SIL for improved sensitivity and spatial resolution

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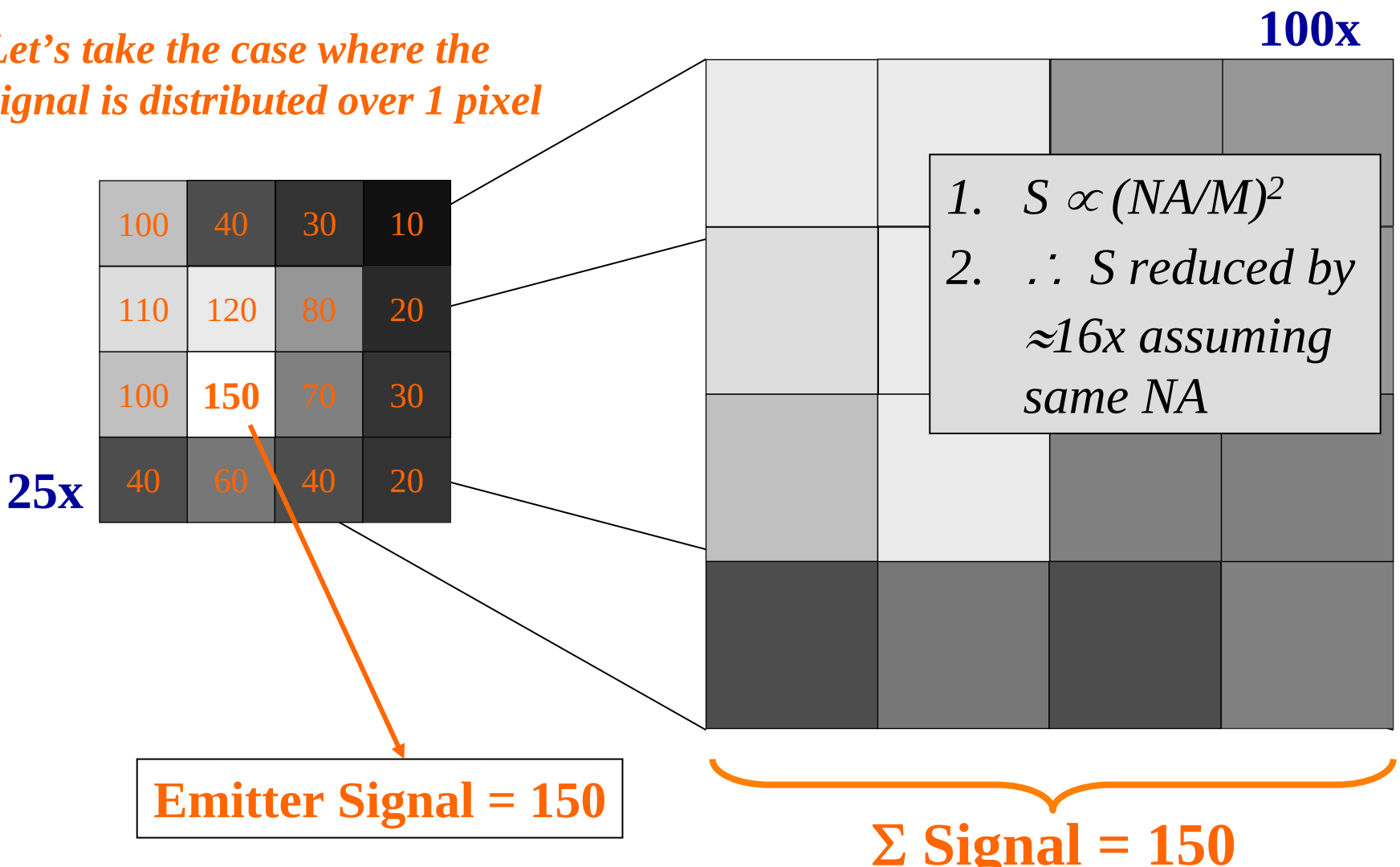
Why is Sensitivity important?

- High resolution fault localization requires *enough* sensitivity at high magnification
- High Sensitivity is required to obtain/maintain “fault detectibility” for advanced technology nodes because Vdd keeps decreasing
- High Sensitivity is required for new dynamic applications

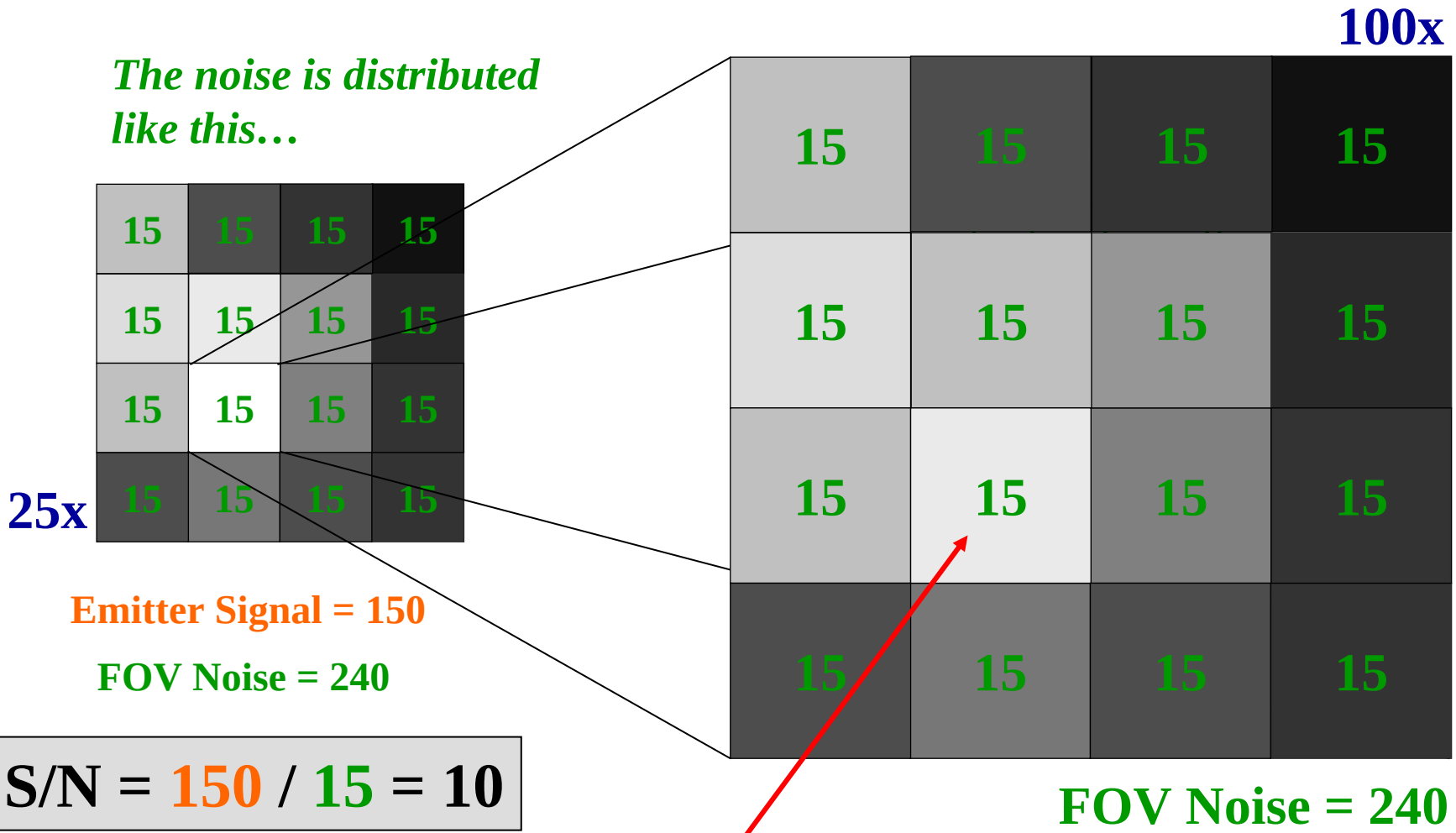
Example: Magnification and SNR (1)

Let's take the case where the signal is distributed over 1 pixel



This case assumes object size >> diffraction-limited spot size

Example: Magnification and SNR (2)

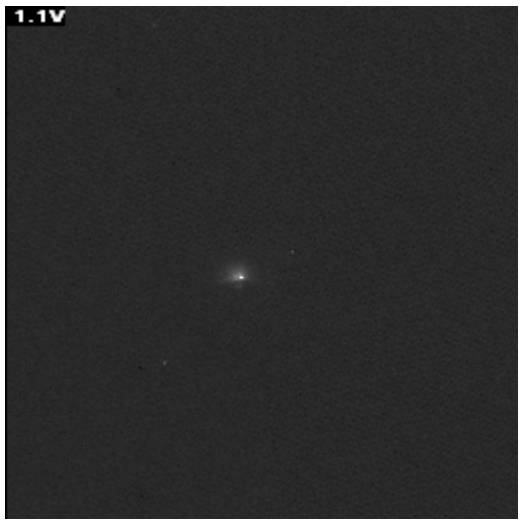


Is high magnification so beneficial ?

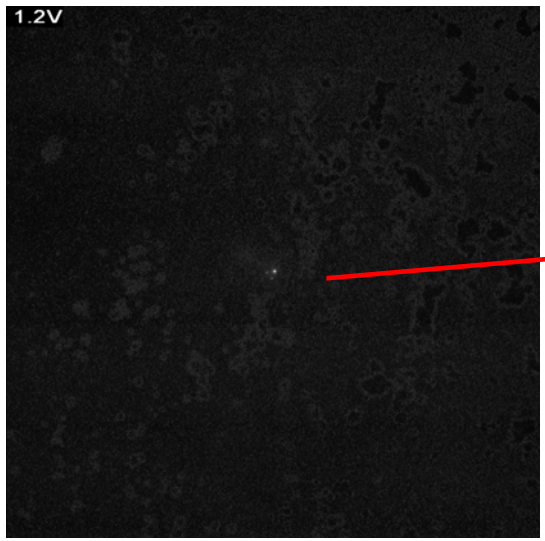
Lens	NA	Mag	(NA/Mag)2	relative
1x	0.25	1	6.3E-02	100.00
20x	0.5	20	6.3E-04	1.00
50x	0.6	50	1.4E-04	0.23
Mit 100x HR	0.7	100	4.9E-05	0.08
LWD SIL	1.45	175	6.9E-05	0.11
STD SIL	2.45	220	1.2E-04	0.20

This case assumes object size >> diffraction-limited spot size

May be not for sensitivity but certainly for resolution

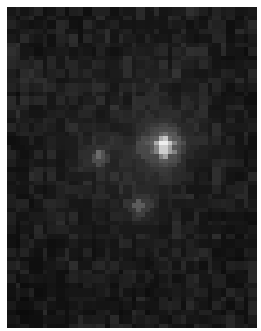


20x – 256 camera



20x – 1K camera

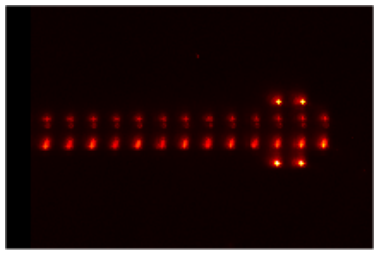
Zoom



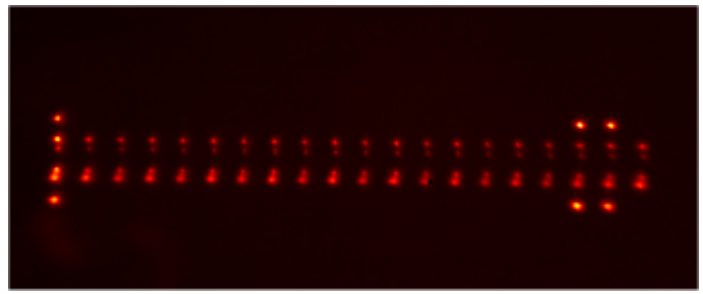
When the image is displayed in its full resolution, we clearly see 3 spots with 20x which is not the case with the 256 camera

Images courtesy of ST

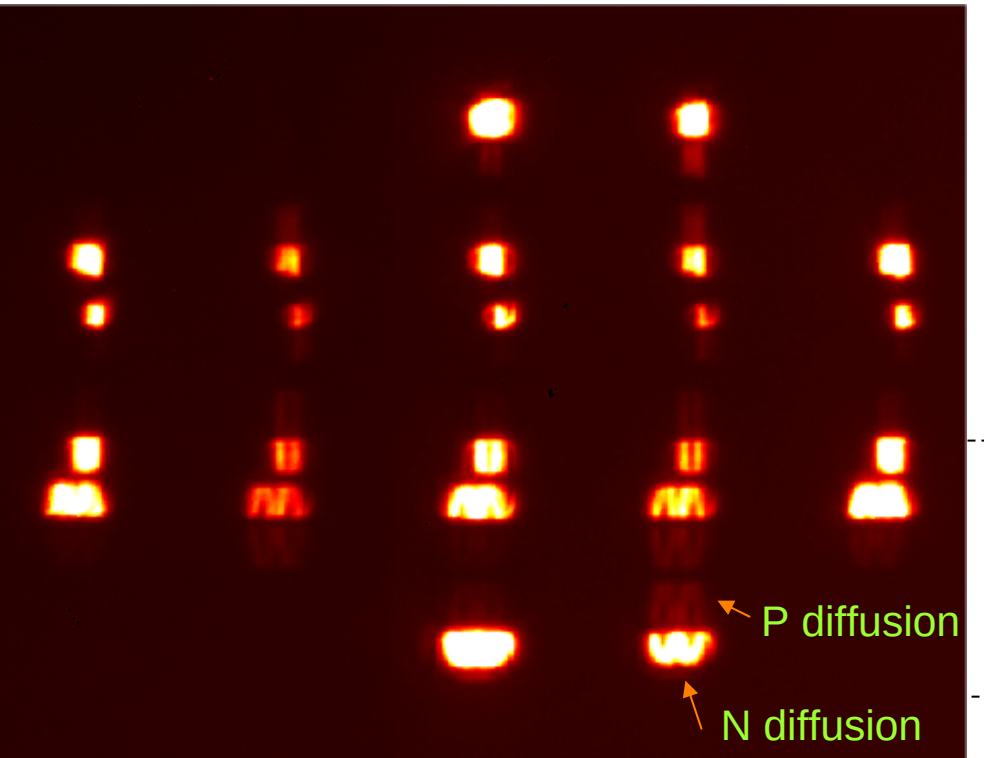
Improved SNR with SIL – Azuma 0.18um



256 InGaAs camera, 50x

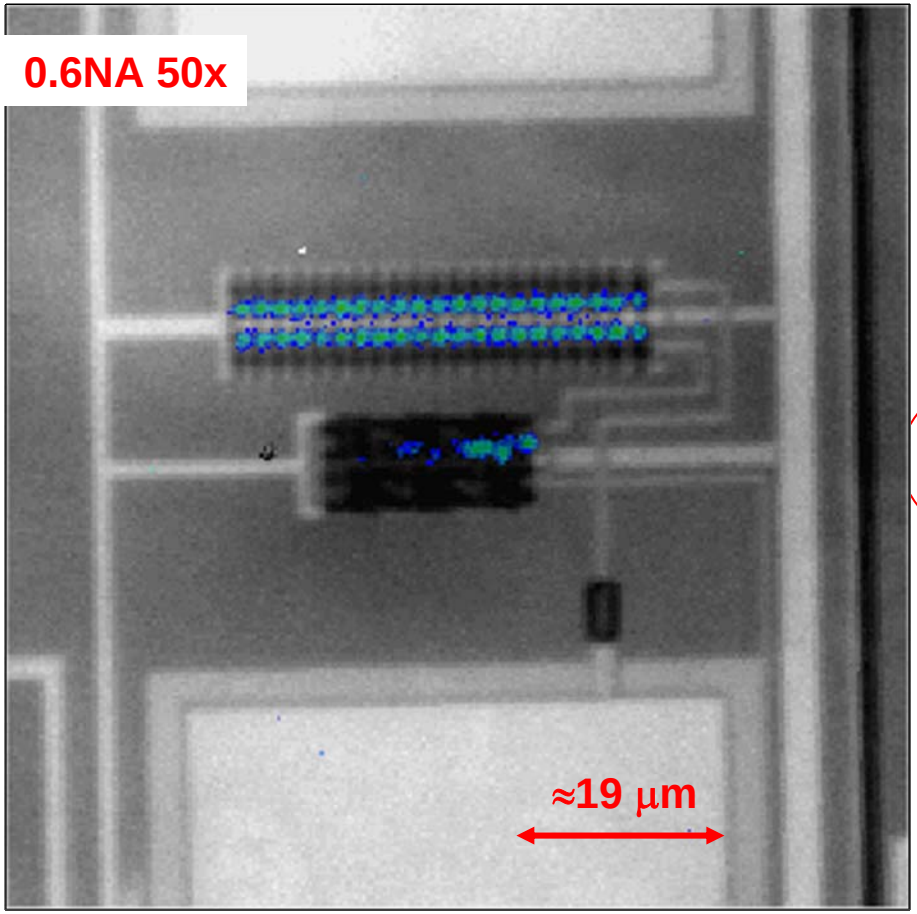


1K InGaAs camera, 50x
Improved resolution
Improved FOV
SNR reduced by ~62%



1K InGaAs camera, 220x SIL
Improved resolution
SNR improved by ~ 80%

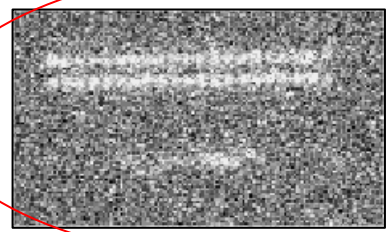
1Kx1K InGaAs Sensitivity Comparison (1/2)



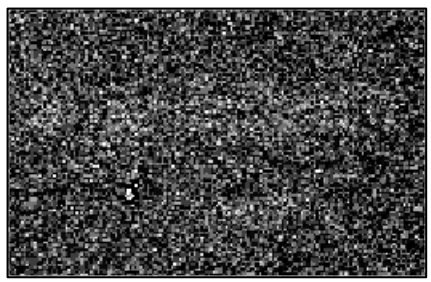
50x, 0.6NA 1K InGaAs overlay image (cropped) of 140nm ring oscillator. 1.3V, INT = 60s. 100μm substrate thickness.

50x Objective

1.3V
INT=60s



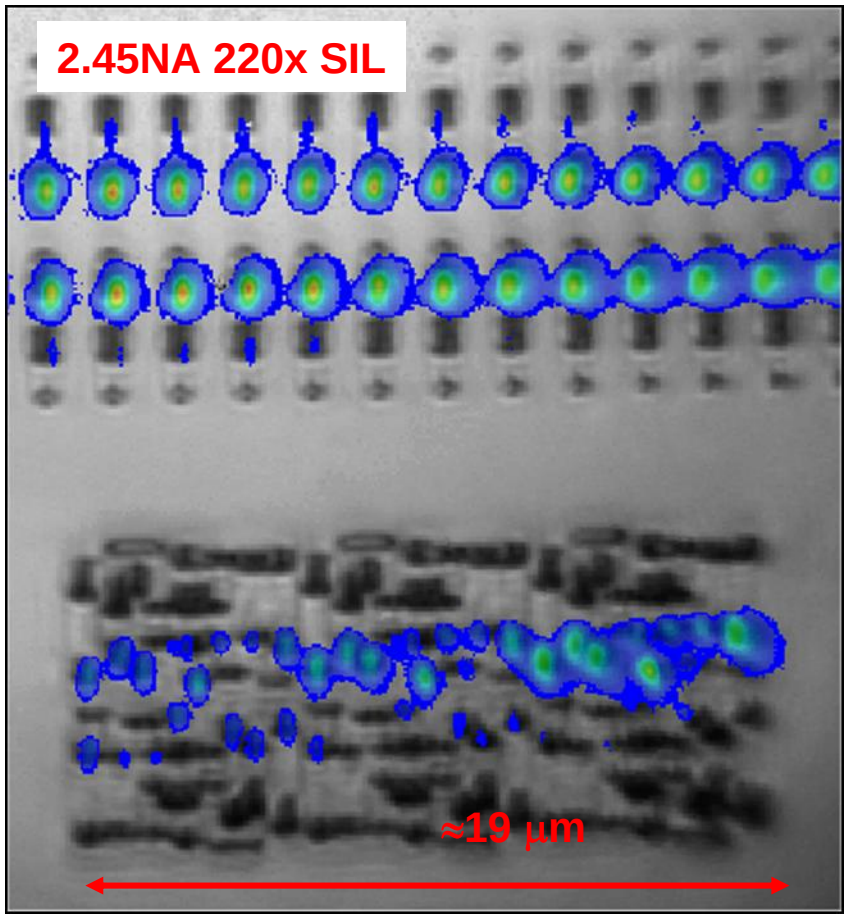
1.0V
INT=60s



0.9V
INT=60s

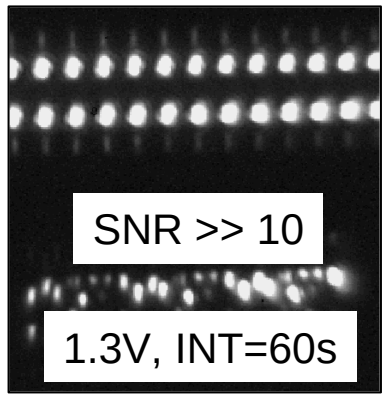
Sensitivity limit at 50x in 60s = 1.0V

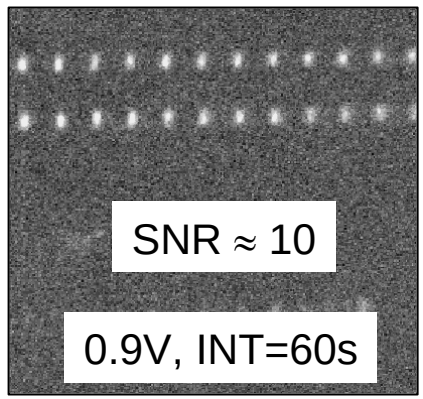
1Kx1K InGaAs Sensitivity Comparison (2/2)

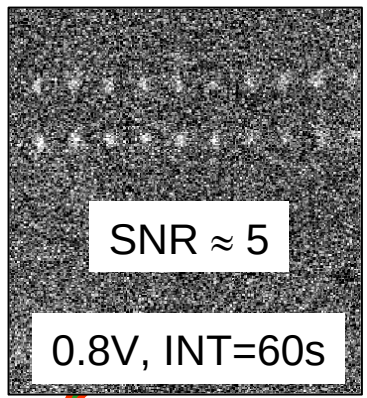


220x SIL (2.45NA) 1K InGaAs overlay image (cropped) of 140nm ring oscillator. 1.3V, INT = 60s. 100μm substrate thickness.

220x SIL





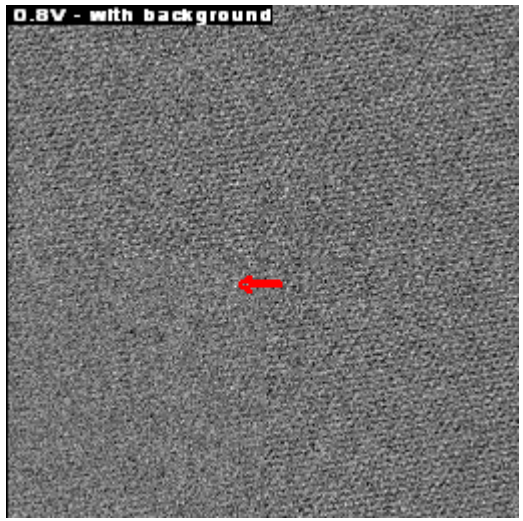


Sensitivity limit with SIL in 60s: 800mV

(200mV better than 50x)

Sensitivity limit for each lens (1/3)

- **Core Voltage is changed by 100mV steps**
- **Integration time is constant for each acquisition**
- **Device is about 100µm Si thick**



50x – 1.2V

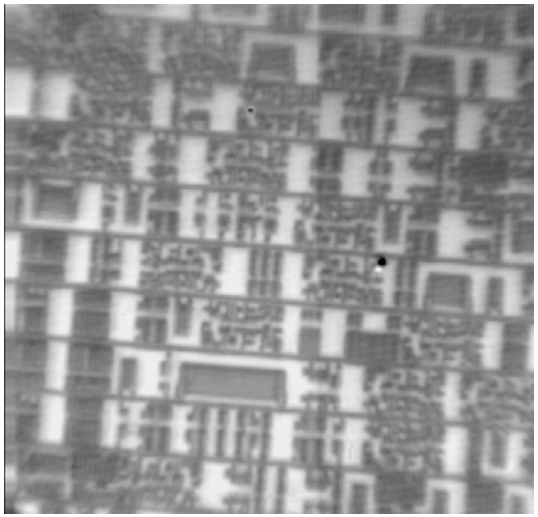
Images courtesy of ST

Detection limit ≈ 0.8V

No background subtraction provides better SNR but is less uniform

Sensitivity limit for each lens (2/3)

STD SIL images



Images courtesy of ST

	LN2 InGaAs
1x	0.9V
20x	0.9V
50x	0.9V
Mit 100x HR	0.9V
Std SIL	0.7V
LWD SIL	0.7V

SIL is the most sensitive lens

Similar performance on another device

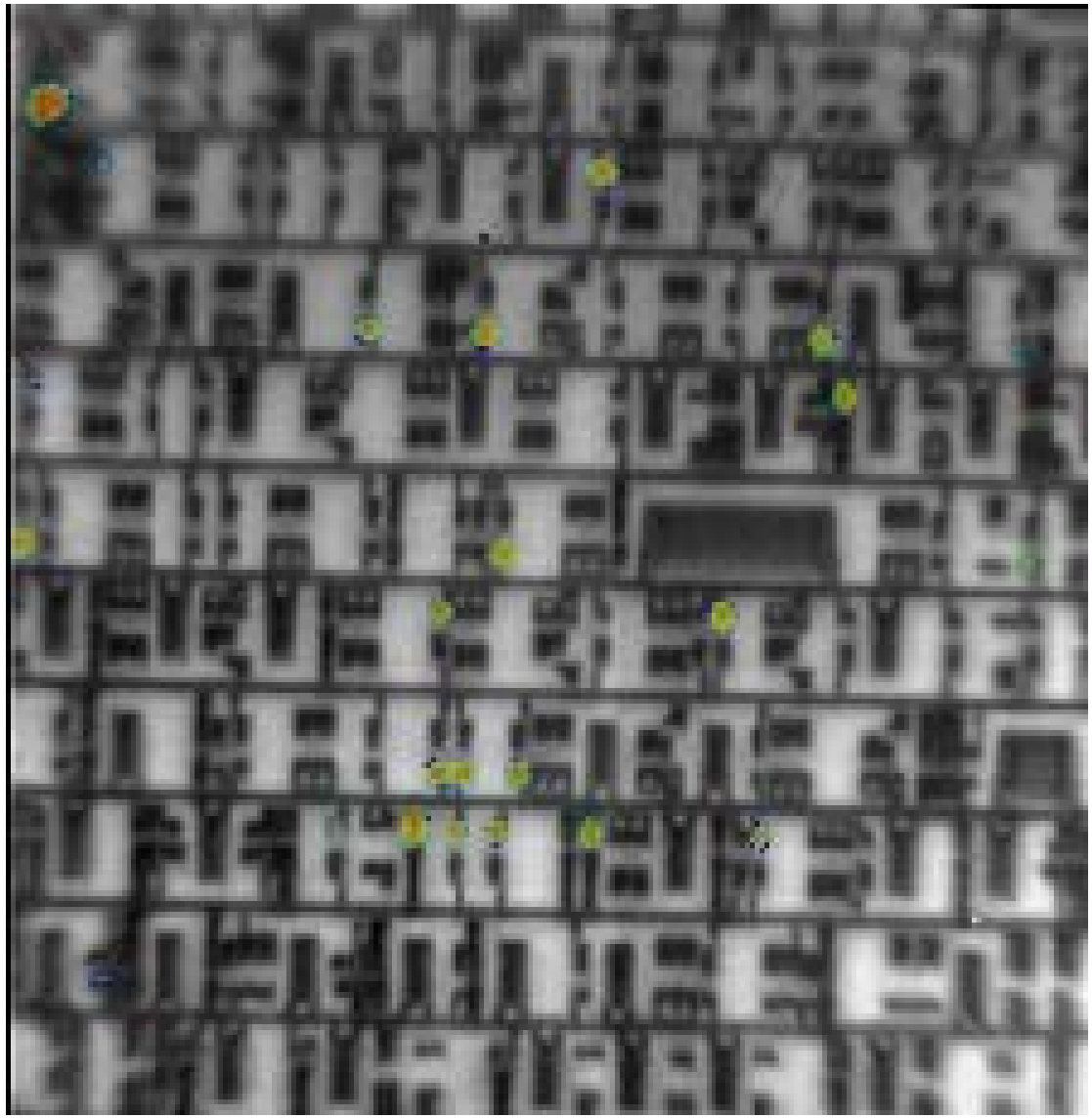


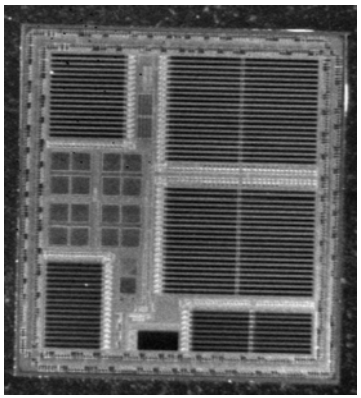
Image courtesy of ST

STD SIL image

Sensitivity limits

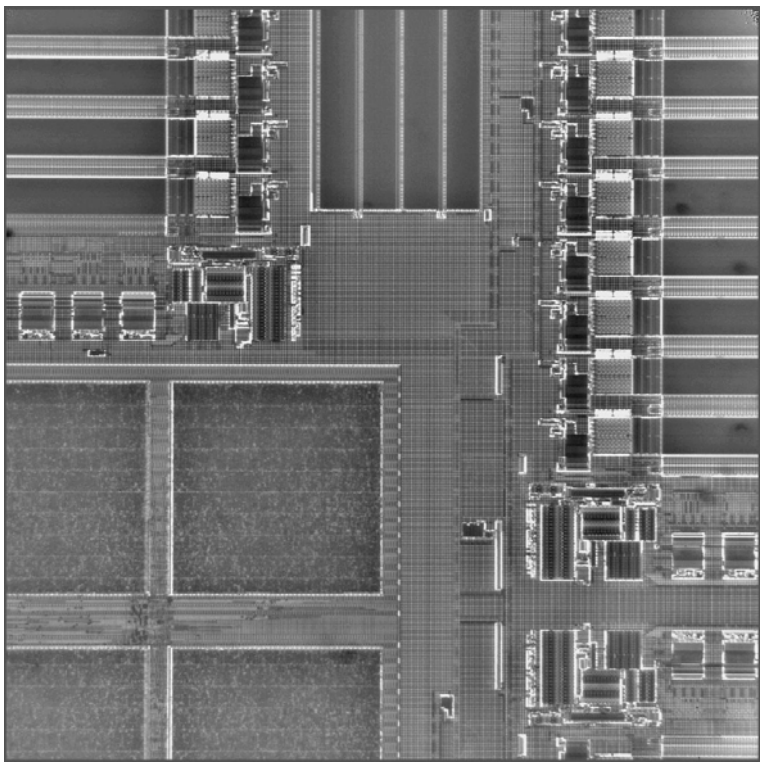
	LN2 InGaAs
1x	<0.7V
20x	0.8V
50x	0.8V
Std SIL	<0.7V

Resolution - 45nm images (1/2)

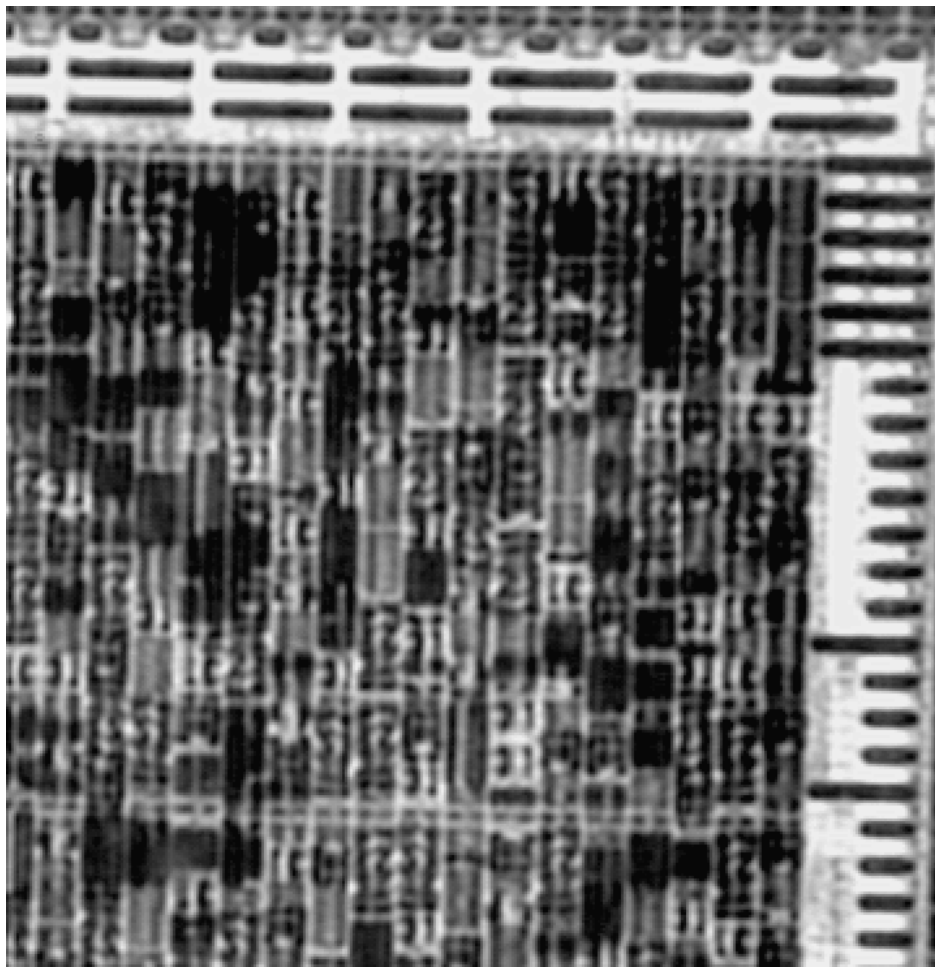


1x

20x



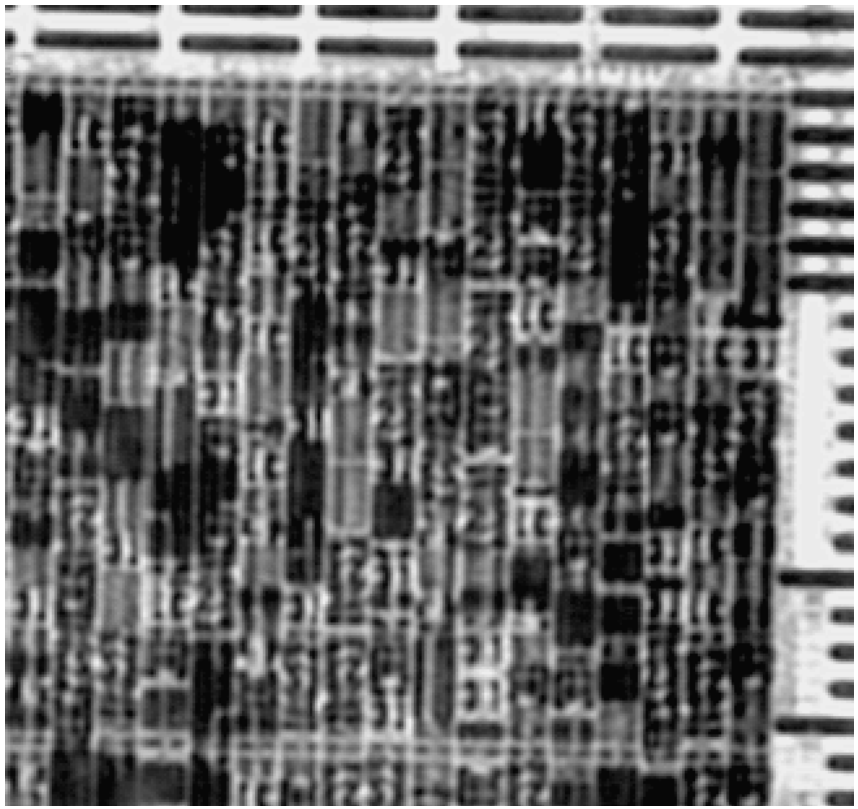
LWD SIL – 1.47 NA



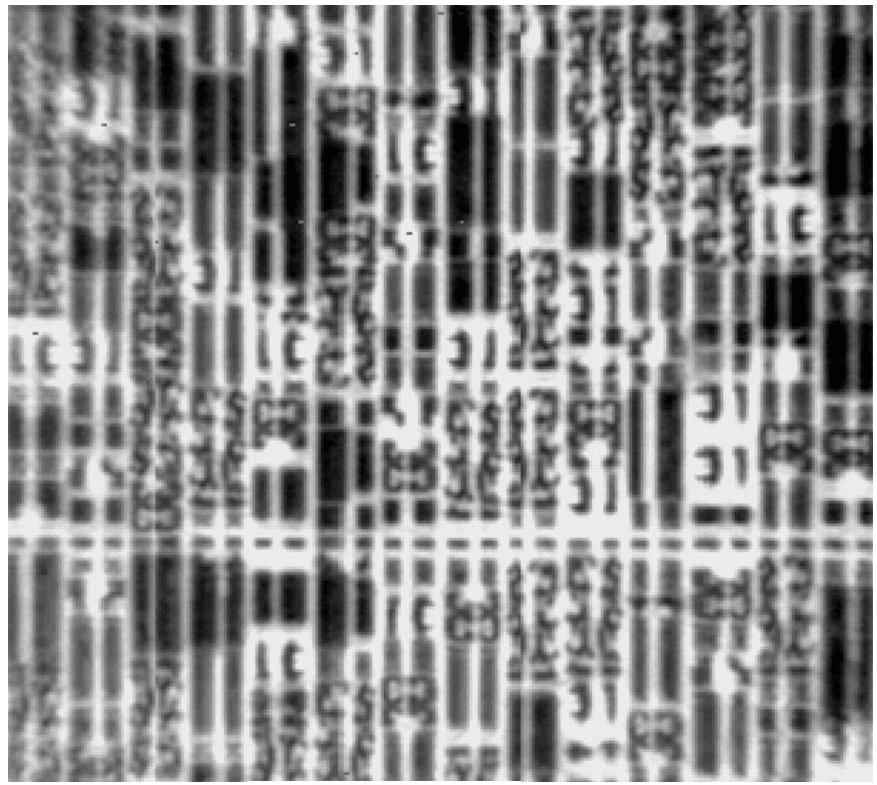
Images courtesy of ST Crolles

Resolution - 45nm images (2/2)

LWD SIL

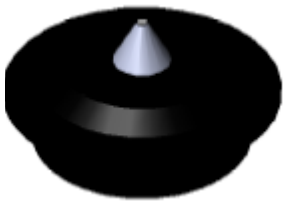


STD SIL



Images courtesy of ST Crolles

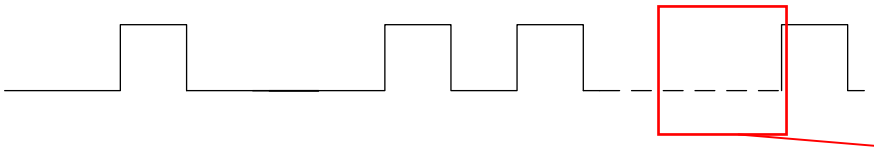
1.47NA
100um Si
(works from 0um to 350um)

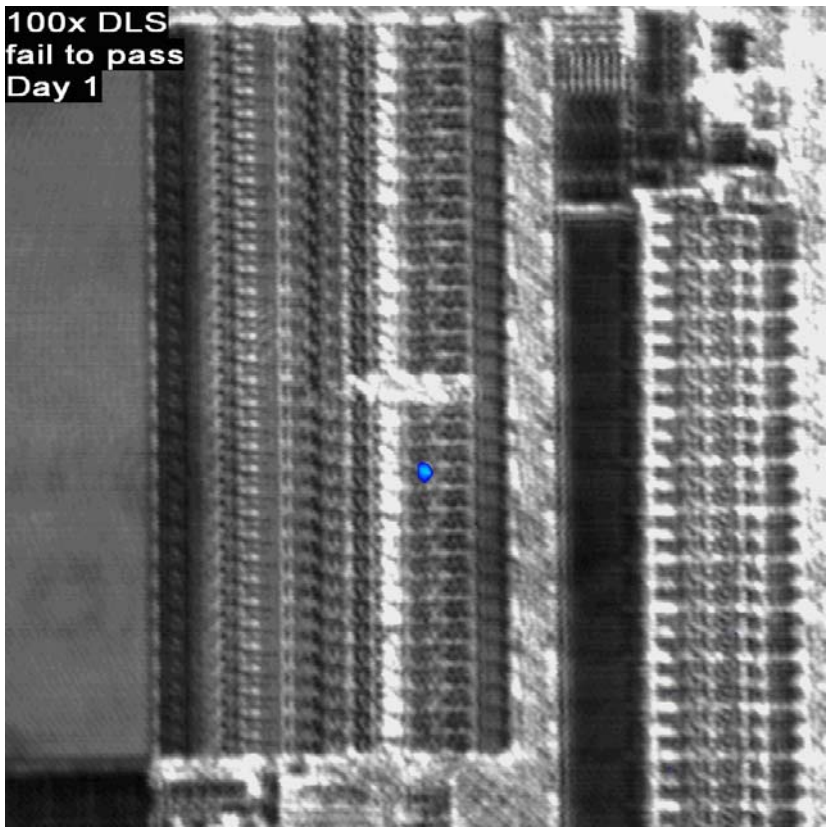


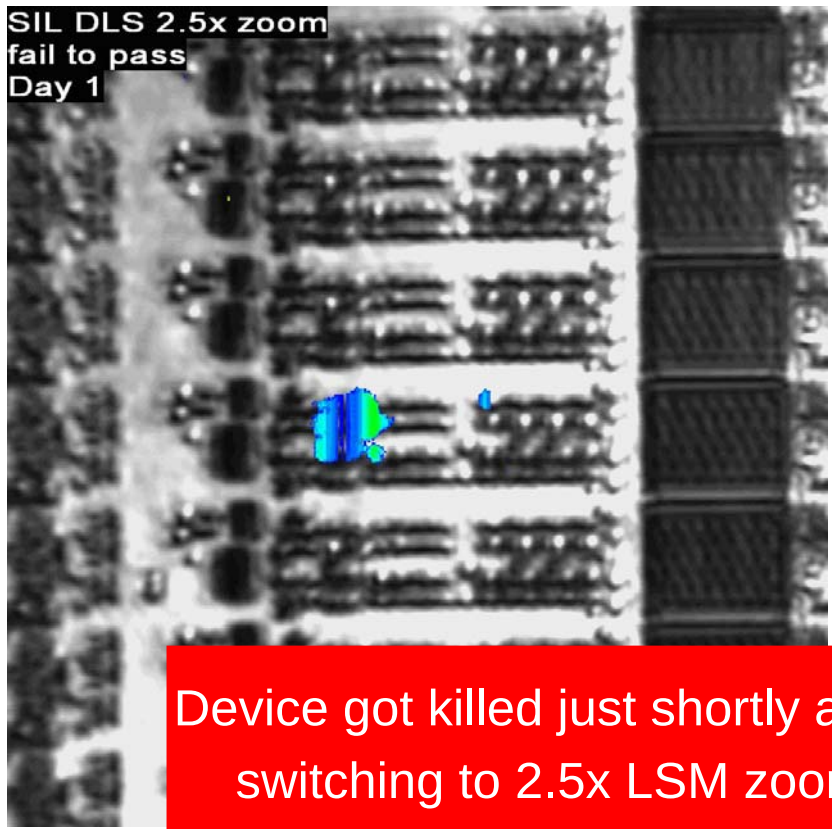
2.45NA
100um Si ± 50um

SIL for DLS applications

- Customer had an issue in a memory and stated that 100x was not giving him enough resolution
- The scan chain output pattern was monitored at a specific vector to determine pass or fail





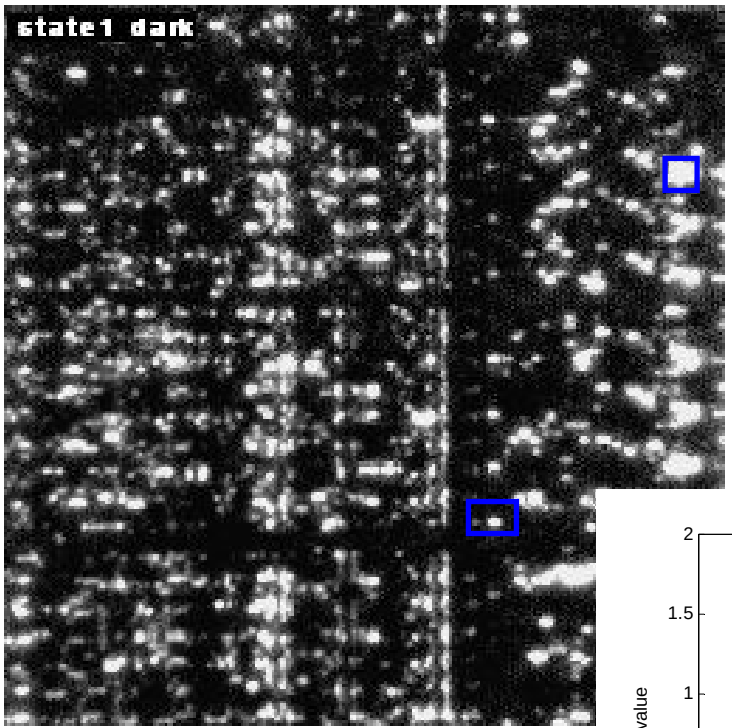


Device got killed just shortly after switching to 2.5x LSM zoom

Images courtesy of Texas Instruments

SIL for Logic State Mapping

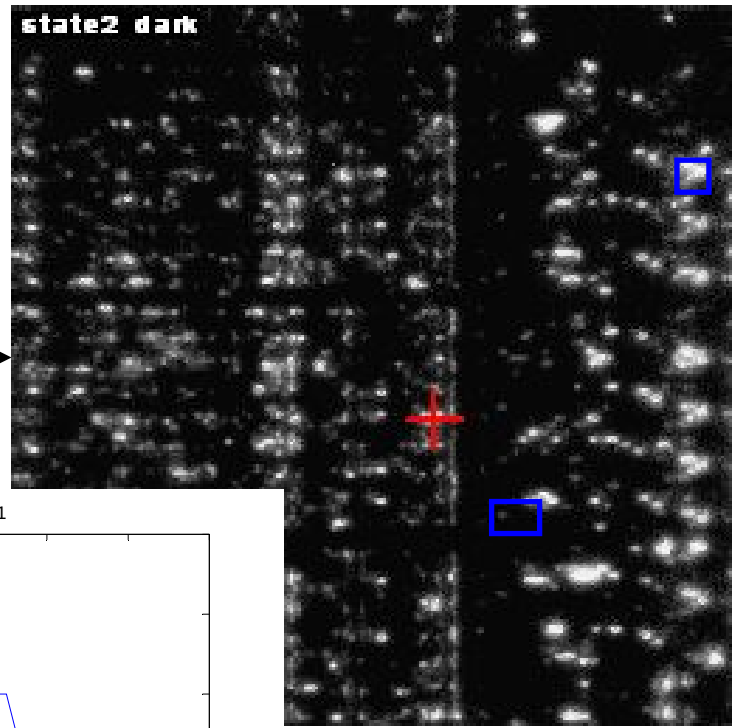
- The emission microscope is linked with the tester to take one emission image and then advance the tester to next vector and re-acquire image…

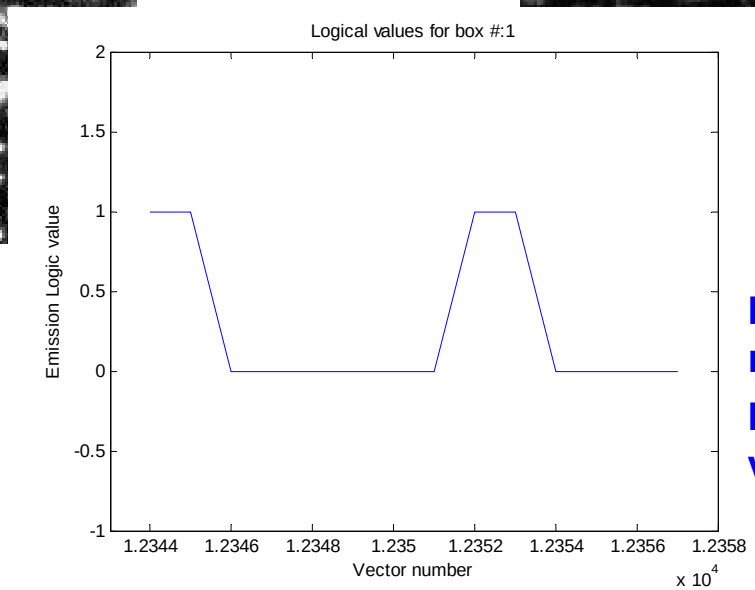


100x images

Tester:

Vector + 1





Logic states can then be measured for each vector.

In this example, from vector 12344 to 12357

CONCLUSION

- SIL improvement for **resolution**.
  - applies for higher pixel count camera with smaller pitch
- Macro lens traditionally was the most sensitive lens
  - No longer true with SIL
  - SIL is the **most sensitive** lens
- SIL benefits both emission & LSM applications
  - Be careful not to apply too much laser power
    - Especially when using LSM optical zoom
- New SILs in development will further improve performance without comprising ease of use