QDI systems

Affordable and efficient SWIR sensors based on quantum dots

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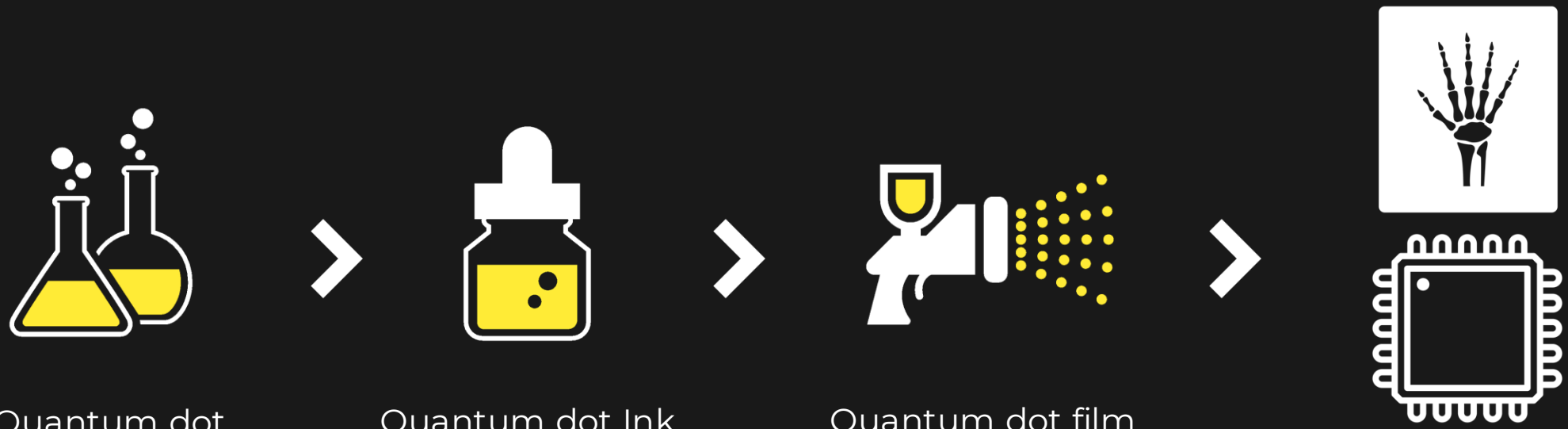
SWIR technologies

	Pixel pitch	Spectral range	Quantum efficiency	Dark current	Cost	Speed	Stability	Comments
InGaAs	-	+	++	+	--	+	++	• Best performance & most mature technology • Cost is very high • Extended range is even more expensive (>1.7um) • Not compatible with consumer market (cost, pixel pitch)
SiGe	-	+/-	-	-	+	+	+	• Higher dark currents • Limited SWIR wavelength range (<1.5um) • Lower pixel pitch and QE
Quantum Dots	++	++	+	+	+	+/-	+/-	• Scalable and compatible with CMOS production • High QE in the SWIR (>60%) • Compatible with consumer market integration requirements (cost, pixel pitch)

WHAT WE DO



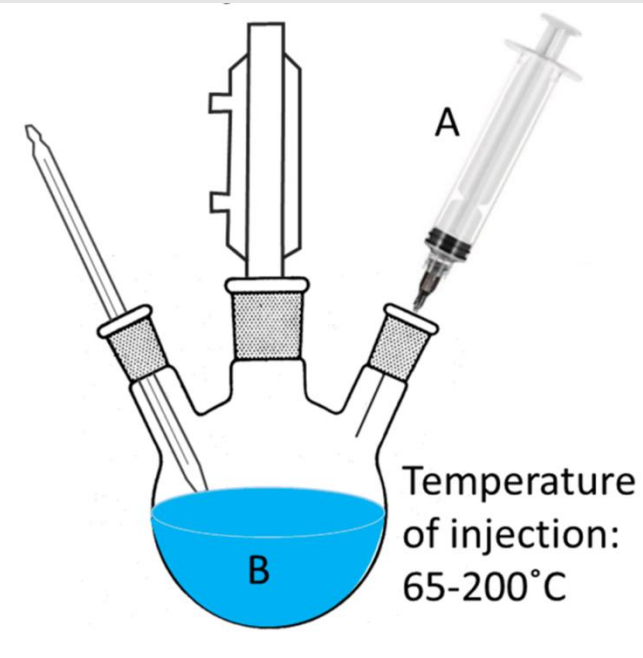
Quantum dot synthesis

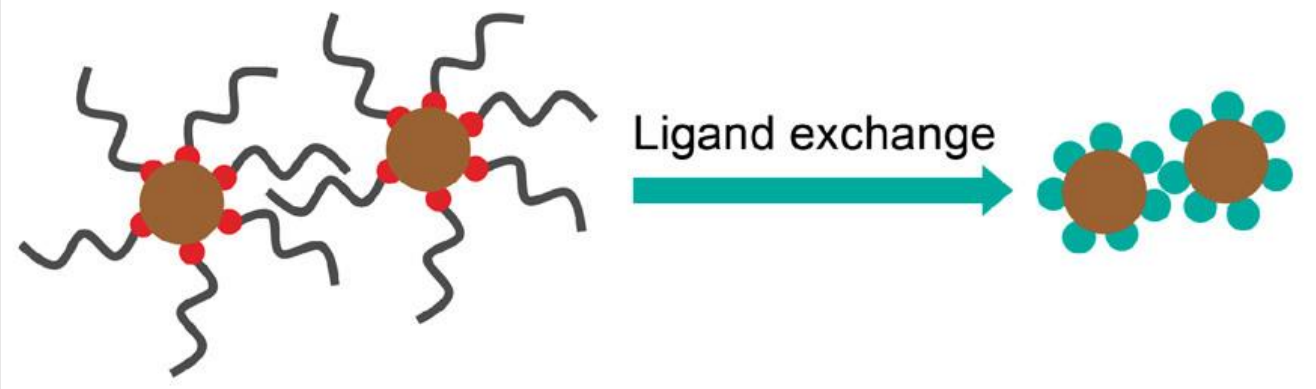
Quantum dot Ink formulation

Quantum dot film deposition

TFT and CMOS Image Sensors

How QDs are made



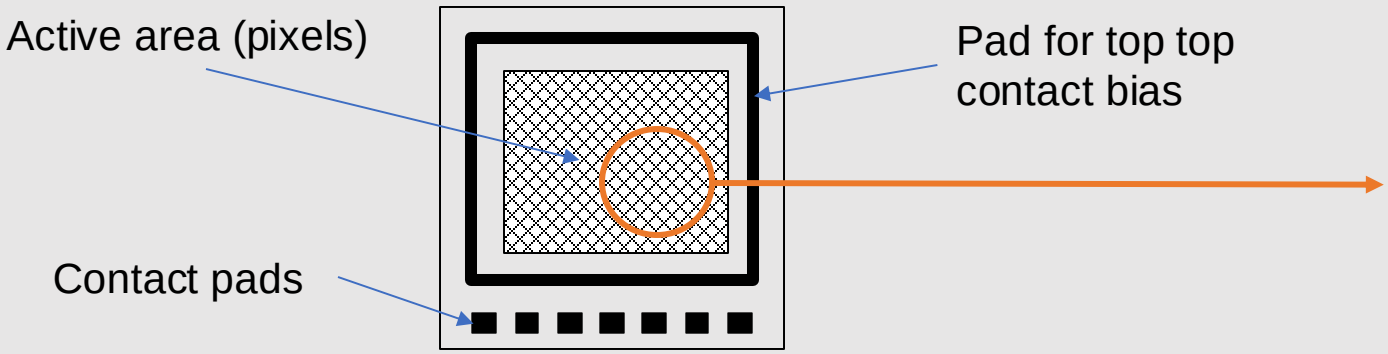


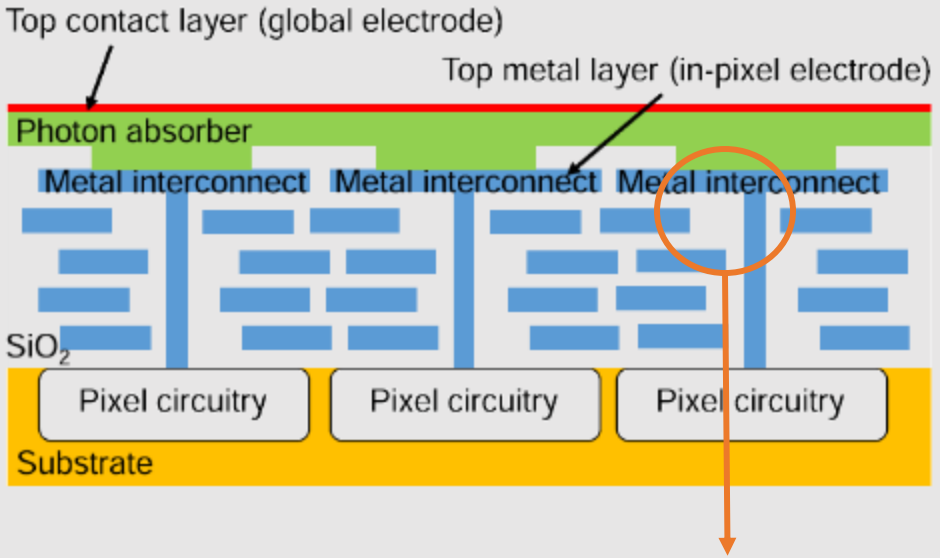
A – precursor of Sulphur (S)

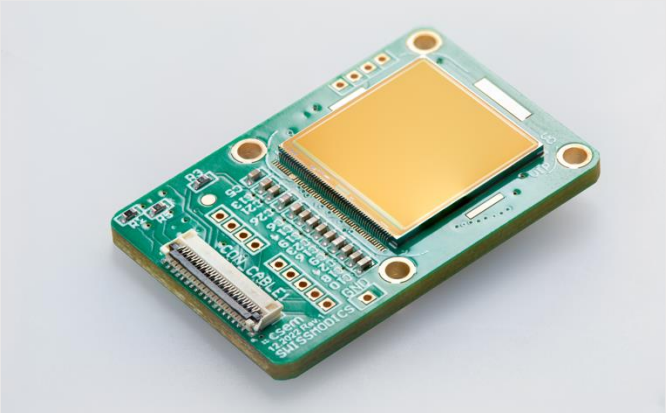
B – precursor of Lead (Pb) mixed with Oleic acid

QD SWIR sensor technology

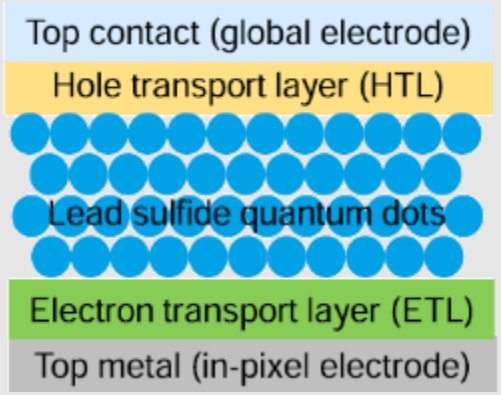
CMOS ASICS for quantum dot technology



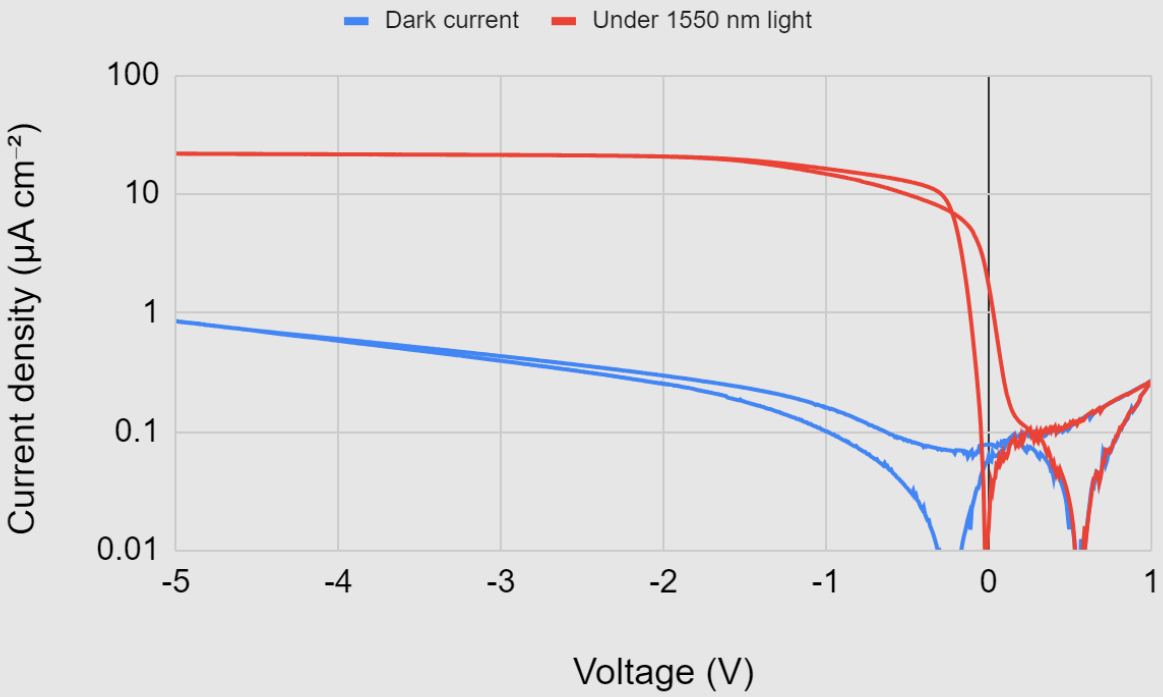


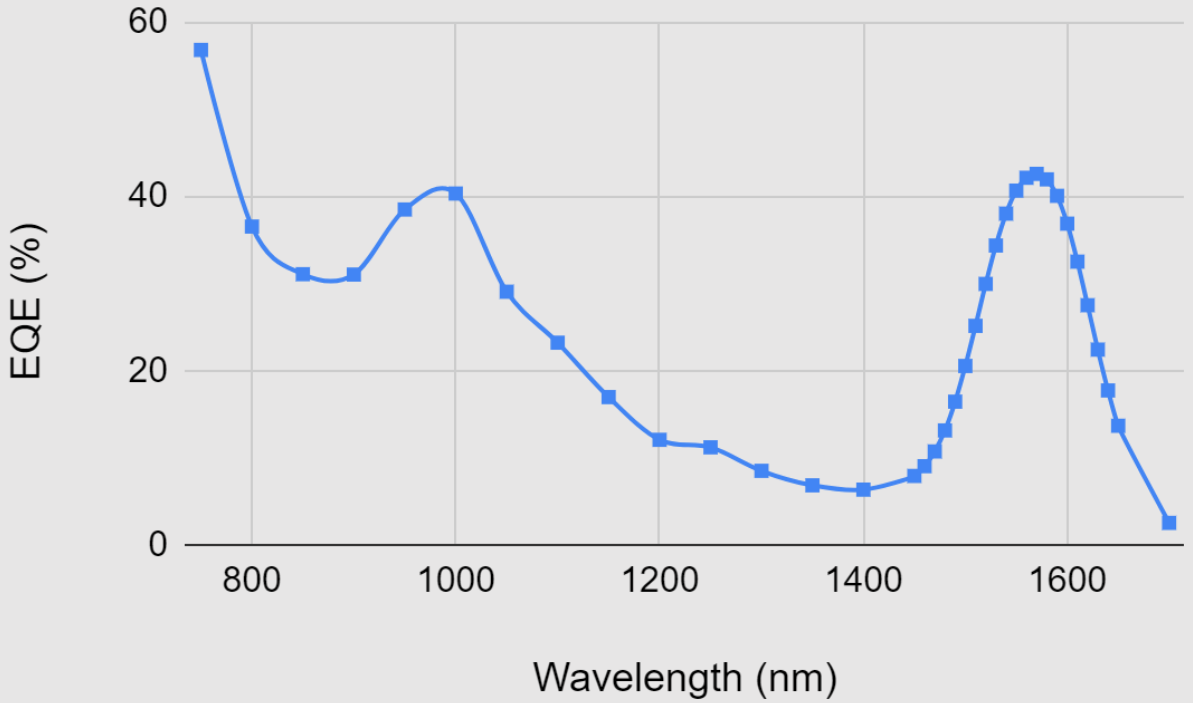


- Resolution: 512 x 512 pixels
- Pixel pitch: 22.5 µm
- Global shutter
- Dynamic range: > 100 dB
- Maximum frame rate: 30 fps



SWIR reference photodiode performance





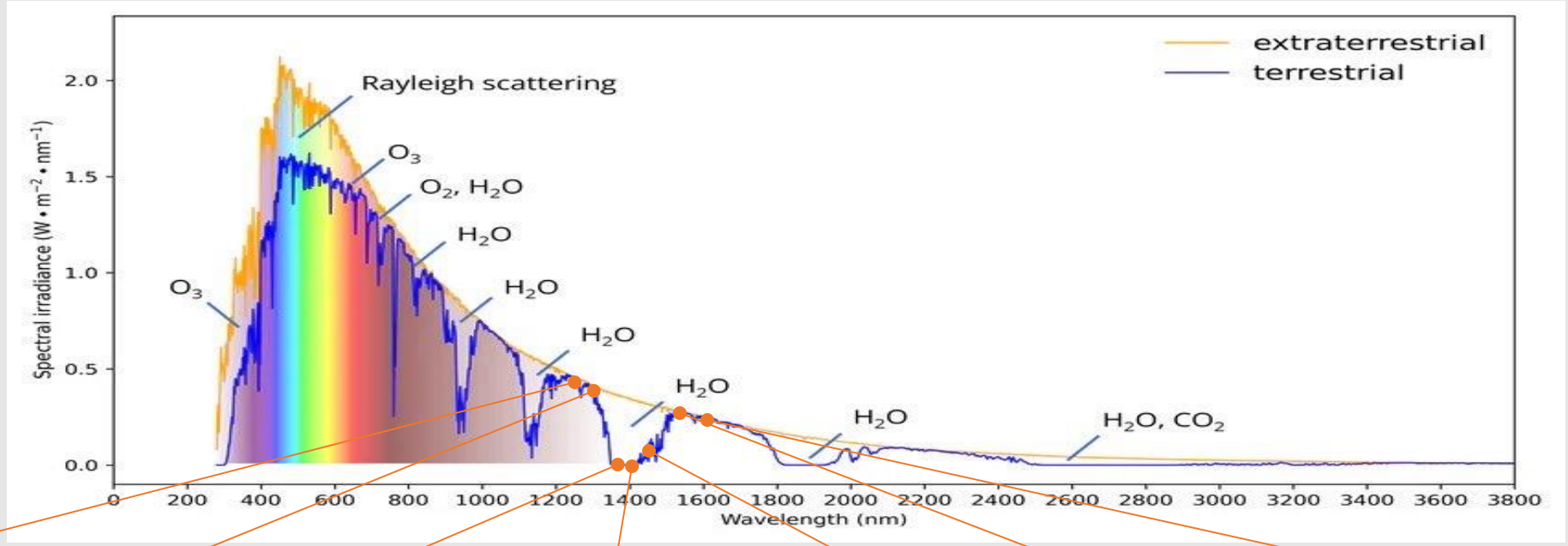
- **Dark current of ~100 nA/cm², >40% EQE at 1550 nm**

QDI SWIR demonstrator camera

- Solution processable QD SWIR light absorber
- QD stack deposited on a single chip
- No encapsulation or cooling
- ROHS compliant
- No image processing software
- Spectral range: 350-1700 nm (up to 2500 nm)

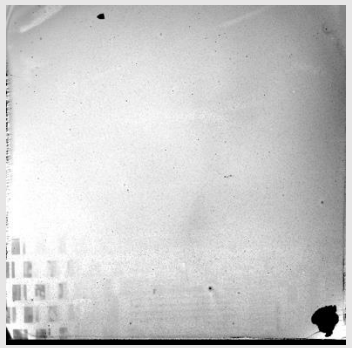
SWIR backlight from solar radiation

Smartphone

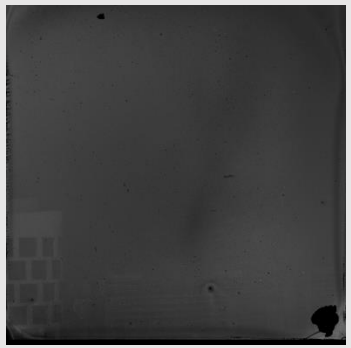


CWL **1250 nm**, FWHM **10** nm

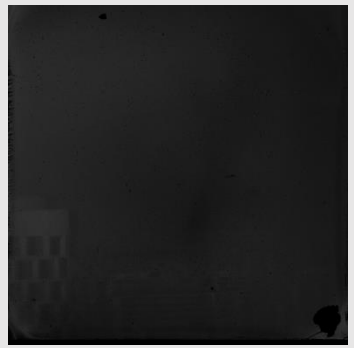
CWL **1300 nm**, FWHM **30** nm



CWL **1375 nm**, FWHM **25** nm



CWL **1400 nm**, FWHM **12** nm



CWL **1450 nm**, FWHM **12** nm

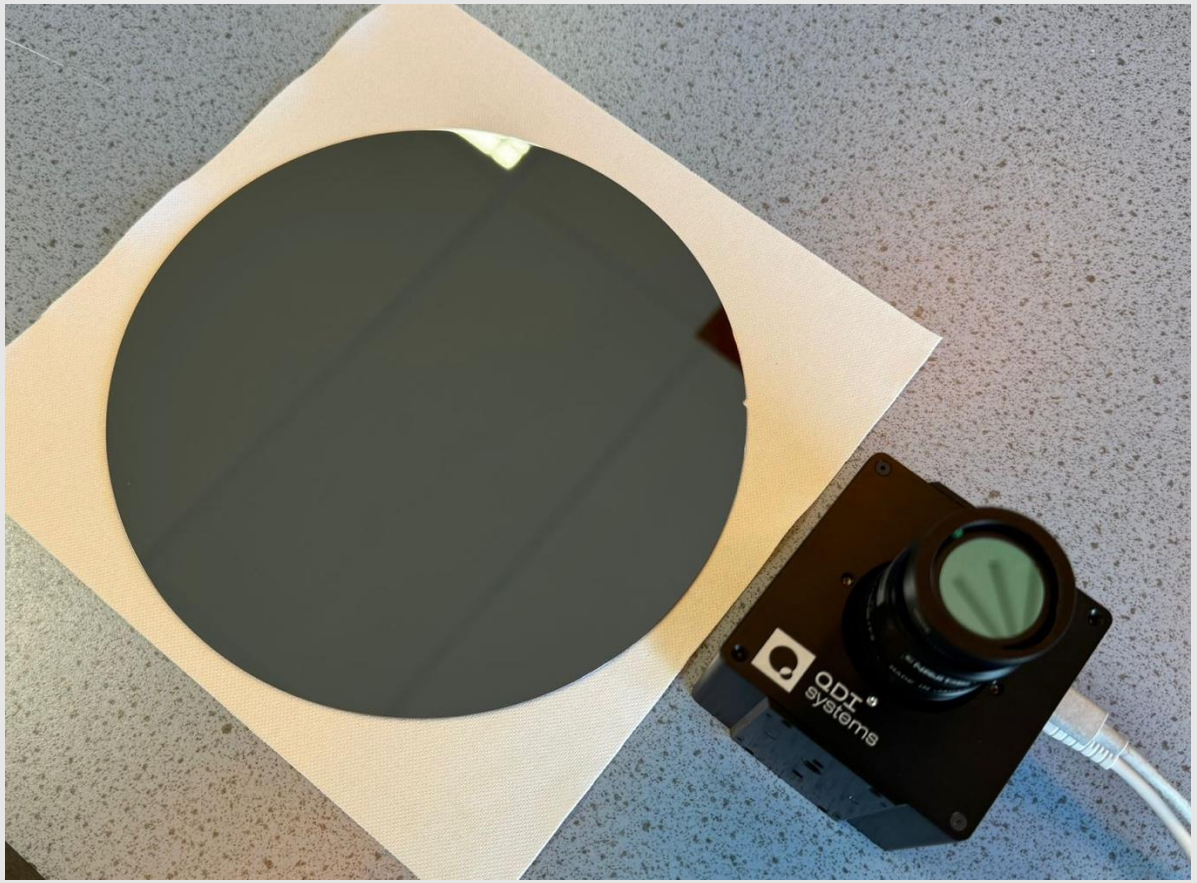
CWL **1550 nm**, FWHM **12** nm

CWL **1600 nm**, FWHM **12** nm

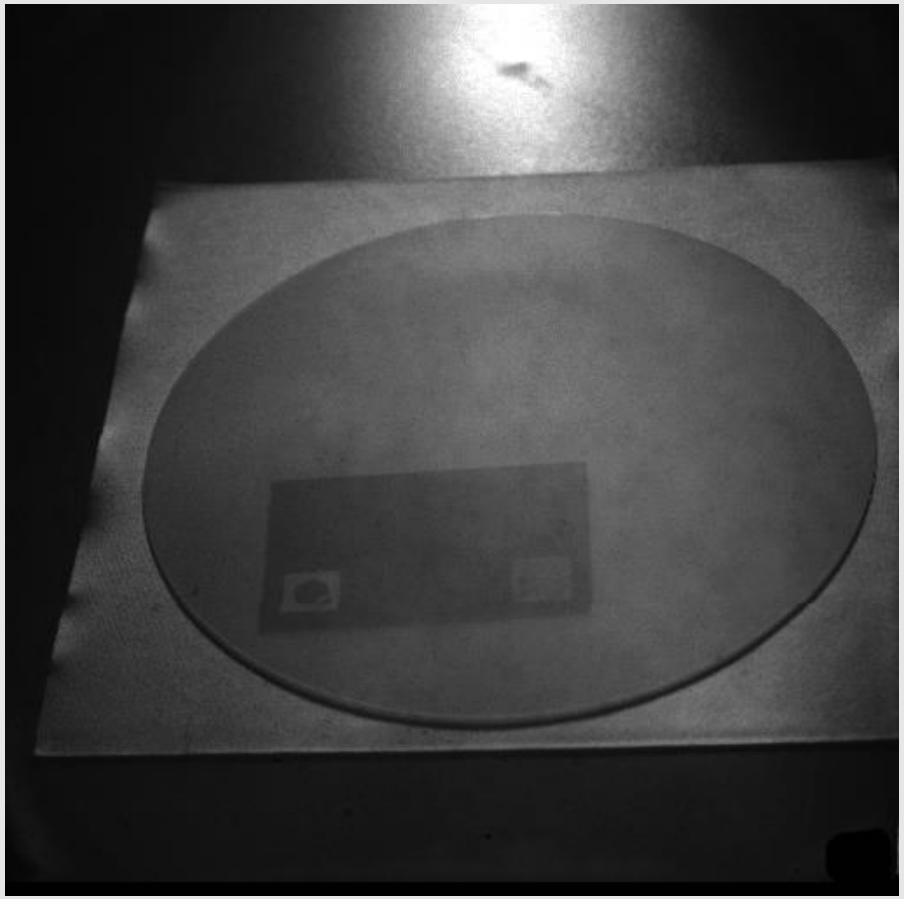
APPLICATION EXAMPLES

Silicon wafer inspection (1550nm)

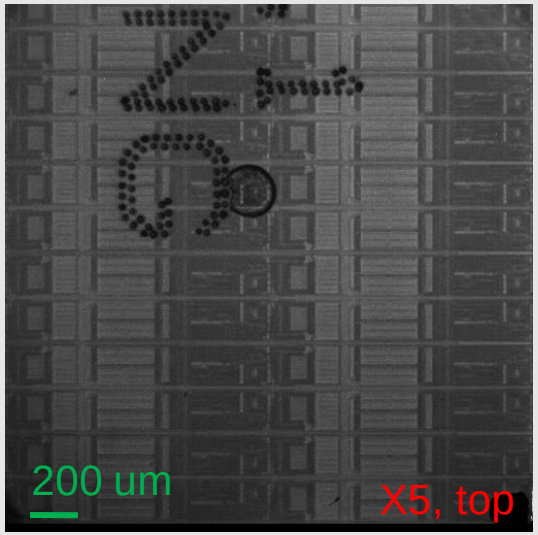
Smartphone:

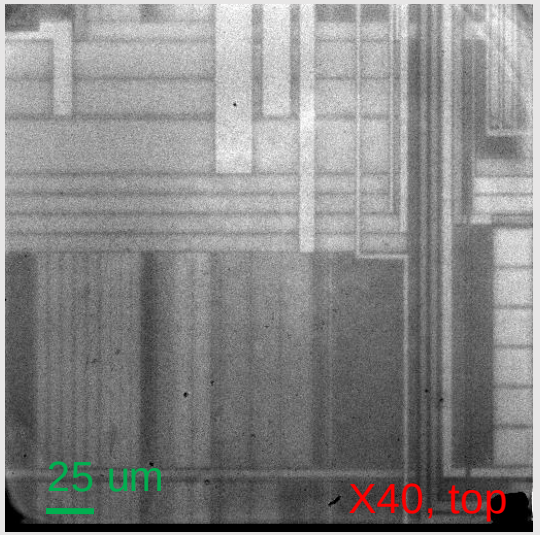


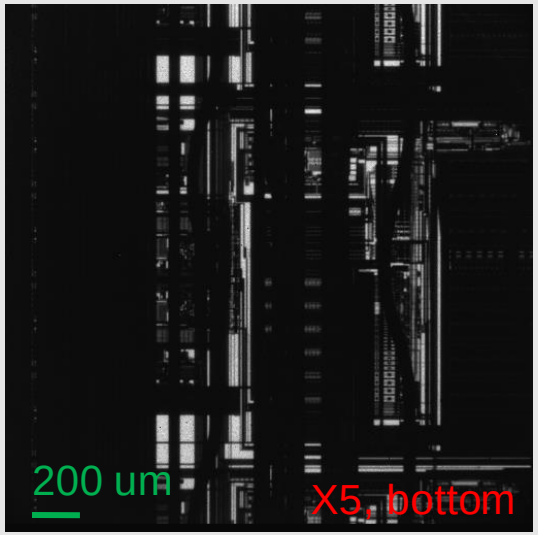
QDI sensor, 1550 nm:

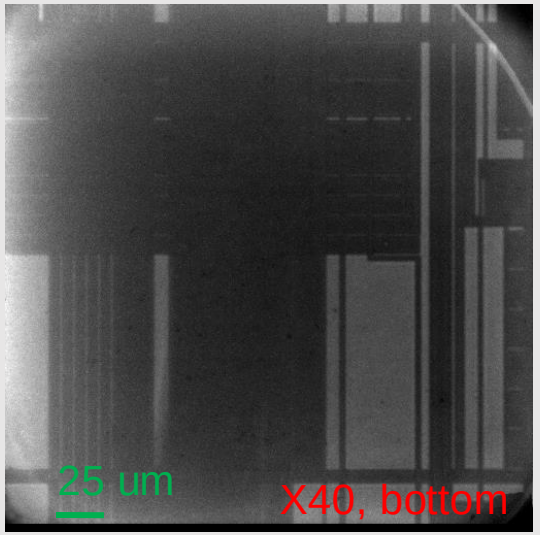


SWIR microscope for Si chip inspection (1550nm)



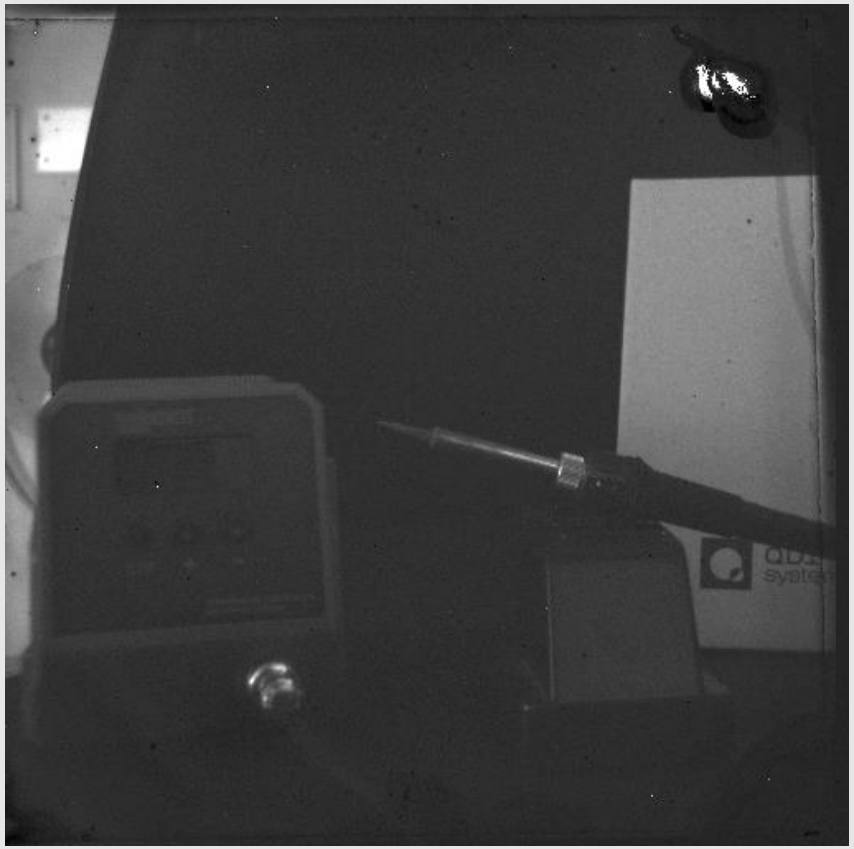




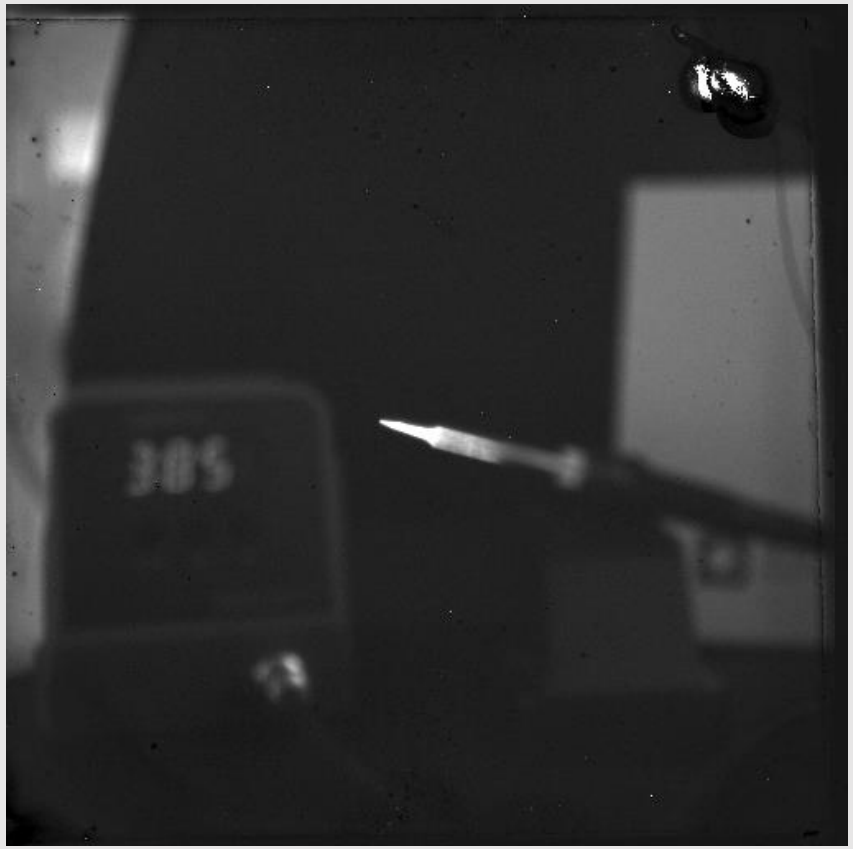


Thermal pictures

Cold



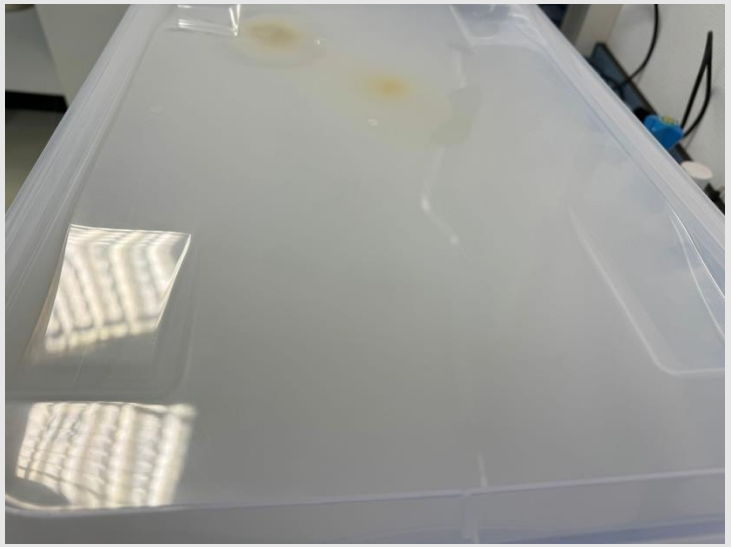
385 C



Thermal emission of a soldering iron is visible in SWIR

Imaging through smoke (1550 nm)

No smoke



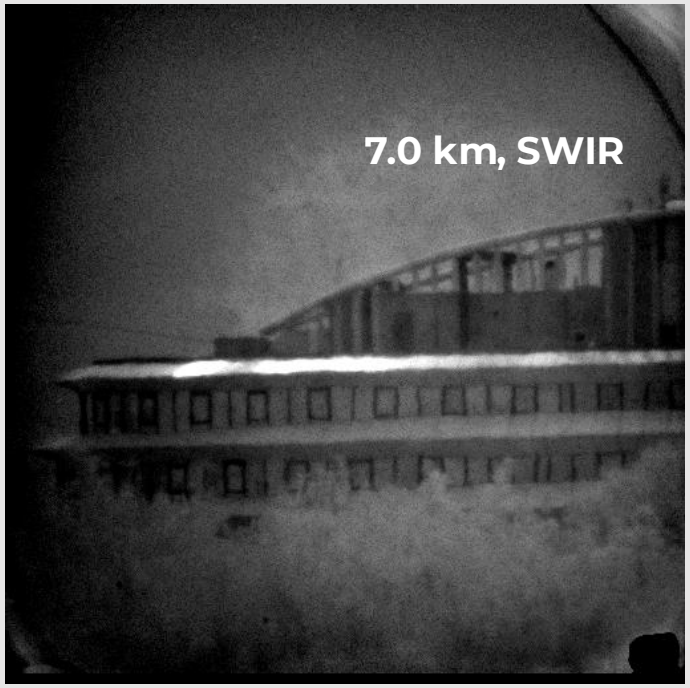
Picture through smoke

Imaging in low light conditions

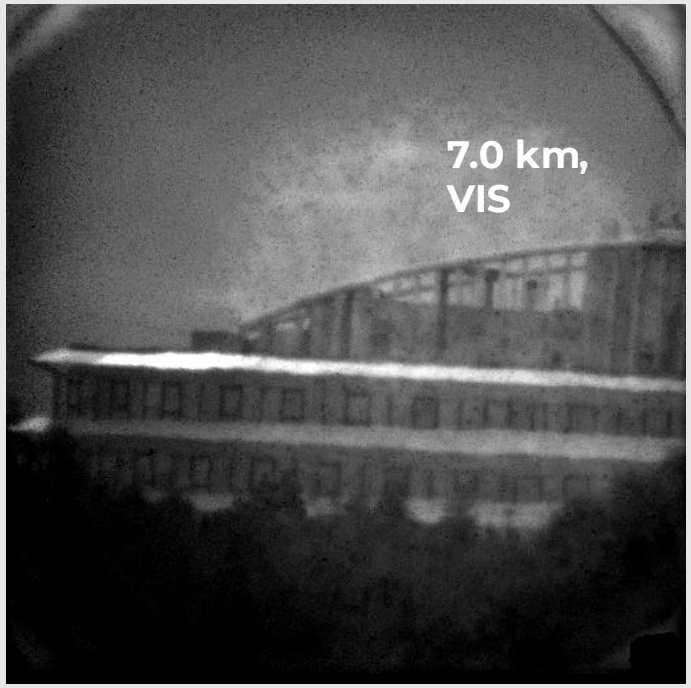
QDI camera

Smartphone

SWIR light (1100 - 1750 nm)



Visible light (400 - 700nm)



Security application

Smartphone selfie

QD sensor, visible light

QD sensor, 1300 nm

QD sensor, 1550 nm

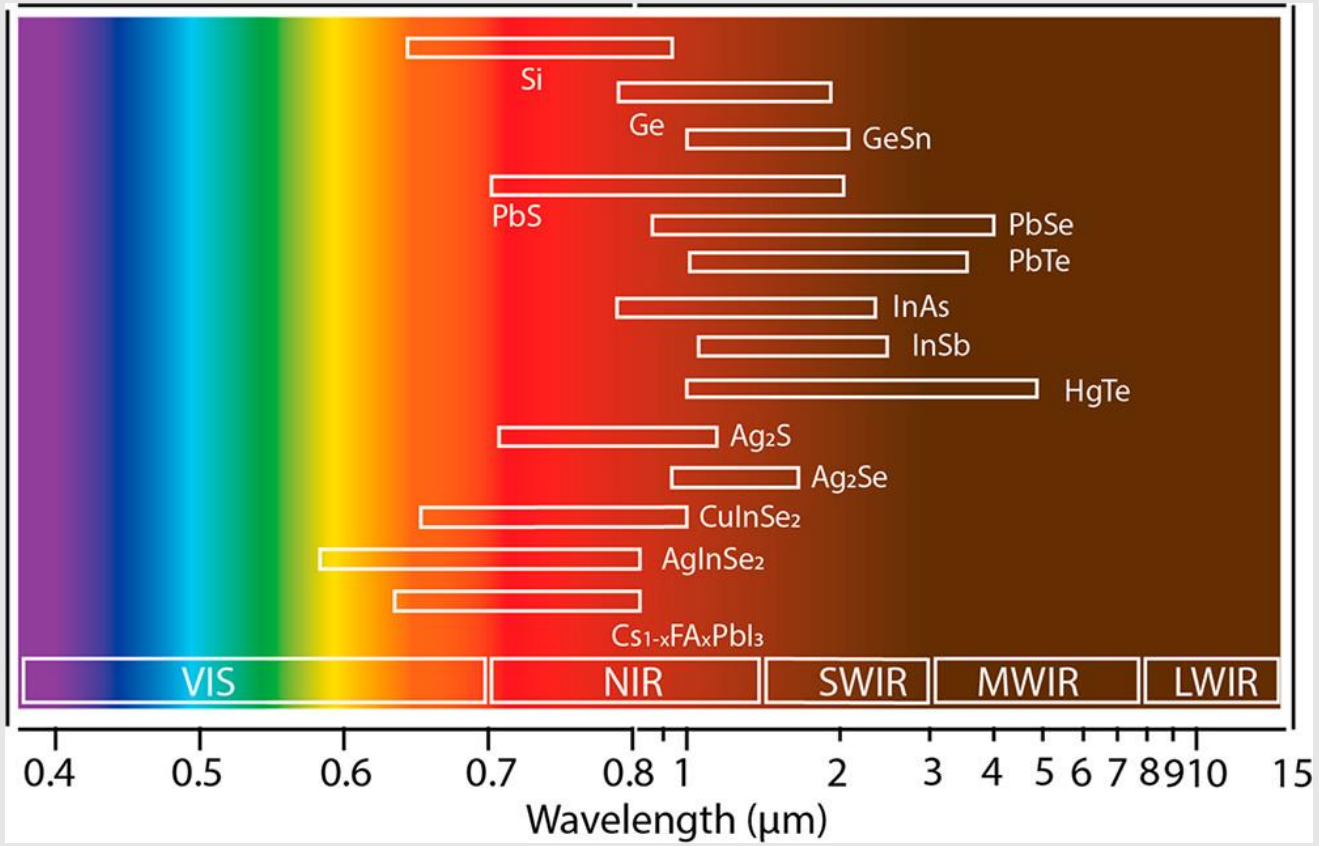
Artificial skin and artificial hair are clearly distinguishable in SWIR

QDI systems
SWIR TECHNOLOGY SUMMARY

- High performance SWIR sensors based QDs
- Full production cycles from material to sensors:
- 15 FTEs, 350/270 m^2 lab/cleanroom space
- Our goal is to increase the field of use of SWIR by making technology more accessible
- Technology is ready for production, assembling a wafer-level manufacturing line in Groningen in 2025


QDI
systems

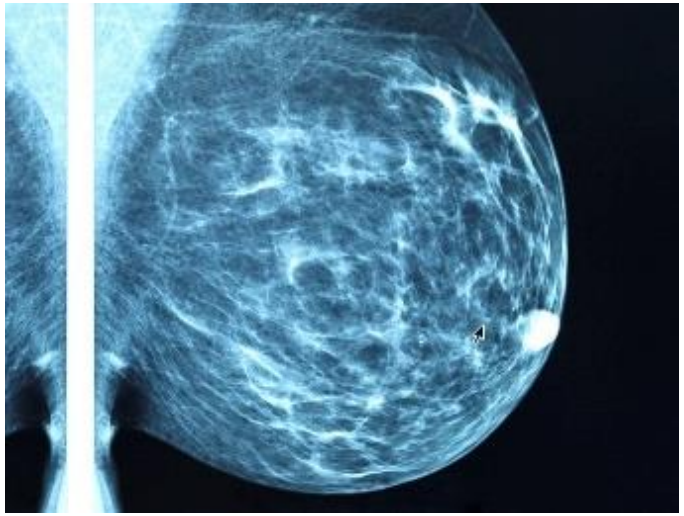
WL range of QDs



doi.org/10.1021/acsnano.8b09815

THE **APPLICATIONS** OF OUR PRODUCTS

Direct X-ray (photoconductor)



Gold standard for mammography and other high-resolution imaging: e.g. dental and micro-CT

Indirect X-ray (photodiode)

Applicable in medical, veterinary, security, and industrial market

SWIR: Short wave infrared (photodiode)

For machine vision, security, consumer electronics, and night vision segments