Electronic Supplementary Material (ESI) for Nanoscale.

Near Full Light Absorption and Full Charge Collection in 1-micron Thick Quantum Dot Photodetector Using Intercalated Graphene Monolayers as Charge Collectors

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Content

FIGURE S1

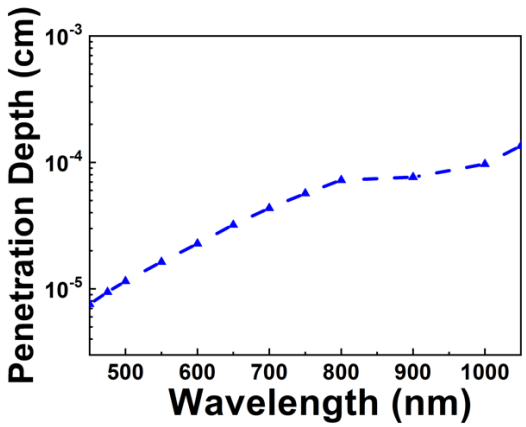
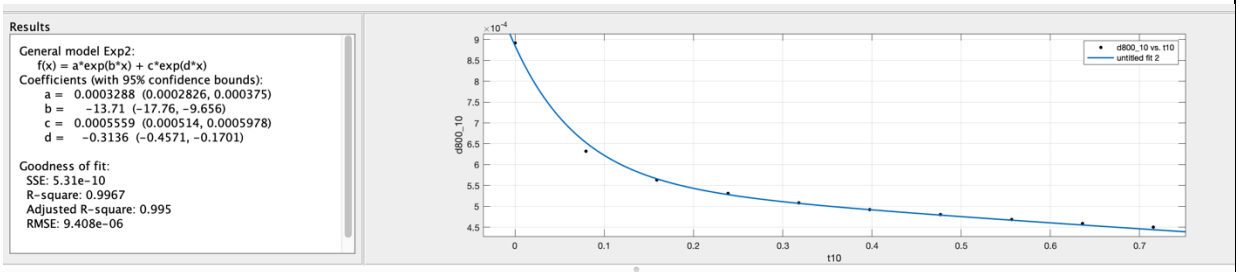
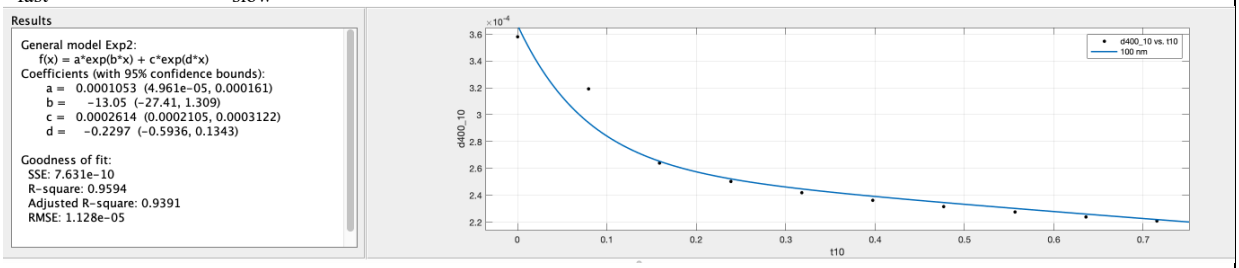
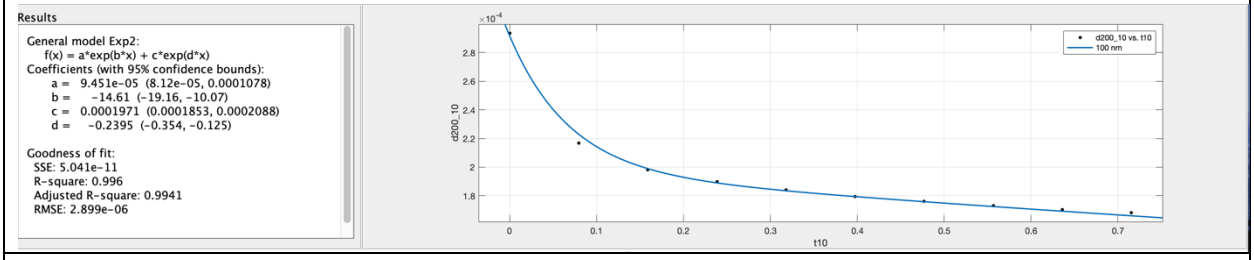
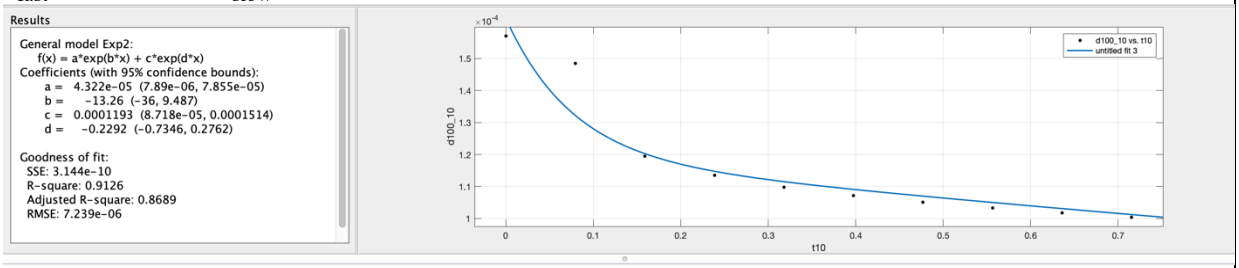
Penetration Depth of QDs Film	
	Penetration as a function of wavelength was extracted from transmission of light as a function of thickness of PbS QDs films by fitting to the Beer-Lambert Law.

FIGURE S2

Time Constants
The time response fits best to a double exponential with a τ_{fast} and τ_{slow} as reported previously (Nat Nano 2012, 7, 363-368)
t = 1000 nm, D_{Gr} = 100 nm τ_{fast} = 0.07 s and τ_{slow} = 3.18 s. 
t = 400 nm, D_{Gr} = 100 nm τ_{fast} = 0.08 s and τ_{slow} = 4.35 s. 
t = 200 nm, D_{Gr} = 100 nm τ_{fast} = 0.07 s and τ_{slow} = 4.17 s. 
t = 100 nm, D_{Gr} = 100 nm τ_{fast} = 0.08 s and τ_{slow} = 4.36 s. 

PANEL S3:

Photogain and EQE Calculations

Based on: ACS Photonics 2016, 3, 2197-2210

Photogain (G)

$$G = \frac{\tau_{lifetime}}{\tau_{transit}} = \frac{\tau_{lifetime}}{L^2}\mu V_{DS}$$

Using L=1 mm, μ_h~400 cm^2/Vs, V_{DS}=10 mV and $\tau_{lifetime}$=3.1 sec

$$G = 1.33 \times 10^3$$

External Quantum Efficiency (*QE*)

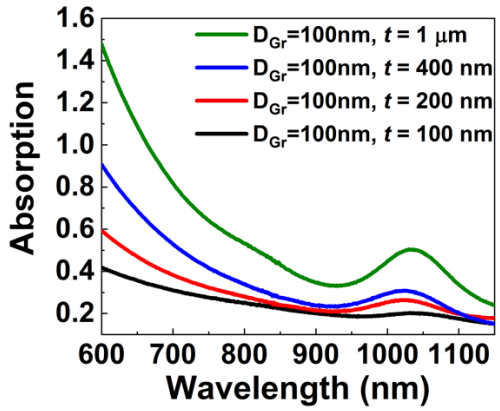
$$EQE = R\frac{hc}{q\lambda}\frac{1}{G}$$

This expression is used to obtain EQE in Figure 3.c from R in Figure 3.b using $G = 1.33 \times 10^3$.

We use the long lifetime since the data for R was obtained with an integration time of 15 s. The high photogain is also associated with long lifetime in QDs in the order of ~1 sec due to traps in the QDs. (Nat Nano 2012, 7, 363-368)

FIGURE S4

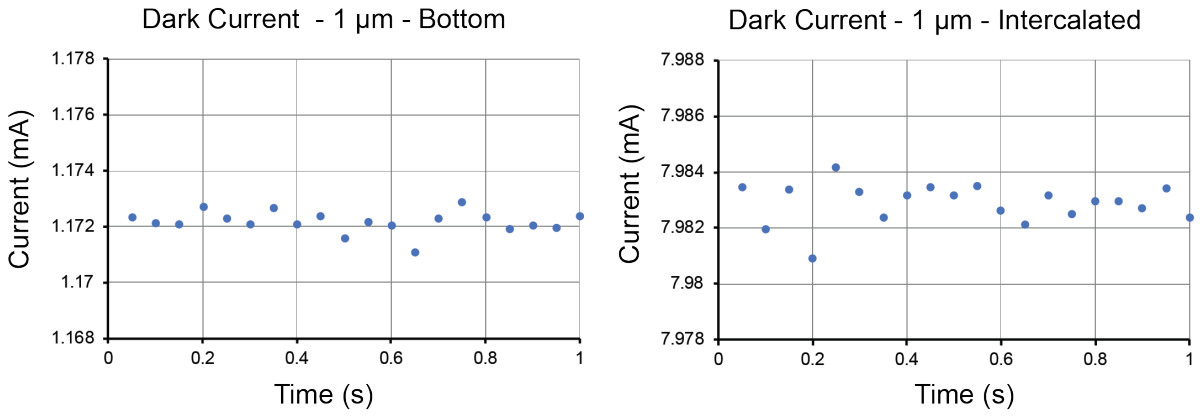
Absorption spectra for QDs films of different thicknesses



Light absorption of QDs films intercalated with graphene with D_{Gr} = 100 nm, with thickness varying from 100 nm to 1 micron.

FIGURE S5

Dark current traces and noise levels



	Signal-to-Noise Ratio (A_S/A_N) @ 20Hz	Signal-to-Noise Ratio (dB) @ 20 Hz	Detectivity @ 20 Hz	NEP @ 20 Hz
Bottom Device	24.55	58 dB	1.1 x 10^{11} Jones	9.01 x10^{-13} W/Hz$^{1/2}$
Intercalated Device	835	27.8 dB	4.31 x 10^{12} Jones	2.35 x10^{-14} W/Hz$^{1/2}$