Low Noise High Efficiency 3.75 µm and 2.8 µm Global Shutter CMOS Pixel Arrays

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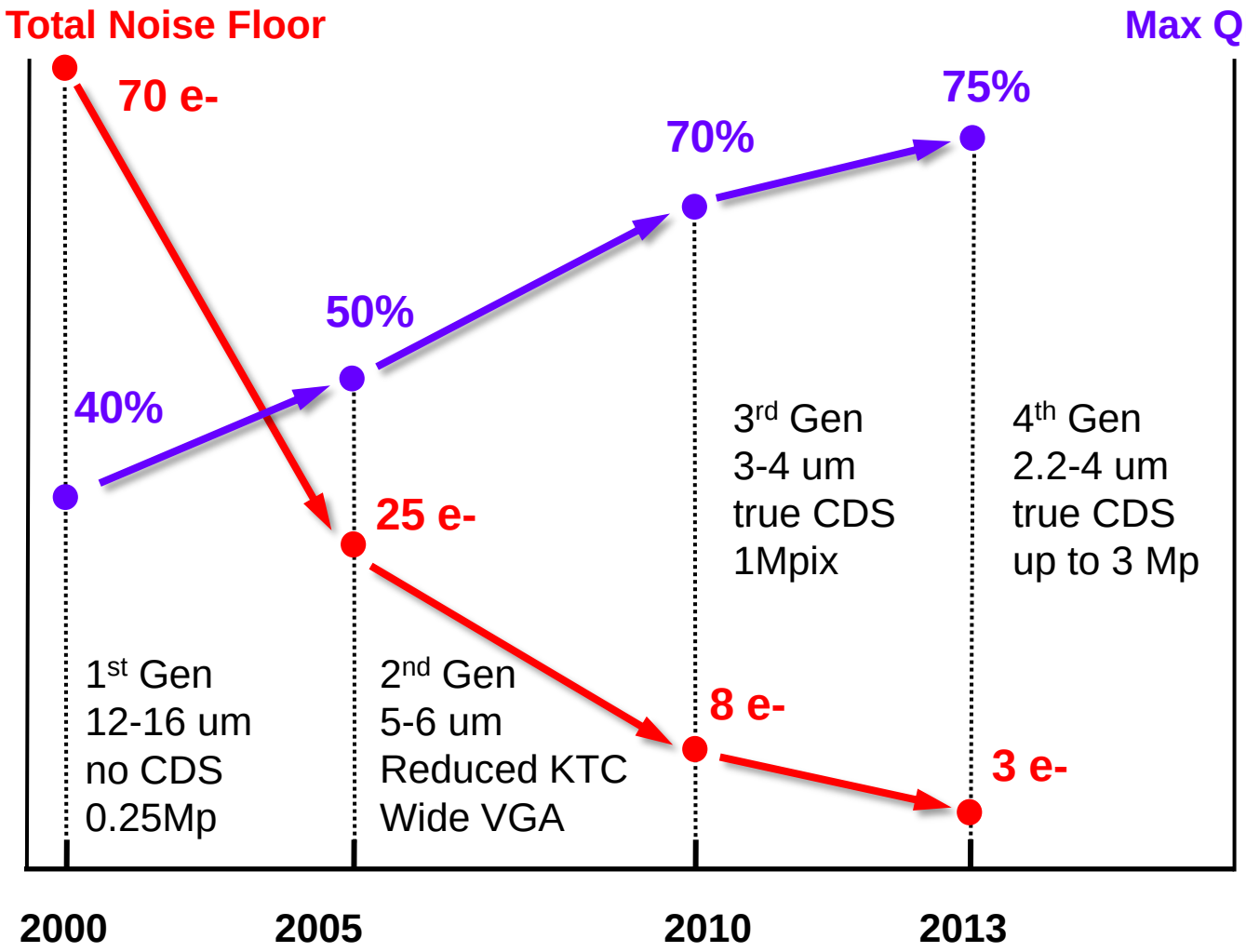
Aptina Global Shutter Pixel Development



Trend of reducing GS pixel size while preserving sensor performance.

1st Gen [1], 2nd Gen [2], and 3rd Gen [3] GS pixels.

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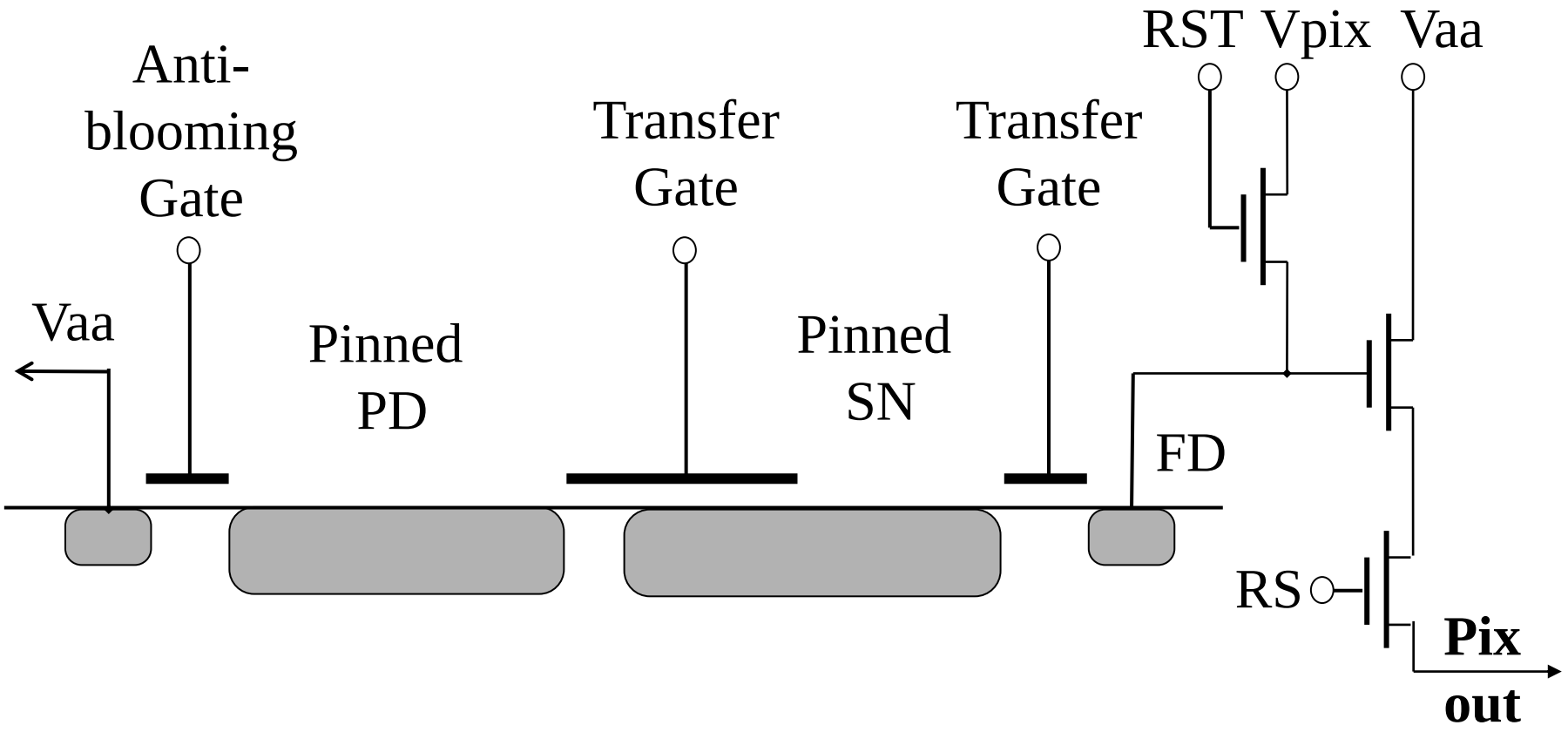
3rd Generation 3.75µm Global Shutter Pixel



6T GS Pixel with true CDS (4T effective in a 2-way CEPA architecture).

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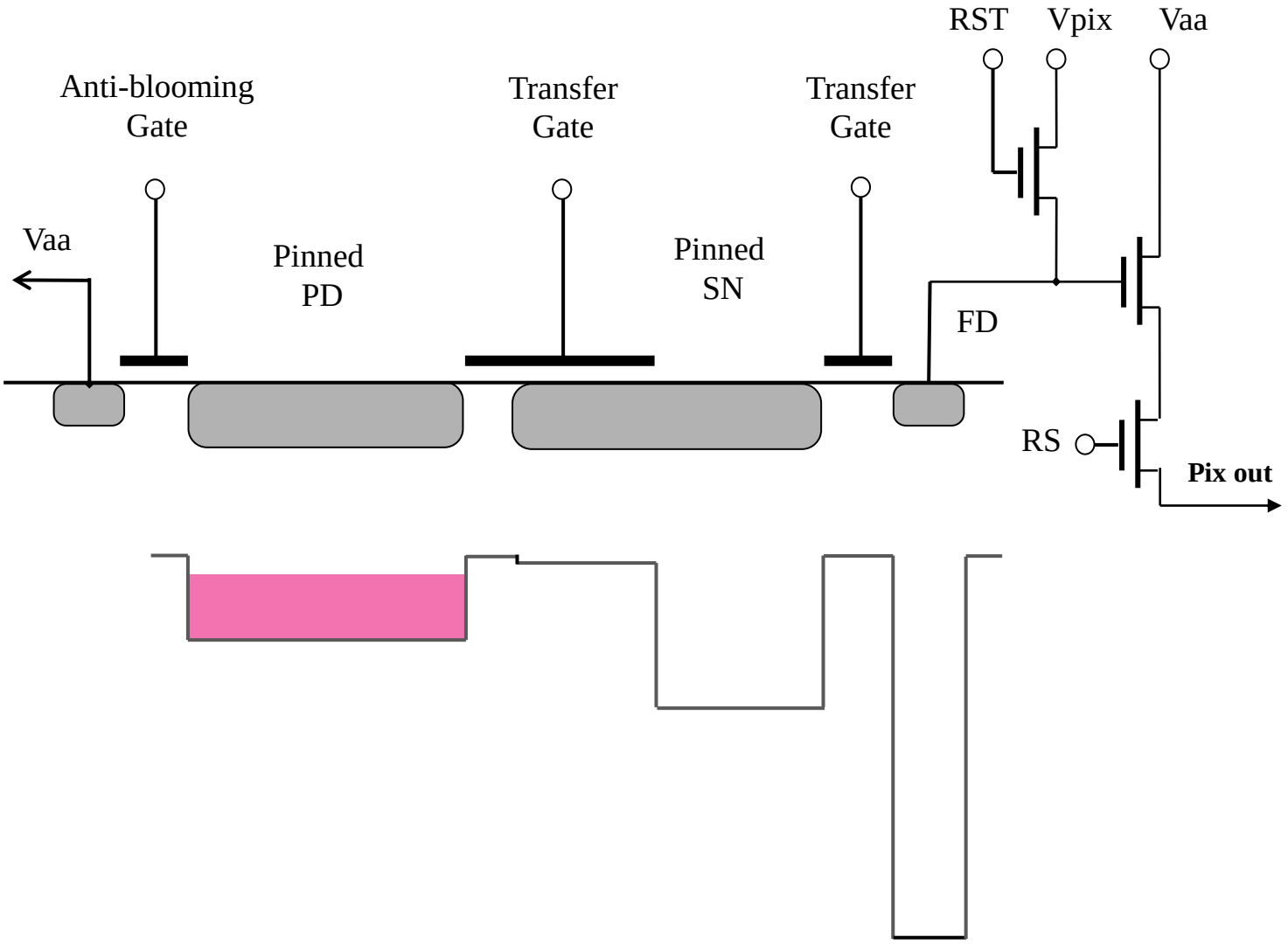
3rd Generation 3.75µm Global Shutter Pixel



Charge Acquisition

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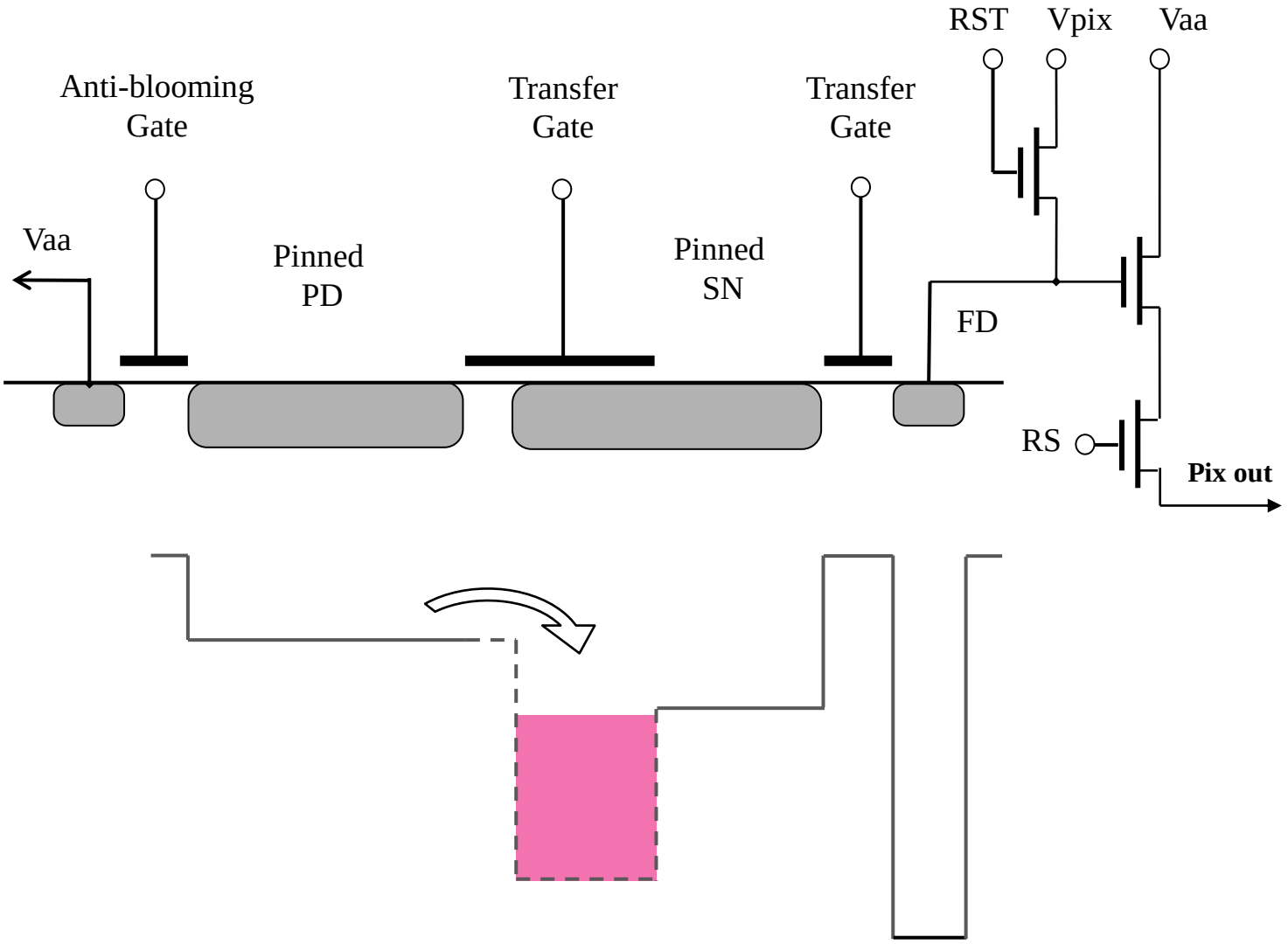
3rd Generation 3.75µm Global Shutter Pixel



Charge Transfer

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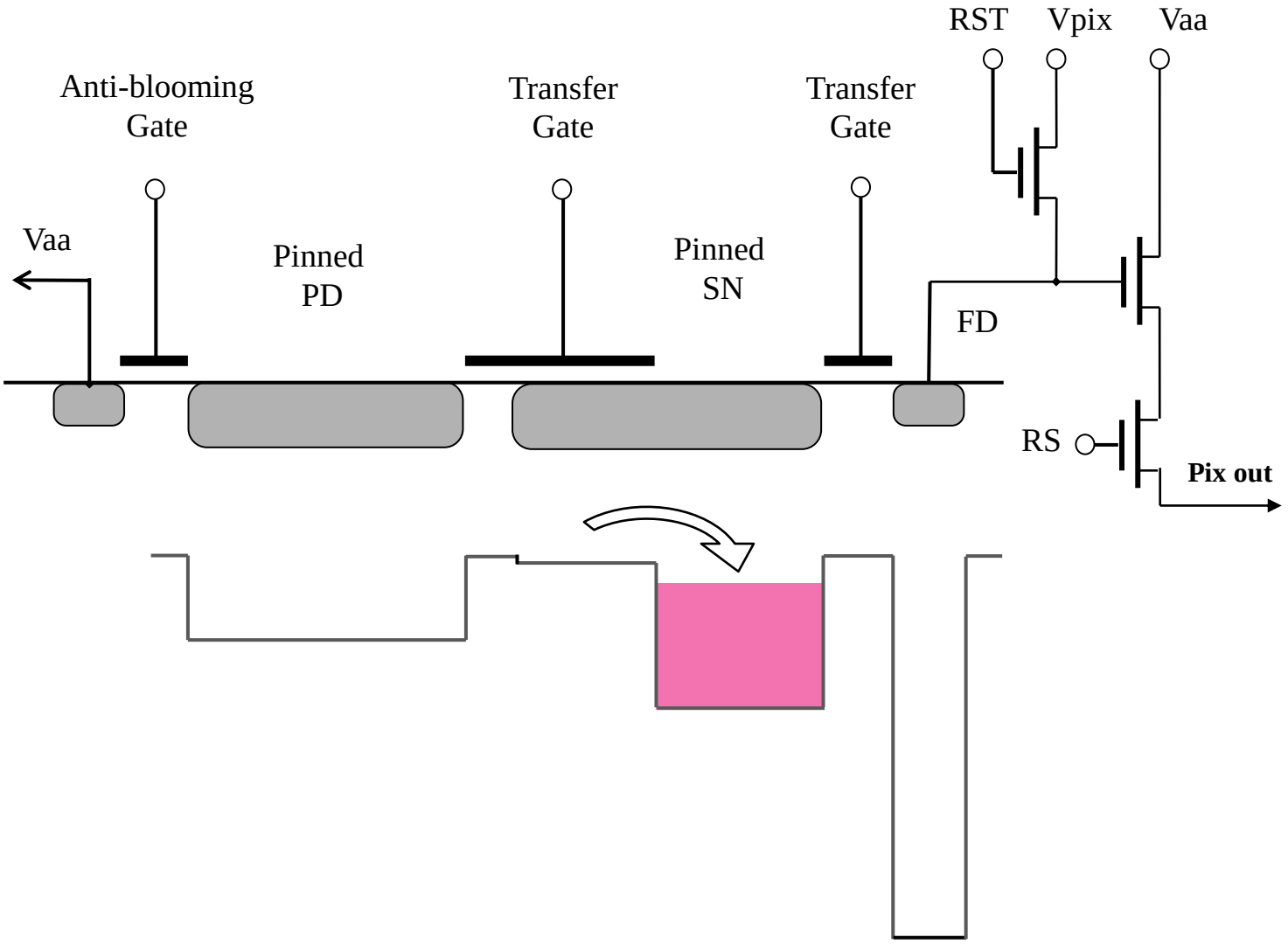
3rd Generation 3.75µm Global Shutter Pixel



Charge Storage

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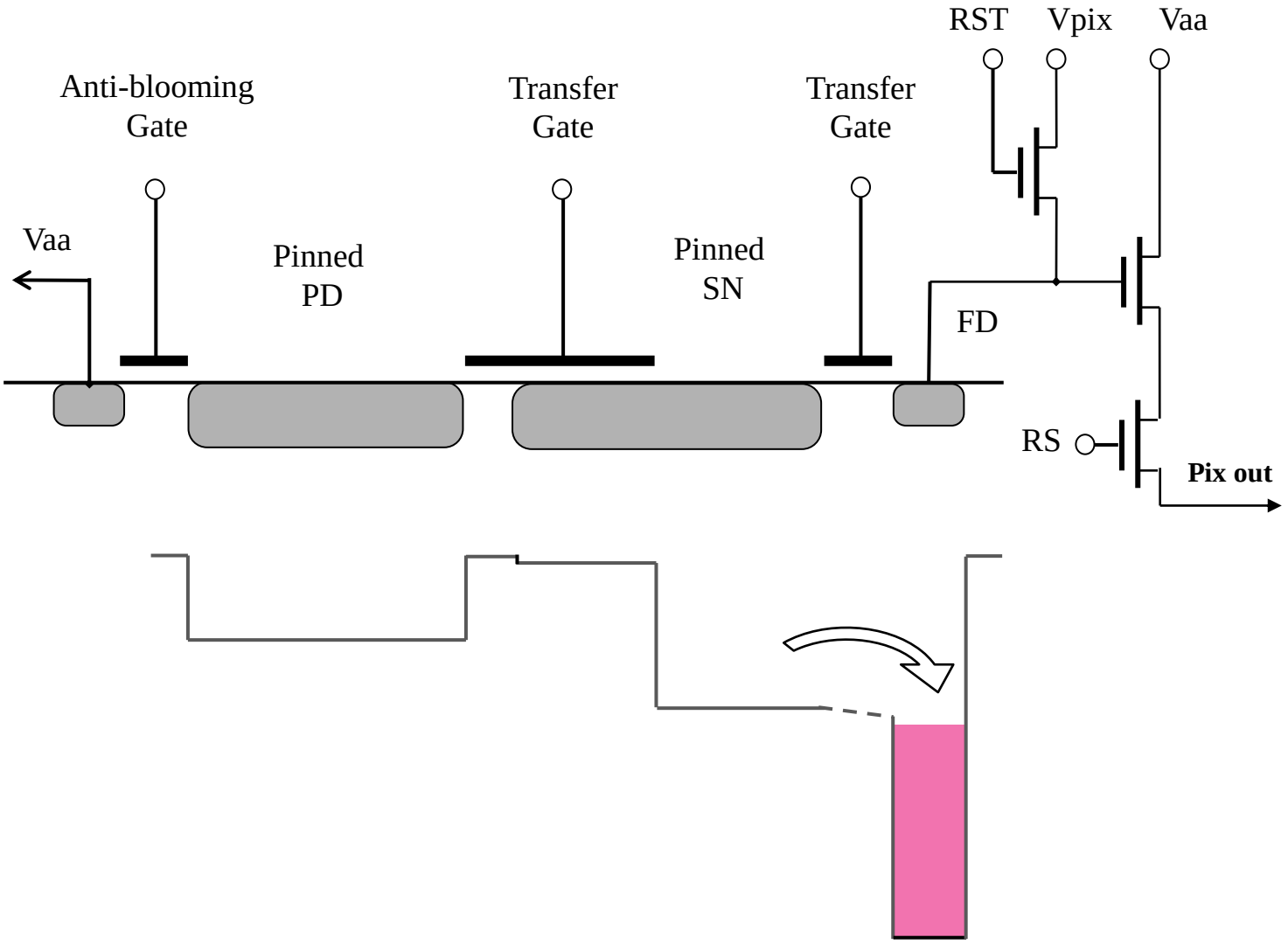
3rd Generation 3.75µm Global Shutter Pixel



CDS Readout

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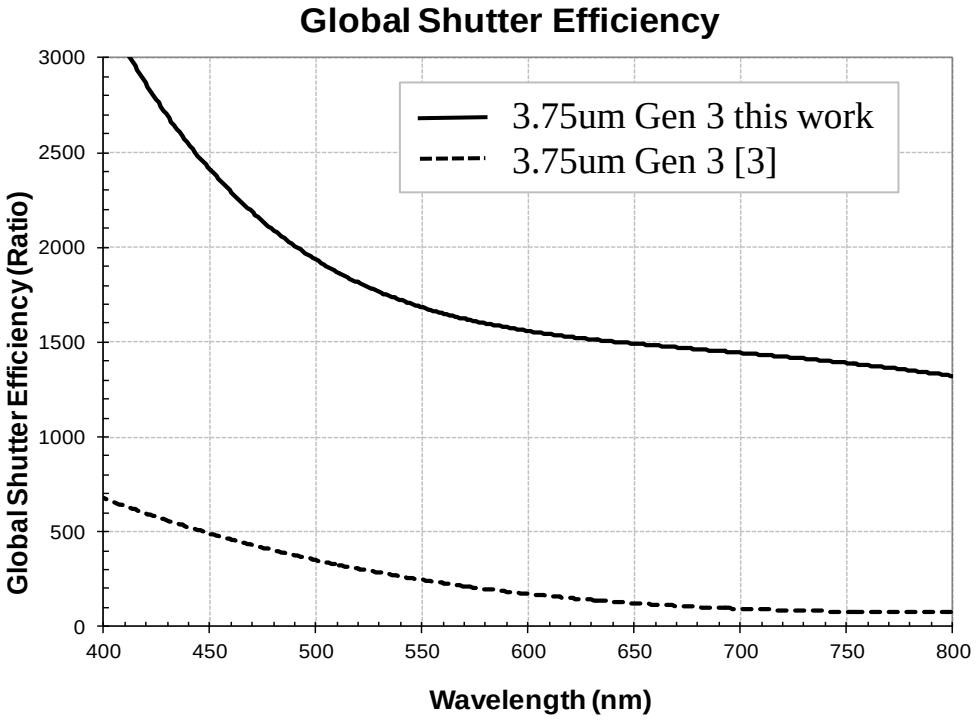
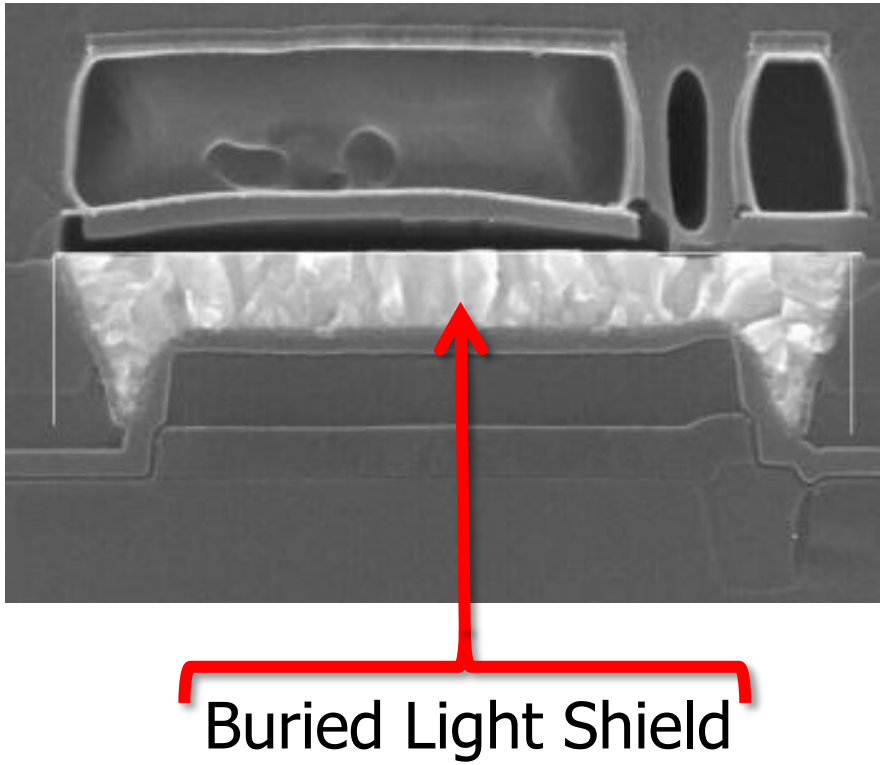
3rd Generation 3.75µm Global Shutter Pixel





3rd Gen Global Shutter Efficiency Improvement. Buried Light Shield.

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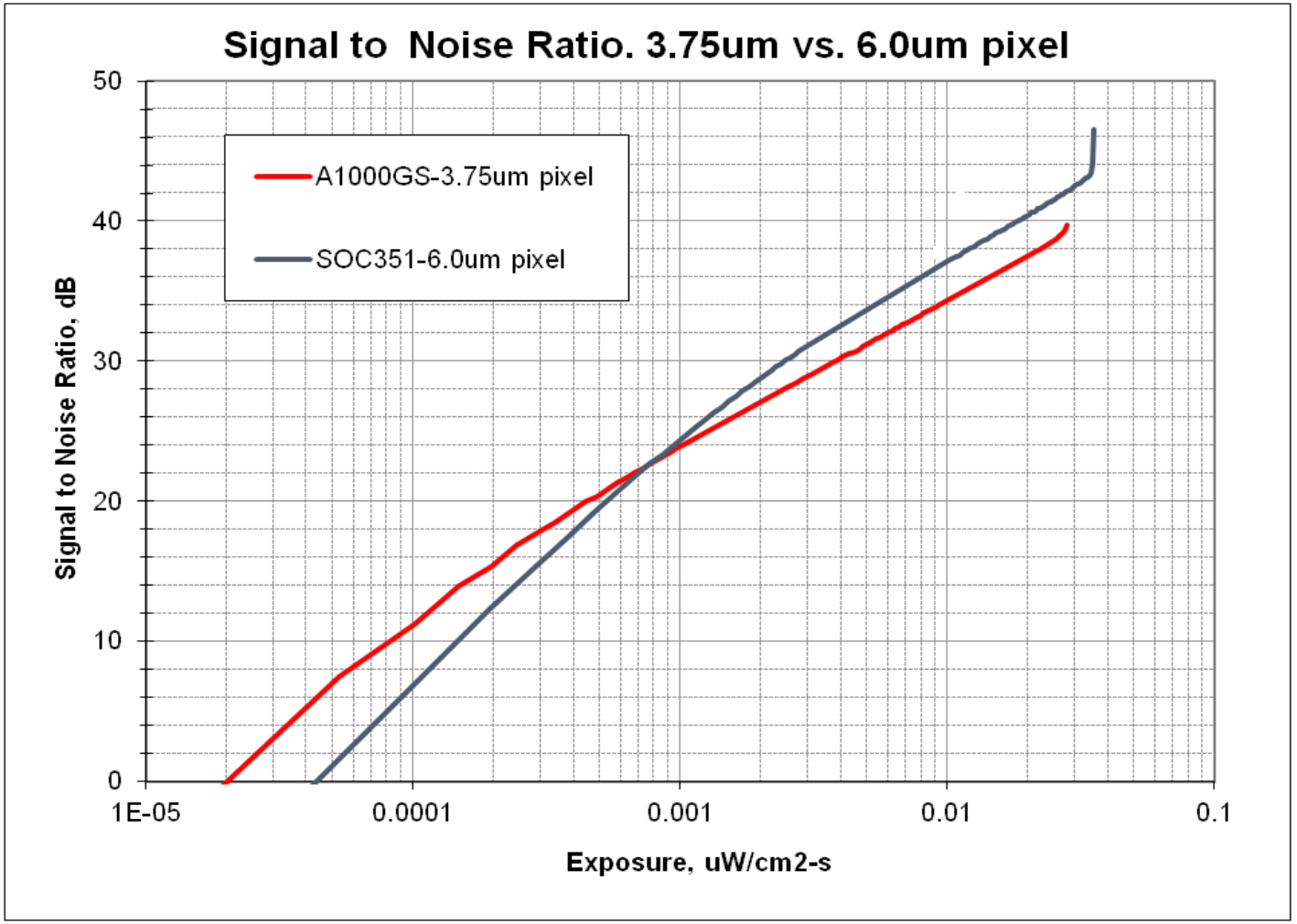
3rd Generation 3.75µm Global Shutter Pixel



3rd Gen 3.75µm GS Pixel vs. 2nd Gen 6.0µm GS Pixel Temporal SNR.

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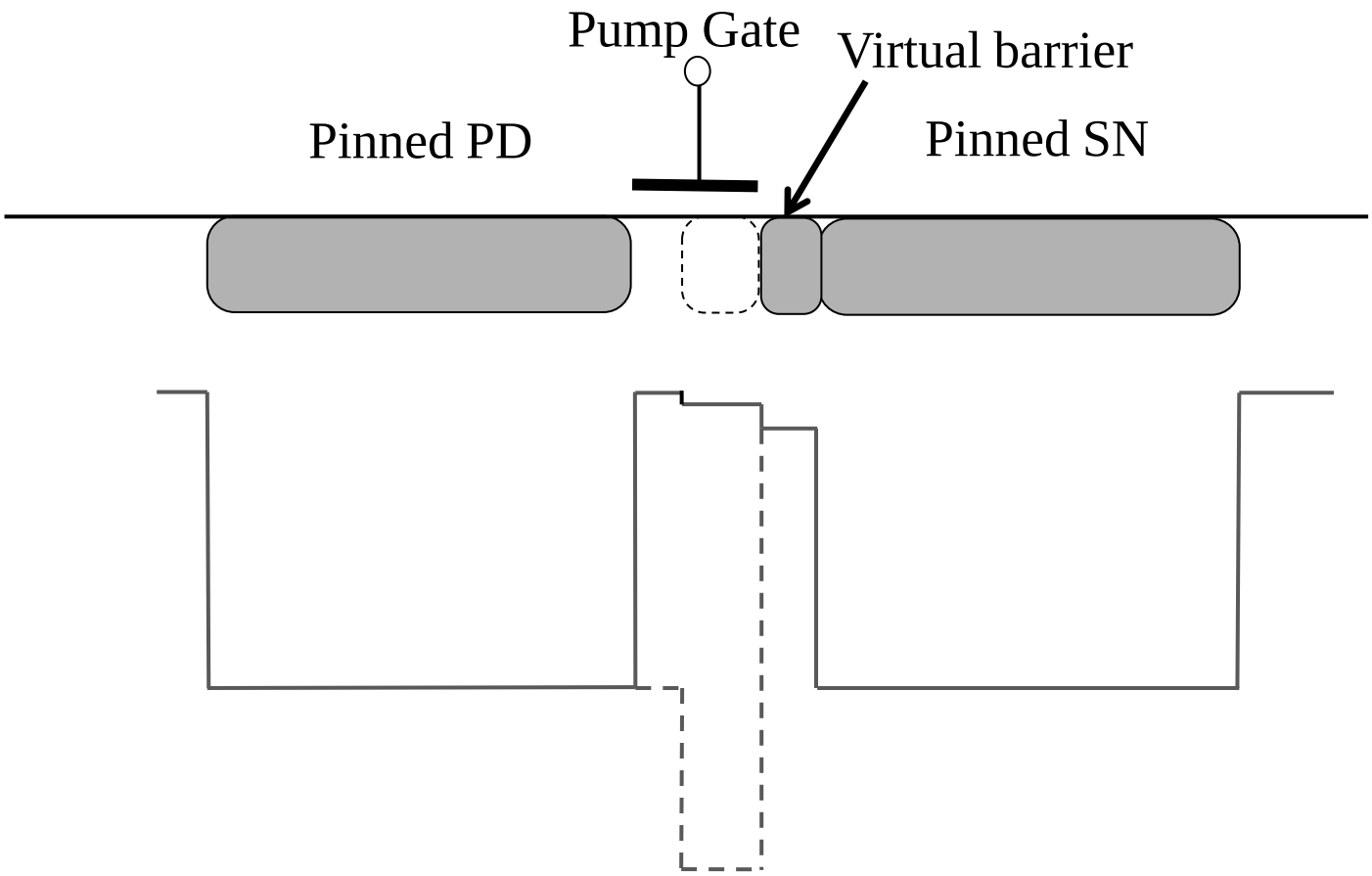
4th Generation Global Shutter Pixel



Pump Gate Concept for Clocked Charge Transfer from PD to SN.

No limitations on PD, SN, and FD potential budgets.

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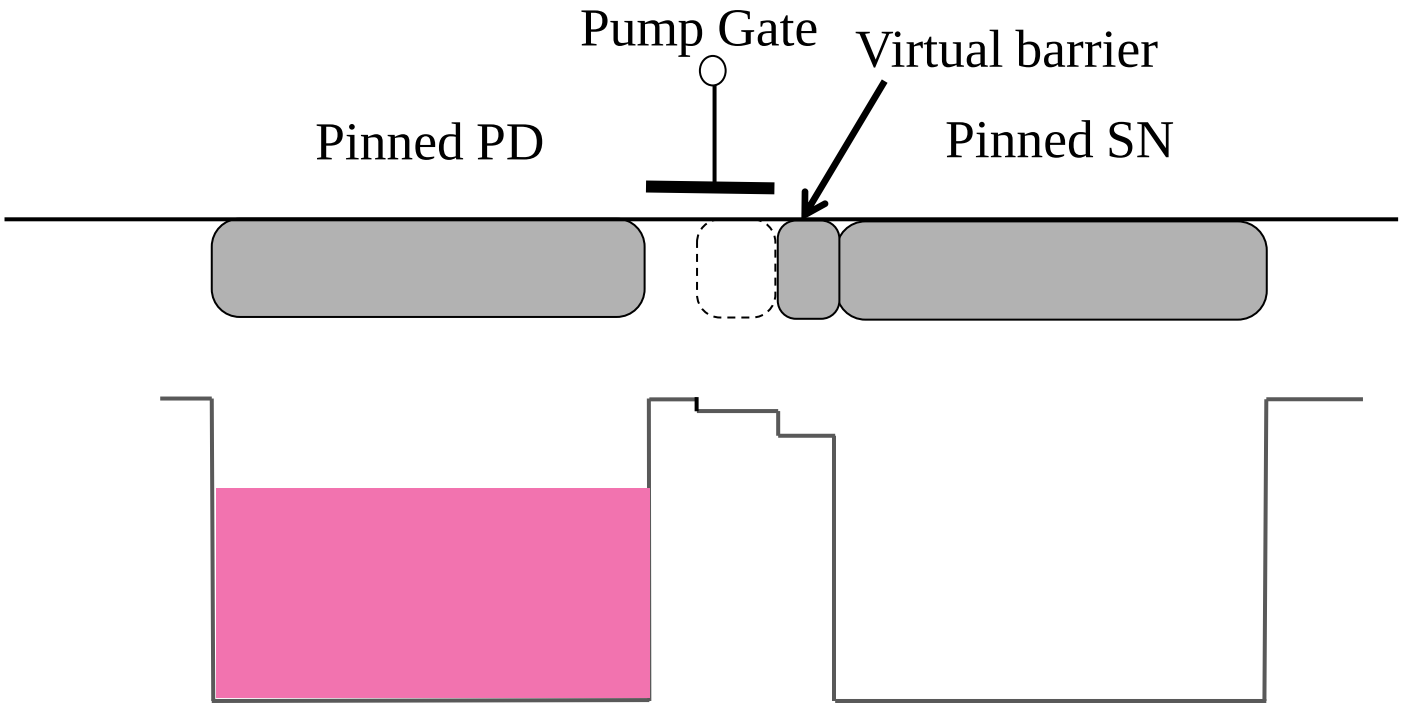
4th Generation Global Shutter Pixel



Charge Acquisition

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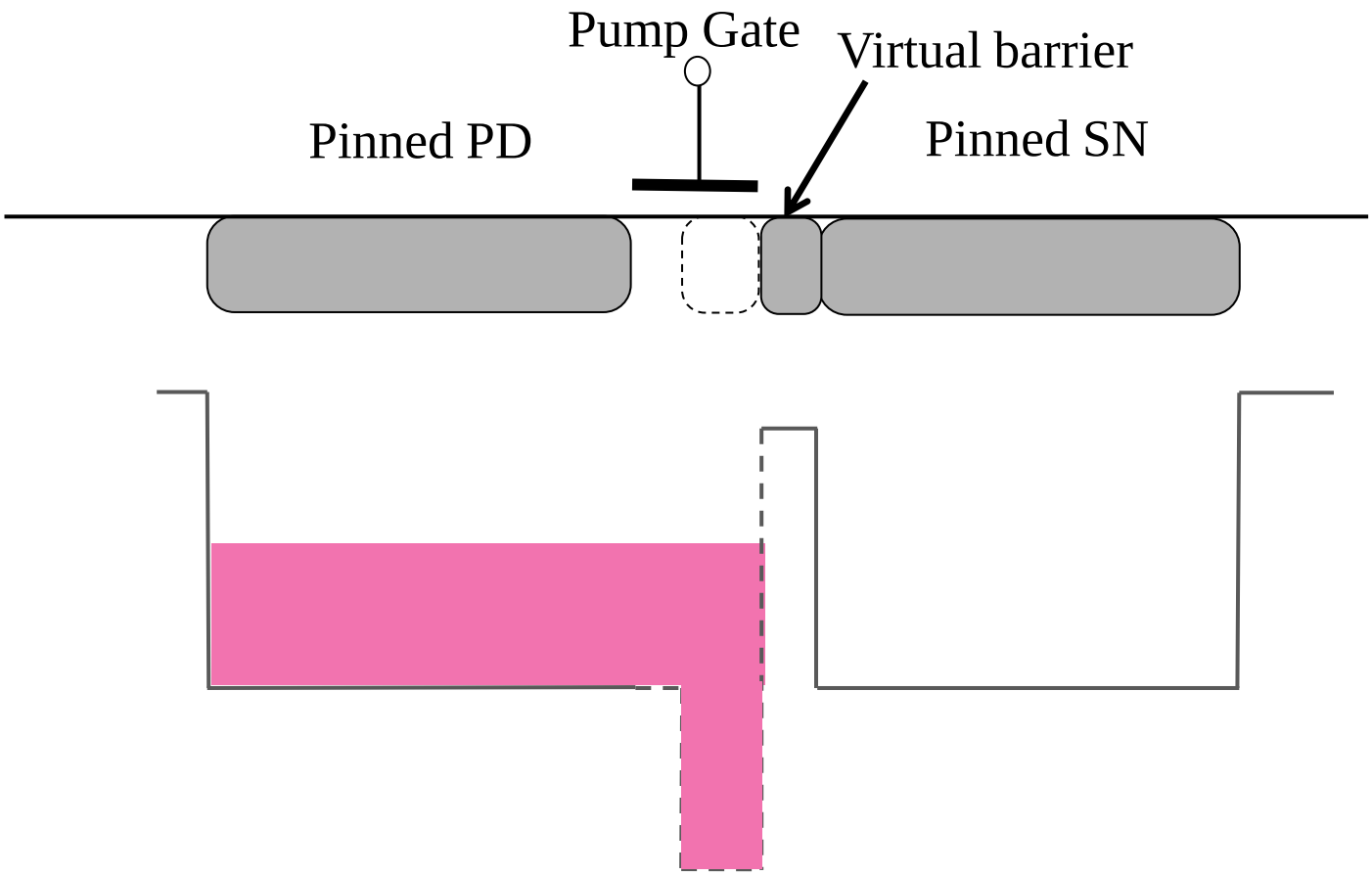
4th Generation Global Shutter Pixel



1st Pump Transfer Beginning

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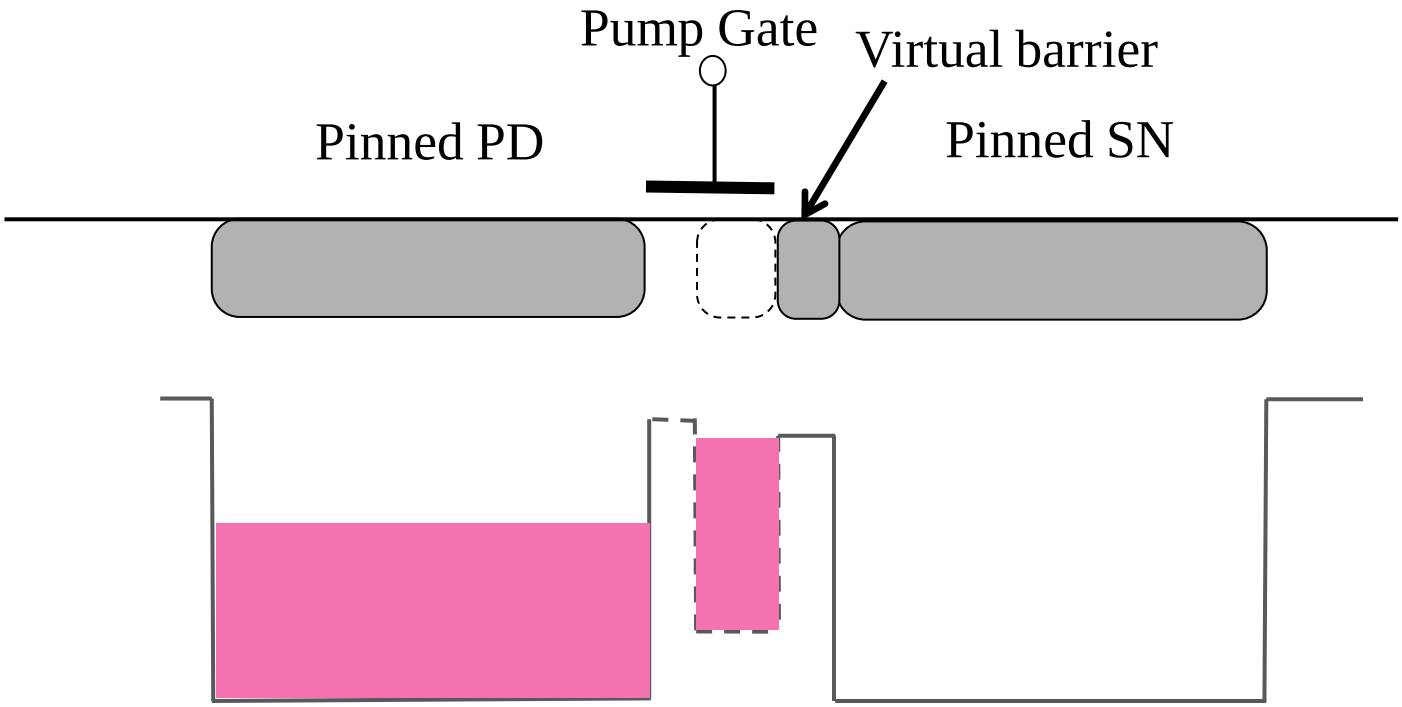
4th Generation Global Shutter Pixel



1st Pump Transfer Transitioning

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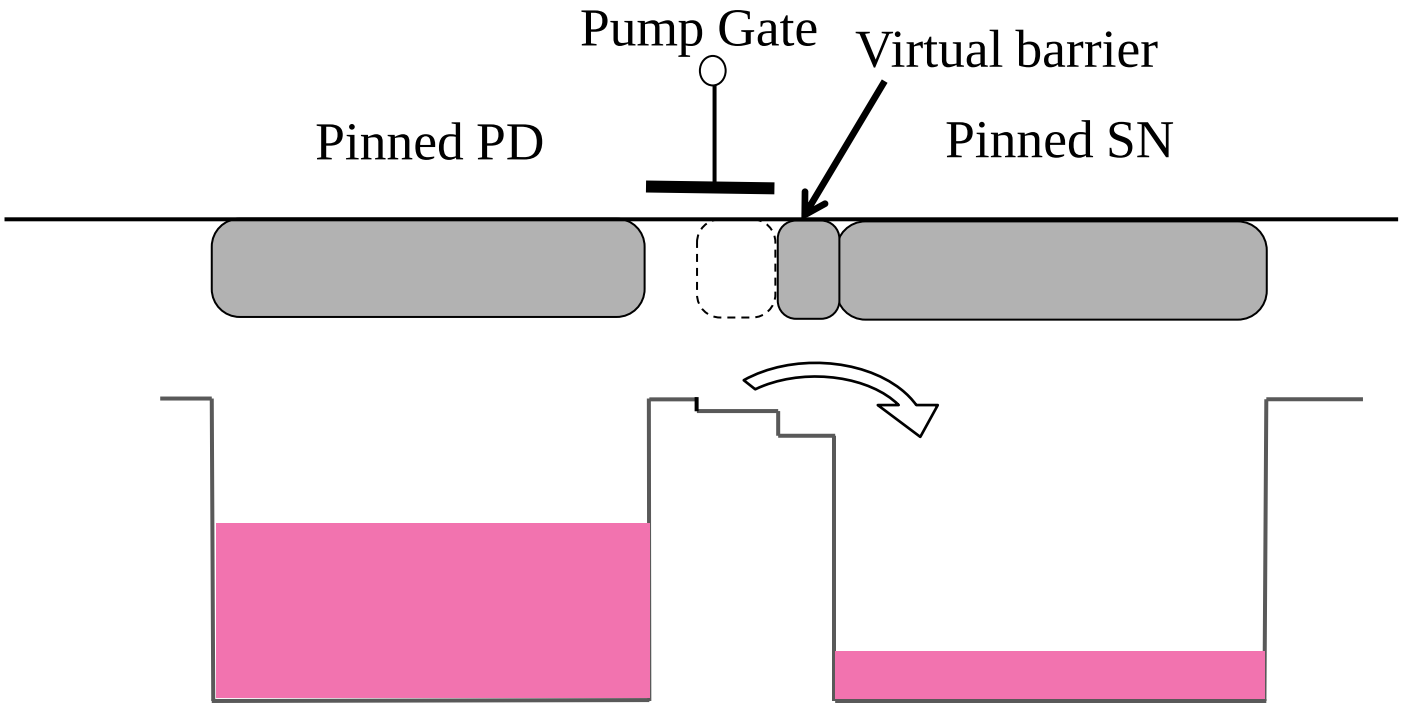
4th Generation Global Shutter Pixel



1st Pump Transfer Complete

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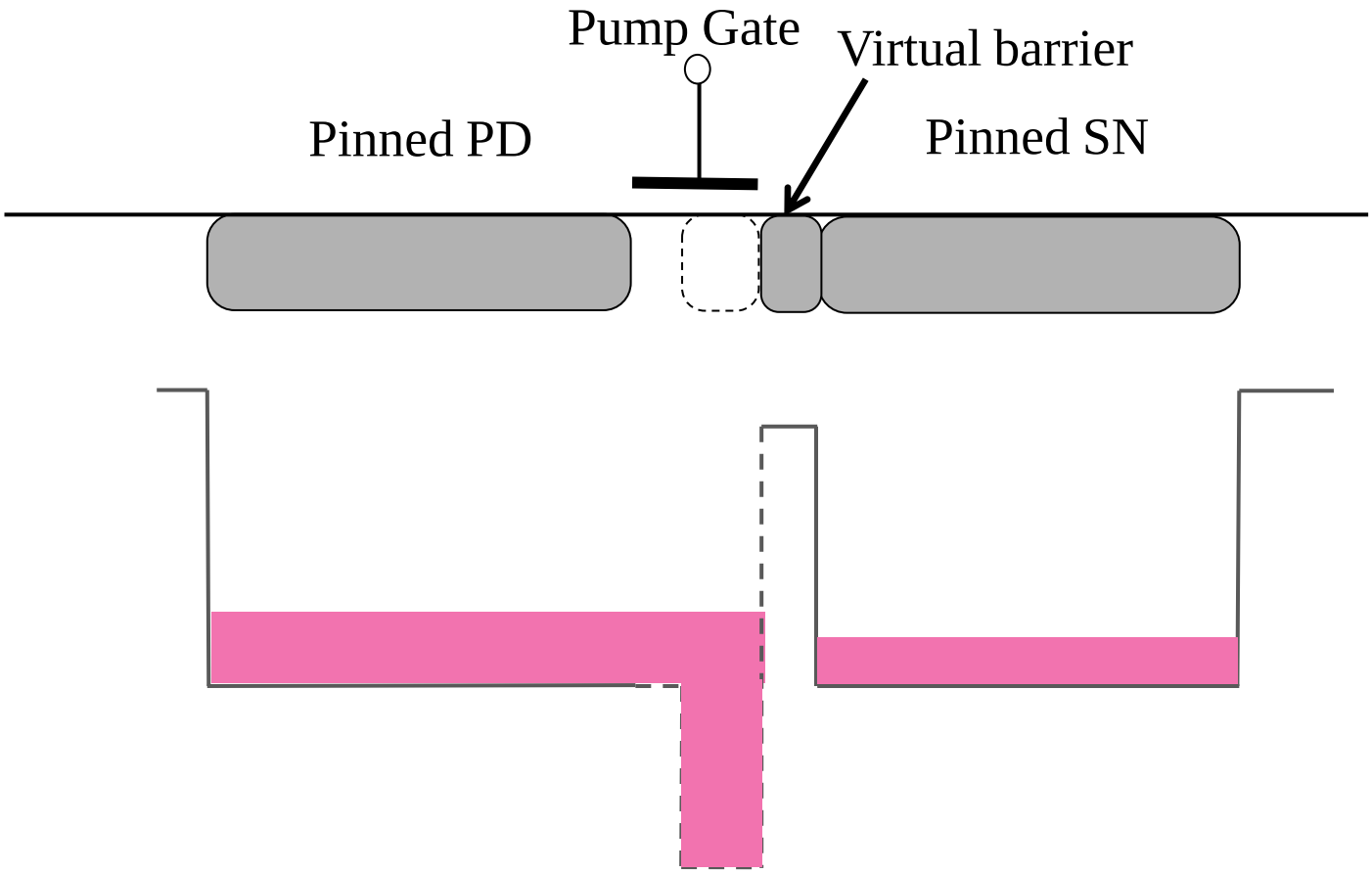
4th Generation Global Shutter Pixel



2nd Pump Transfer

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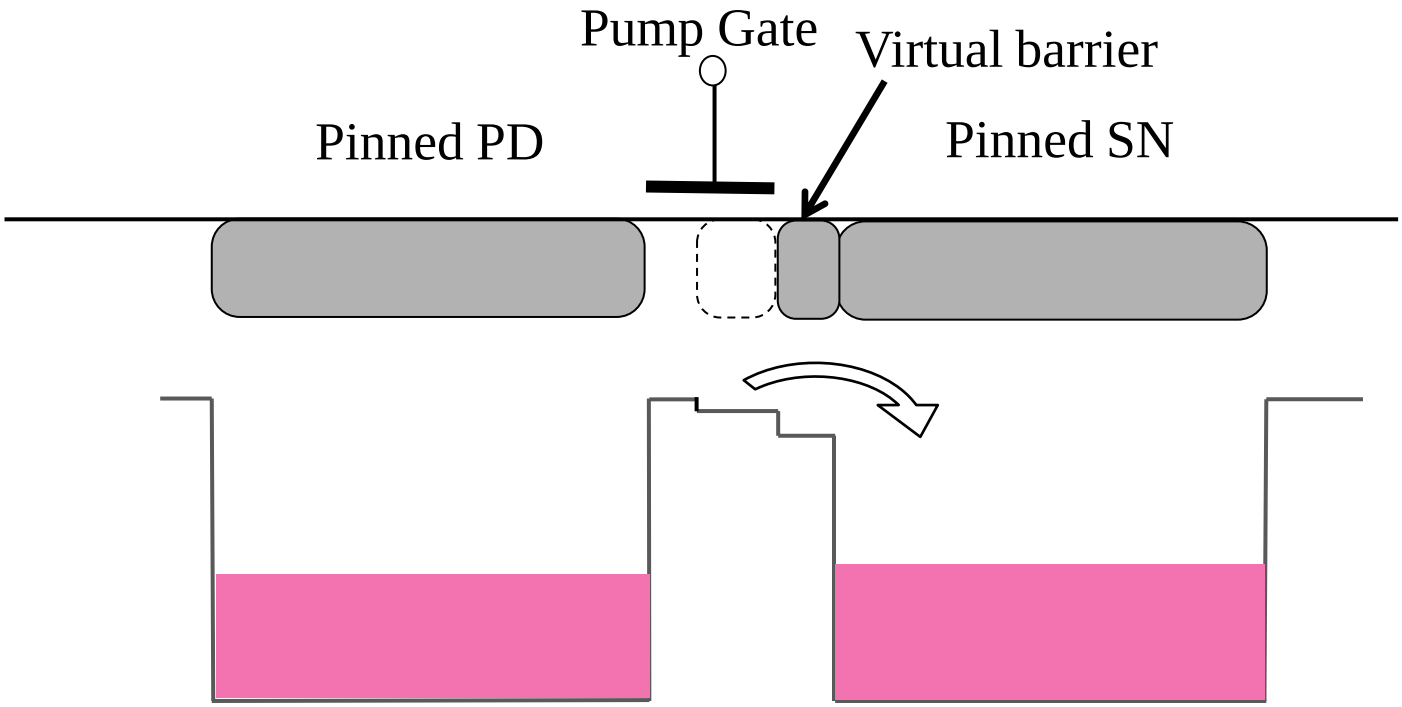
4th Generation Global Shutter Pixel



2nd Pump Transfer Complete

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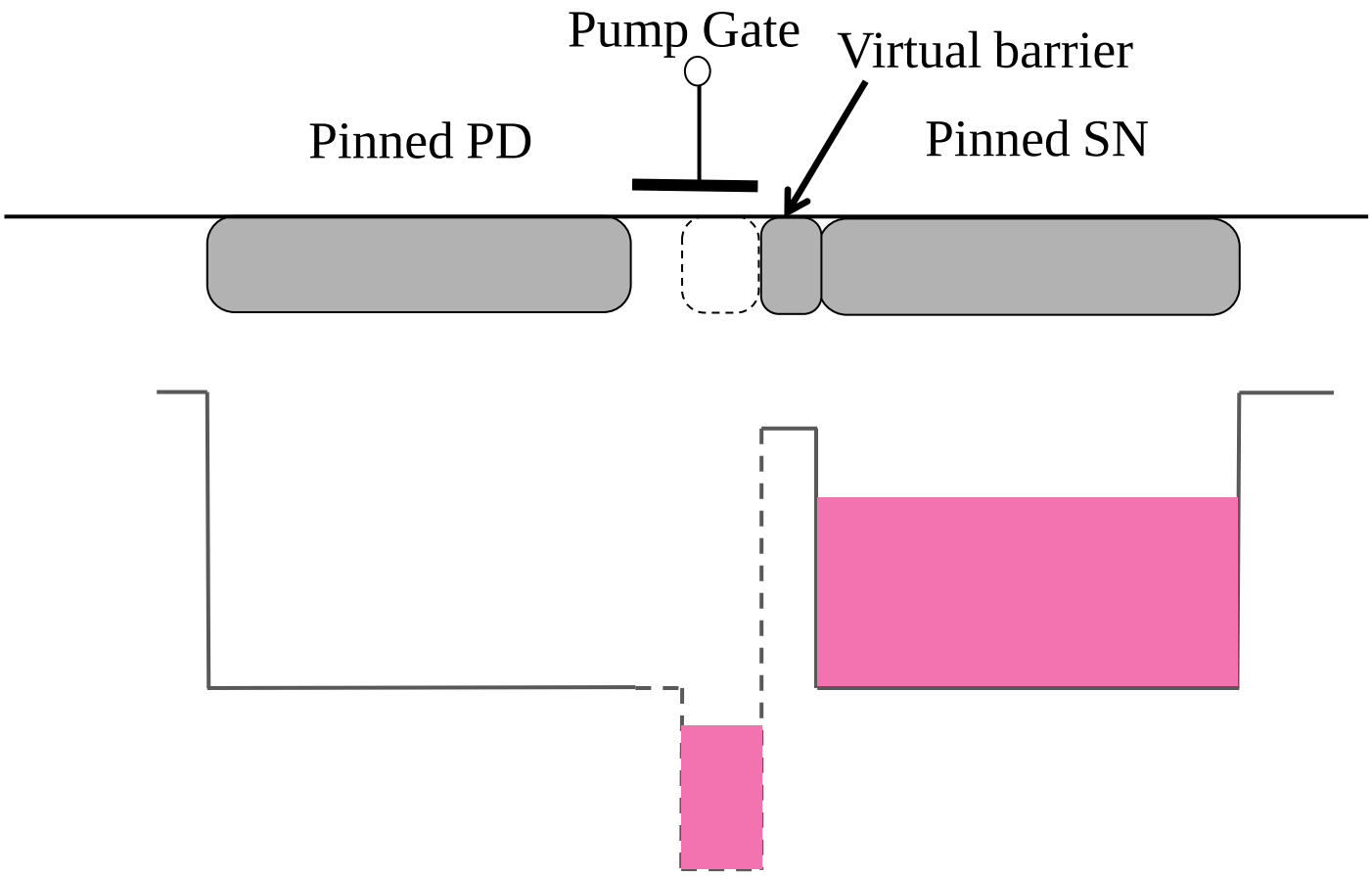
4th Generation Global Shutter Pixel



Nth Pump Transfer

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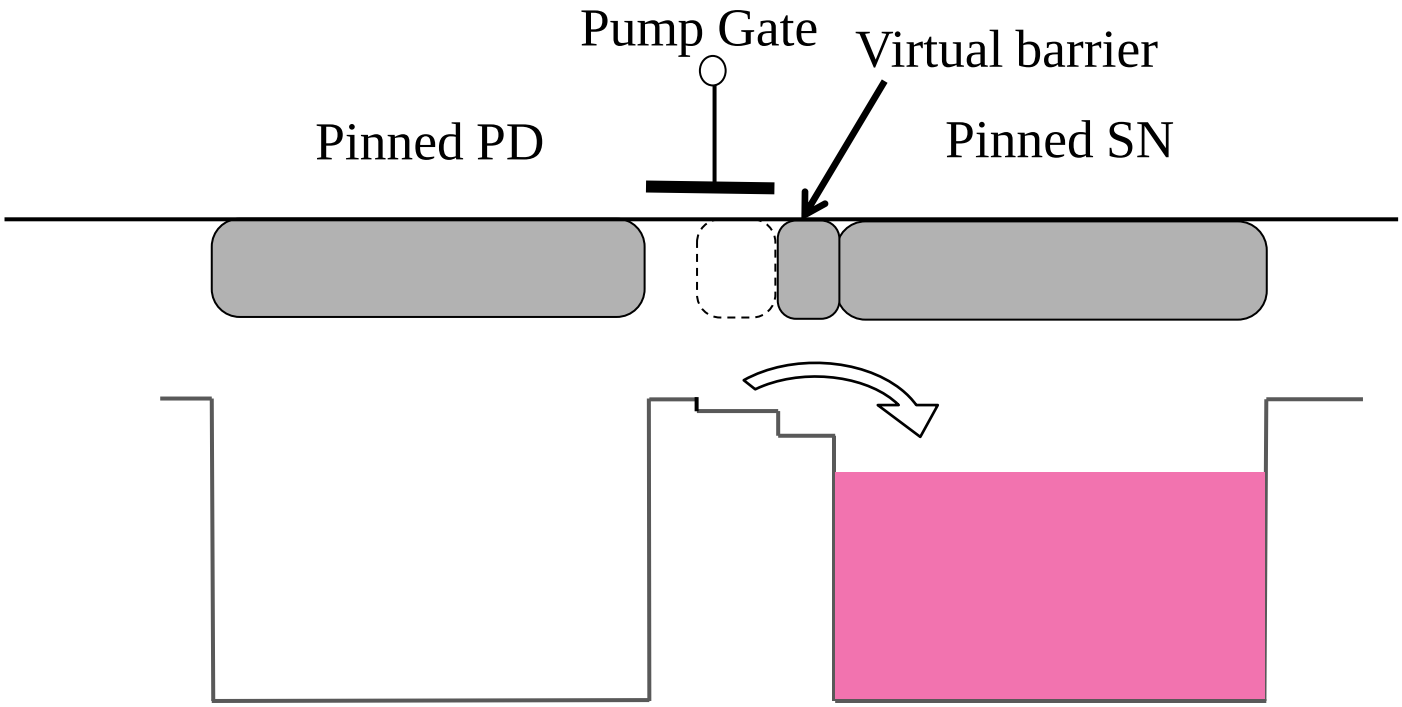
4th Generation Global Shutter Pixel



Nth Pump Transfer Complete

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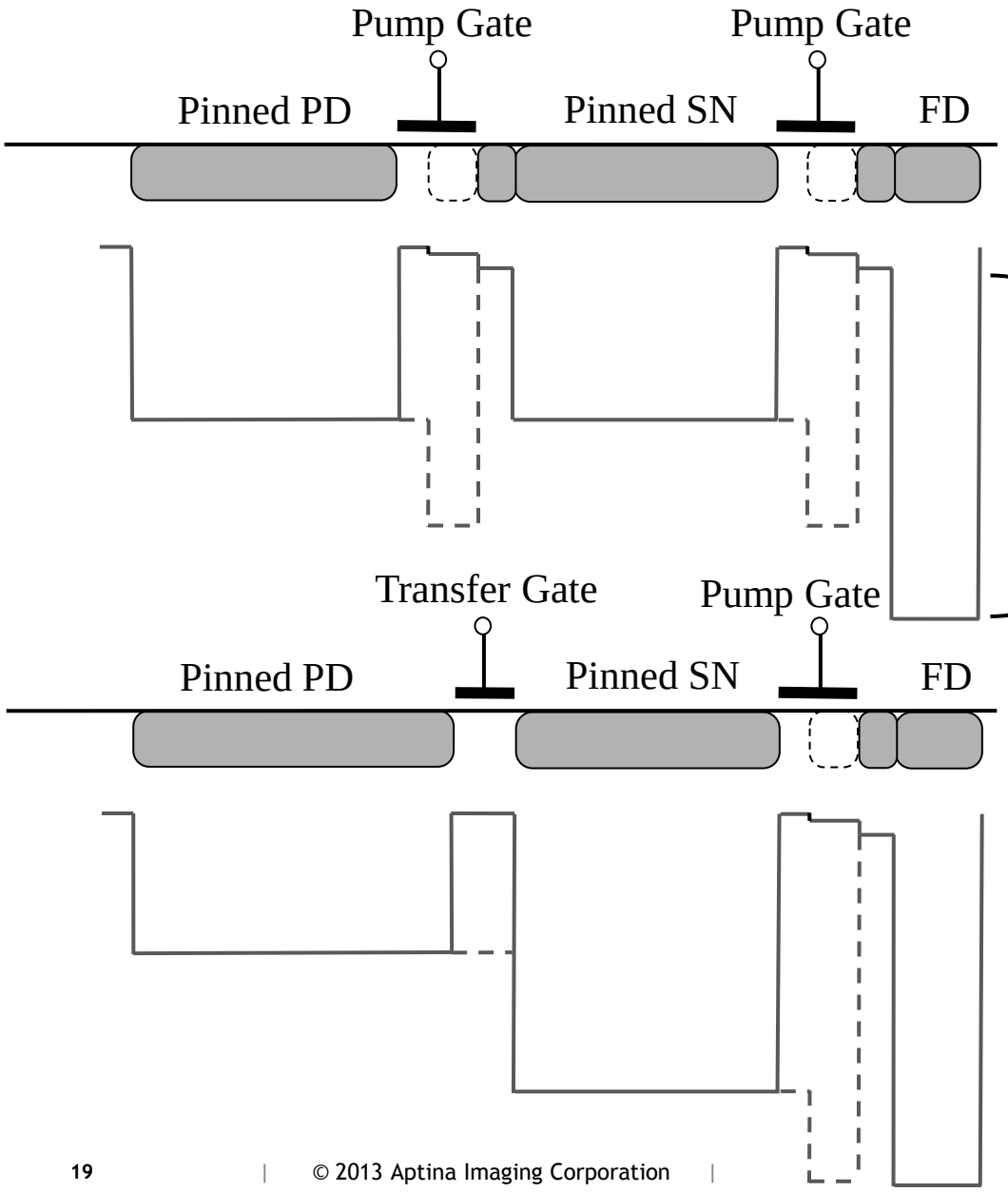
4th Generation Global Shutter Pixel



PG-PG configuration:

- SN pinned potential <= PD pinned potential
- Low Dark Current
- Highest Capacity

→ Large CDS FD swing = smaller FD

TX-PG configuration:

- SN pinned potential > PD pinned potential
- Bigger PD (sensitivity)
- Low Dark Current
- High Capacity

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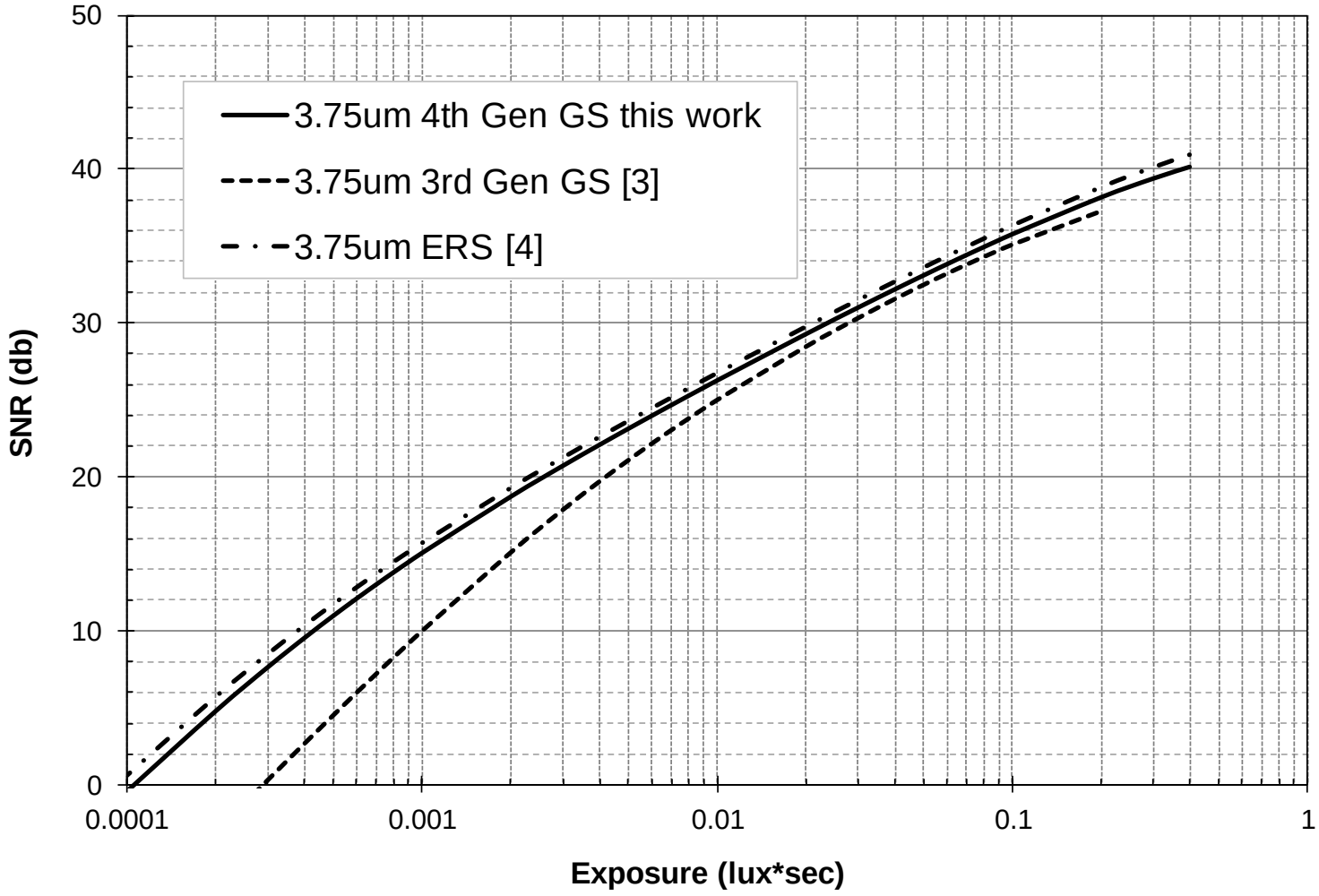
4th Generation Global Shutter Pixel



4th and 3rd Gen 3.75µm Global Shutter vs. ERS Pixel Total SNR.

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4th Generation Global Shutter Pixel

Table 1

	Unit	Gen2 [2]	Gen3 [3]	Gen3	Gen4		Note
Pixel Pitch	um	6	3.75	3.75	3.75	2.8	
True CDS		No	Yes	Yes	Yes	Yes	
Max Quantum Efficiency	%	58	70	70	75	70	mono
Linear Full-well	Ke-	17.5	7.5	7.5	> 15	> 12	
Pixel Response Non-uniformity	%	0.7	0.8	0.8	0.6	0.6	50% signal
Pixel Total Noise Floor	e-	25	8	8	3	3	25C Tj
Storage Dark Current	e-/sec	3000	2000	2000	90	60	60C Tj
Global Shutter Efficiency	ratio	1700	310	2000	3000	2200	average

Comparison of Global Shutter Pixel Generations.

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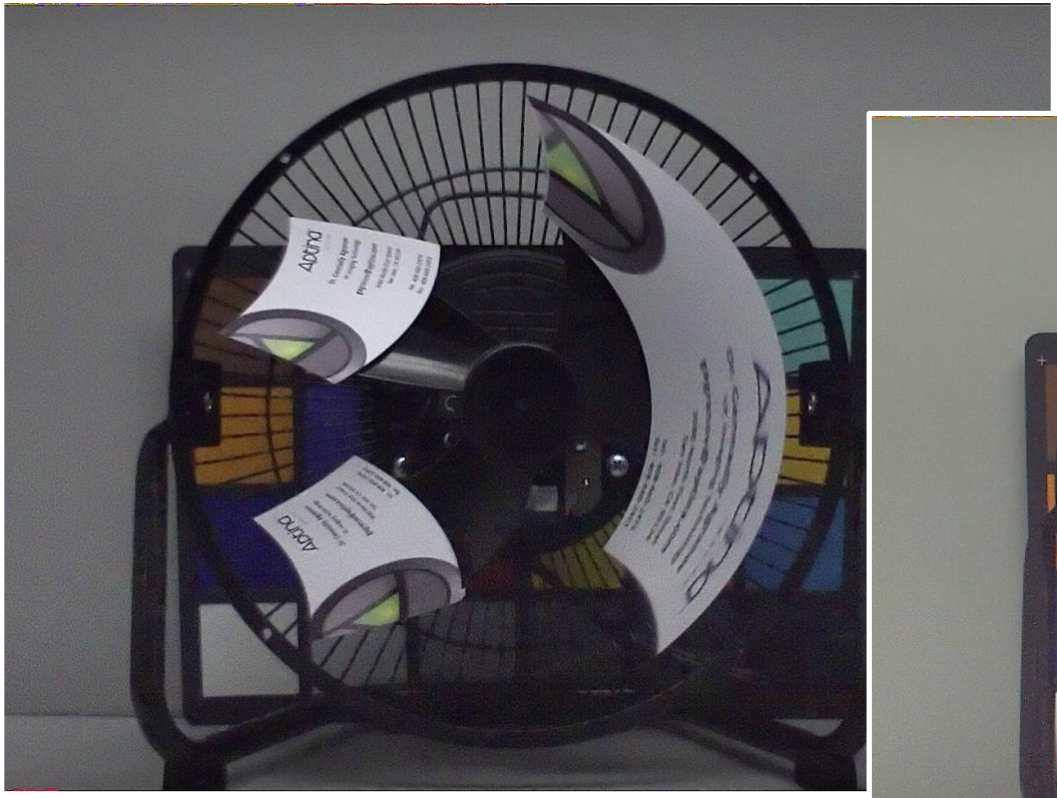
ERS vs. GS Image Performance



a.

b.

Image of the rotating fan taken with GS and RS sensors:

a. 1Mpix sensor, 3.75µm rolling shutter pixel

b. 1Mpix sensor, 3.75µm global shutter pixel

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Conclusion

- We successfully demonstrated 4th generation of global shutter (GS) pixels utilizing pump charge transfer method.
- 4th generation implemented into 3.75µm and 2.8µm GS pixels with significant improvements in dark current, noise floor, dynamic range, and global shutter efficiency.
- 4th generation 2.8µm GS pixel, to our knowledge, is the smallest published CMOS GS pixel with true CDS.
- 4th generation architecture opens further pixel shrinking and extension of applications range.
- 3rd generation of 3.75µm GS pixel demonstrated significant improvement of global shutter efficiency.

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