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Supplementary Information for

Design of photoactive hybrids based intelligent photodetectors for identifying the detected wavelength

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1. High-resolution SEM image of graphene/ZnS/CdS films

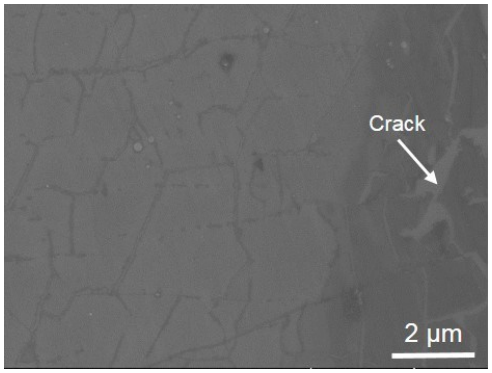

Figure S1. High-resolution SEM image of graphene/ZnS/CdS films. Cracks at graphene edges are clearly identified, while no cracks exist in central area, indicating crackless transfer of graphene.

2. Roughness characterization of graphene/ZnS/CdS films

After graphene was transferred on ZnS/CdS films deposited on 300 nm SiO_2/Si substrate, the roughness of graphene/ZnS/CdS films was characterized by AFM. The roughness is estimated to be around 1 nm excluding particles resulted from the transfer process.

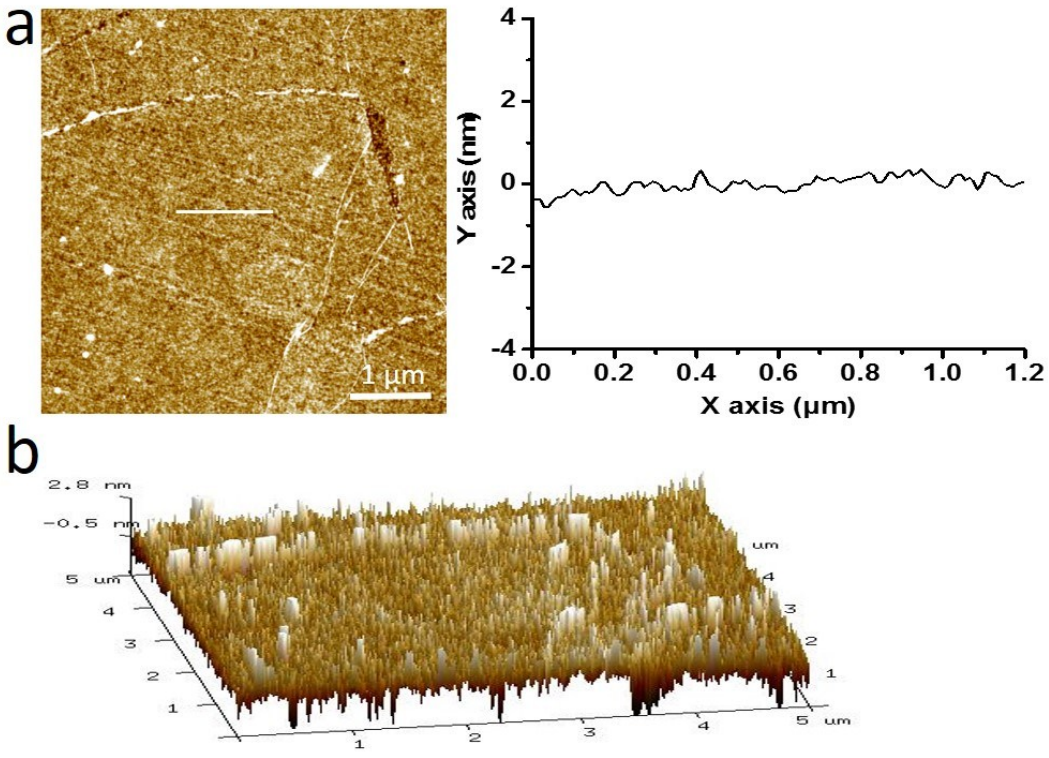

Figure S2. (**a**) Roughness characterization of graphene after transfer on ZnS/CdS films. The roughness is estimated to be around 1 nm. (**b**) AFM image of 3D view corresponding to AFM image in (**a**).

3. Time-dependent response of graphene/CdS hybrid photodetector

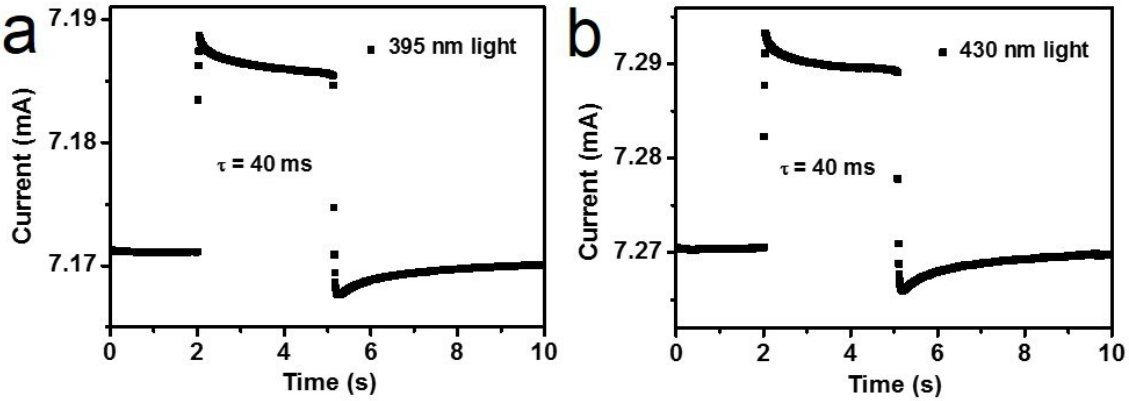

Figure S3. Time-dependent response of graphene/CdS film hybrid photodetector by switching (**a**) 395 nm and (**b**) 430 nm light illumination with power of 1 mW/cm^2 on and off at V_{sd} = 1 V with V_g = 0 V.

4. Time-dependent response of graphene/ZnS/CdS hybrid photodetector

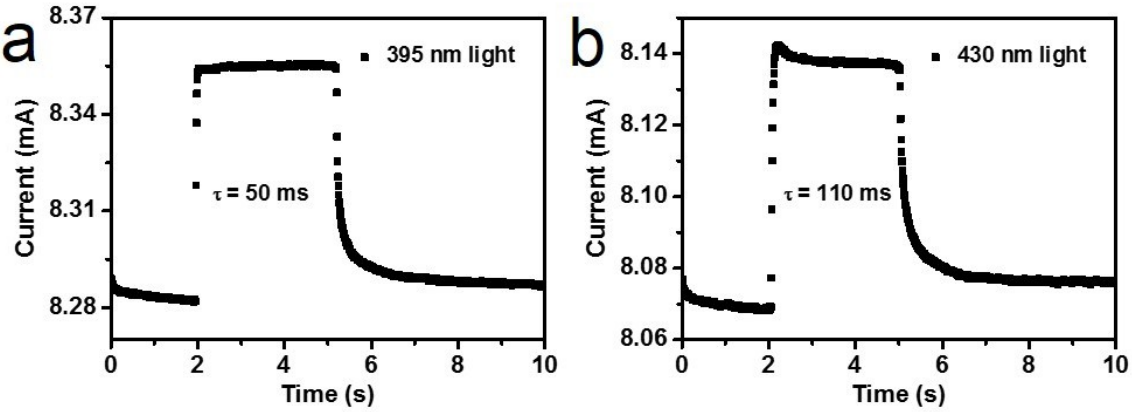

Figure S4. Time-dependent response of the graphene/ZnS/CdS hybrid photodetector by switching (**a**) 395 nm and (**b**) 430 nm light illumination with power of 1 mW/cm^2 on and off at V_{sd} = 1 V with V_g = 0 V.

5. Time-dependent response of graphene/CdS hybrid photodetector ilumiated by 365 nm light with different power intensity

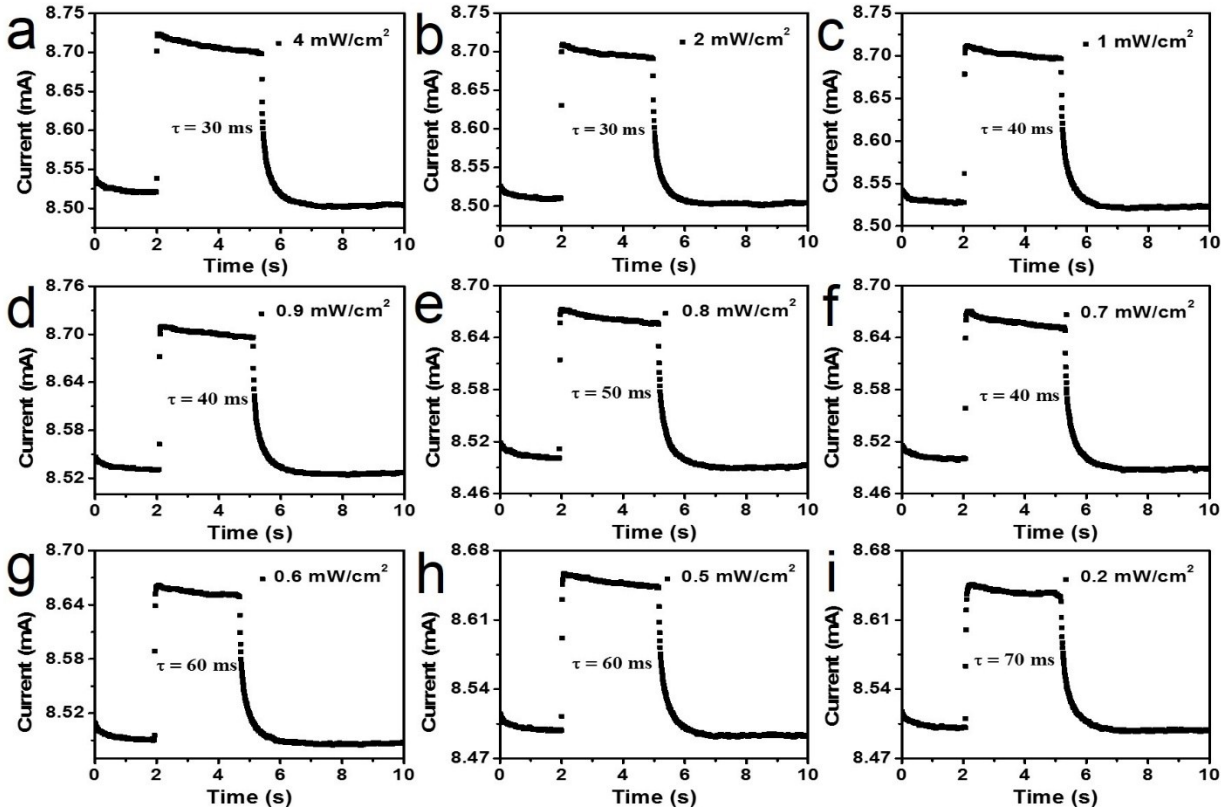

Figure S5. Time-dependent response of graphene/CdS hybrid photodetector ilumiated by 365 nm light with different power intensity.

6. Time-dependent response of graphene/CdS hybrid photodetector ilumiated by 470 nm light with different power intensity

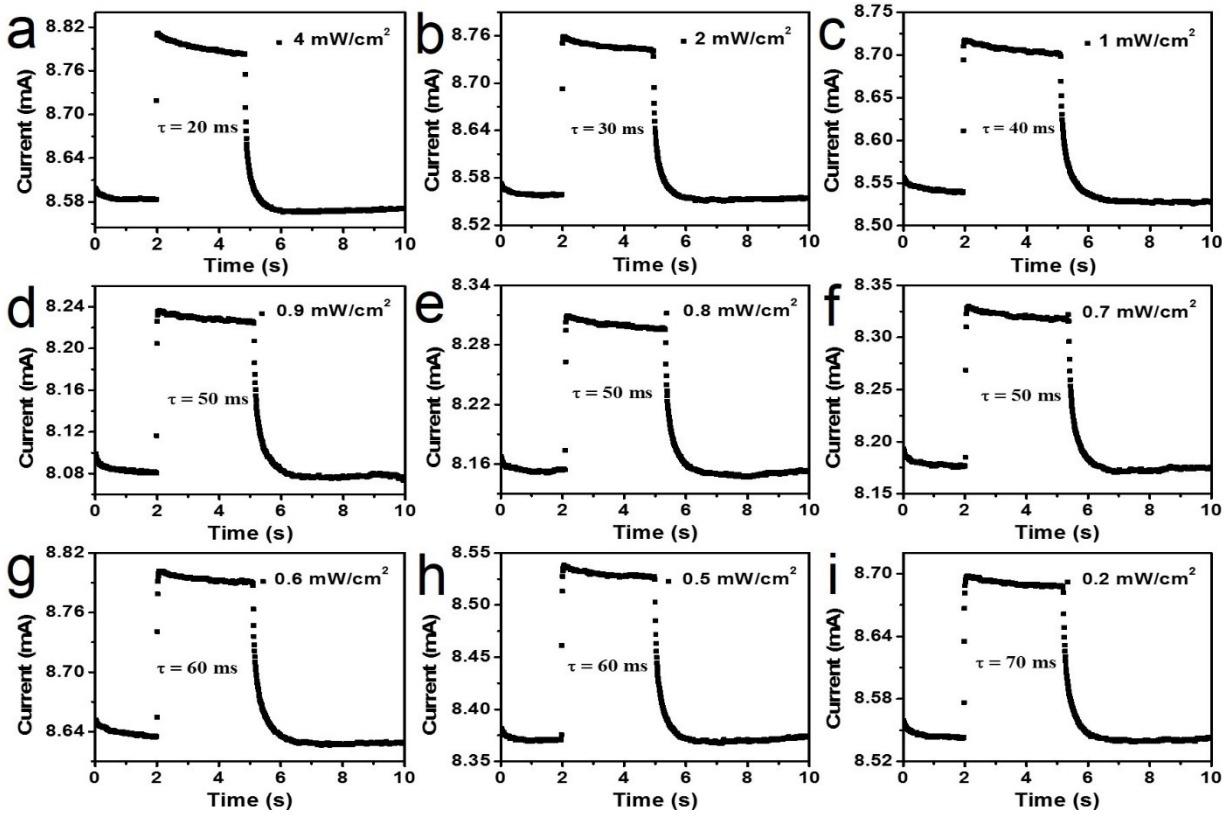

Figure S6. Time-dependent response of graphene/CdS hybrid photodetector ilumiated by 470 nm light with different power intensity.

7. Time-dependent response of graphene/CdS hybrid photodetector with different ZnS thickness ilumiated by 430 nm light

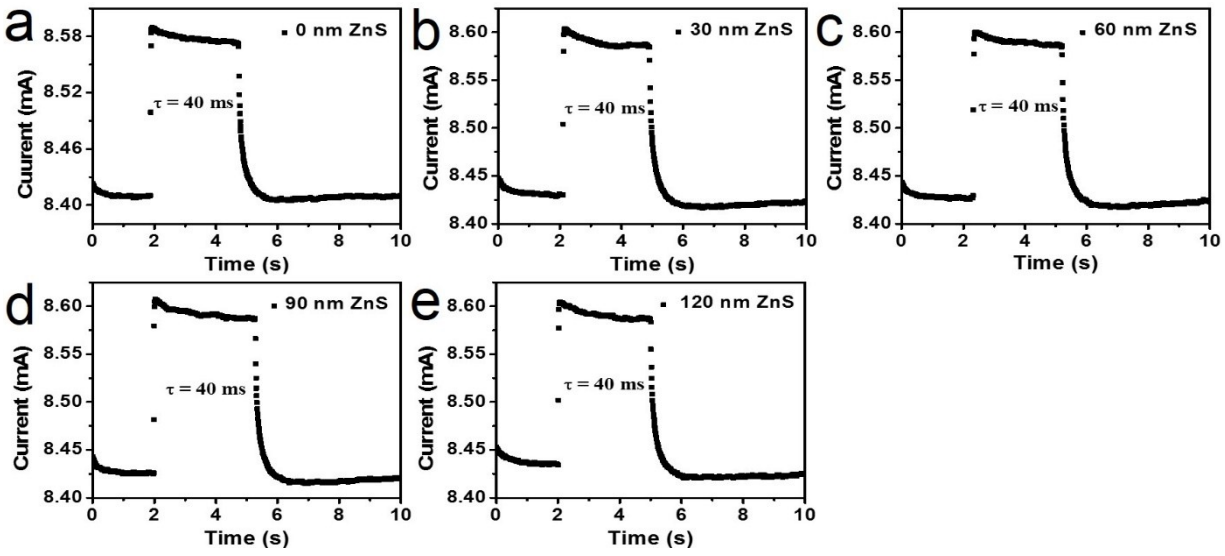

Figure S7. Time-dependent response of graphene/CdS hybrid photodetector with different ZnS thickness ilumiated by 430 nm light with power of 1mW/cm^2.

8. Time-dependent response of graphene/CdS hybrid photodetector with different ZnS thickness ilumiated by 470 nm light

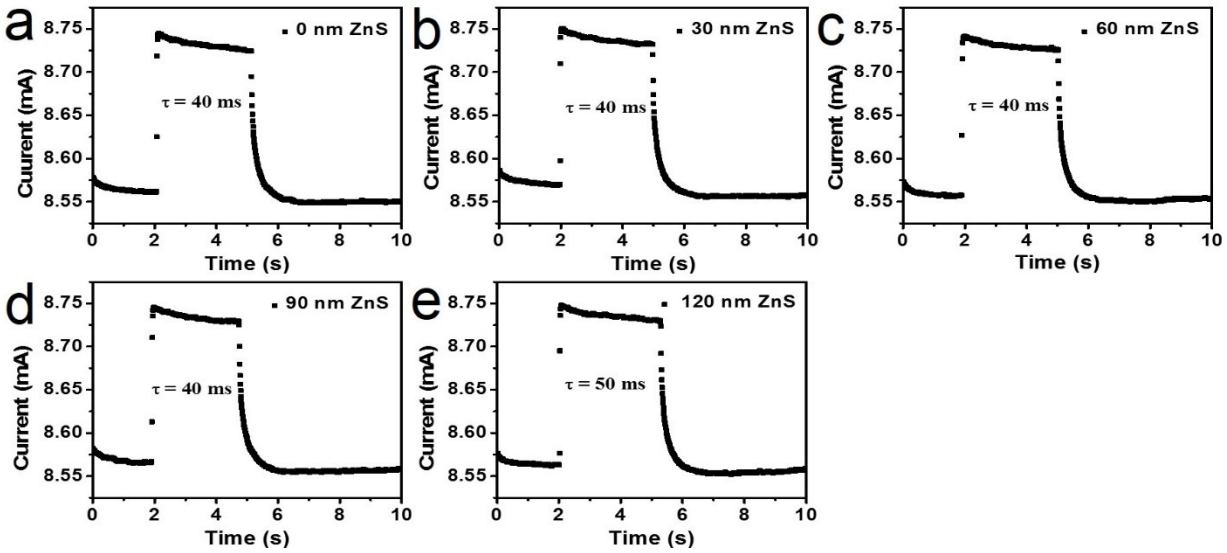

Figure S8. Time-dependent response of graphene/CdS hybrid photodetector with different ZnS thickness ilumiated by 470 nm light with power of 1mW/cm^2.

9. TEM characterization of ZnS and CdS films

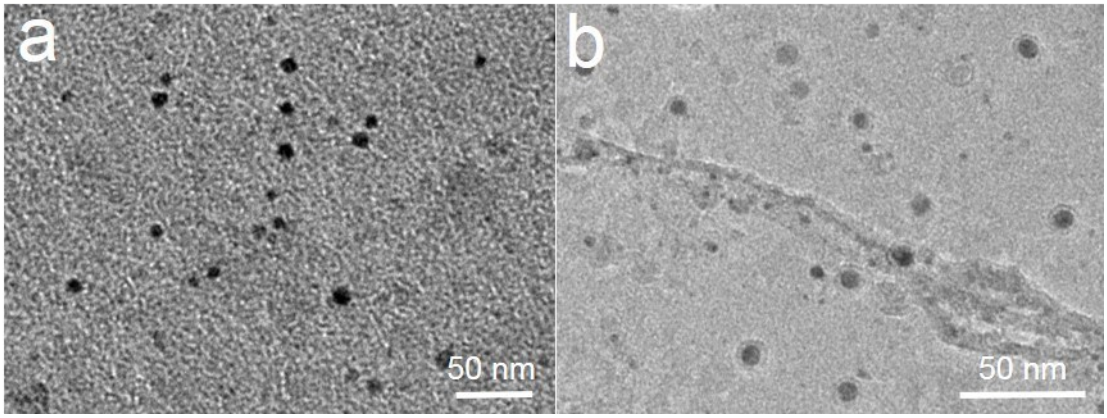

Figure S9. TEM images of (a) ZnS and (b) CdS films. It shows that ZnS and CdS films consist of nanocrystals with the size of about 7 nm.

10. Photoluminescence of ZnS films

Four types of point defects in pure ZnS include zinc vacancies (V_{Zn}), sulfur vacancies (V_S), sulfur interstitial atoms (I_S) and zinc interstitial atoms (I_{Zn}), which generate four trap levels inside the energy gap.[1] V_S and I_{Zn} are considered as localized donor states, while V_{Zn} and I_S are localized acceptor states. To confirm the presence of defects in the deposited ZnS films, the photoluminescence (PL) characterization was conducted (Figure S10), which is the most common characteristic showing the energy structure and defects of the films. The peak at 420 nm is attributed to V_S related emission and the peak at 520 nm is assigned to the electron transfer from V_S to I_S.[2-5] The energy calculation shows that the I_S band energy is about 0.2 eV above valence band of CdS.

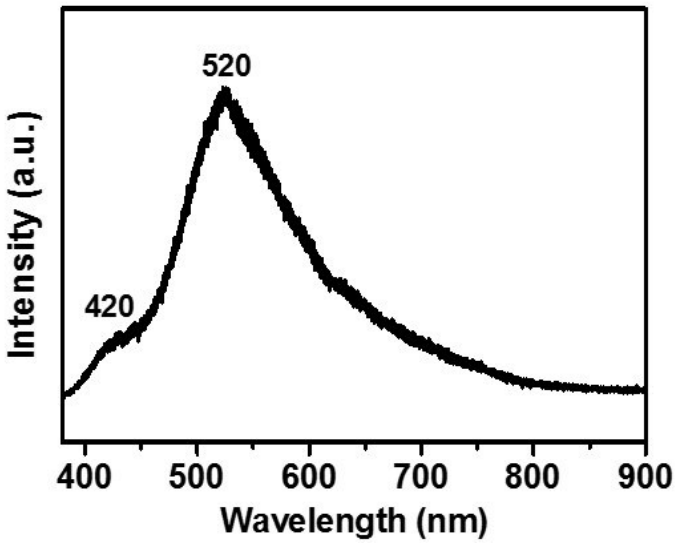

Figure S10. PL spectrum of ZnS films deposited by e-beam evaporation method. Two emission peaks around 420 nm and 520 nm are noted.

11. Time-resolved photoluminescence spectroscopy

The proposed charge transfer in ZnS/CdS hybrids is further supported by time-resolved PL spectroscopy in Figure S6. Compared to CdS, the average PL lifetime is shortened in the ZnS/CdS hybrids. It is reasonably attributed to the transfer of excited holes from CdS to ZnS through defect states.[6]

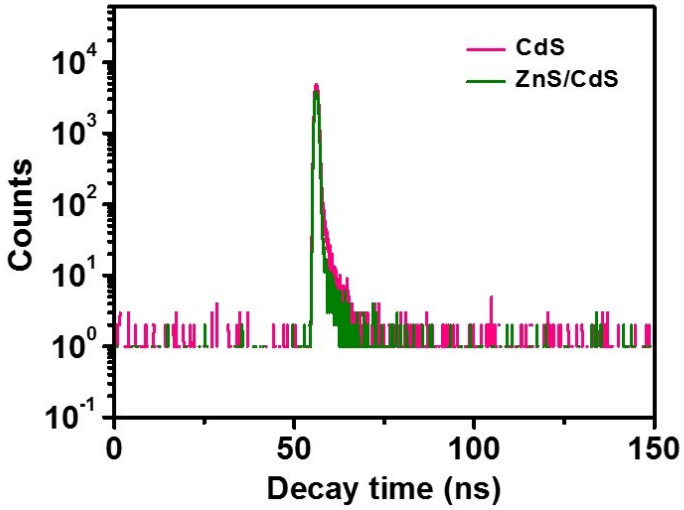

Figure S11. PL decay curves of CdS and ZnS/CdS monitored at 650 nm. A pulsed light emitting diode laser (460 nm) with pulse width of 1.3 ns was used for the excitation.

12. References

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