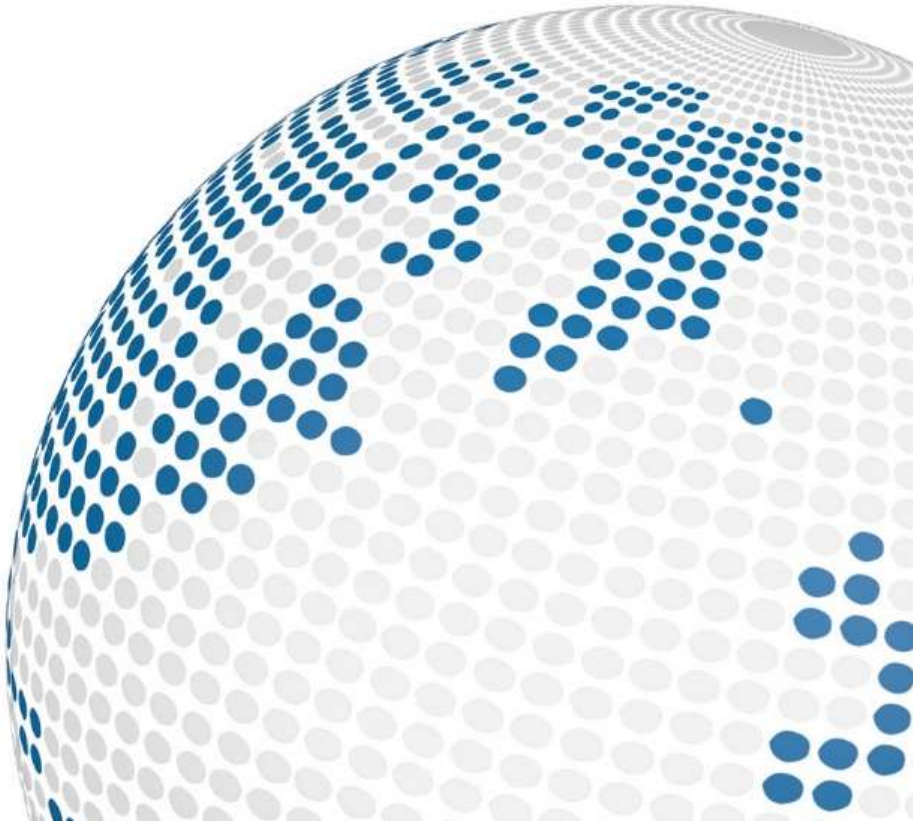
ams' Technology Concepts on Monolithic Integrated Photosensors

Ingrid Jonak-Auer

ICHEP 2018



Topics

ams at a glance

Front end developments for Monolithic Integrated Photosensors

Multi junction, UV, radiation hard, SPADs and PIN PDs

Back end developments for Monolithic Integrated Photosensors

Anti-reflective coatings, Filters and 3D-integration

ams at-a-glance

ams delivers…

- **un-matched systems know-how and groundbreaking sensor solutions**
- **unprecedented** levels of miniaturization, integration, lower power, and higher accuracy than ever before possible
- **world-class** sensor solutions, sensor ICs, interfaces and related software
- **solutions designed for consumer & communications, automotive, industrial,** and **medical end markets**

A strong industry foothold:

- **2017: record revenues** → USD 1.3bn with 93.5% growth year-on-year (y-o-y)
- **22** design centers around the globe
- **11,000** employees worldwide, **35+ years** of design and manufacturing experience

In-house wafer manufacturing, Austria

In-house optical production and packaging, future VCSEL manufacturing in Singapore

ams at-a-glance

Strategic value chain

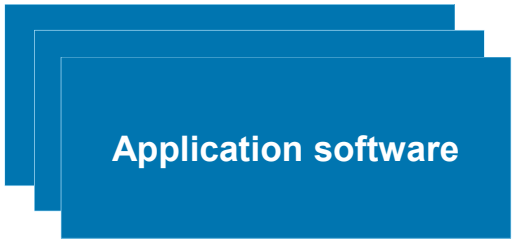
Sensor ICs

- Optical
- Imaging
- Environmental
- Audio

Sensor solutions

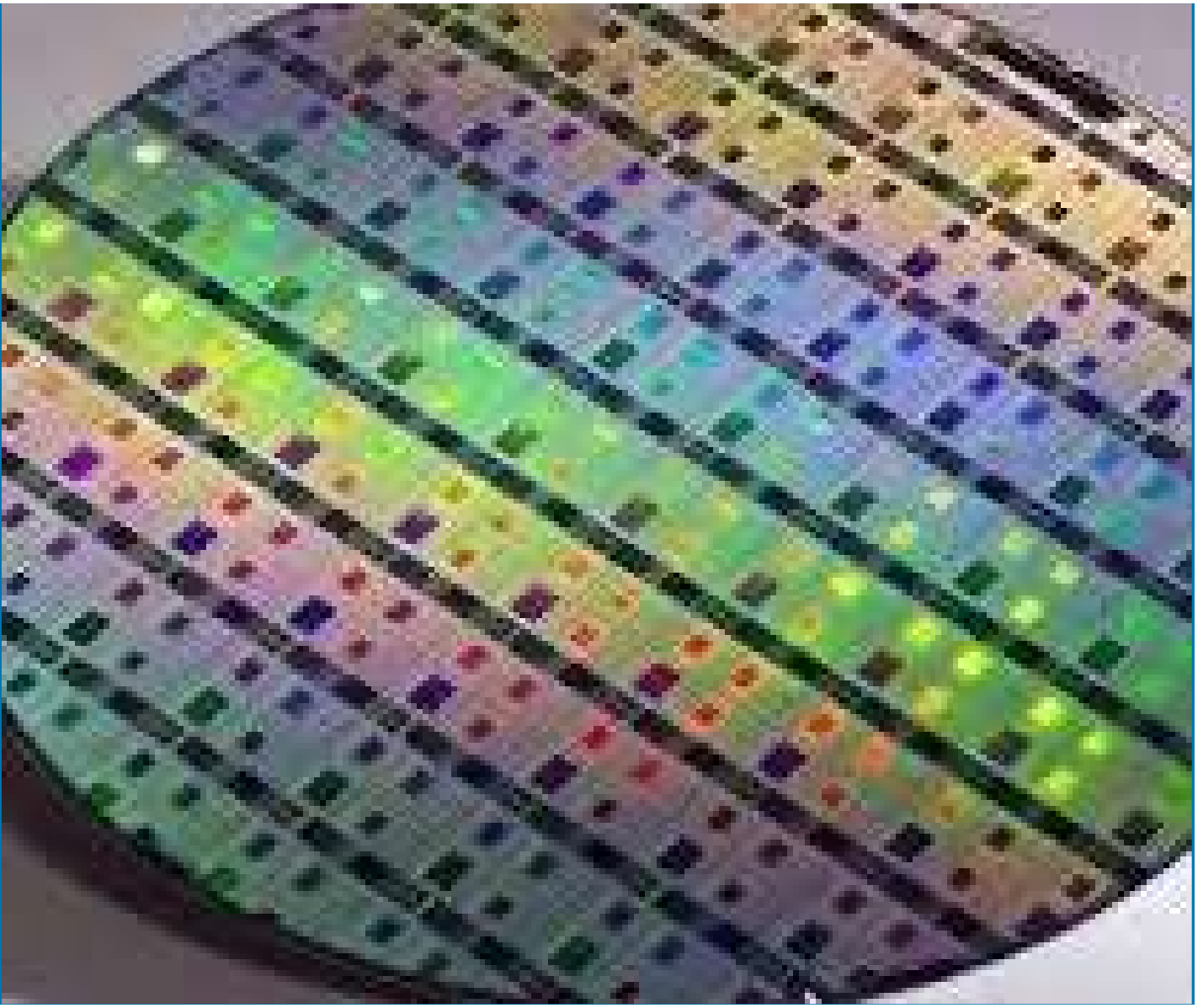
- Multi-sensor packages & modules
- Sensor algorithms
- Monolithic integrated sensors
- Sensor fusion algorithms
- Ultra-low power connectivity and processing

Application solutions



Hardware

Software and reference designs



Sensing is life.

FRONT END

multi-junction PD

UV-PD

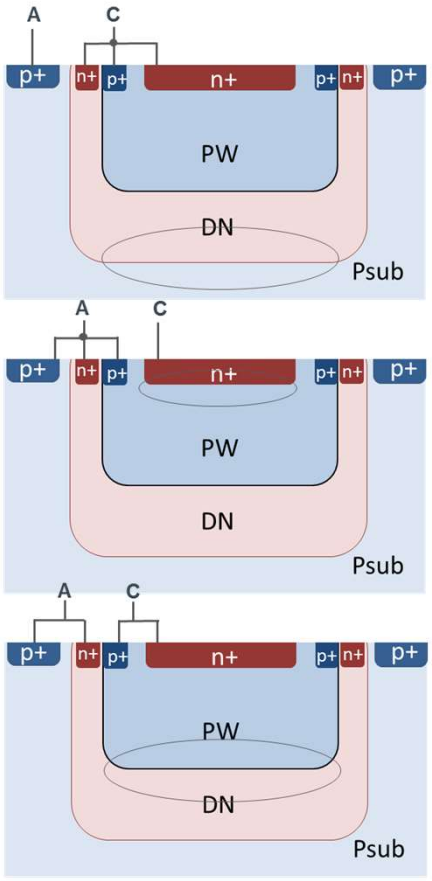
radiation hard PD

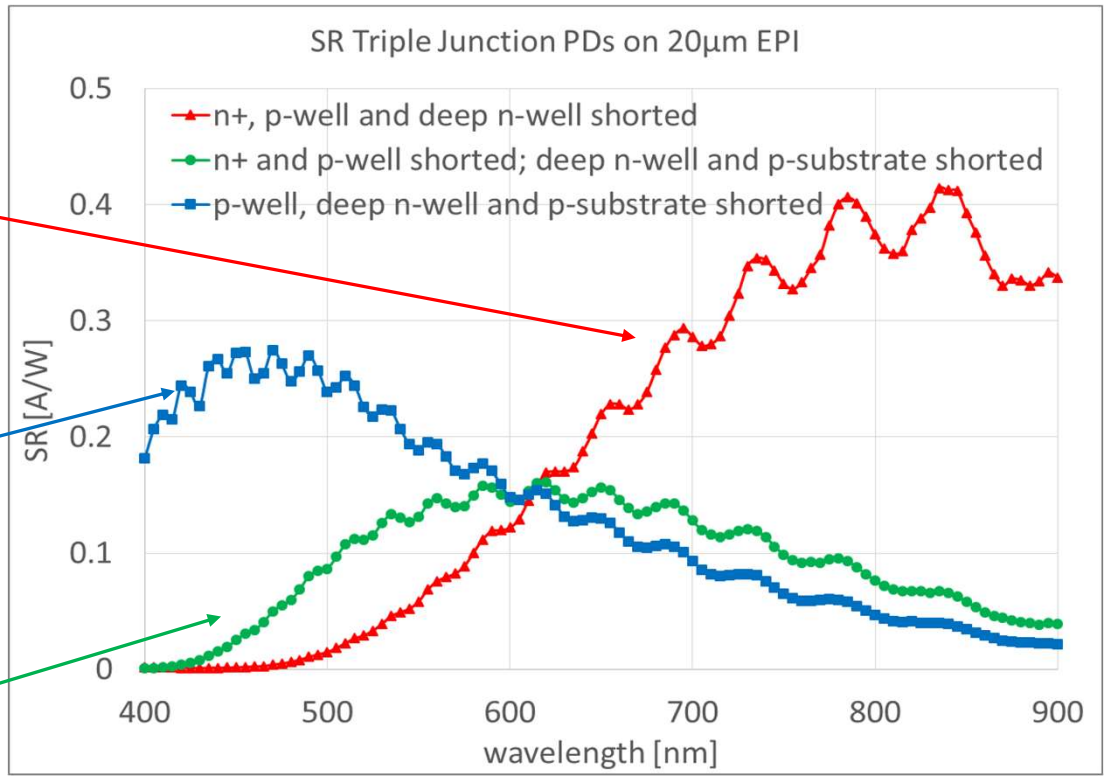
SPAD

PIN PD Integration concept

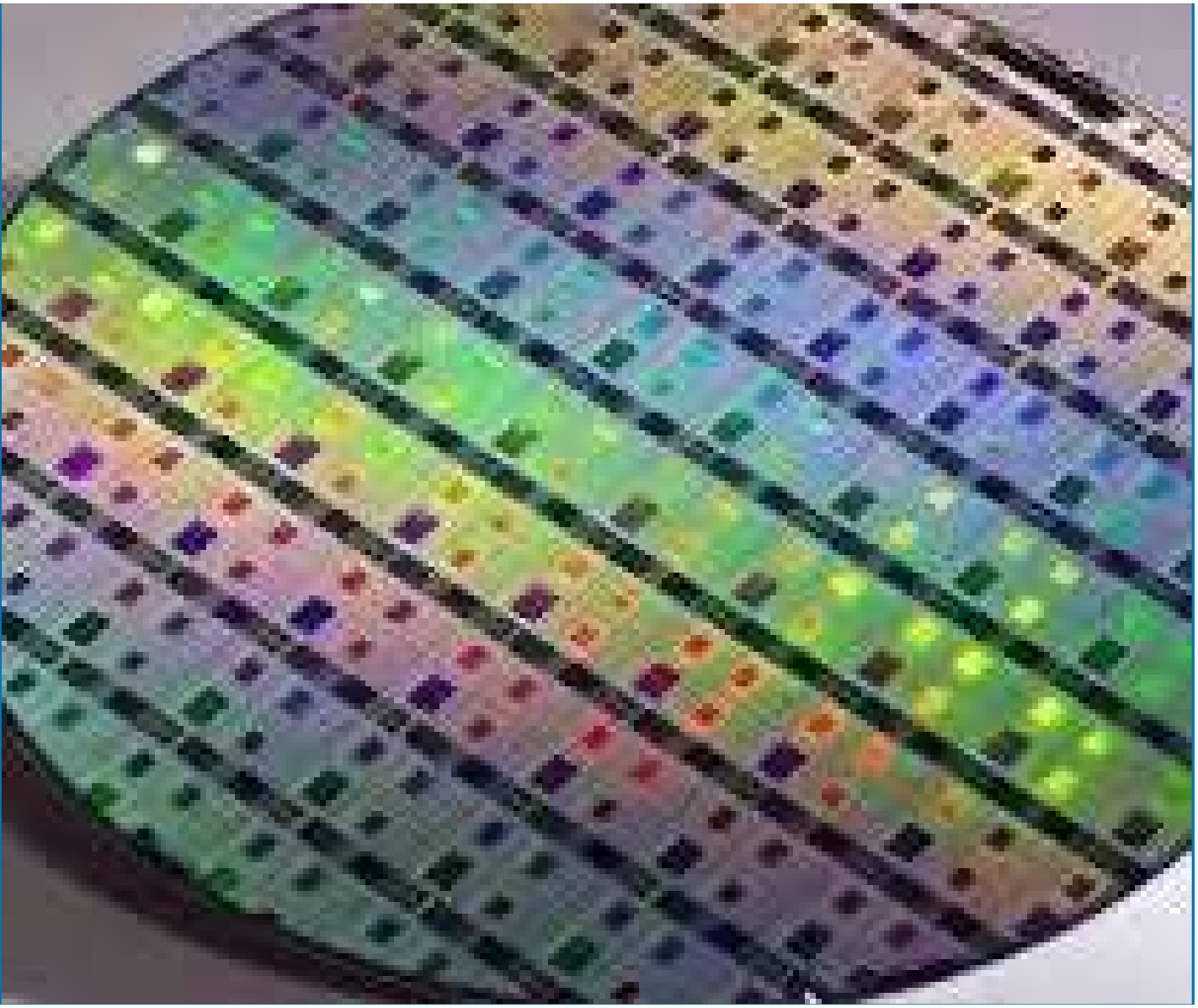
Multi-junction Photodiodes

ams 350nm, 180nm





I. Jonak-Auer et al., "Characterization of various Si-photodiode junction combinations and layout specialities in 0.18µm CMOS and HV-CMOS technologies", Journal of Physics Conference Series 12/2017; 939(1):012028.



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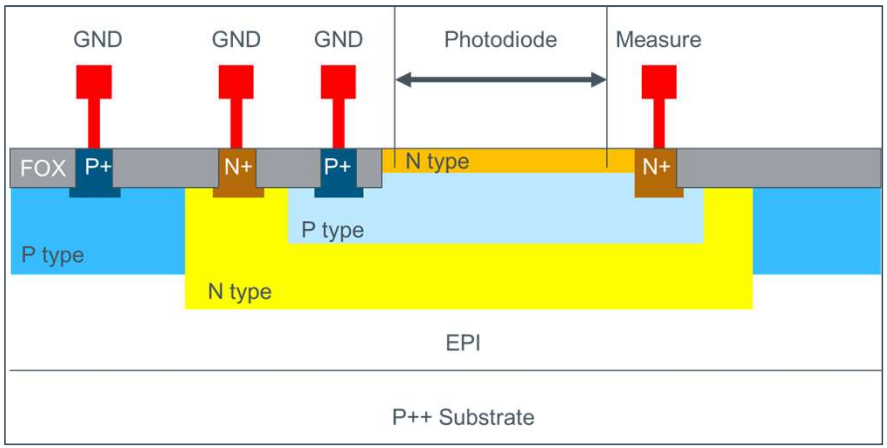
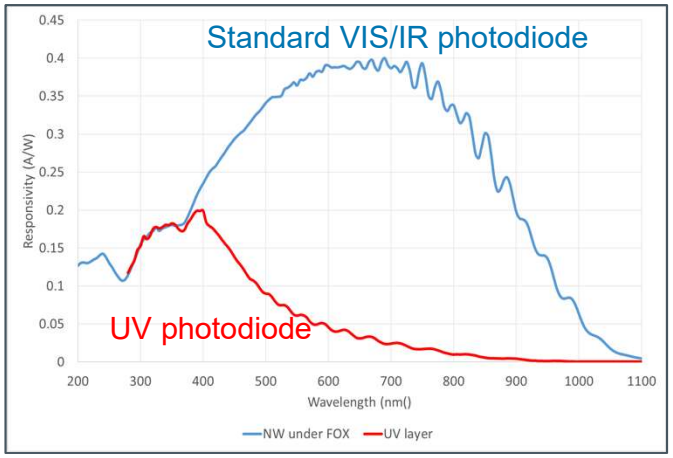
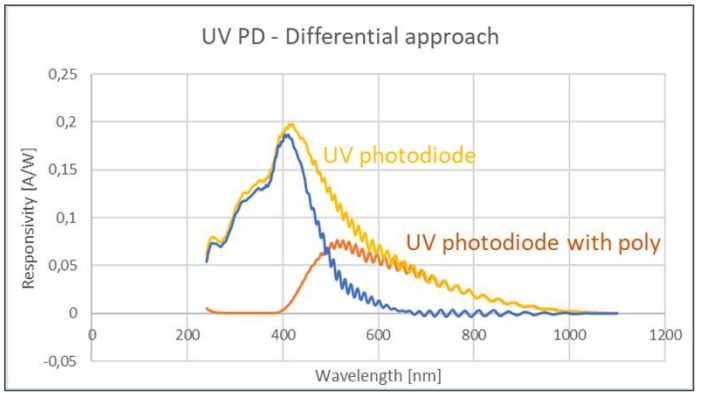
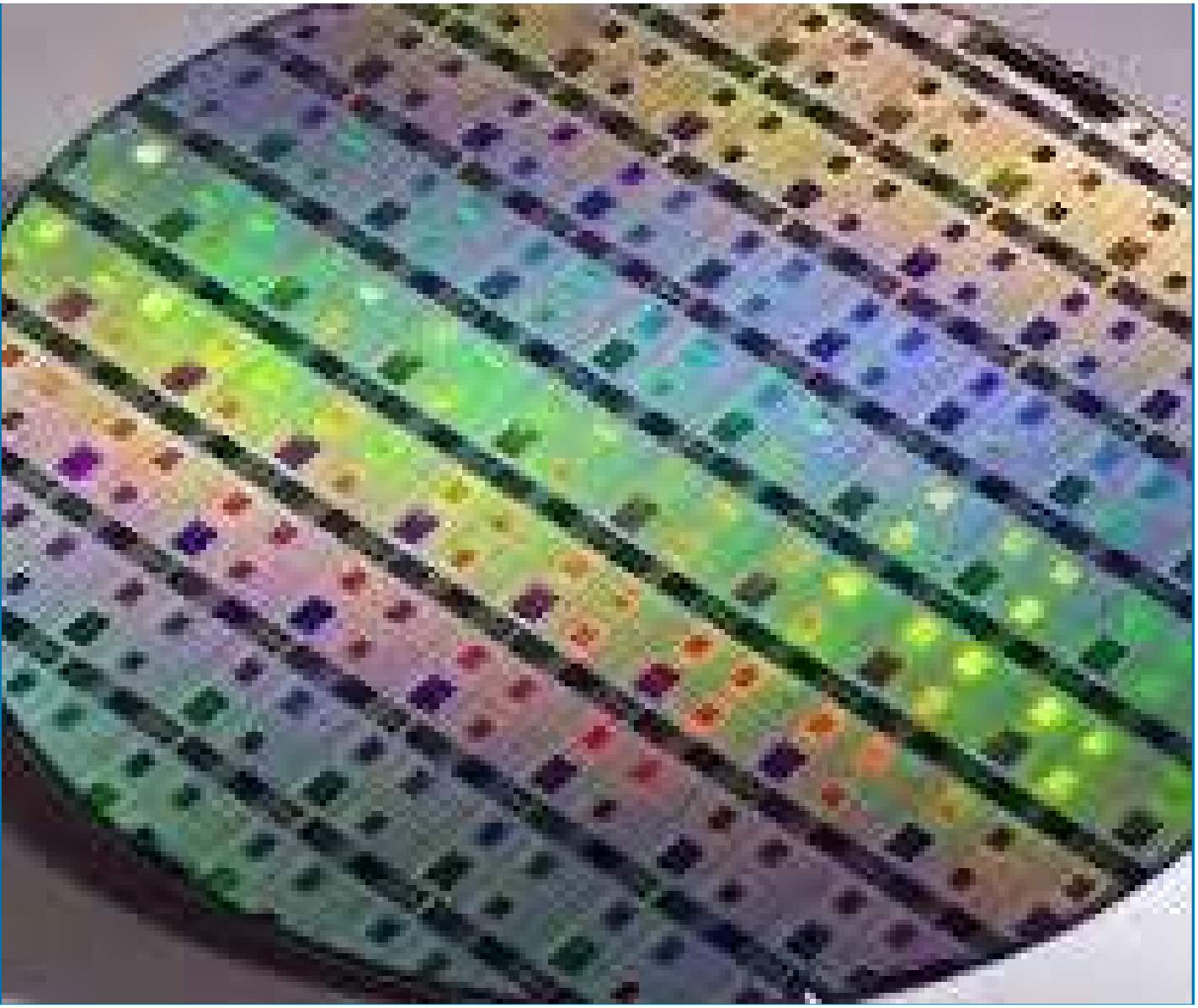


Patent: F. Roger et al., "Sensor device and method for manufacturing a sensor device", ams International AG, EP3229278







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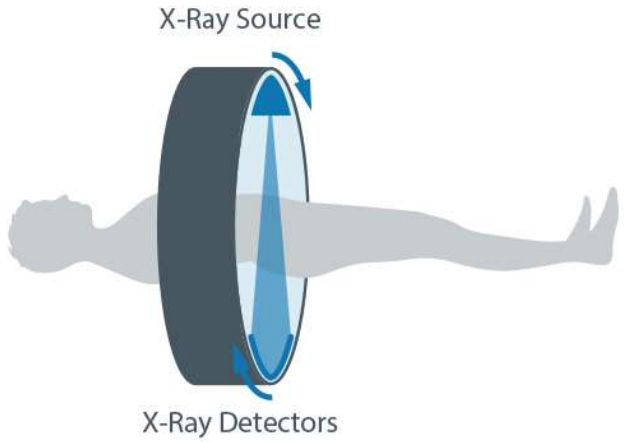
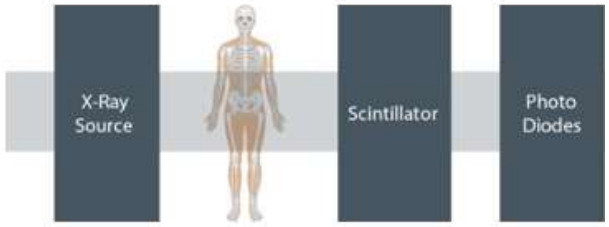
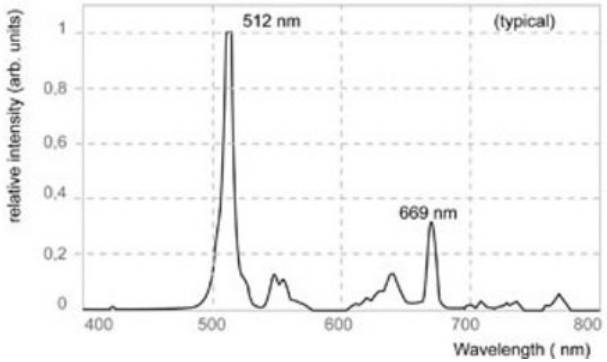
Radiation hard Photodiodes medical applications

CT Operation Principle





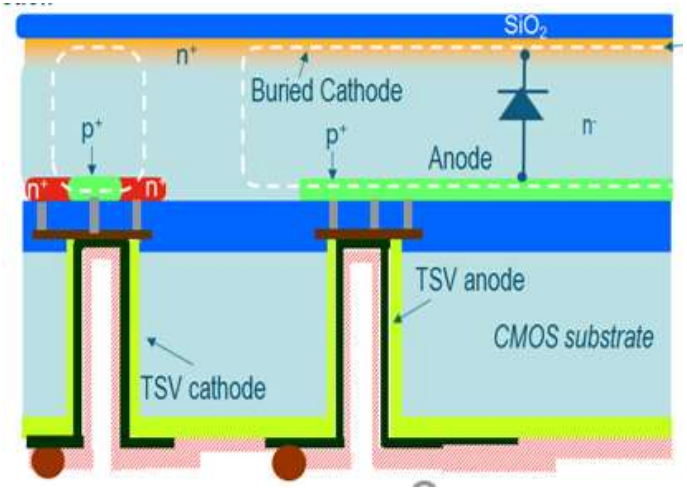
- X-rays undergo absorption in human being under test.
- Scintillator transmits X-rays to visible spectrum
- PD is designed to fit to scintillator spectrum

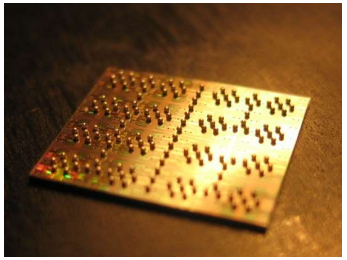


Radiation hard Photodiodes for CT applications

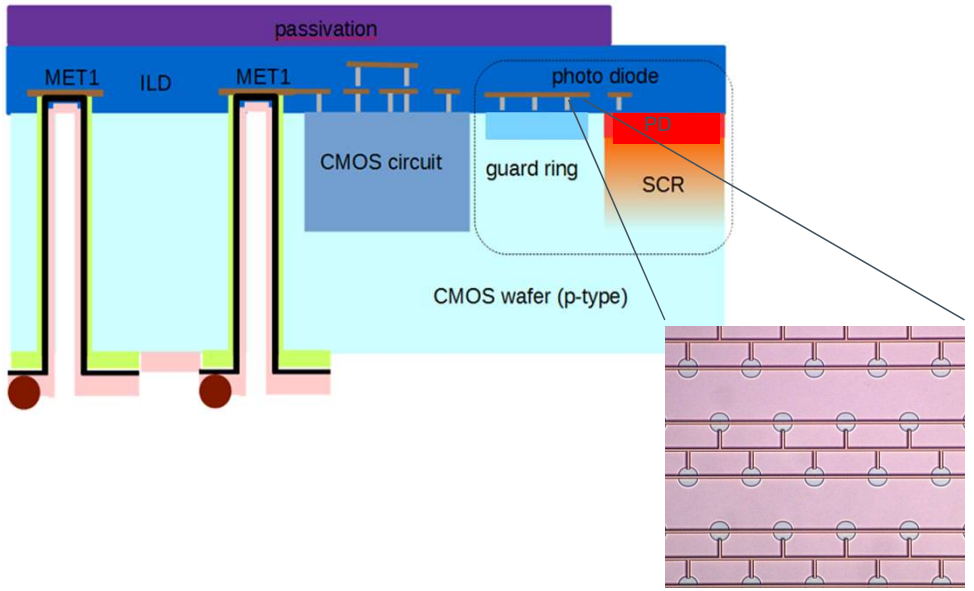
ams 350nm

3D integrated PD (backside illuminated)





Monolithically integrated PD (frontside illuminated)

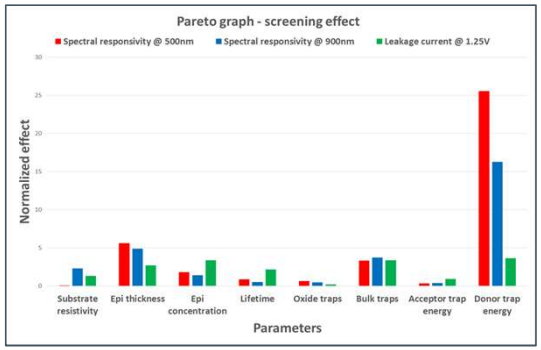


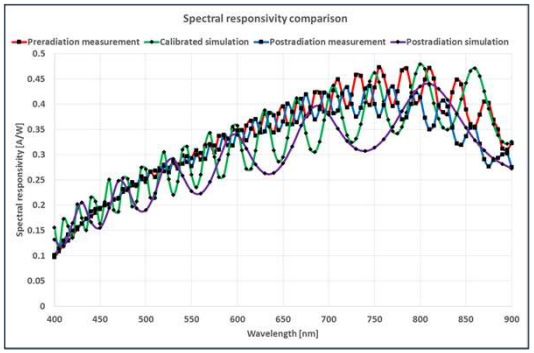
Patent: G. Meinhardt et al., "Radiation-hard high-speed photodiode device", ams International AG, EP3331034

STREAM – EU funding project

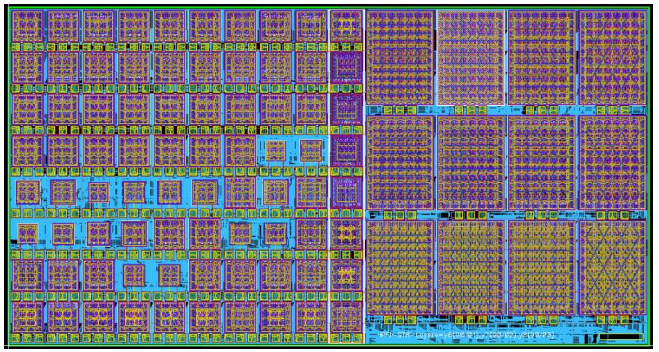
Design and process development for improved radiation hard X-ray (VIS) and NIR CMOS sensor applications

- **TCAD simulations of PDs in ams 350nm and 180nm technology; inclusion of irradiation induced traps:**





- **Testchip Design and technology comparison in 180nm**



F. Segmanovic et al., "Impact of TCAD Model Parameters on Optical and Electrical Characteristics of Radiation-Hard Photodiode in 0.35µm CMOS Technology" to be published in IEEE Xplore, Proceedings of MIPRO 2018, 41st International Convention on Engineering Education.

F. Segmanovic et al., "Optical and electrical simulations of radiation-hard photodiode in 0.35µm high-voltage CMOS technology ", to be published in proceedings of Patmos 2018, 28th International Symposium on Power and Timing Modeling, Optimization and Simulation.

STREAM – EU funding project

Radiation hard IC design for space and medical applications

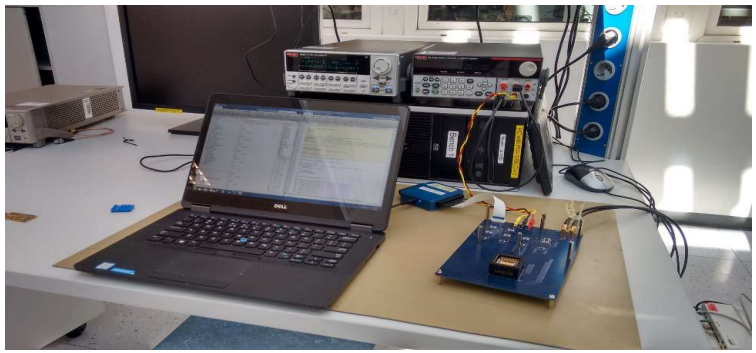
ams Sensing is life.

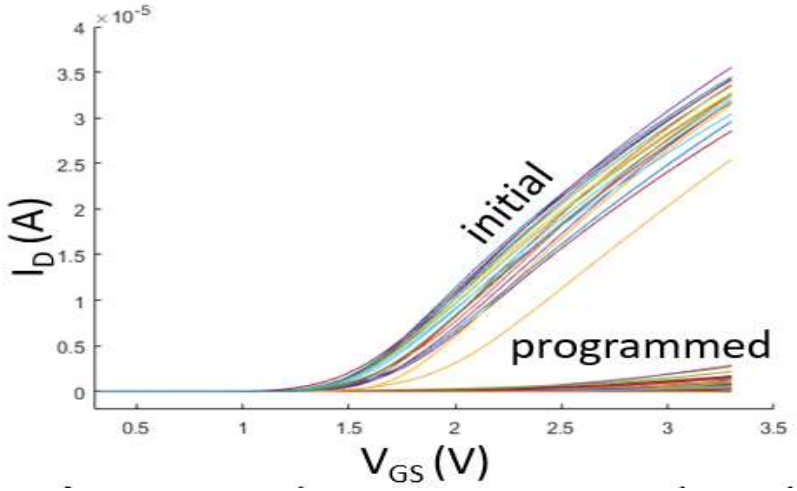
Characterization of radiation effects on memory bit cells:

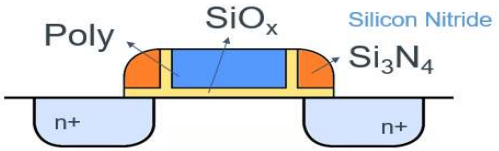
1st run with tsmc 180nm

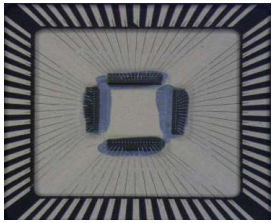
2nd run with tsmc 55nm (Q4 2018)

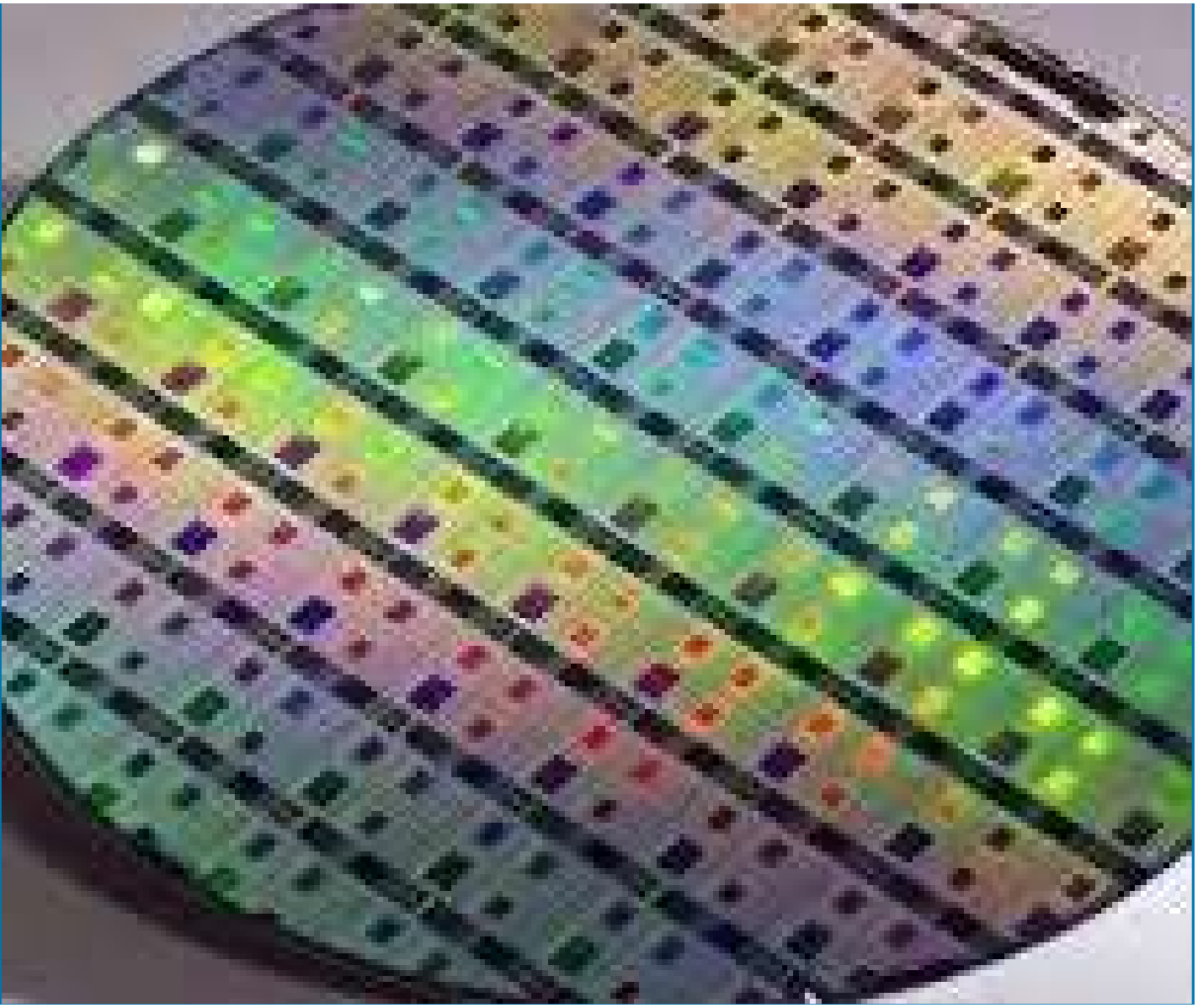
Irradiation of cells with 60eV X-rays up to 1Mrad











FRONT END

multi-junction PD

UV-PD

radiation hard PD

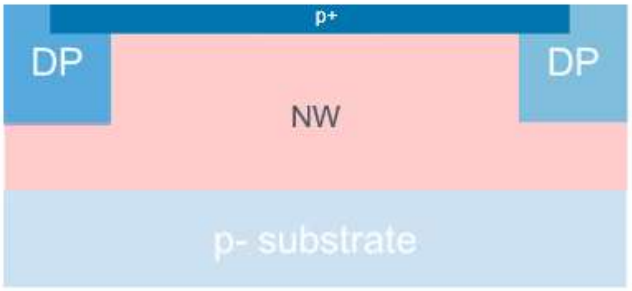
SPAD

PIN PD Integration concept

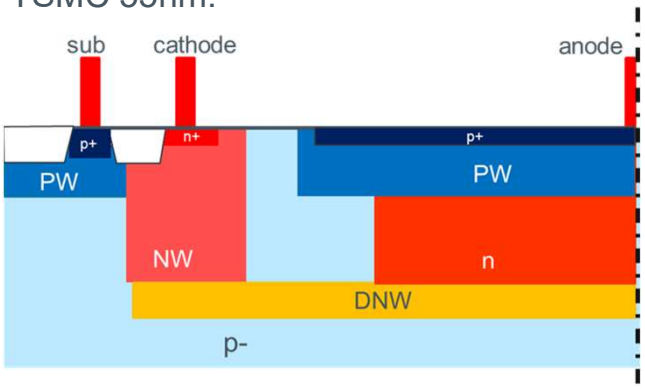
SPADs

Direct ToF Applications

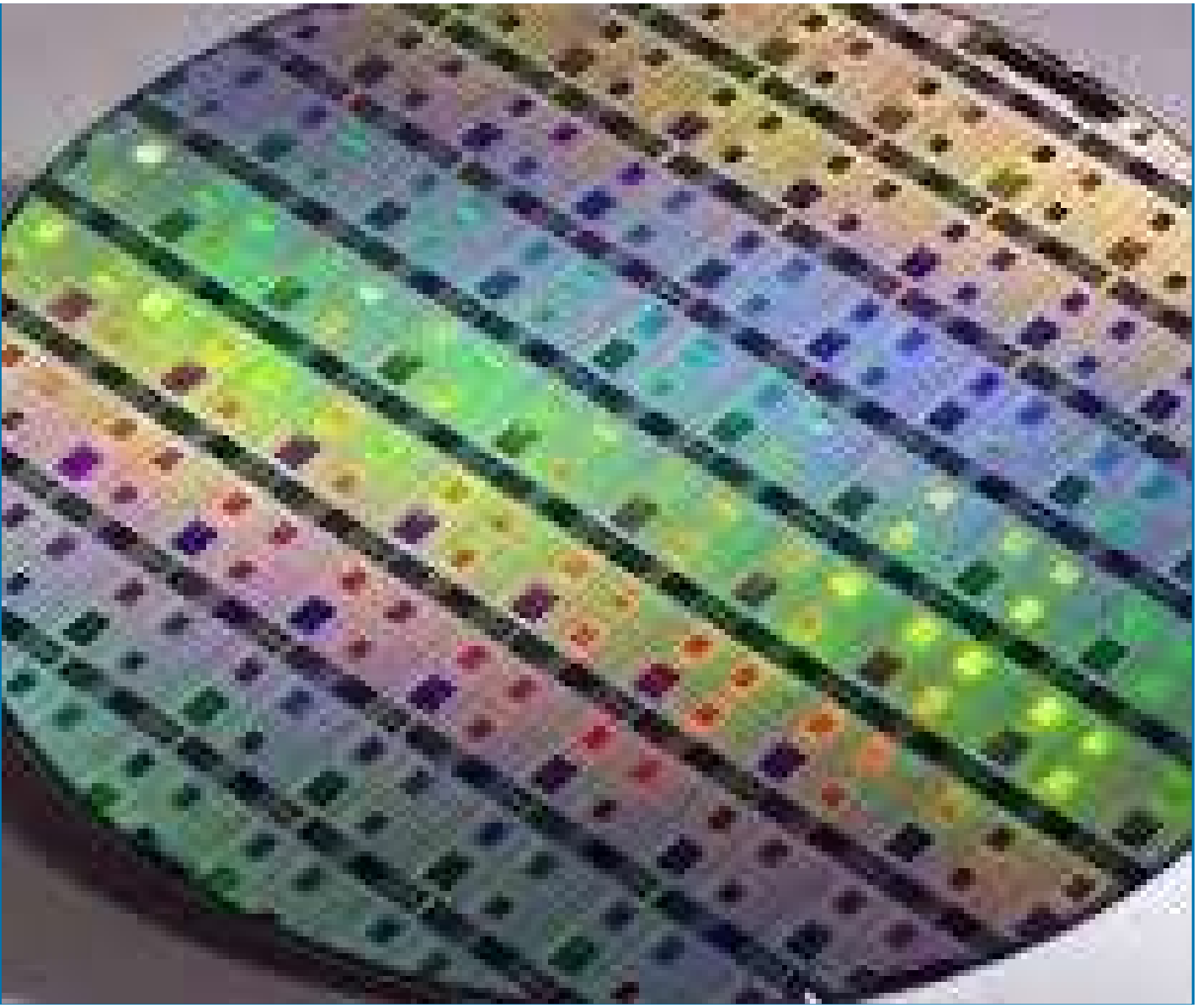
ams 350nm:



TSMC 55nm:



- Camera autofocus
- Selfie quality improvement - perspective correction
- Improved eye tracking
- Proximity – ensure no false phone call disconnects
- Gesture – 3D Sensing



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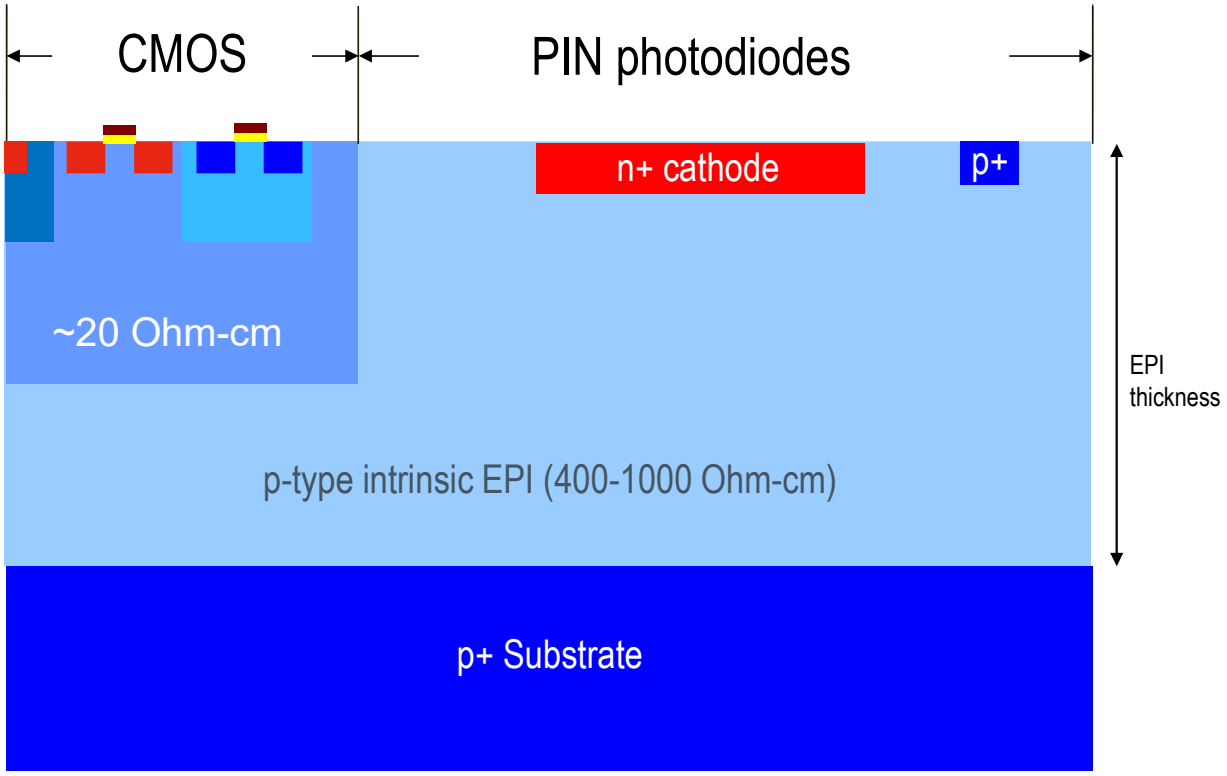
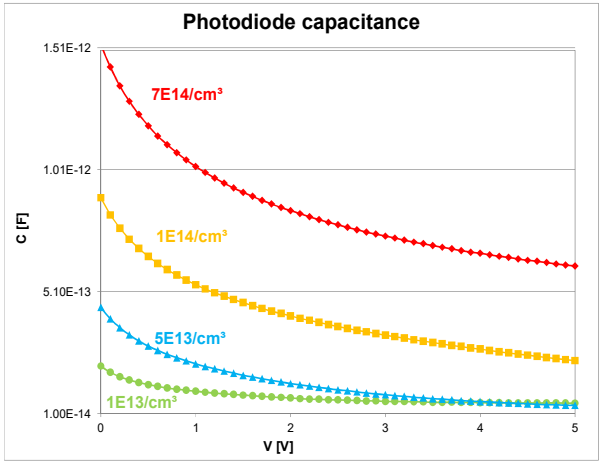
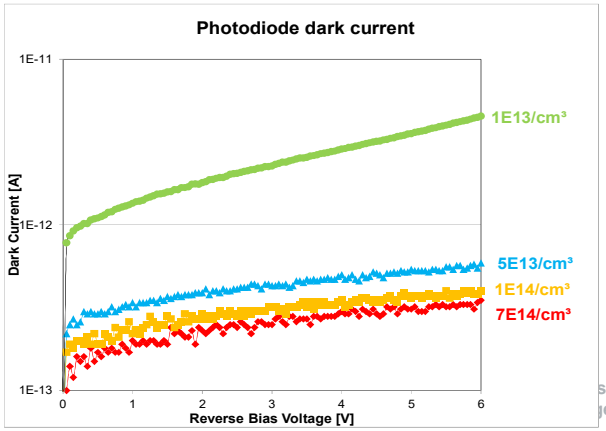
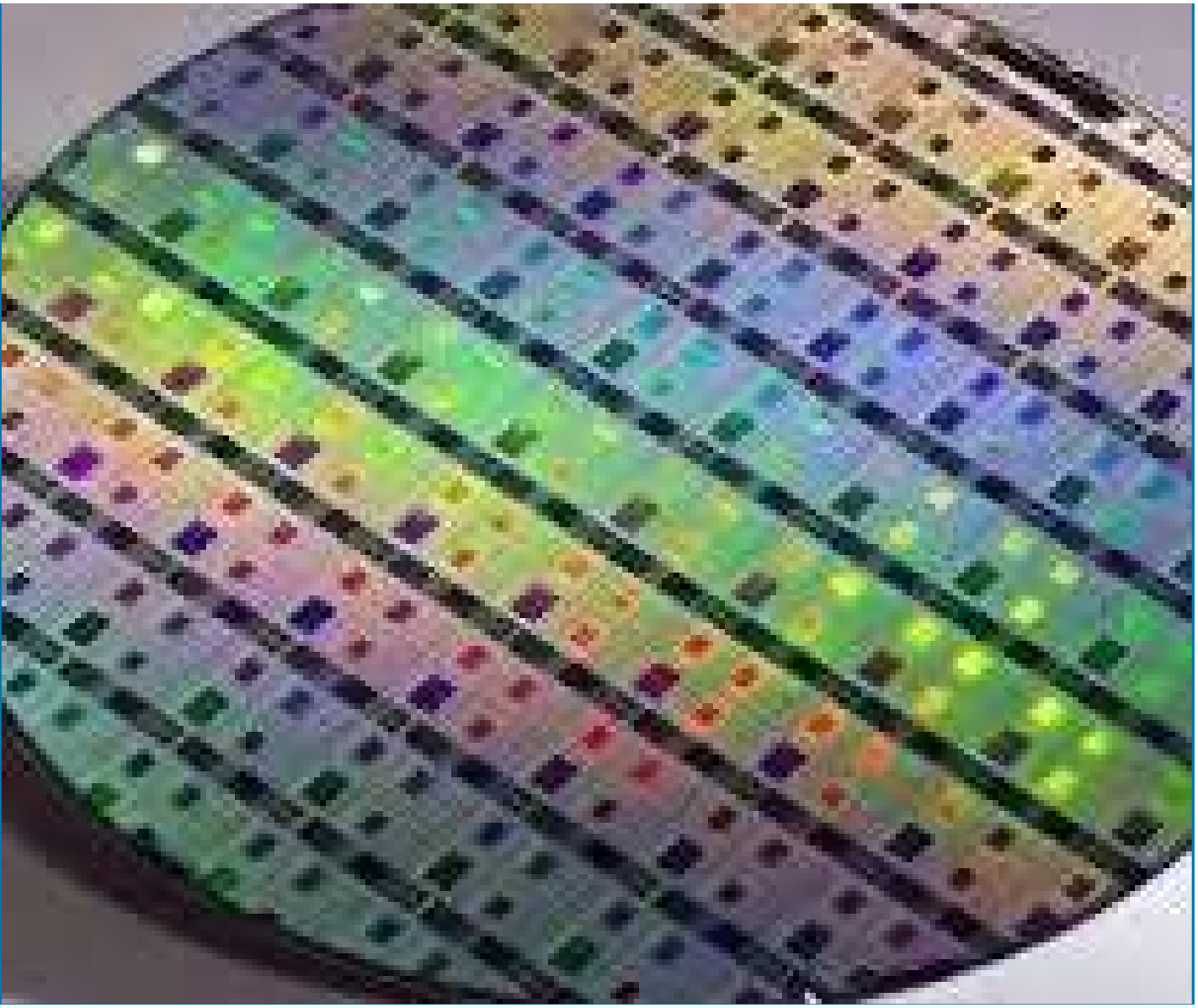
PIN PD Integration Concept









BACK END

Anti reflective Coatings

Filters

3D Integration

Anti-reflective Coatings

ARC, BARC and eBARC

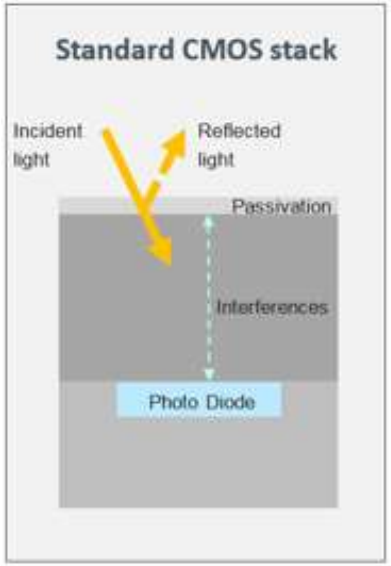


Figure 1: cross section of a standard CMOS oxide stack with passivation on top.

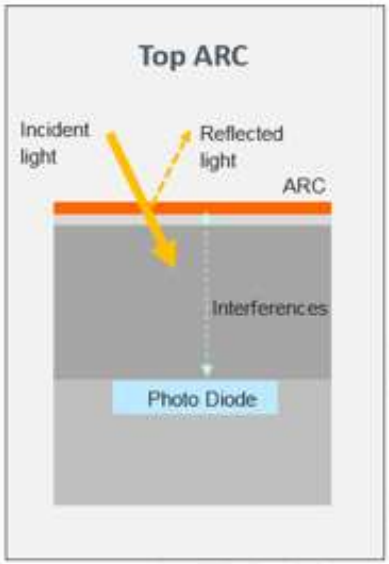


Figure 2: cross section of a standard CMOS stack and TopARC on top.

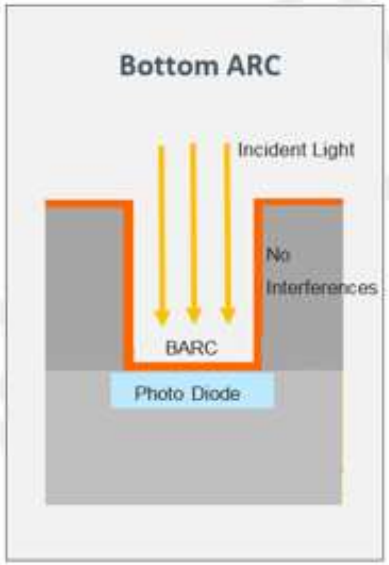


Figure 3: cross section of a PD with BARC and removed oxide stack.

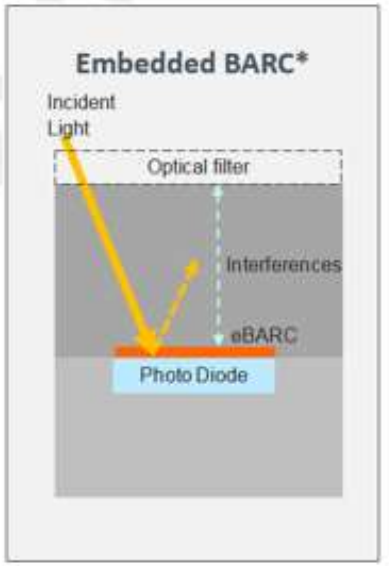
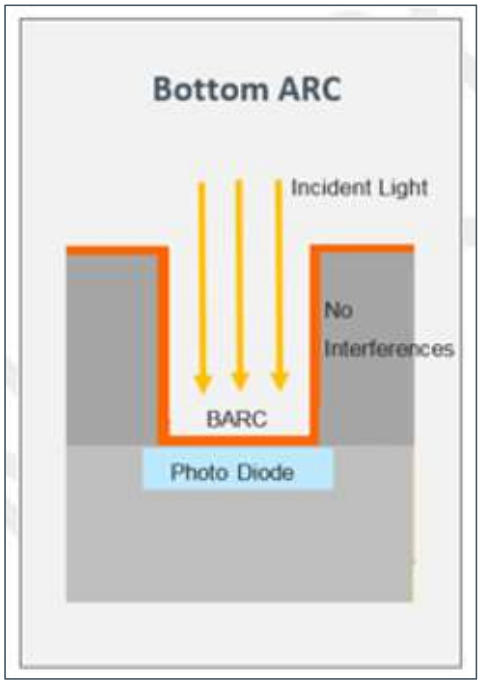
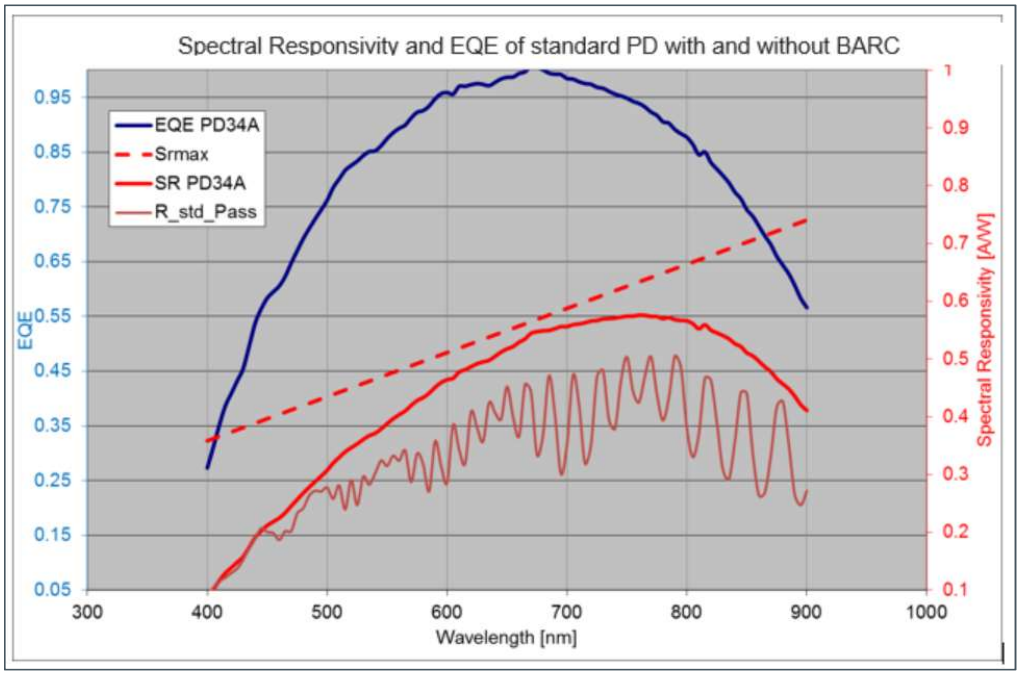


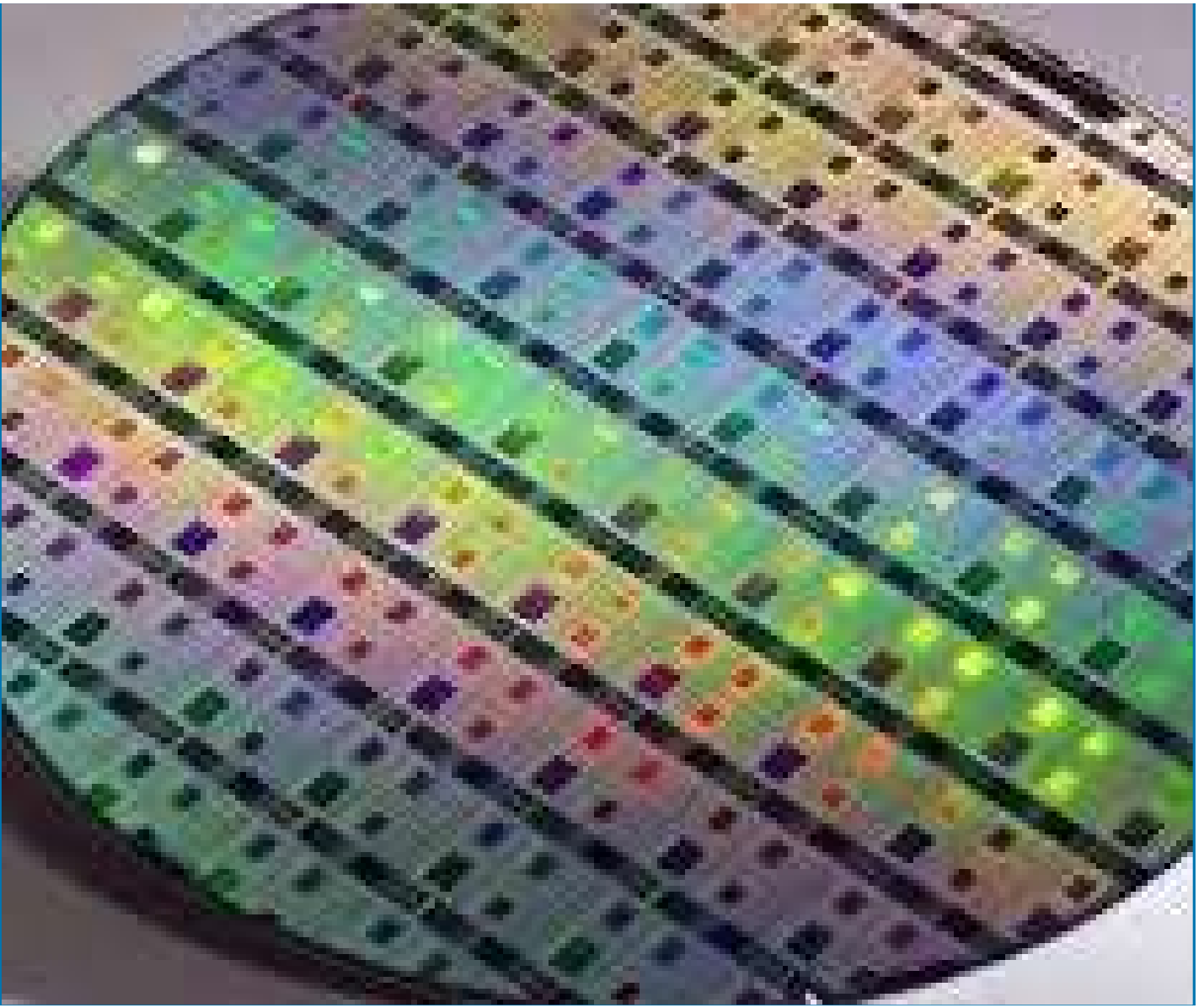
Figure 4: cross section of a PD with eBARC in combination with optical filters.

Bottom Antireflective Coatings

Results







Sensing is life.

BACK END

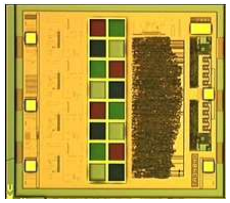
Anti reflective Coatings

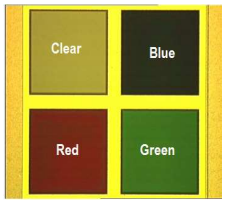
Filters

3D Integration

Filter options

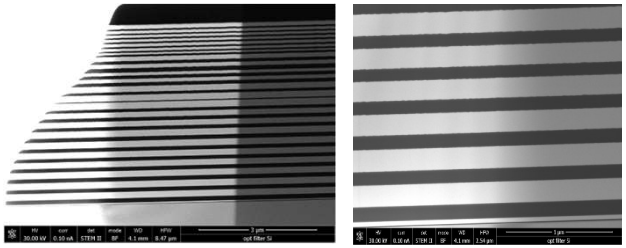
RGB organic coatings





- based on absorption effect due to metal pigments.
- straight forward processing
- no angular dependence of spectral response.

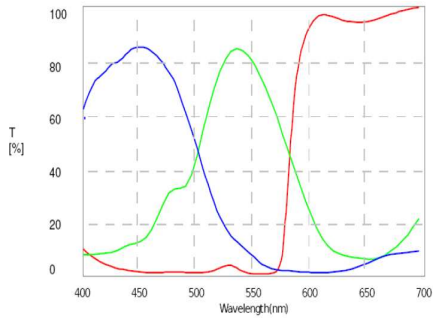
Interference Filters



- non absorbing, spectral response relies on interference effects only
- spectral response shows angular dependence
- transmission characteristics can be designed for any specific application

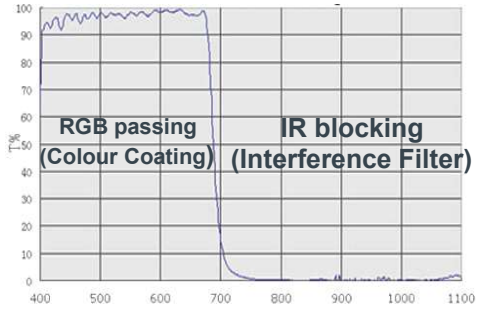
Applications: ARCs, high reflectance mirrors, beam splitters, edge filters, band pass filters, notch filters, color filters

Filter Combinations

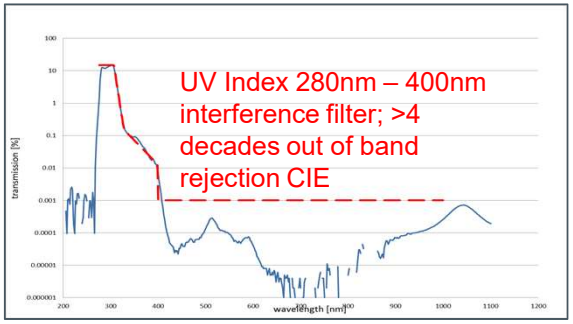


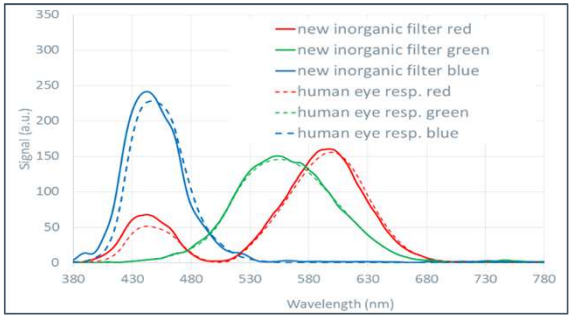
Transmission of Colour Coatings:

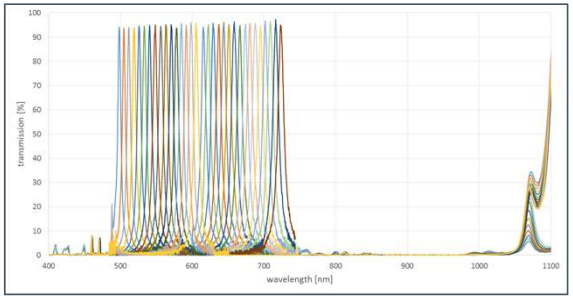
+

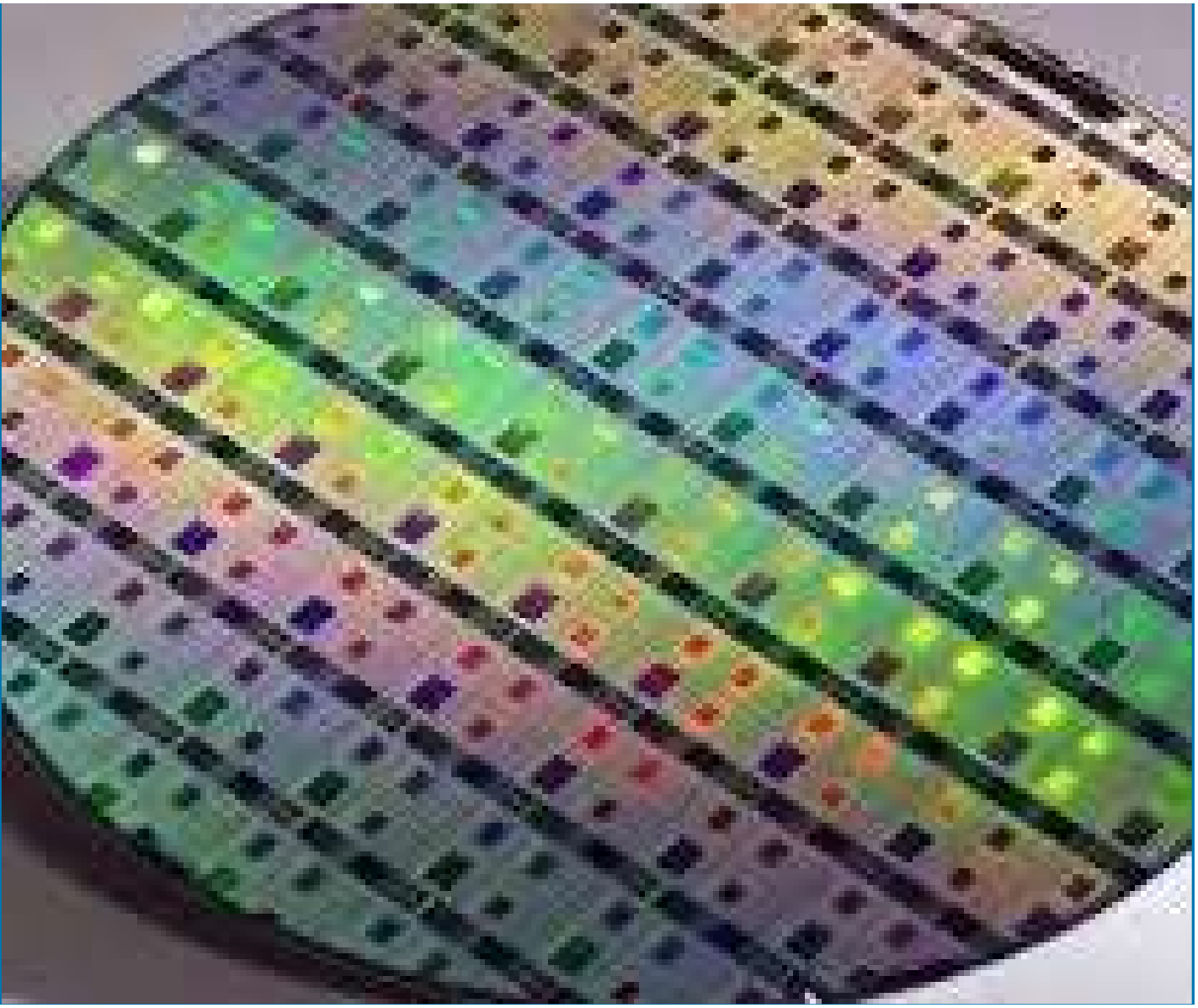


Interference Filters - Applications









BACK END

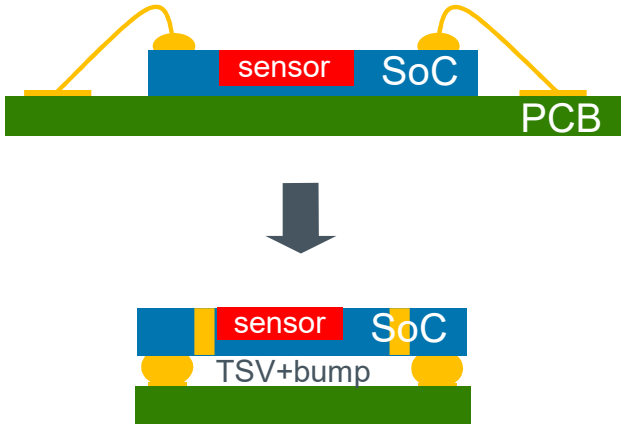
Anti reflective Coatings

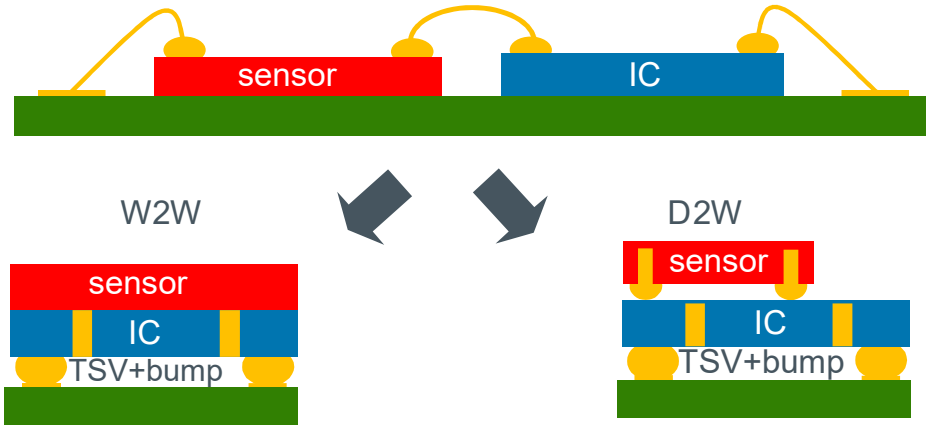
Filters

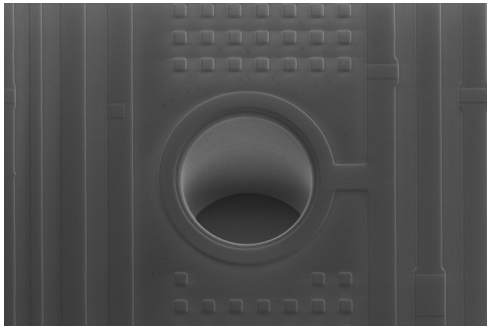
3D Integration

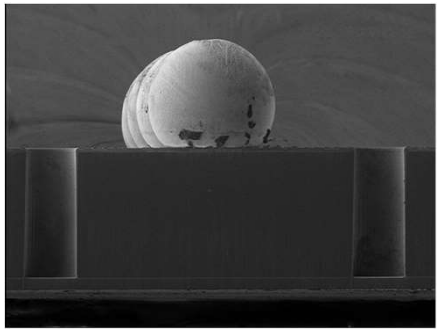
Sensor integration options

2.5D and 3D









- Form factor reduction
- Performance advantages
- System cost reduction

Sensing is life.

Megatrends drive sensor markets

Thank you!

Please visit our website
www.ams.com