Electronic Supplementary Information (ESI)

Efficient $FAPbI_3$-PbS quantum dot graphene -based phototransistors

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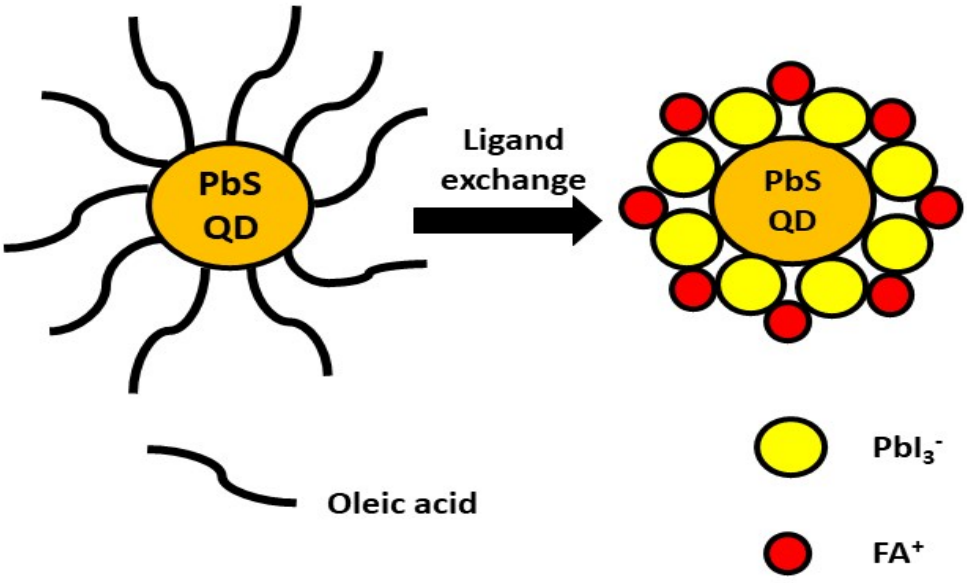

Fig.S1. Schematic illustration of ligand exchange process.

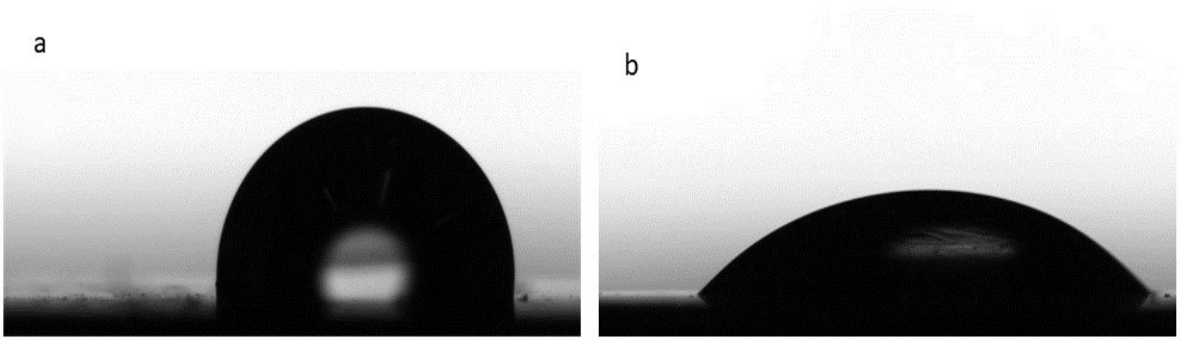

Fig.S2. Wetting angle measurement of a) LPE (102□) and b) GP (43□) samples on graphene.

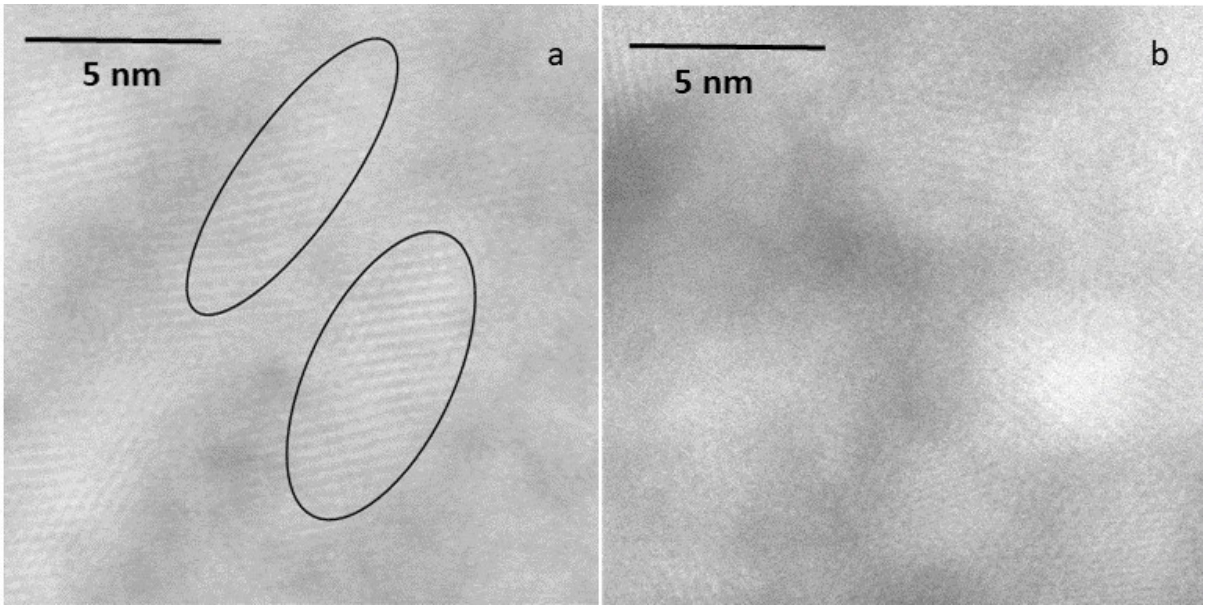

Fig.S3. High resolution TEM images showing QDs. a) SPE with marked paralleled-fringe areas. b) LPE without signs of inter-dot fusion.

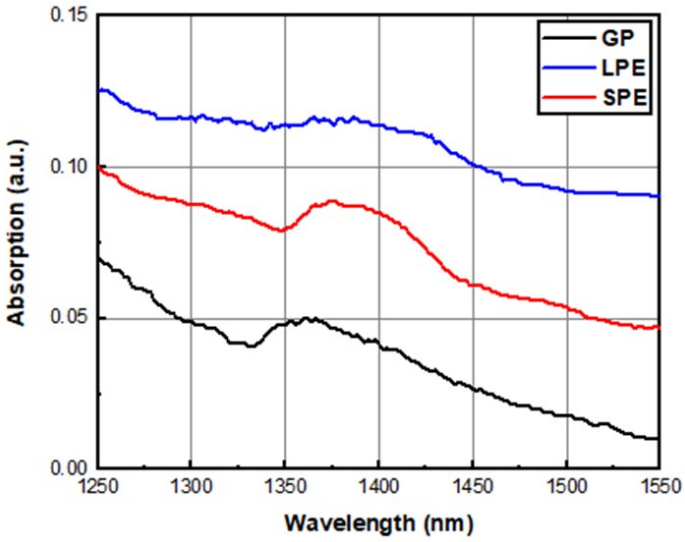

Fig.S4. Absorption spectra of CQD films on Graphene/Si/SiO_2 substrate.

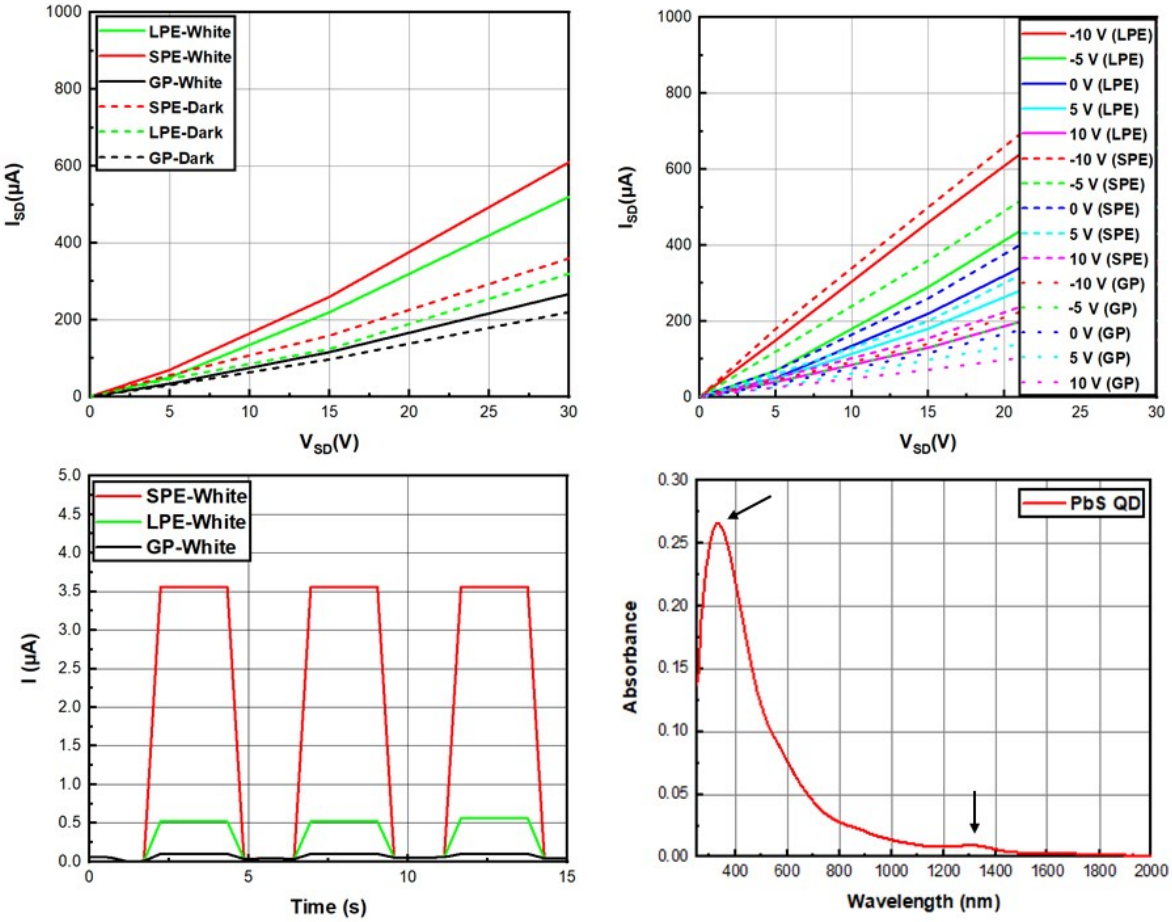

Fig.S5. I-V curves of GP, LPE and SPE phototransistors a) in dark condition and under white illumination at V_G= 0V and b) under white illumination at various gate voltages. c) I-t characteristics of all three devices under white illumination and V_{SD} = -1 V and d) the absorption spectrum of PbS QDs.

Table.S1. Figures of merit for the graphene-based phototransistors examined under white illumination at V_{SD} = 20 V.

Device	R(A/W)	J_d(A/cm^2)	D*(Jones)
GP	0.002	0.004	$5*10^7$
SPE	0.004	0.006	10^8
LPE	0.003	0.005	$7*10^7$

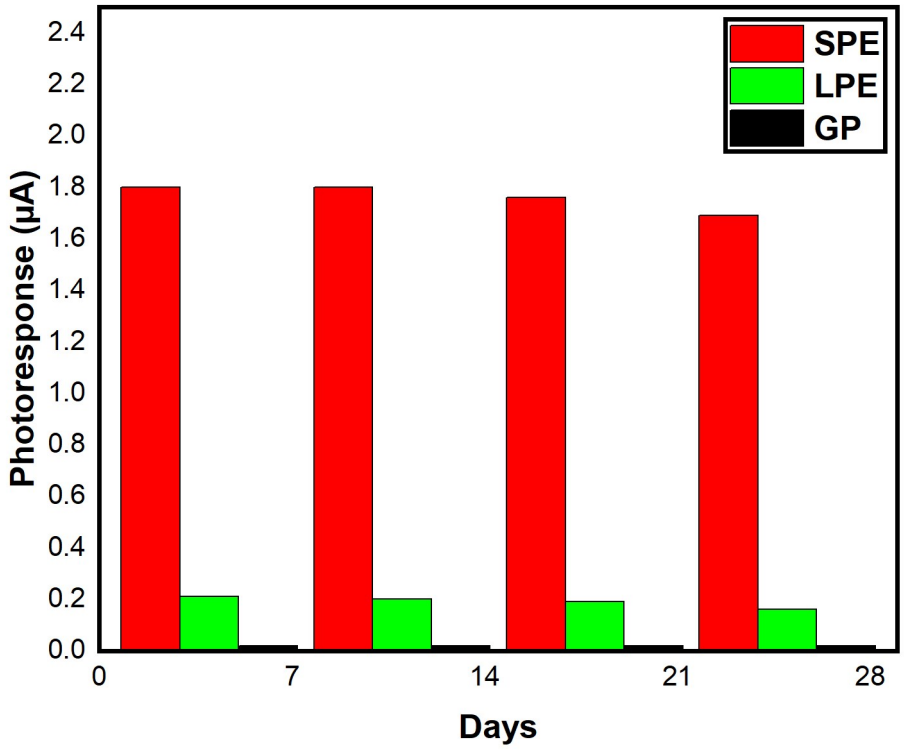

Fig.S6. Air stability results of the devices.

Table.S2. The air stability results of all devices for 28 days.

Photoresponse(μA)in day / Device name	1st	7th	14th	21th	28th
GP	0.02	0.02	0.02	0.02	0.02
LPE	0.21	0.20	0.19	0.16	0.15
SPE	1.8	1.8	1.76	1.69	1.66

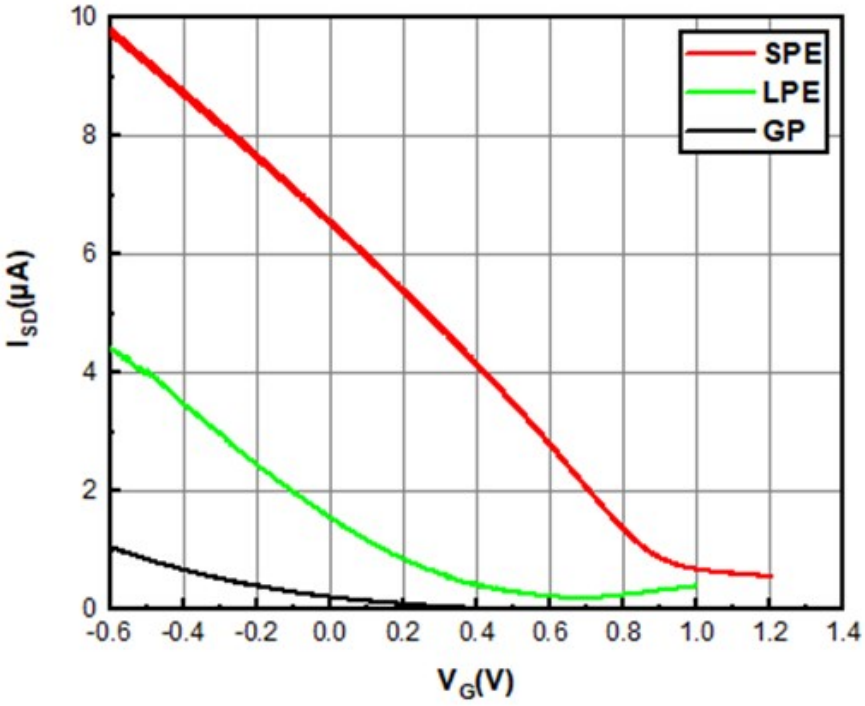

Fig.S7. Transfer characteristics of GP, LPE and SPE samples under IR illumination at V_{SD}= 1V.

Table.S3. Performance of PbS QDs/graphene phototransistors.

Ref.	V_g(V)	Light power (mW)	I_{LIGHT}/I_{DARK}
PbS-OA/G [A]	30-60	30pW	1.4
PbS/G [B]	-20-80	0.00068mW	1.1
PbS-EDT/G [C]	-40-60	267pW	2
G/PbS-EDT/G [D]	20	0.86μW	13
PbS-$FAPbI_3$/G [this work]	-1	110mW	34

Table.S4. Fitted data values from the Nyquest polts according to the equvalent circuit.

Sample	R_s(Ω)	C_1(μF)	R_1(Ω)
GP	44	0.9	14230
LPE	18	0.5	1260
SPE	20	5.3	94

References:

(A) Z. Sun, et al. Infrared Photodetectors Based on CVD-Grown Graphene and PbS Quantum Dots with Ultrahigh Responsivity, Advanced Materials, 14 (2012), 5878-5883.

(B) D. Zhang, et al. Understanding Charge Transfer at PbS-Decorated Graphene Surfaces toward a Tunable Photosensor, Advanced Materials, 24 (2012), 2715-2720.

(C) G. Konstantatos, et al. Hybrid graphene–quantum dot phototransistors with ultrahigh gain, Nature nanotechnology, 7 (2012) 363-368.

(D) Q. Nian, et al. Graphene/PbS-Quantum Dots/Graphene Sandwich Structures Enabled by Laser Shock Imprinting for High Performance Photodetectors, ACS Applied Materials & Interfaces, 9 (2017), 44715–44723.