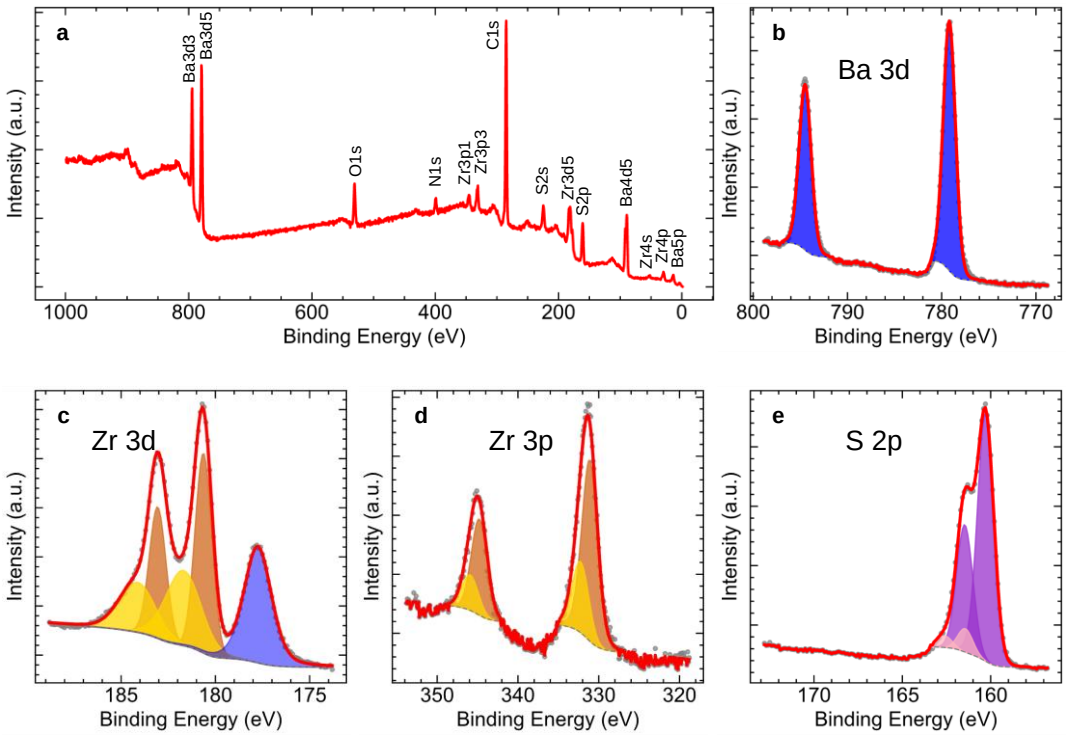


**Fig. S2.** High-resolution XPS spectra. **a)** Wide survey scan; Spectra of **b)** Ba 3d; **c)** Zr 3d; **d)** Zr 3p; **e)** S 2p core levels

X-ray photoelectron spectroscopy (XPS) measurements were performed using a monochromatic Al Kα radiation source. Survey spectra were acquired with a pass energy of 187.85 eV and a step size of 0.5 eV, while high-resolution spectra were collected with a pass energy of 23.50 eV and a step size of 0.1 eV. The binding energy scale was calibrated by referencing the aliphatic C 1s peak to 284.8 eV. The samples were prepared by spin-coating the colloidal solution onto glass substrates.

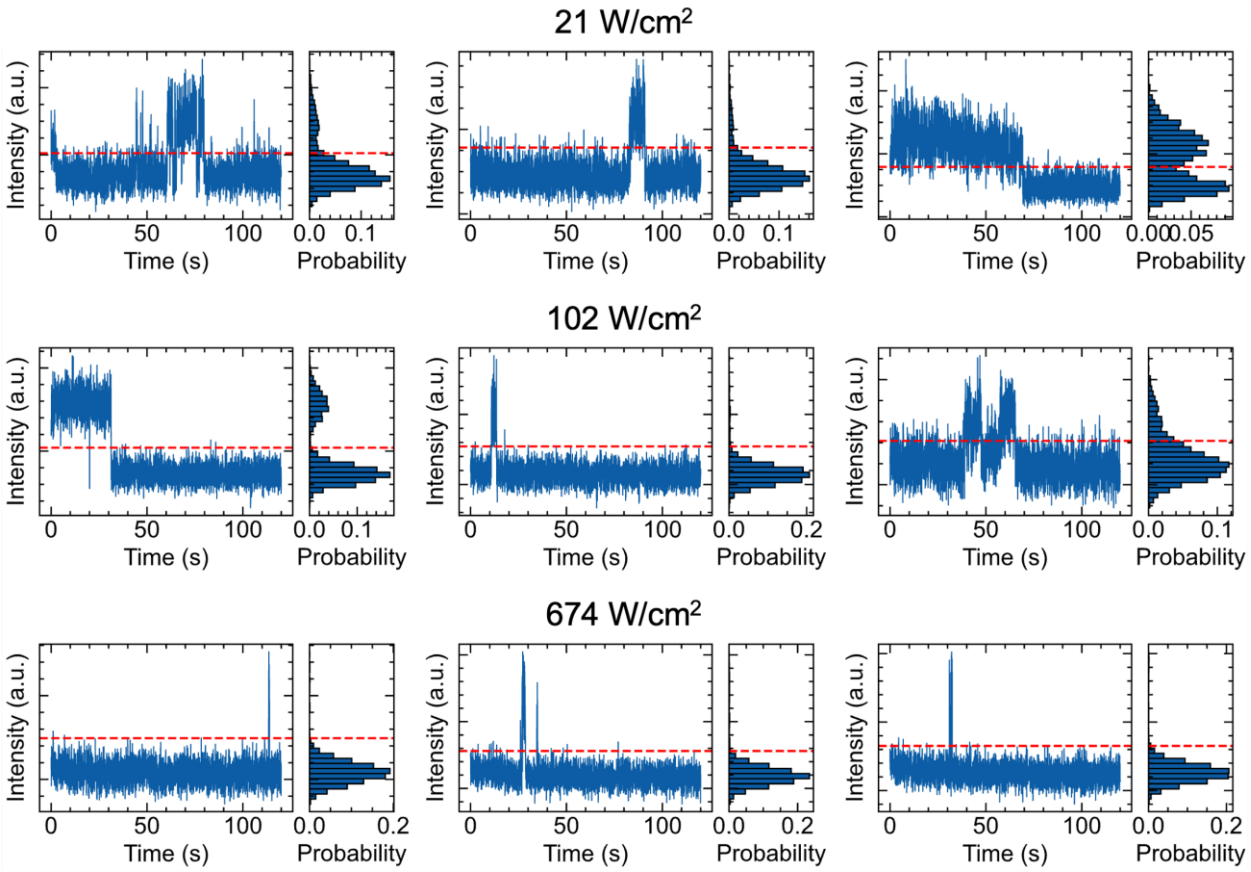


**Fig. S3.** Representative PL intensity time traces and corresponding intensity histograms of single $BaZrS_3$ QDs showing blinking behavior. The excitation powers are 21 W/cm$^2$ (top row), 102 W/cm$^2$ (middle row), and 674 W/cm$^2$ (bottom row).

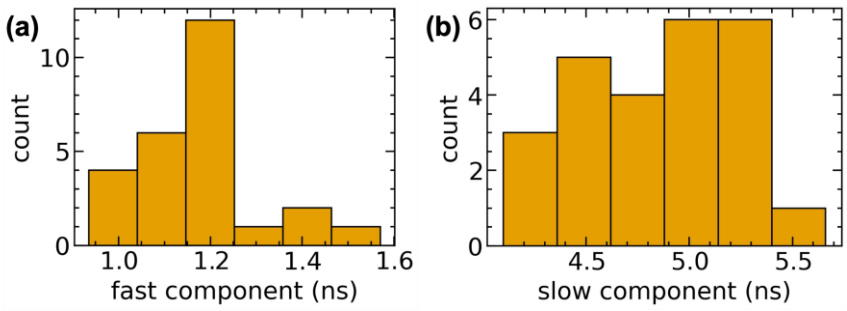


**Fig. S4.** Distribution of fast (a) and slow (b) PL lifetime components measured for 26 individual $BaZrS_3$ QDs.

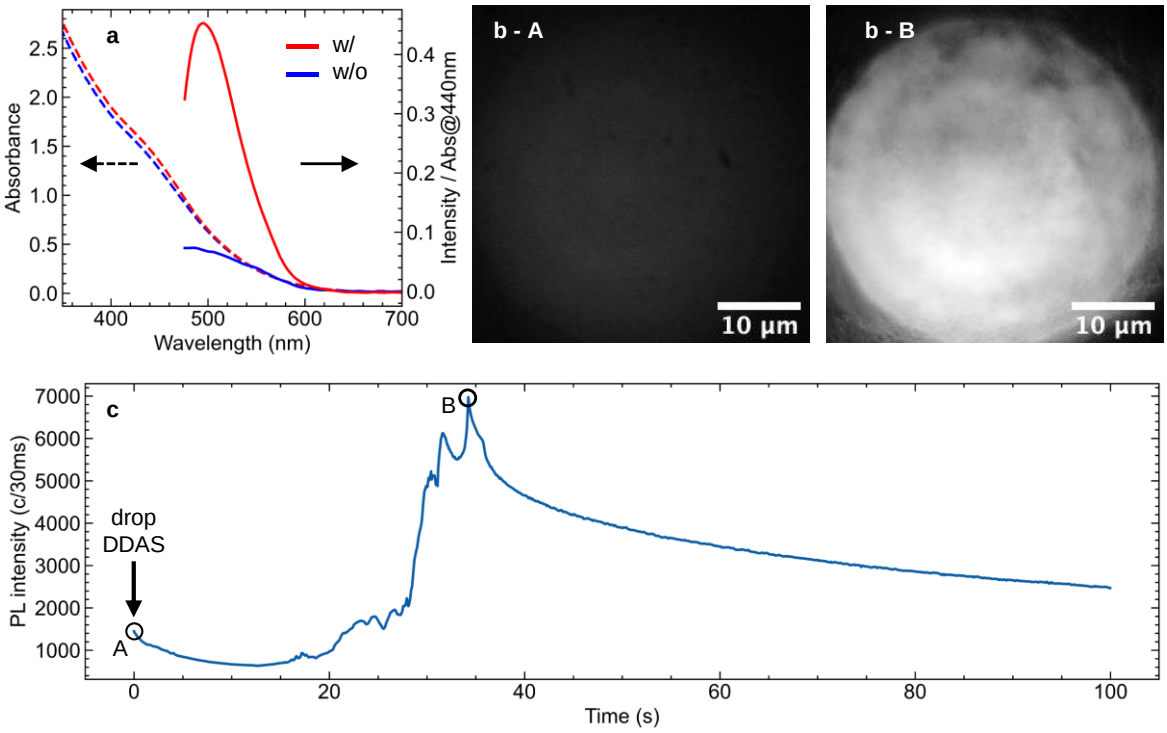


**Fig. S5.** Ligand engineering using DDAS. **a)** Absorption (dashed) and PL (full line) spectra of the $BaZrS_3$ QD solution before (blue) and after (red) adding a toluene solution of DDAB; **b)** Microscopic PL images of $BaZrS_3$ QD dispersion on glass before (A) and ~ 35 s after (B) dropping a DCM solution of DDAB; c) Time evolution of PL intensity integrated from the whole microscopic view-field after dropping the DCM solution of DDAB; the points A and B correspond to the images in **b)**; the PL intensity decline at longer time is caused by photobleaching.