

QDotTM stack materials for SWIR photodetectors & image sensors

Application Notes

SWIR (short-wave infrared) sensing is becoming increasingly important in various applications such as:



Machine vision

for quality inspection and control of goods



Automotive

for 3D aerial and geographic mapping, advanced driver-assistance systems in adverse weather conditions like mist, fog, and snow, and night vision



Smartphone cameras

for biometrics and 3D photography

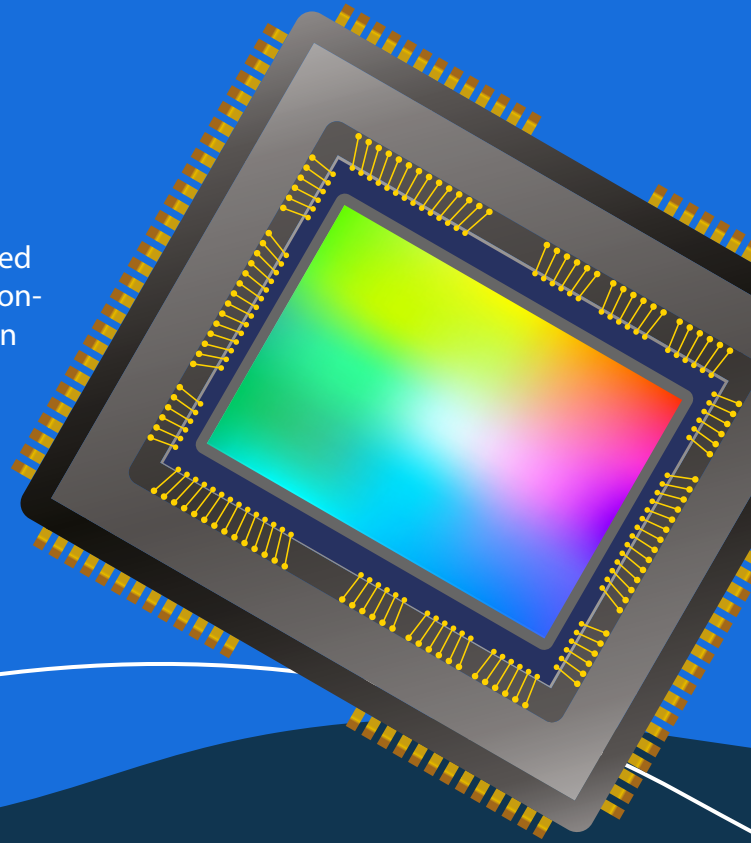


AR and VR headsets

for eye tracking



Surveillance



However, current SWIR sensors that use absorbers like epitaxially grown InGaAs and HgCdTe (MCT) compound semiconductors are expensive to produce, and have limited camera resolution. Quantum Solutions offers a range of materials that can be used for fabricating a QDot™ photodiode stack for sensing applications, including QDot™ quantum dot absorbers, QDot™ ETL, and HTL materials.

BENEFITS



Wide Range

QDot™ quantum dot absorber with broad tunable absorption in SWIR range from 700 to 2500 nm and superior photoelectrical properties with high devices EQE and detectivity, low dark current



Full Stack

Carefully designed QDot™ ETL (electron transport layer) and QDot™ ETL (hole transport layer) semiconducting materials to be used in combination with QDot™ quantum dots with various energy levels choices



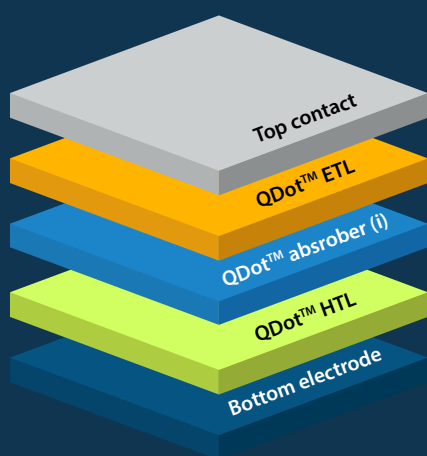
Solution-processable

Easy integration on substrates (glass, silicon, or CMOS wafers) by spin-coating or other printing processes, guaranteeing affordability and manufacturability.

DEVICE ARCHITECTURE EXAMPLES

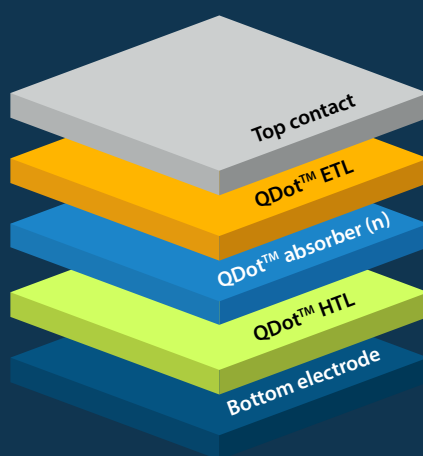
The QDot™ stack architecture can vary in the implementation and QDot™ layer types, sequence, thicknesses, and spin-coating conditions, depending on the required specifications of the photodiode performance, such as sensitivity range, EQE, dark current, response time, reliability, etc.

For example, there are several options for the sequence implementation of QDot™ layers.



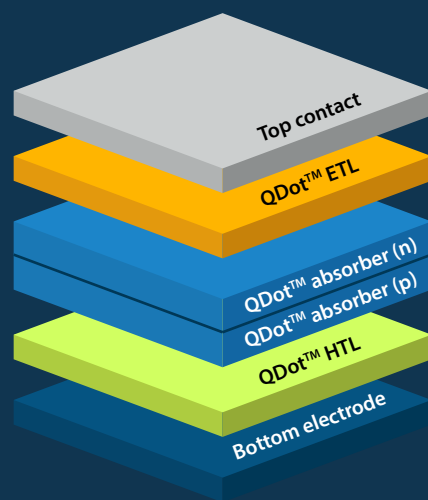
A

Type (A) represents the typical photodiode stack with the bottom QDot™ HTL, followed by absorber QDot™ quantum dots (i-type), QDot™ ETL, and the top electrode.



B

Type (B) represents the photodiode structure where the absorber is QDot™ quantum dots (n-type).



C

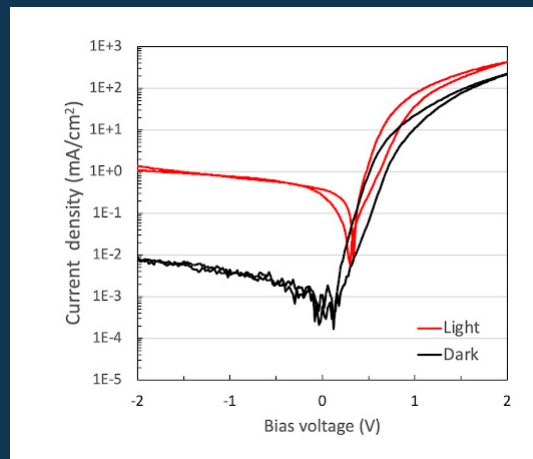
Type (C) demonstrates an example where the QDot™ PbS layer includes two types: n and p types within the same stack.

Further details can be found in the following articles: [\[1\]](#), [\[2\]](#), [\[3\]](#), [\[4\]](#), [\[5\]](#).

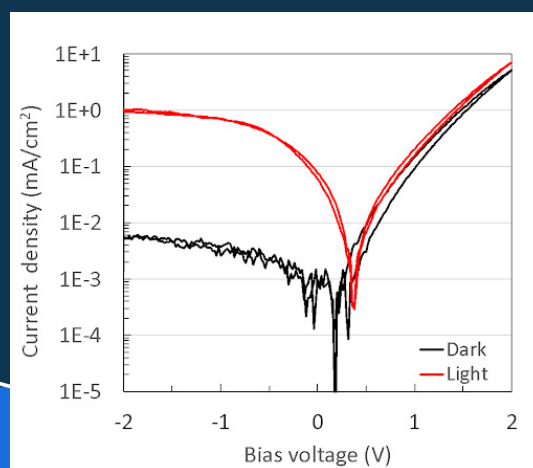
CASE STUDIES

QDot™ PbS quantum dots, oleic acid capped, with an absorption wavelength of 1420 nm (QDot™ PbS-1420-abs) were used as the absorber layer in the SWIR photodiode device with the type (A) QDot™ stack architecture. The QDot™ PbS-1420-abs layer was deposited using spin-coating and solid ligand exchange techniques to create i-type absorber layer [6]. Depending on the choices and thicknesses of the QDot™ ETL and HTL, the EQE can be varied by up to 40-60% at 1450 nm. The dark current can be minimized to the range between 100 to 1,000 nA/cm² at 0.5V bias. Examples of I-V curves for some variants are presented in the Figures 1 and 2. The variant (1) utilizes QDot™ ETL-ZnO and QDot™ HTL-PbS, while the variant (2) exploits QDot™ ETL-ZnO and QDot™ HTL-POL.

1

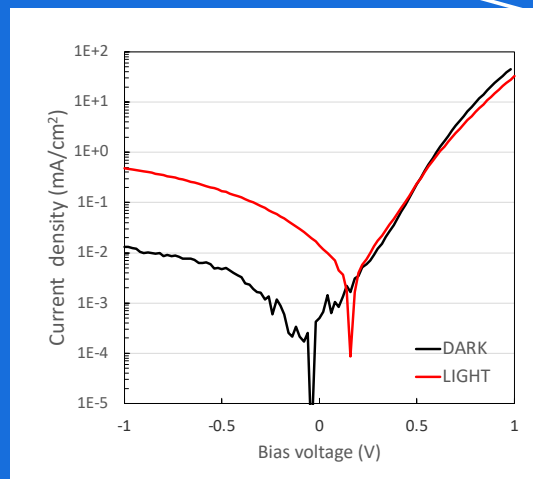


2



QDot™ PbS n-type ink, with an absorption wavelength of 1420 nm (QDot™ PbS-1420-abs n-ink), was used as the absorber layer in the SWIR photodiode device with a type (B) stack architecture that included QDot™ ETL-ZnO and QDot™ HTL-PbS. The QDot™ PbS-1420-abs layer was deposited by a simple spin-coating process, involving 3 deposition steps to create a thick absorber layer of 300 nm. This deposition process did not require any solid ligand exchange. The EQE reached 50-60% at 1450 nm, with a dark current of 13 $\mu\text{A}/\text{cm}^2$ at a 0.5V bias (Figure 3). The dark current can be reduced to values below 1 $\mu\text{A}/\text{cm}^2$ by using the type (C) architecture, which additionally incorporates a p-type quantum dot absorber.

3



PRODUCTS PORTFOLIO



**QDot™ PbS Quantum Dots,
oleic acid capped**



**QDot™ InAs Quantum Dots,
oleic acid capped**



**QDot™ PbS Quantum Dots,
n-type ink**



QDot™ ETL and HTL materials