Optimized BSI CMOS Pixel for both UV and Visible Light

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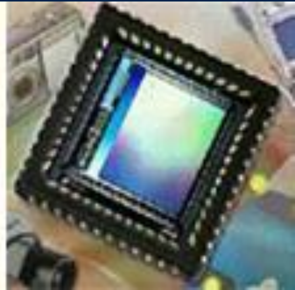
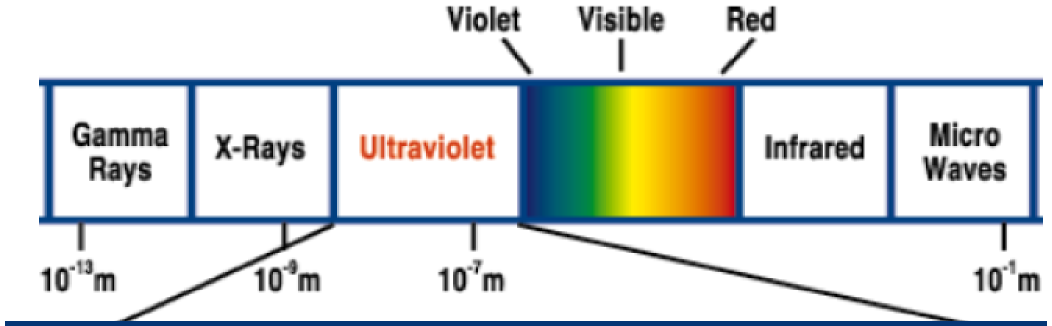
June 4th, 2025



UV sensors applications

UV light spectrum



Extreme UV **(EUV)**	Vacuum UV **(VUV)**	Short wave UV **(UV-C)**	Middle wave UV **(UV-B)**	Long wave UV **(UV-A)**

10 nm **100 nm** **200 nm** **280 nm** **315 nm** **400 nm**

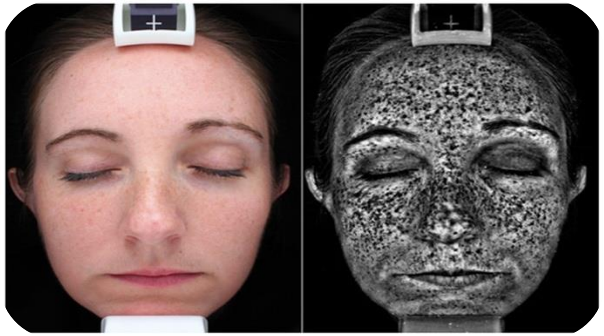
E = 124 eV

E = 3.1 eV

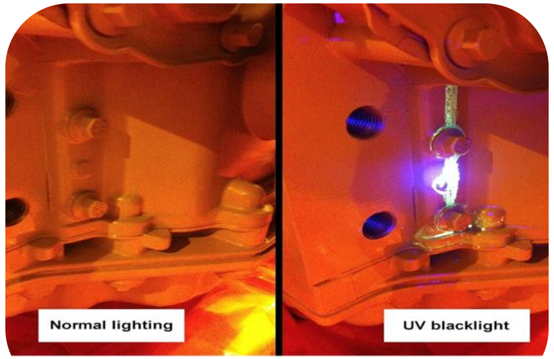
UV range this study focusses on

Different applications

Security & authentication



Healthcare & skin monitoring



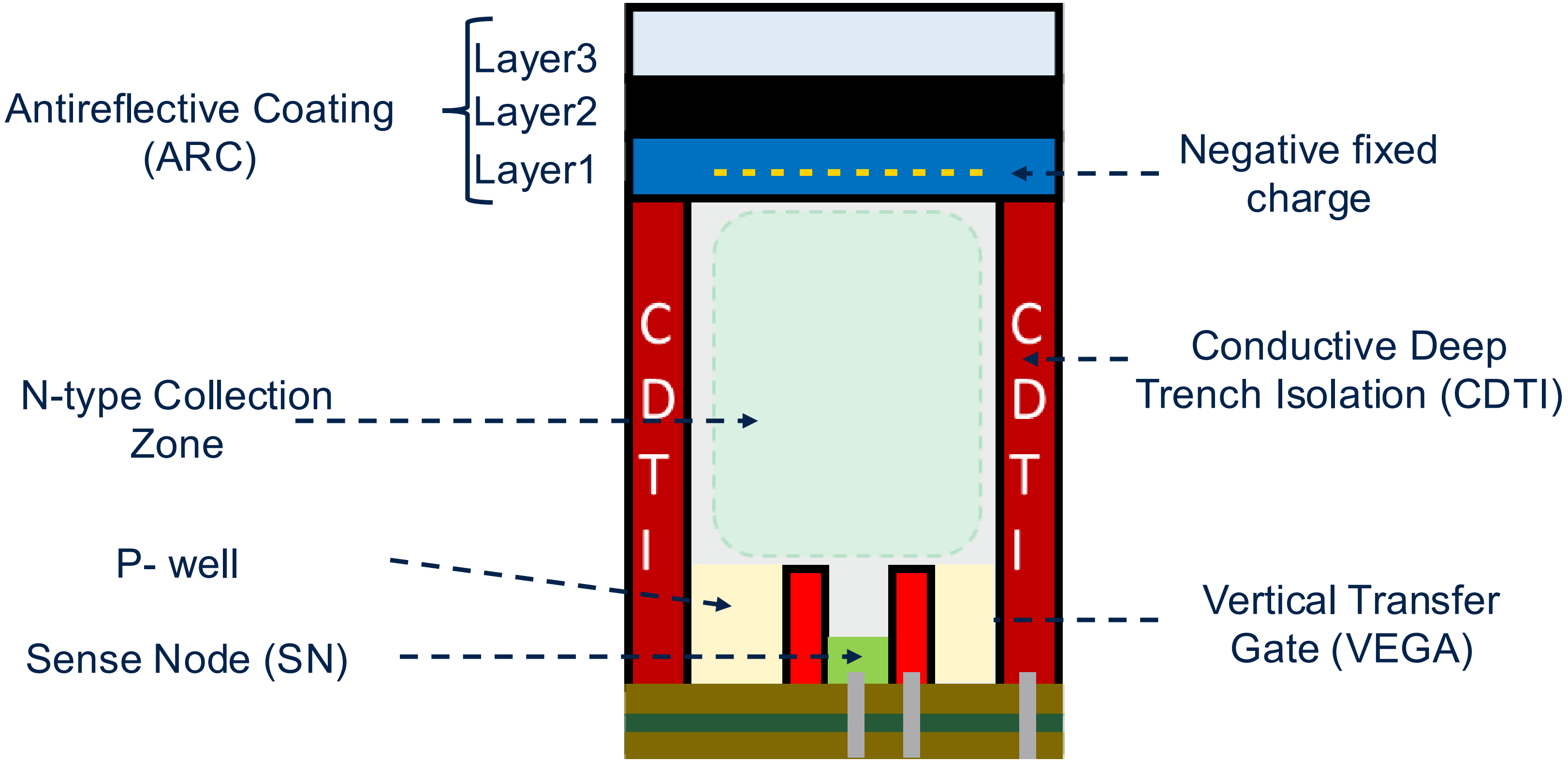
https://uv-light.co.uk/fluid-leaks/

Environment hazard detection

*alog.miniscience.com/electricity/Black_Light_*

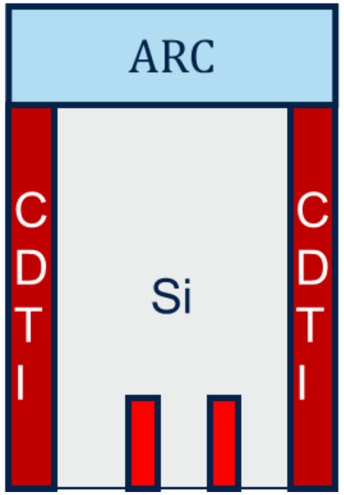
Antique evaluation

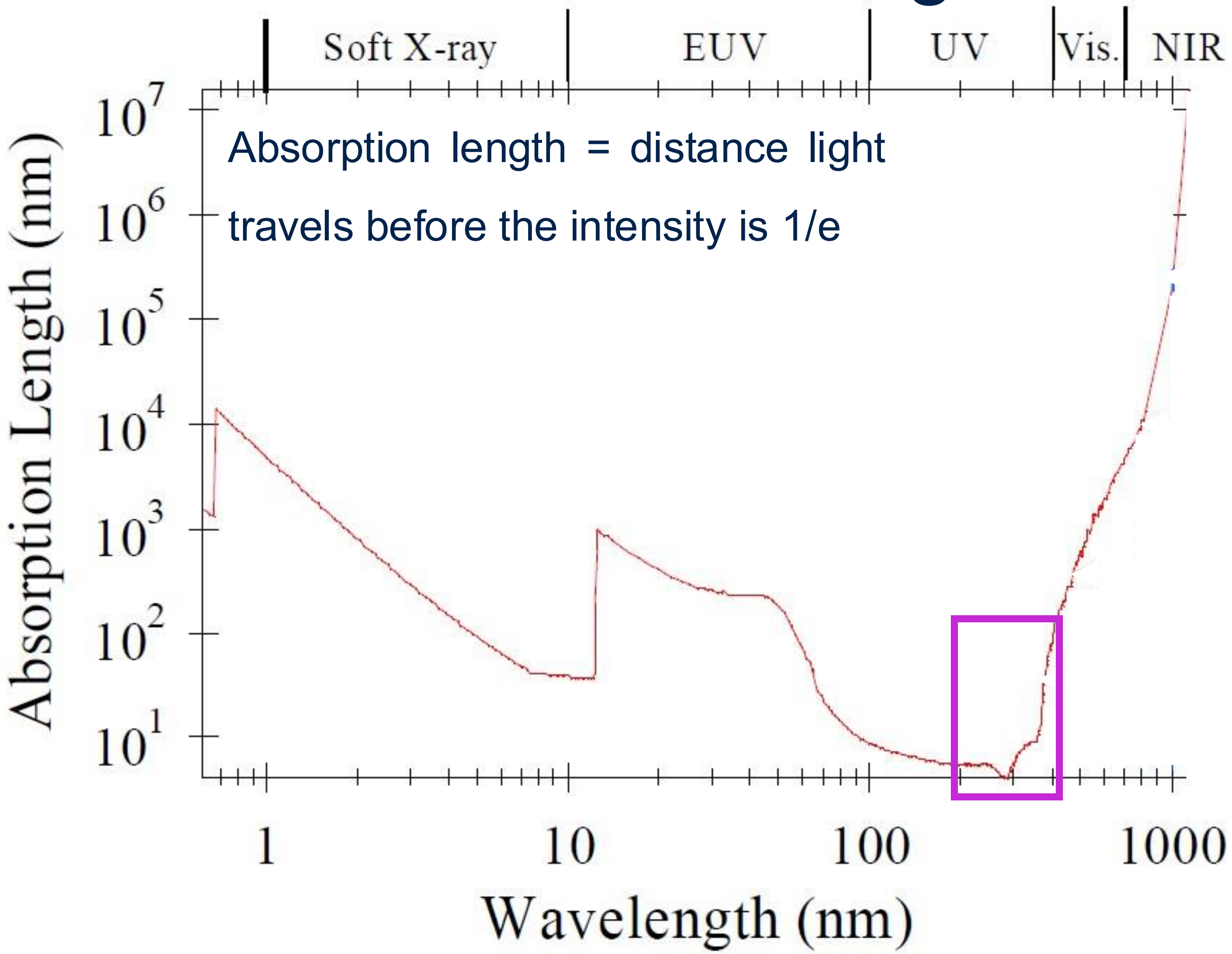
Pixel description



Vertical pinned photodiode pixel

Challenges in UV CIS design

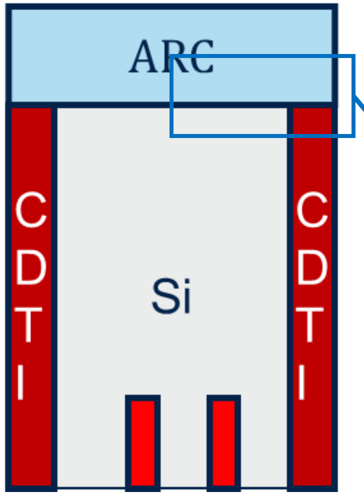




Absorption length = distance light travels before the intensity is 1/e

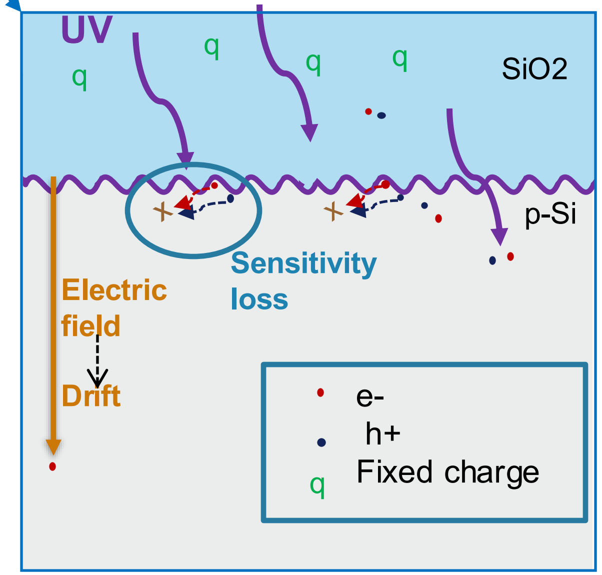
Absorption length < 20nm below 350nm wavelength

Challenges in UV BSI CIS design



Interface defects

→ Charges’ recombination



Solution:

High electric field at the interface

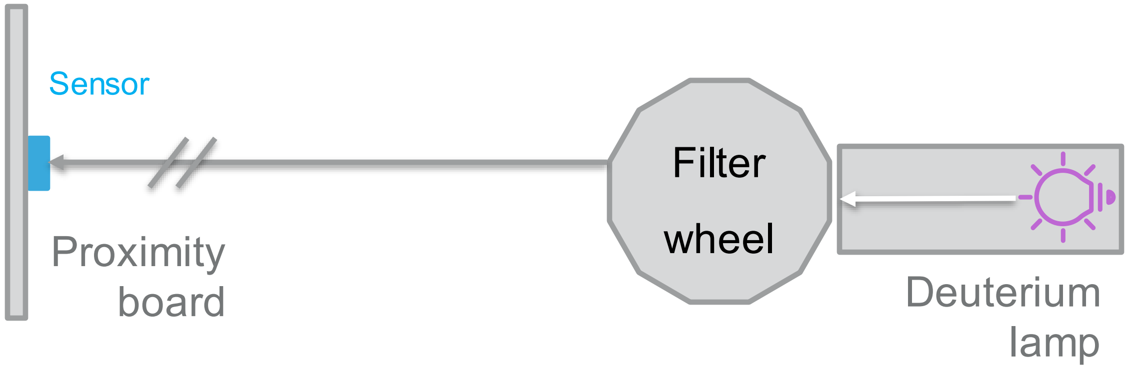
→ Low interface states density

→ Doping the near-interface region

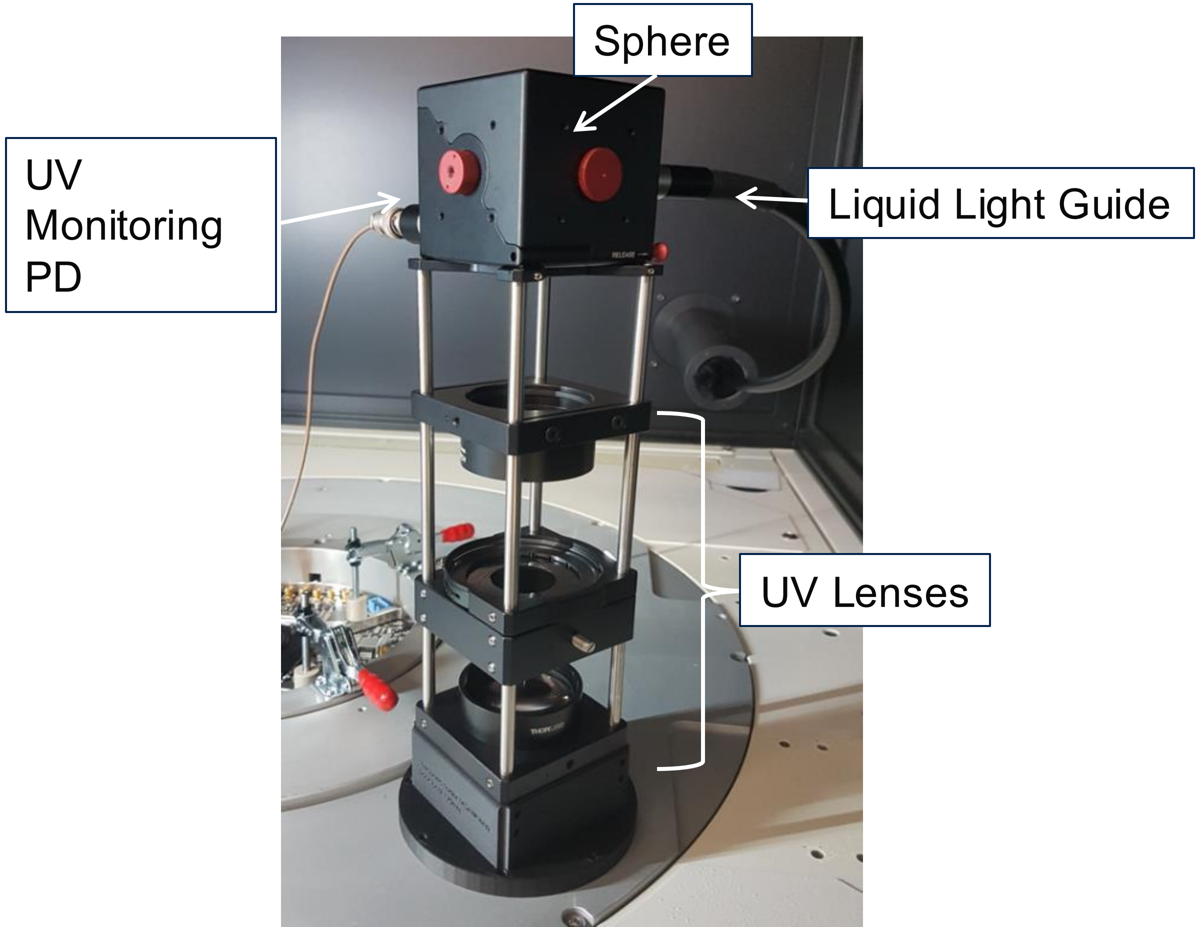
Experimental setup

Two quantum efficiency (QE) measurements methods:

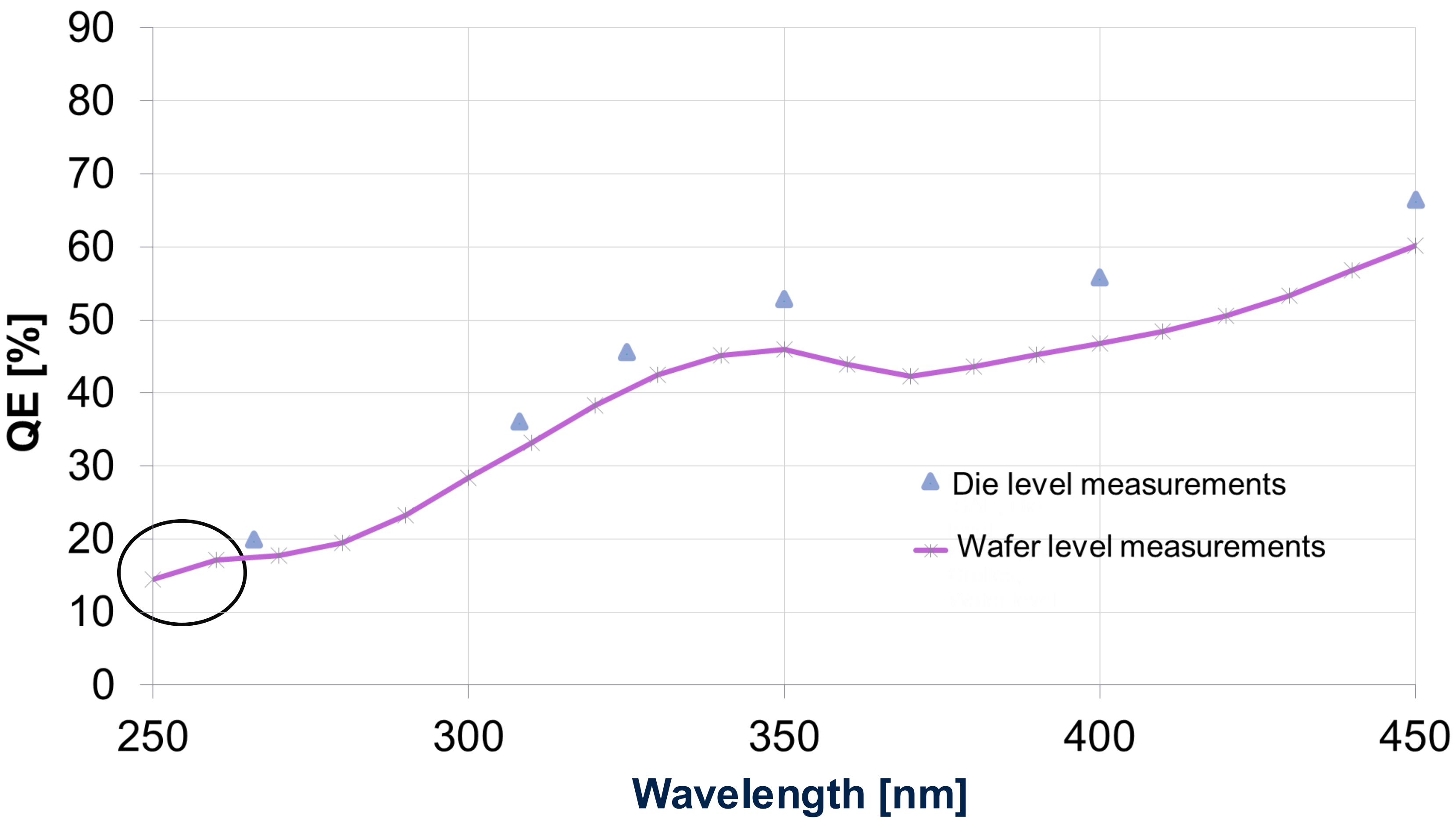
Die level QE bench



Wafer level QE bench

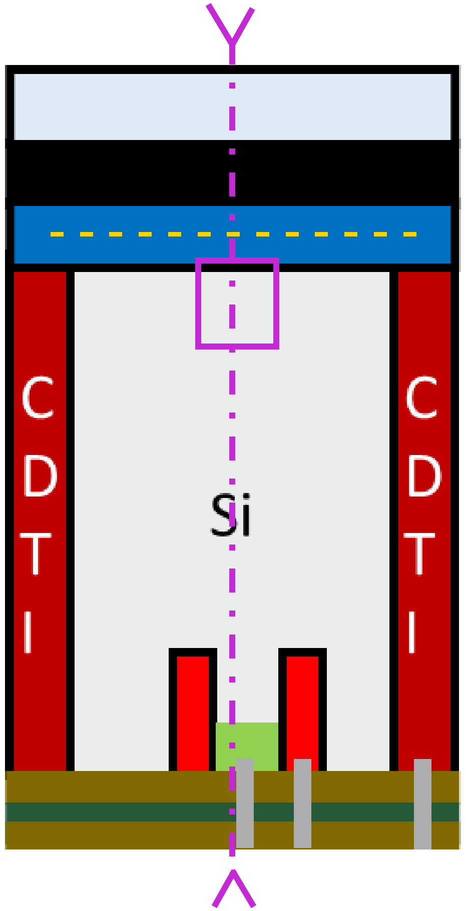


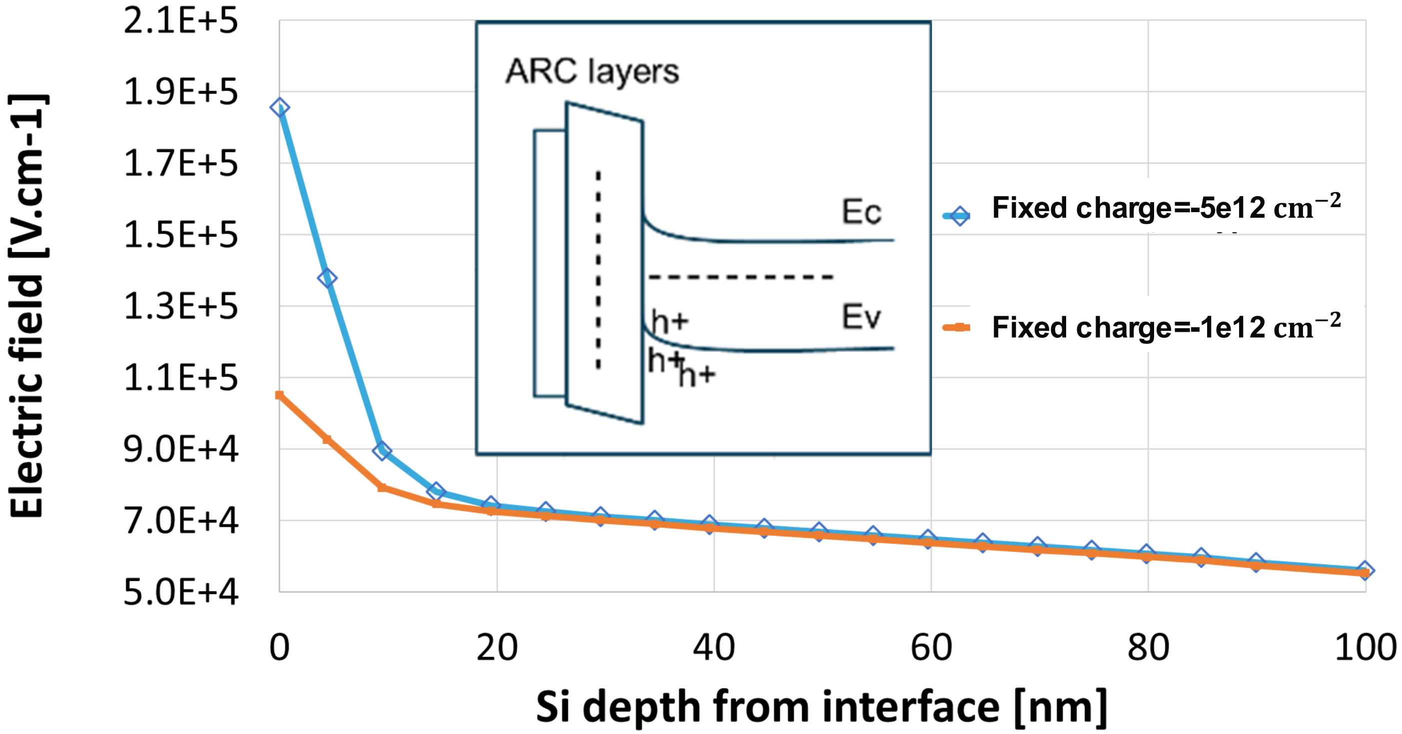
QE results



QE = 15% at λ =250nm

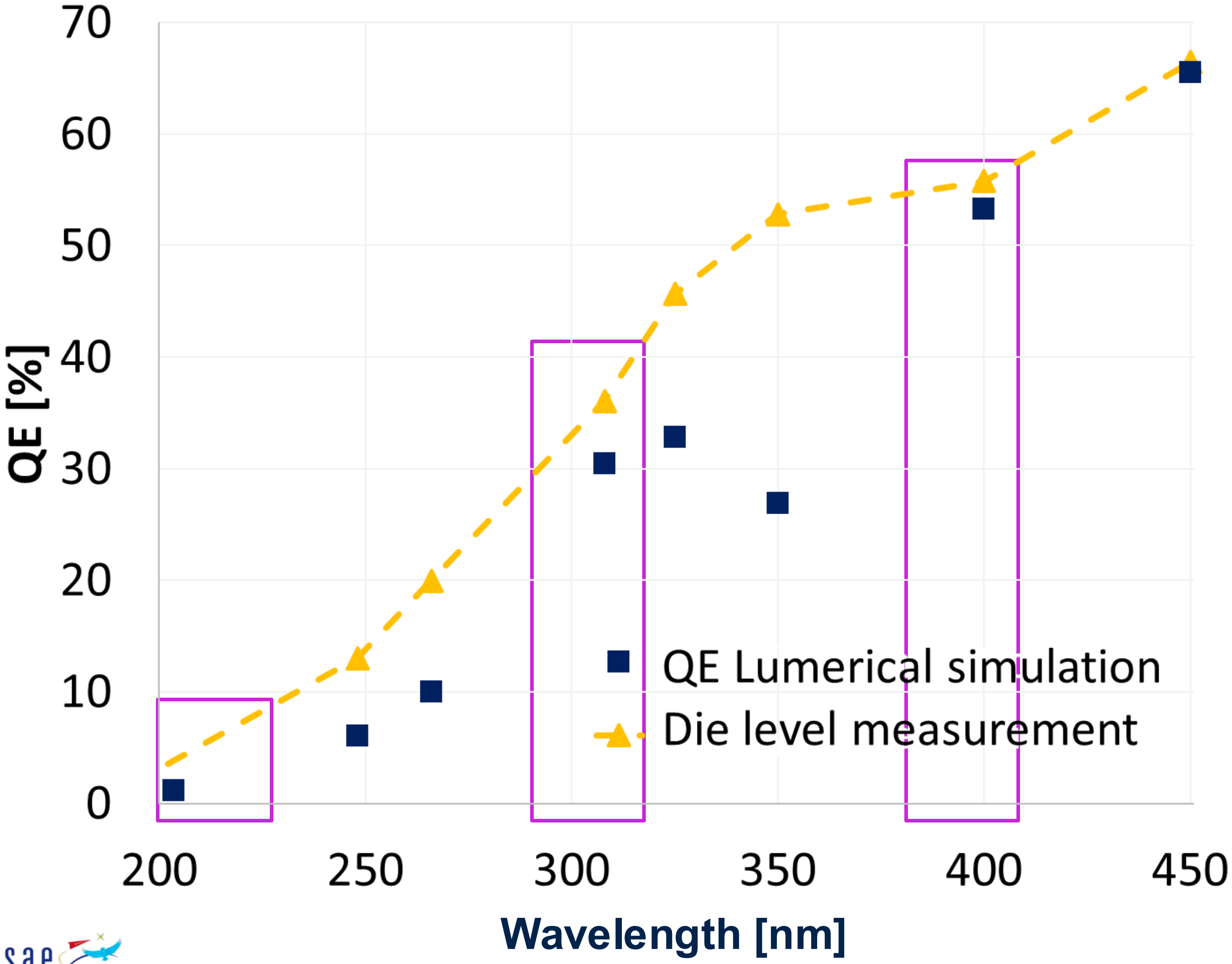
Backside interface electrical simulations





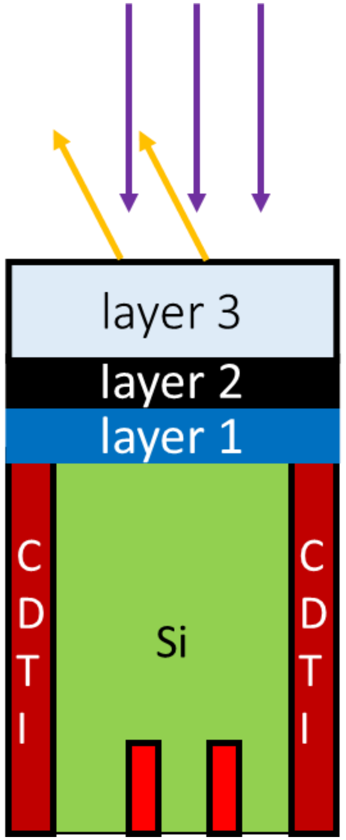
100% of collection efficiency, even under UV light

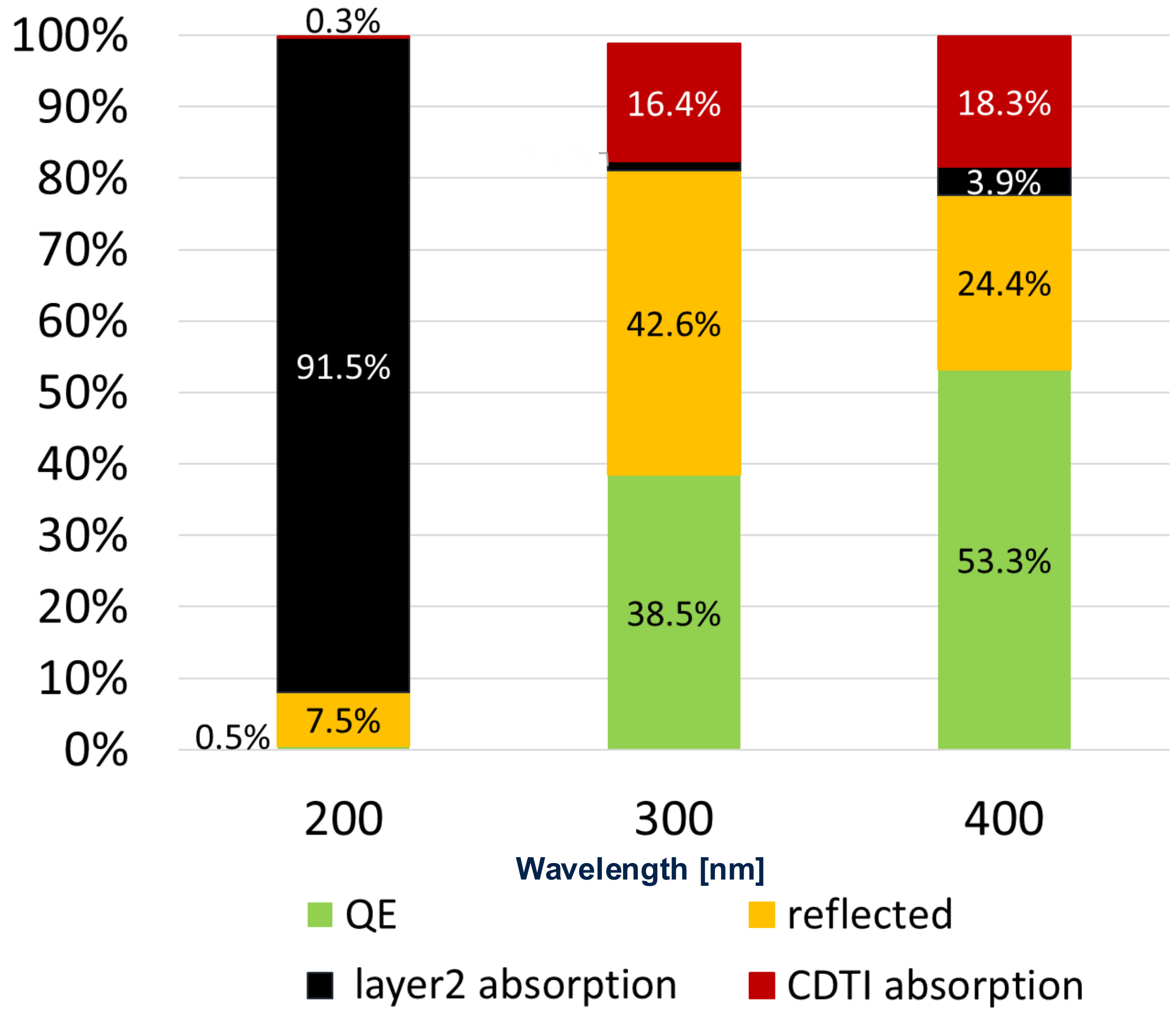
Backside ARC optical simulations



Good agreement between measured and optically simulated data

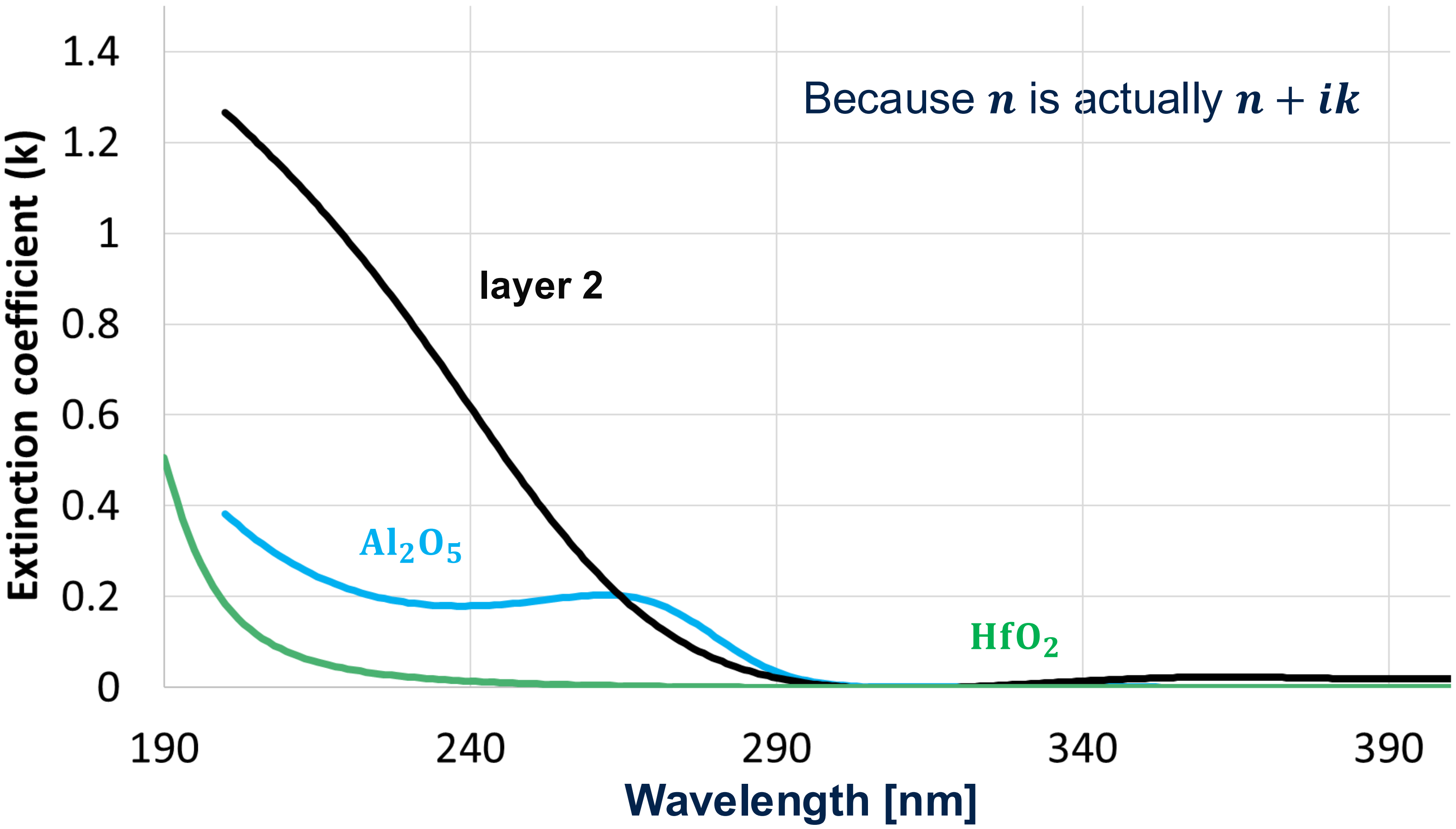
Backside ARC optical simulations



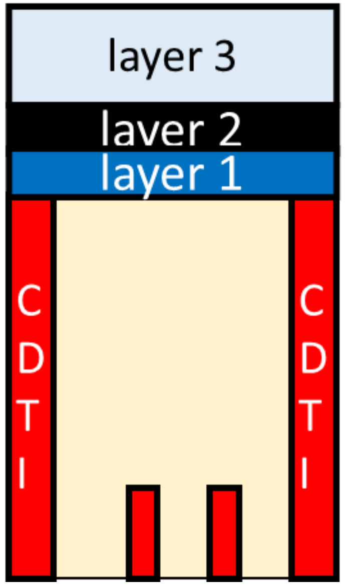


High absorption in layer 2 at 200nm

Optimizing ARC



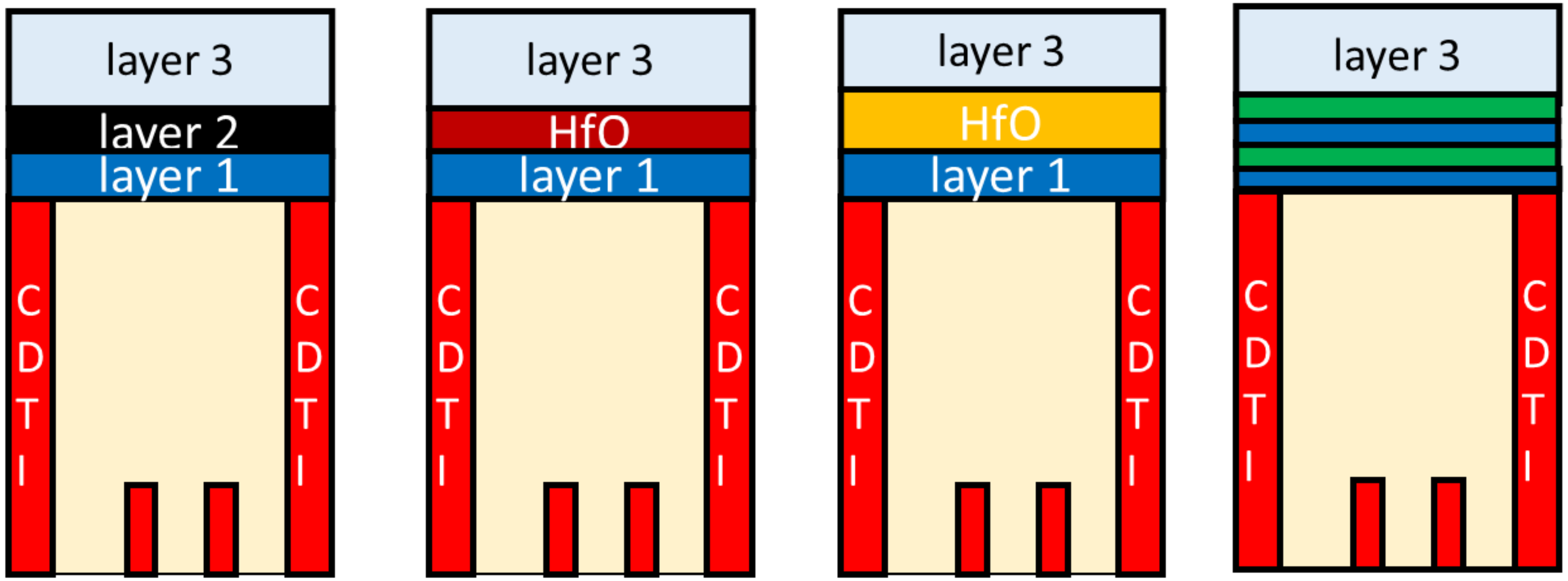
Because n is actually $n + ik$



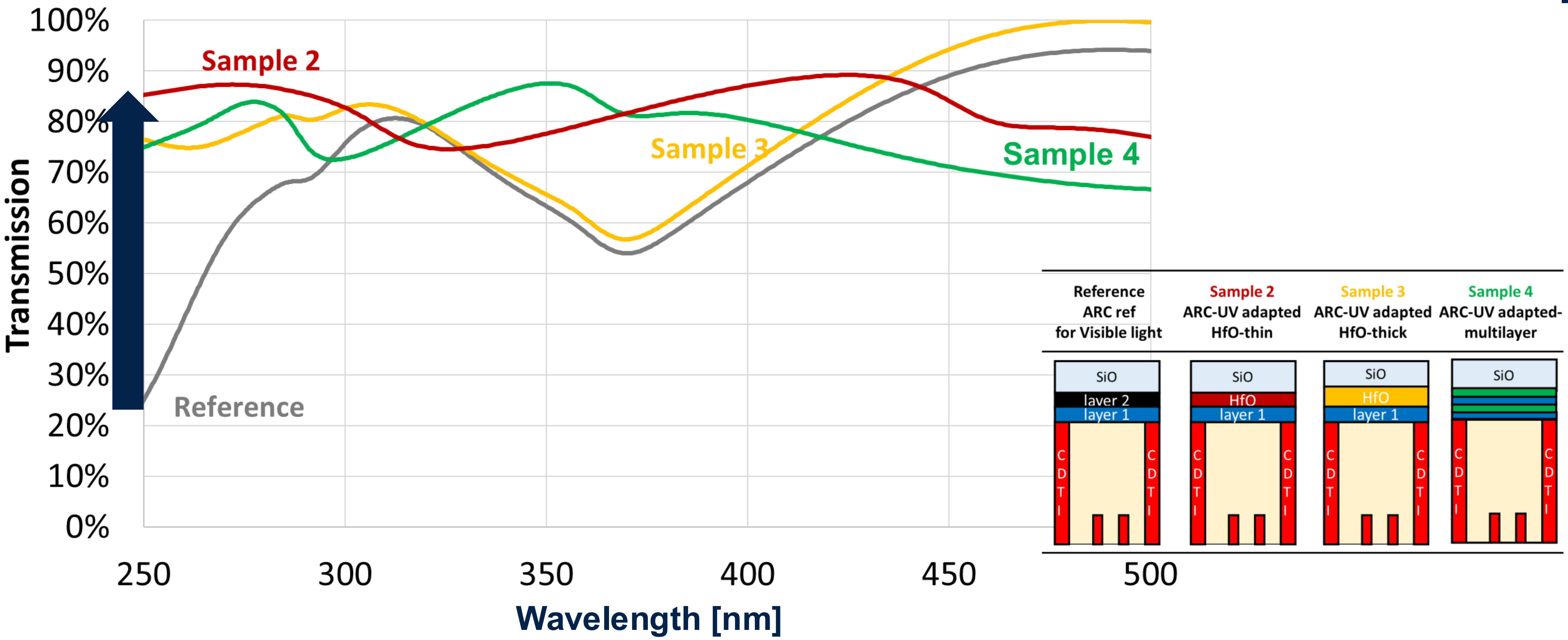
HfO_2 is the best alternative to ARC layer 2

Design of experiments for the new ARC

Reference **ARC ref** **for Visible light**	**Sample 2** **ARC-UV adapted** **HfO-thin**	**Sample 3** **ARC-UV adapted** **HfO-thick**	**Sample 4** **ARC-UV adapted-** **multilayer**

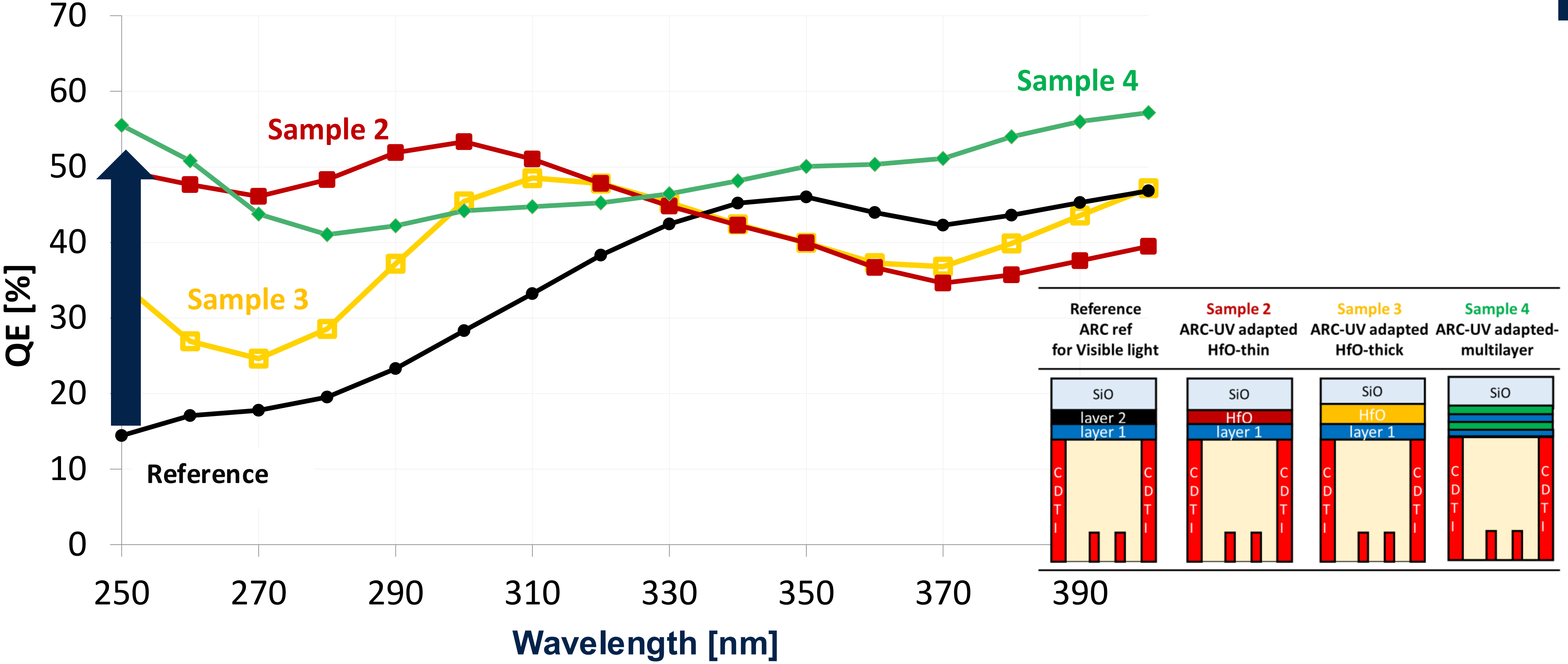


Optical simulation of the new ARC transmission



3 times improvement at $\lambda = 250nm$

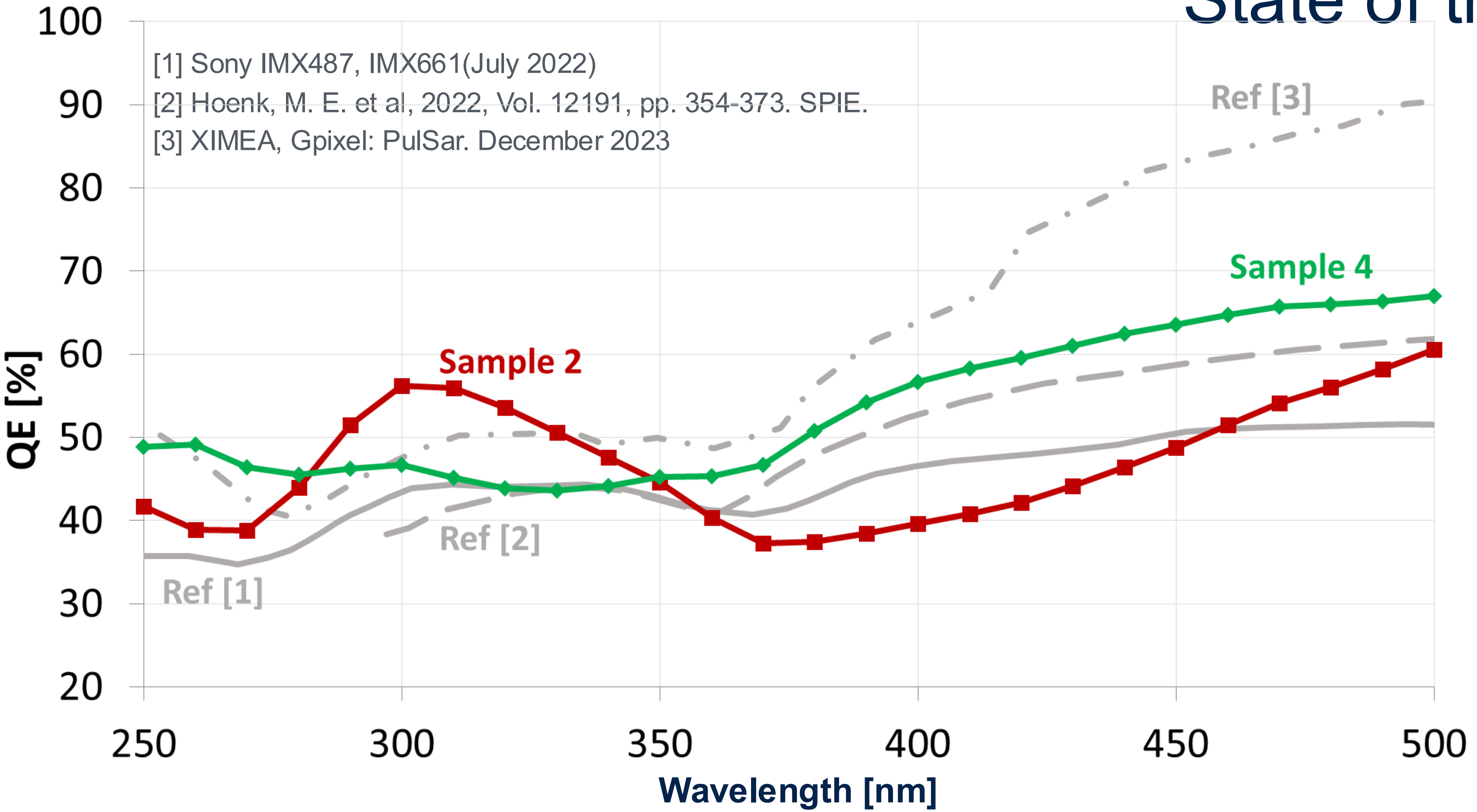
QE measurements of optimized pixels



Reference ARC ref for Visible light	Sample 2 ARC-UV adapted HfO-thin	Sample 3 ARC-UV adapted HfO-thick	Sample 4 ARC-UV adapted- multilayer

3 times improvement in QE at $\lambda = 250nm$

State of the art



[1] Sony IMX487, IMX661(July 2022)

[2] Hoenk, M. E. et al, 2022, Vol. 12191, pp. 354-373. SPIE.

[3] XIMEA, Gpixel: PulSar. December 2023

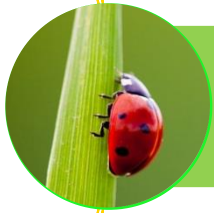
QE at the state of the art

Overall pixel performances

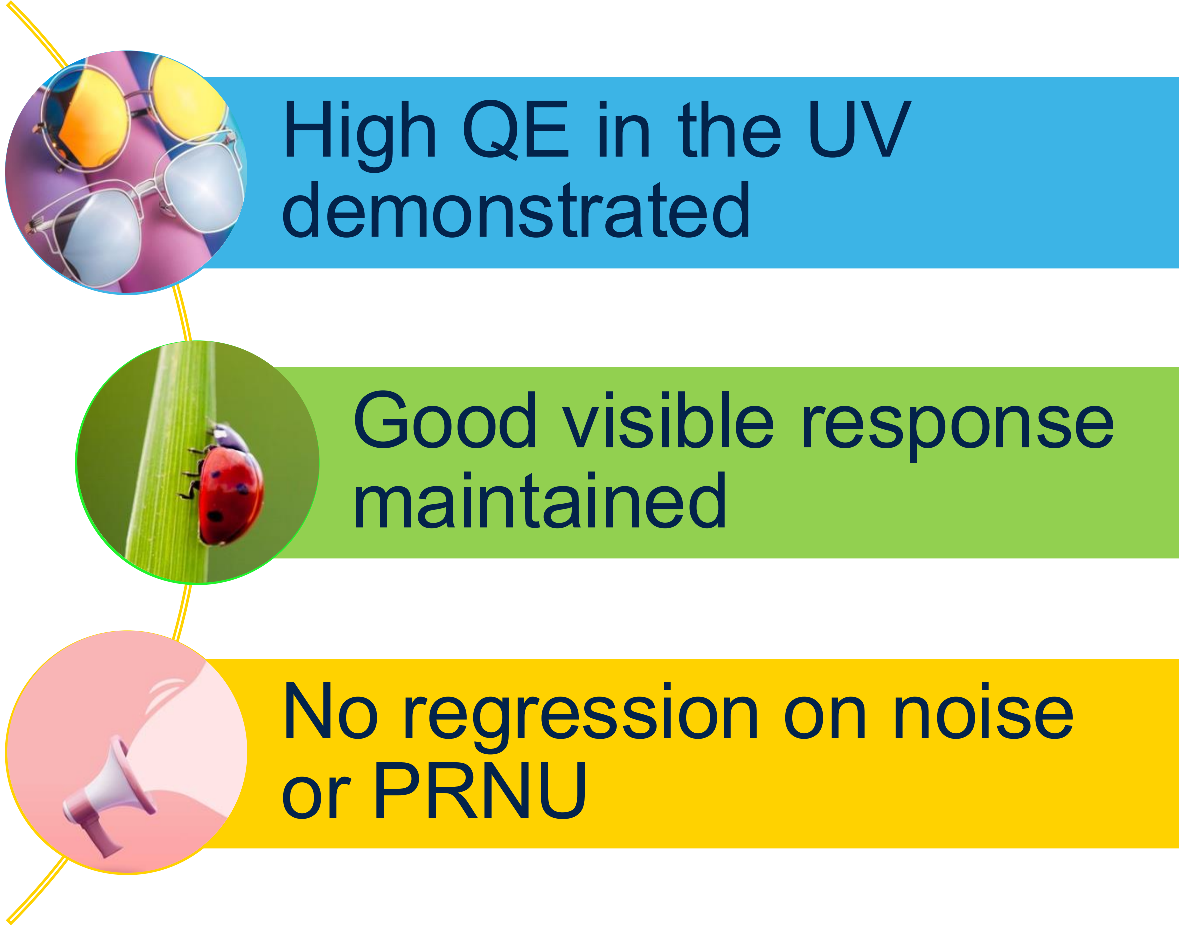
	1-ARC ref for Visible light	2-ARC-UV adapted HfO-thin	3-ARC-UV adapted HfO-thick	4-ARC-UV adapted multilayer	Ref [1] (Sony)	Ref [2] (JPL Sandia)	Ref [3] (Gpixel)
Pixel type	BSI				BSI	FSI	BSI
Pitch (μm)	<1.1				2.47	25	11
CVF ($\mu V/e$)	120						
PRNU @ 2ke-	<1%					<1%	
FPN	<1e-						
Temporal Noise (e)	<2e-						~1.7e-
Full Well (e)	>8k				9.9k	>100k	90k
relative Idark (a.u.)	1.0	1.1	0.9		--	--	--
QE_520nm(%)	85	67	86	69	56% (at 500nm)	62	90
QE_400nm(%)	47	40	47	57	46	52	65
QE_300nm(%)	28	56	40	47	44	39	46
QE_250nm(%)	14	42	37	49	35		49

Conclusion


High QE in the UV demonstrated


Good visible response maintained


No regression on noise or PRNU



High QE in the UV demonstrated

Good visible response maintained

No regression on noise or PRNU

Acknowledgements

- CIMI team, ISAE SUPAERO
- PI, DPOS, EOCS, TT, Etch teams, STMicroelectronics, Crolles

Thank you

I am pleased to answer your questions