

Critical Role of Testing For Image Sensor Development

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Agenda

- Introduction
 - Sony Semiconductor & Image Sensor Business.
- Main Presentation
 - Critical Role of Testing For Image Sensor Development.
- Summary



Sense the Wonder

“Fascinate with the wonders of the world.”

Sense

Word that suggests humans' actions to notice or feel something, their sensibilities, and image sensors

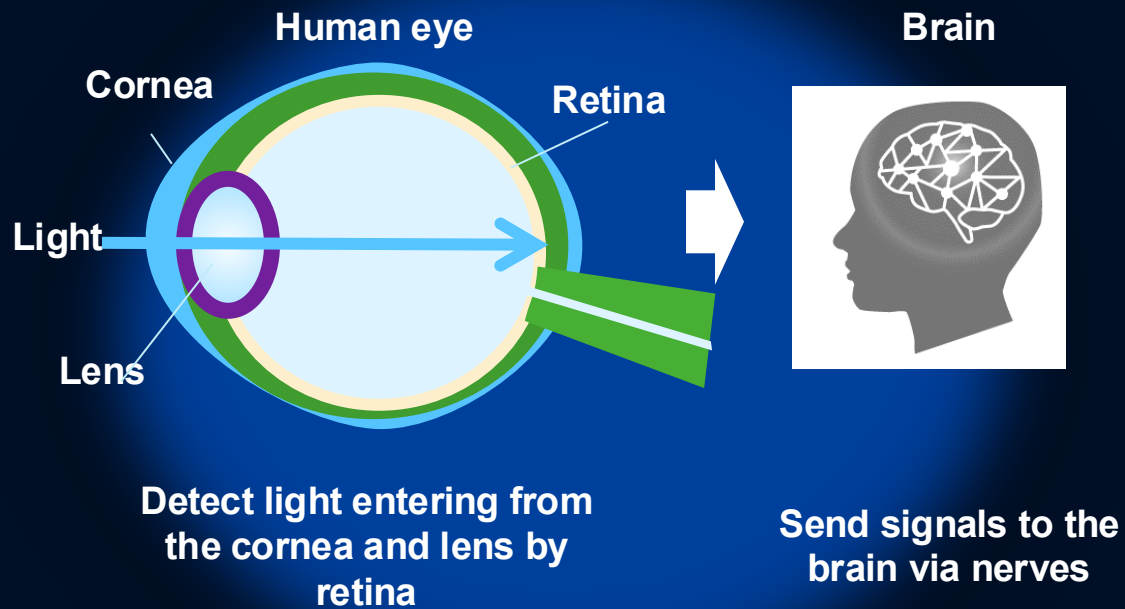
Wonder

Word that suggests corporate culture that Sony has been cherishing, and the origin of research and development, recalls amazing discoveries and move people's heart

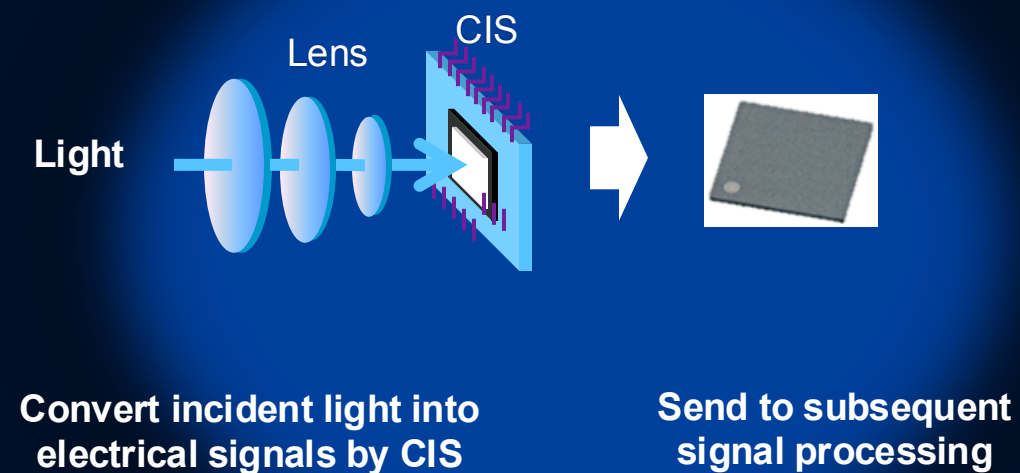
CMOS Image Sensor (CIS) is...

A semiconductor that plays the role of the "retina" of the human eye, called the "electronic eye"

Retina

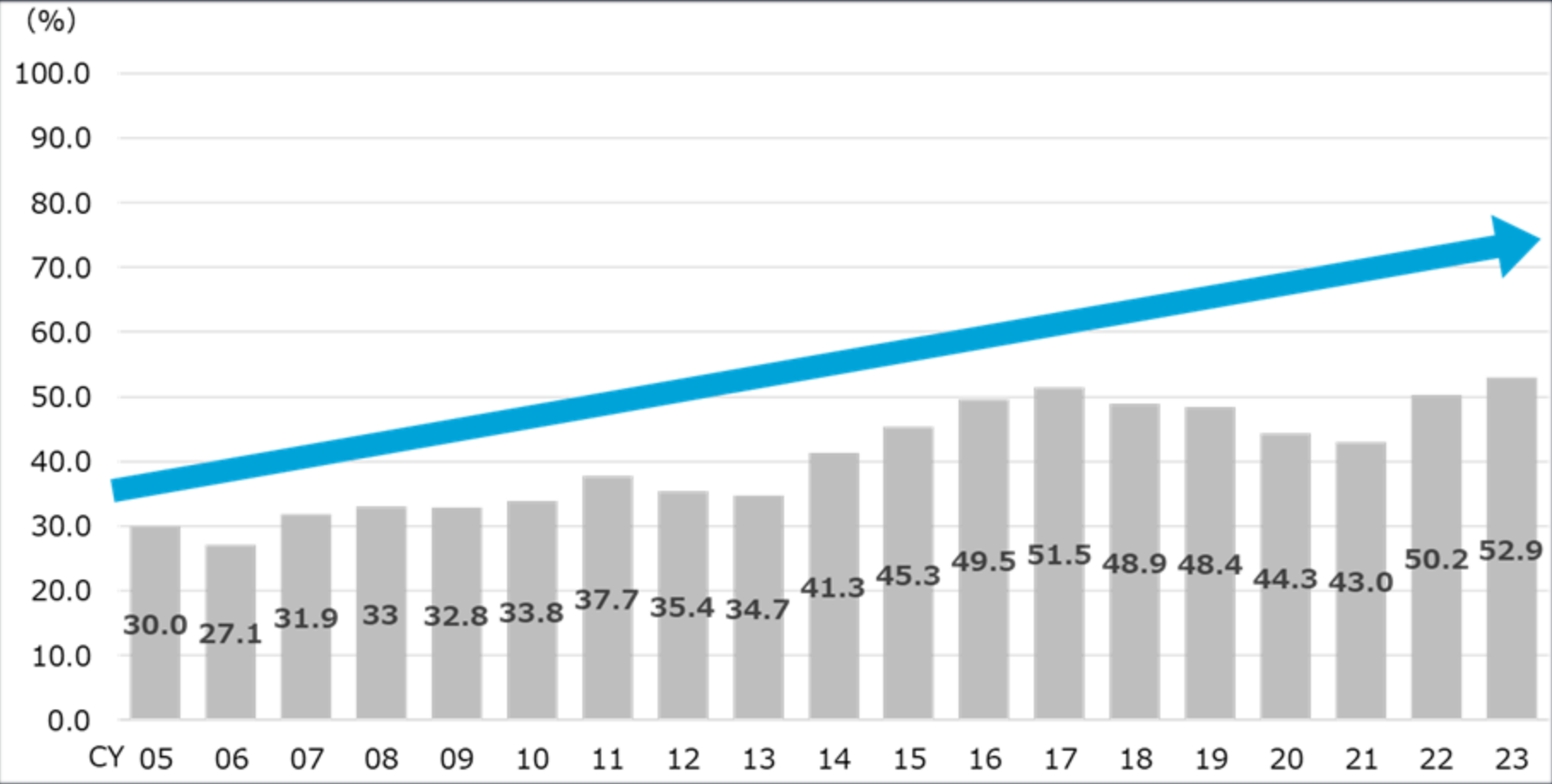


CIS



Sony Semiconductor Solutions Group's CIS market share trends (Revenue basis)

Further expanding market share



#Source: Techno System Research

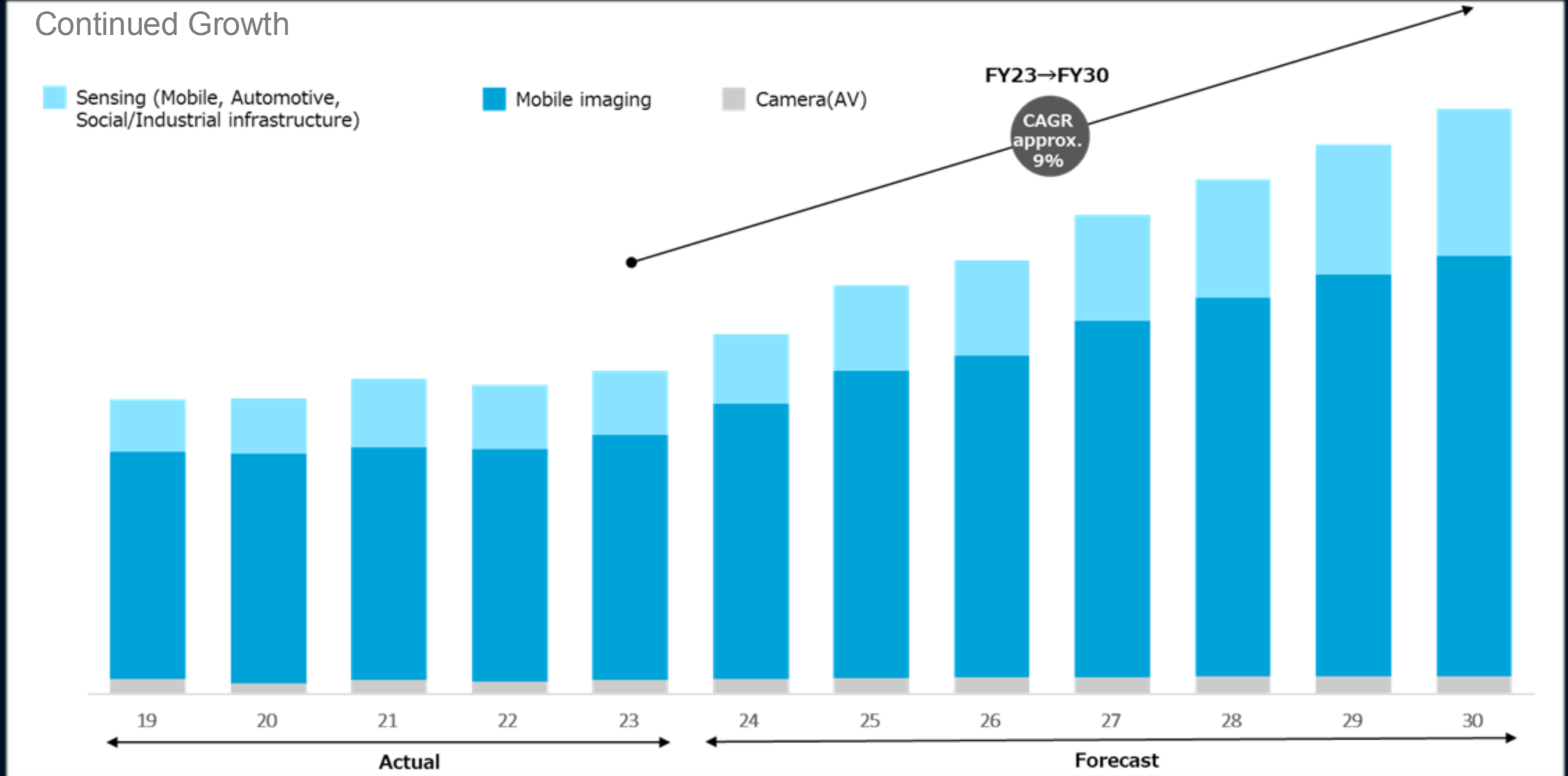
FY23 Sony's Share

Category	Share (monetary basis)
Smartphone	58%
DSLR	76%
Social Infrastructure	21%
Industrial Infrastructure	38%
Automotive	32%

*1 Public security, Home security, DR、ITS、 Webcam, Medical
*2 Invisible light, Large scale inspection, General-purpose C mount MV, Recognition MID
*3 Excluding in-cabin/2M~

#Source: Sony Semiconductor Solutions Corp.

CIS Market Outlook (Revenue Basis)



#Source: Sony.

Activities for Mobile ~Potential for Technological Evolution / Strength of SSS Group~

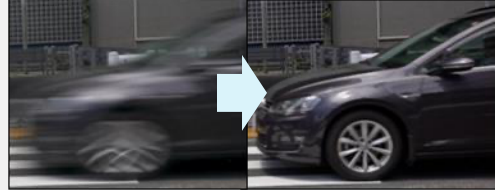
Take the lead in realizing new technologies

Event-based Vision Sensor (EVS)

High-speed readout



Removal of blur



Near InfraRed (NIR)

Low-illuminance
RGB



NIR



=

Fusion



and more...



Mobile
imaging

2D

3D

4D

5D

Spectral

Time

Depth

Imaging

RGB Sensor

Evolution of pixel characteristics



Resolution
Sensitivity
Dynamic range
Low noise,
etc.

ToF Image Sensor

Bokeh



Auto focus



To more "KANDO"

Main Presentation

『Because testing is an expense』

『Testing is the last line of defense』

『Testing doesn't add value』

What do you think?

I'm going to tell you what I'm thinking today.

Terminology

- Production Flow Development

Design environment Development
Process/Device Development
Test Technology Development



Design
Prototyping
Evaluation



Mass Production



Manufacturing Flow
Sorting Flow

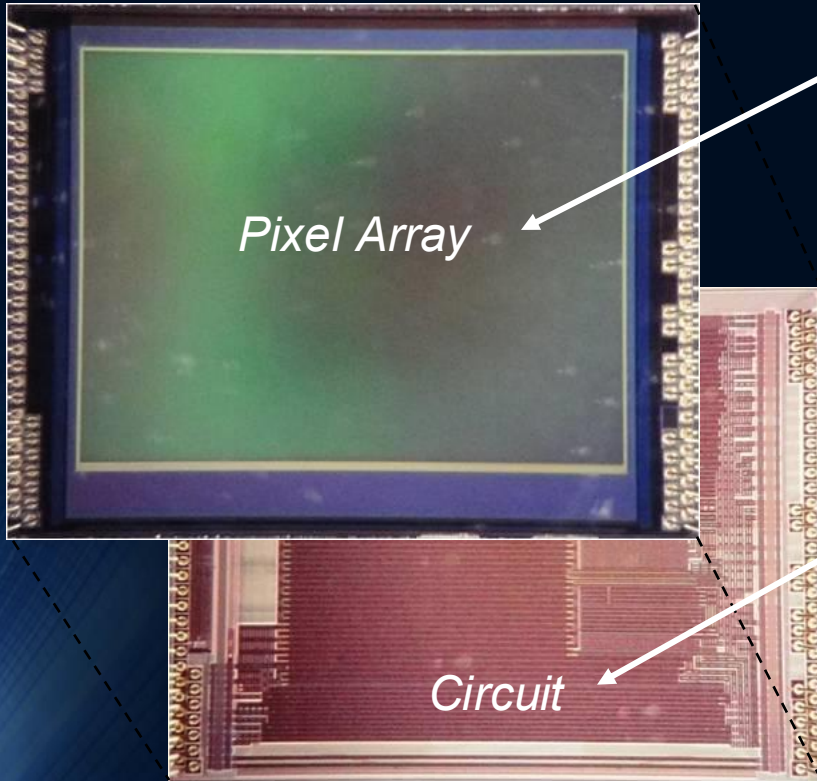


Product

- Test Technology
 - Test Methodology
 - Test Systems
 - Test Equipment
 - Test Programming
 - Test Environment

CIS Structure(Wafer Stack)

Stacked CIS



Pixel Array

- ✓ Each pixel consists of a photodiode and several transistors
- ✓ Each pixel converts optical information to voltage level

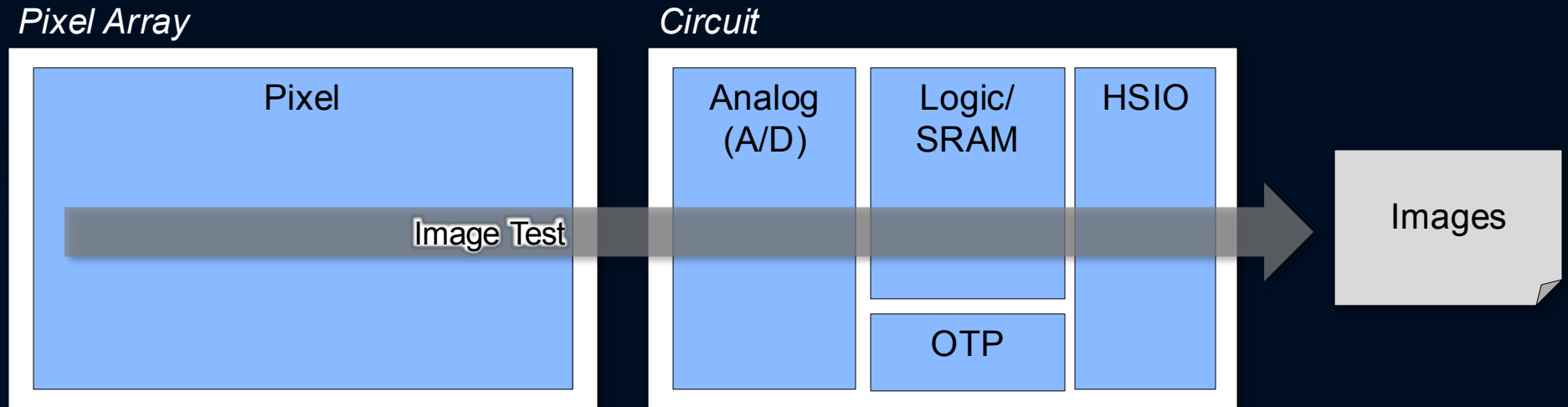
Circuit

- ✓ Convert voltage level to digital data (ADC)
- ✓ Digital signal processing
- ✓ Defective pixel correction
- ✓ High speed IO to output image data

CIS Test Methodology



Light Source

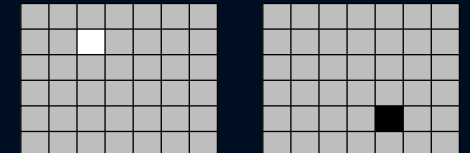


Test Items	Target
DC	Power, I/O, Standby, etc.
SCAN	Stack-at, Transition
MBIST	SRAM, ROM
Analog	A/D, PLL, etc.
Loopback	High Speed IO
Image Test	Pixel Array w/ Multiple Light Intensity
OTP Blow	Defective pixel correction, SRAM repair, etc.

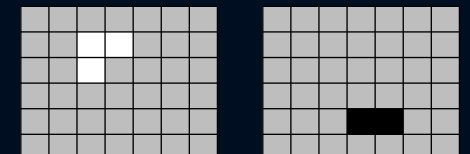
CIS Oriented Item →

Example of Failure Symptoms

Defective Pixel (Single)



Defective Pixel (Mass)



Defective Line

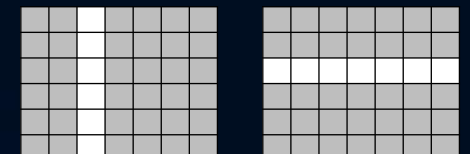


Image processing is needed

Roles of CIS Testing (Same as others)

Product

Product Quality

- ✓ Ensuring the quality of products delivered to customers
- ✓ Key Point:
 - Product Completeness
 - Manufacturing Completeness
 - High-quality Test System (Sorting quality)

Product Delivery

- ✓ Sufficient product supply capacity to meet demand
- ✓ Key Point:
 - Product Completeness
 - Manufacturing Completeness
 - High-Efficiency Test System (Sorting Ability)

Development

Product Completeness

- ✓ Ensuring the Completeness of Development
- ✓ Key Point:
 - High-quality Test System (Data quality)

Manufacturing Completeness

- ✓ FeedBack and FeedForwad to Design/Manufacturing/Sorting
- ✓ Key Point:
 - High-Efficiency Test System (Amount of Data)

To fulfill these roles, a high-quality & high-efficiency test system

Difficulty in CIS Testing

Failure symptoms are classified into two categories

Intrinsic

- ✓ Defective device(open, short, etc.)
- ✓ Example
 - Defective pixel
 - Defective circuit
 - Intrinsic noise (RTS, dark current)

Extrinsic

- ✓ The impact of the test system
- ✓ Example
 - Optical Lens Shading
 - Random noise due to power & signal
 - Bit error through HSIO



Must be Zero.

Conceptual diagram of CIS Test System.

Prober/Light source

Light Source

<Feature of CIS testing(1)>
A special light source that can reproduce various shooting situations is required.

Wafer (Device)

Testing Board

Probe Card

Prober

Signal

Register

Bias

CLOCK

DPS

Tester

Numerical processing

LUT
Logic
Arithmetic
etc.

Spatial Filtering

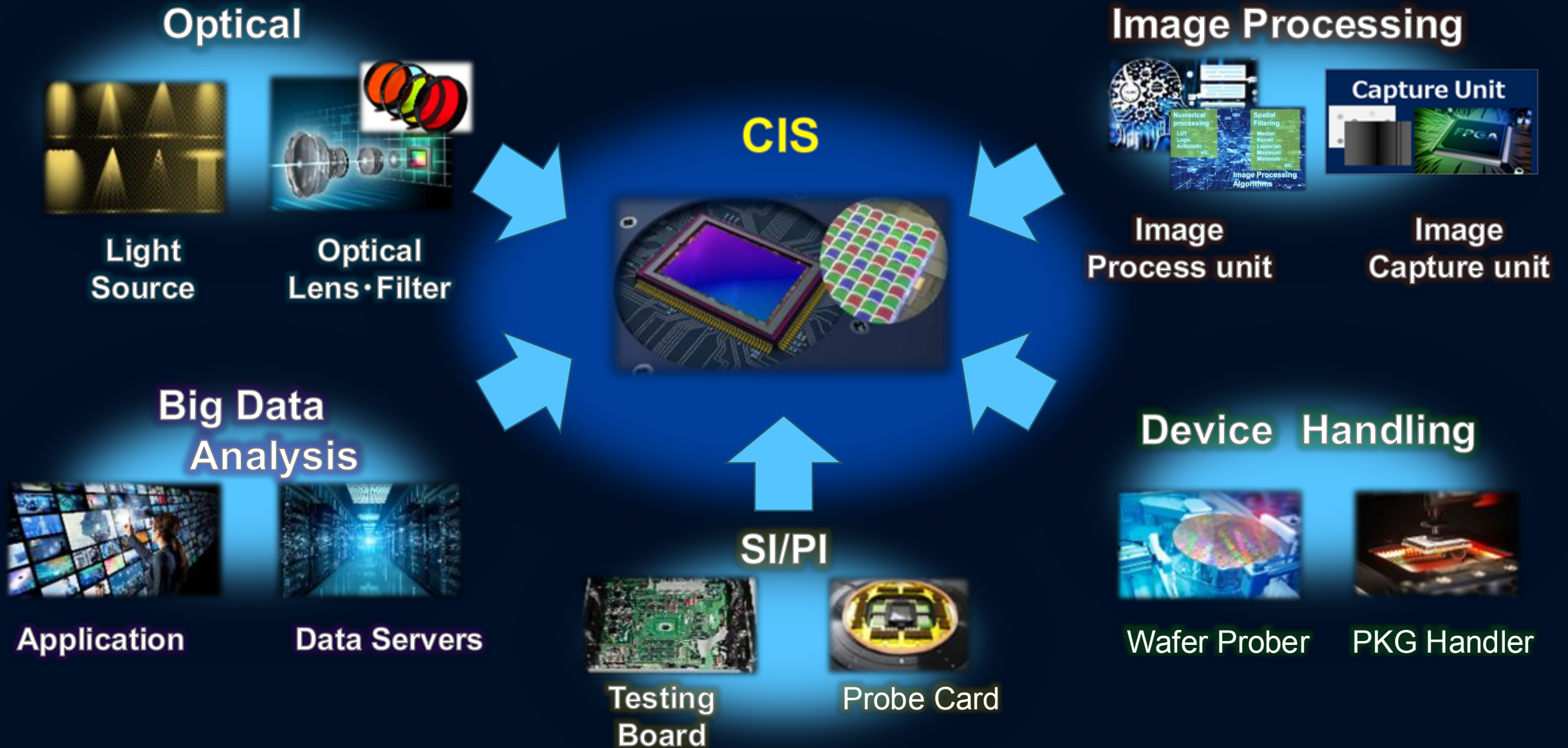
Median
Kernel
Laplacian
Maximum
Minimum
etc.

Image Processing Algorithms

Capture Unit

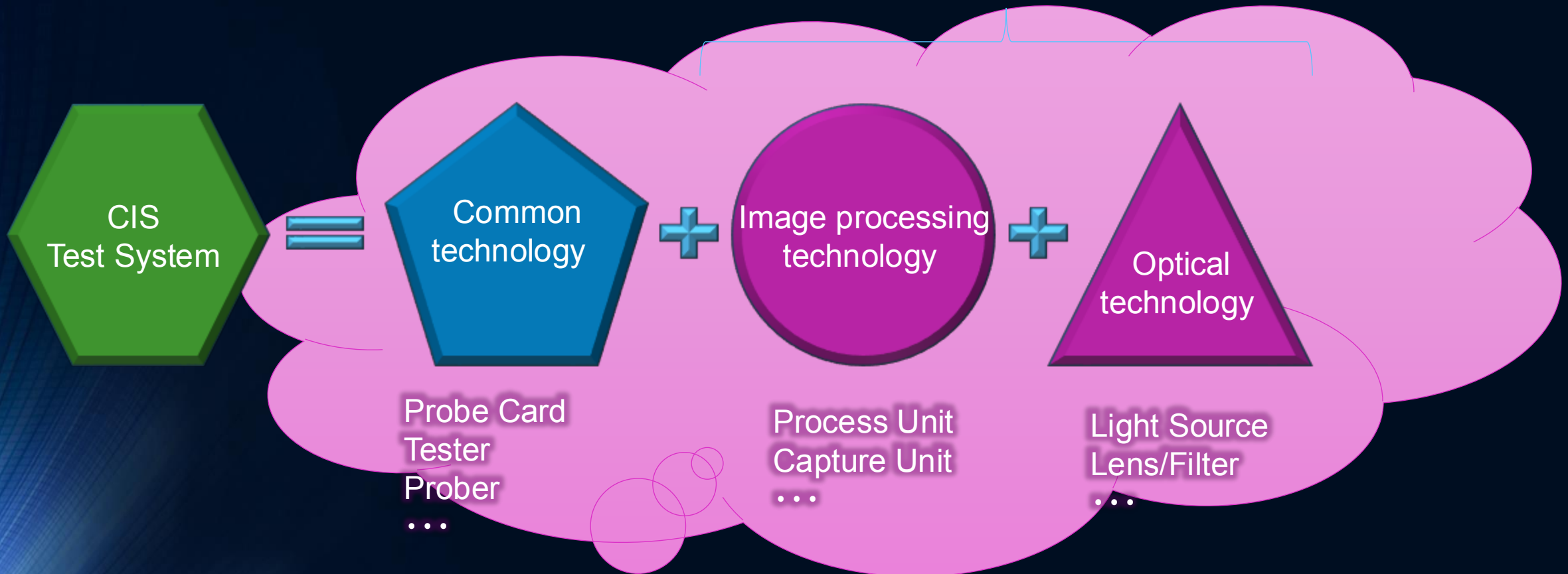
<Feature of CIS testing(2)>
High-speed image processing technology that can filter multi-pixel image sensors is required.

CIS Test Technology



CIS test system and test technology

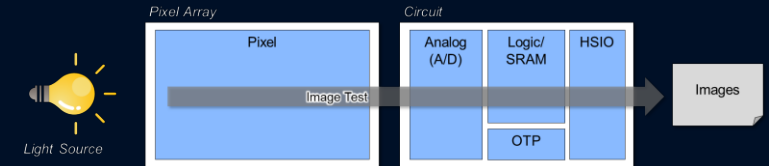
CIS Oriented



Environment (Noise and Dust)

An unseen but very important part

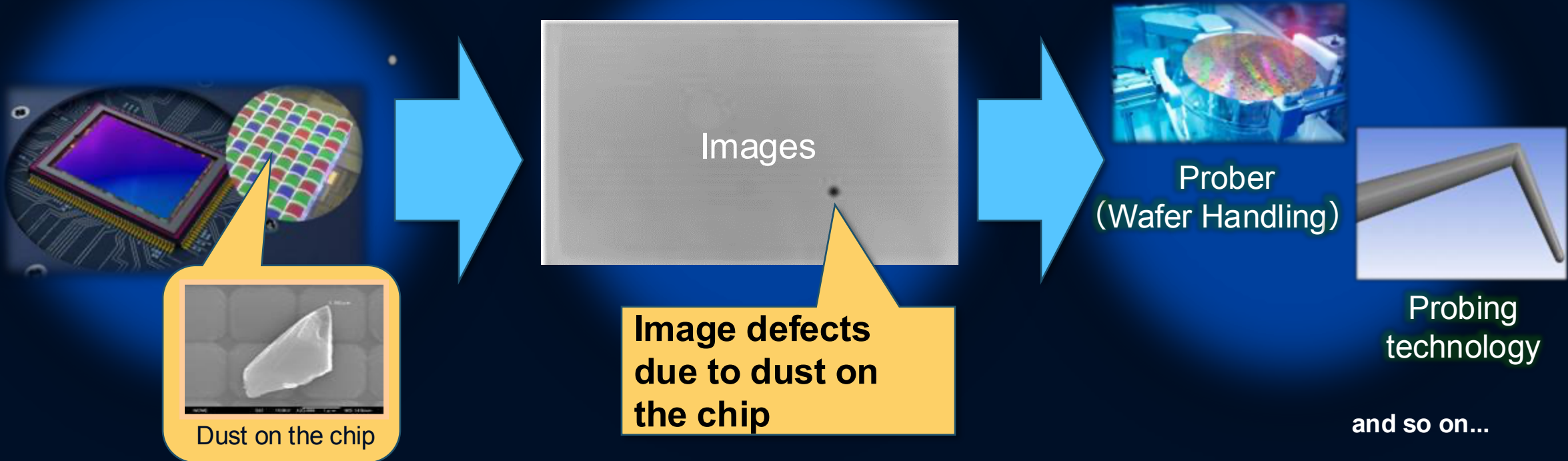
Dust reduction is mandatory for CIS



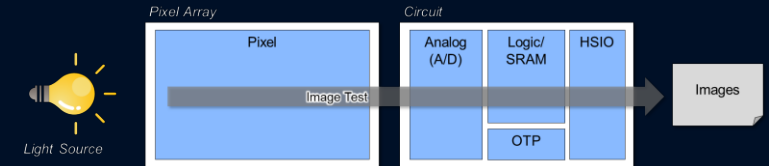
In the Wafer test process
If dust adheres to it...

Since the image defect occurs
in the wafer test process,
the yield is reduced.

It is necessary to develop
less-dust wafer handling and
less-damage probing technology.



Noise reduction is essential for CIS

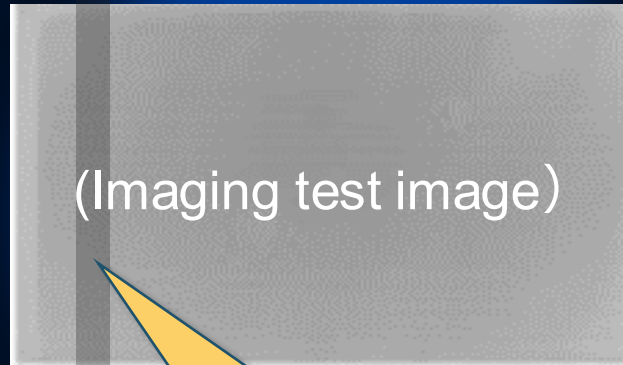
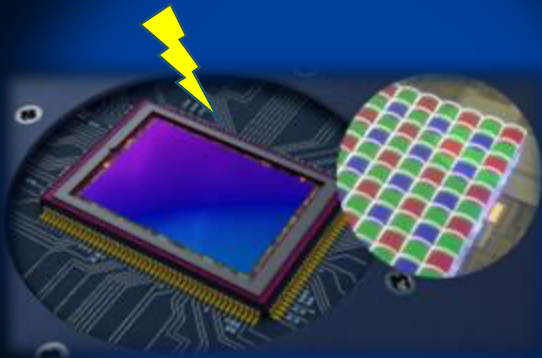


In the wafer test process
If environmental noise affects
the device...

Since the image defect occurs
in the wafer test process,
the yield is reduced.

It is necessary to develop
a test system that minimizes
environmental noise.

Environmental noise



Noise may appear in the
image that, where image
processing cannot
eliminate.



Noise is various ,
and reproducibility
is poor, so cause
analysis is difficult.

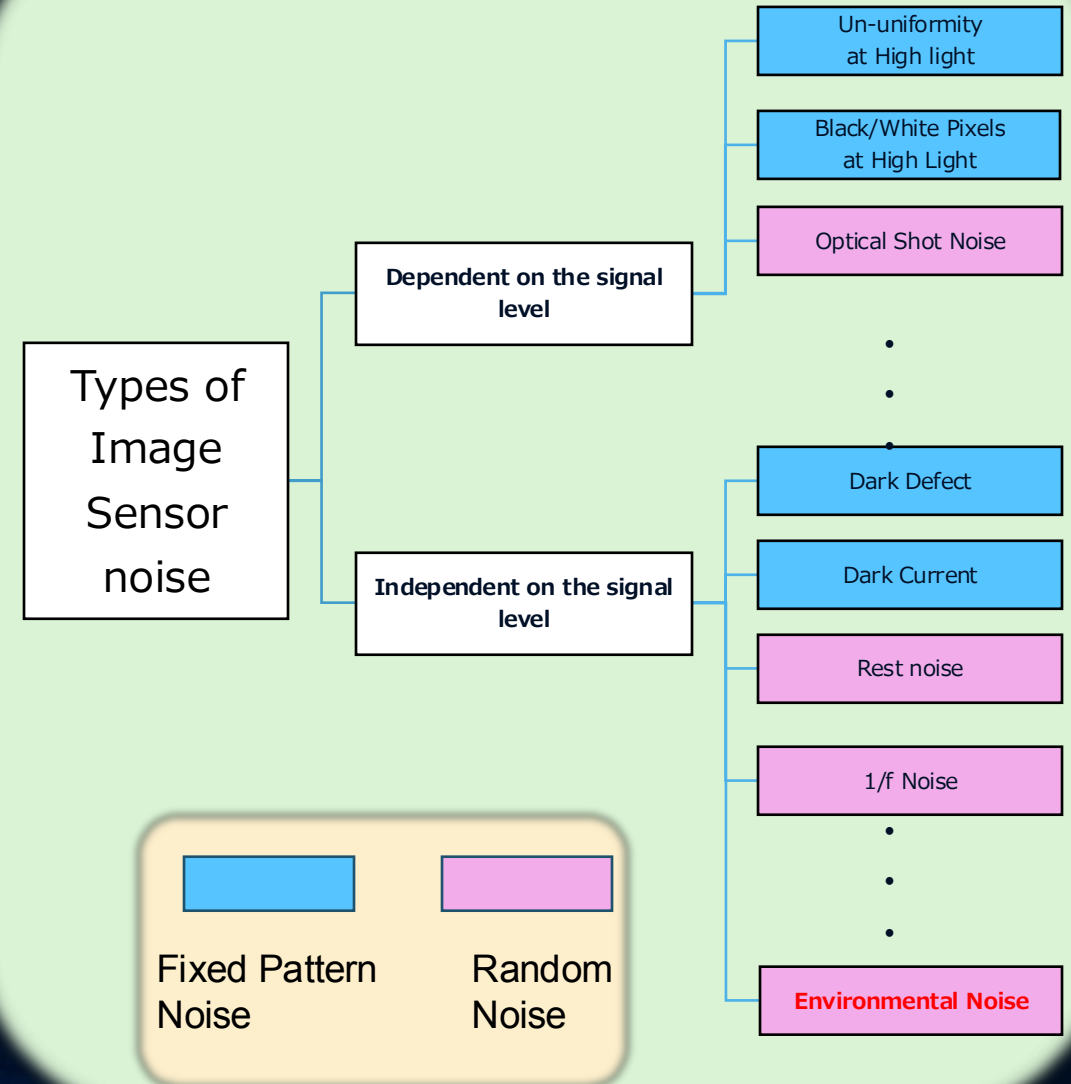
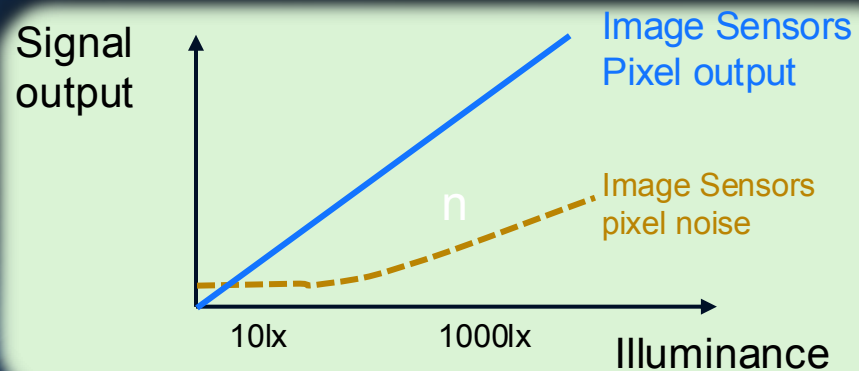
Noise is especially noticeable in dark areas



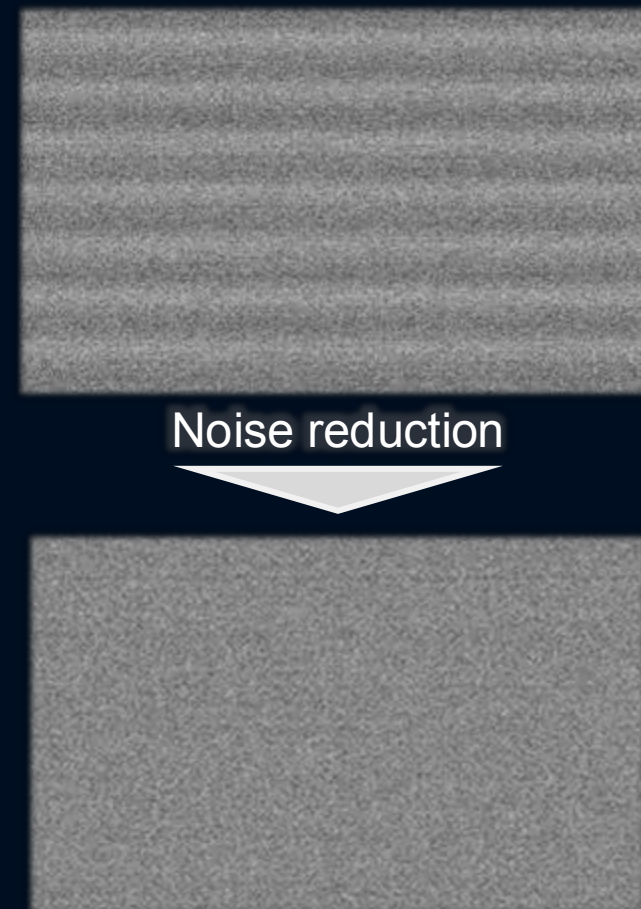
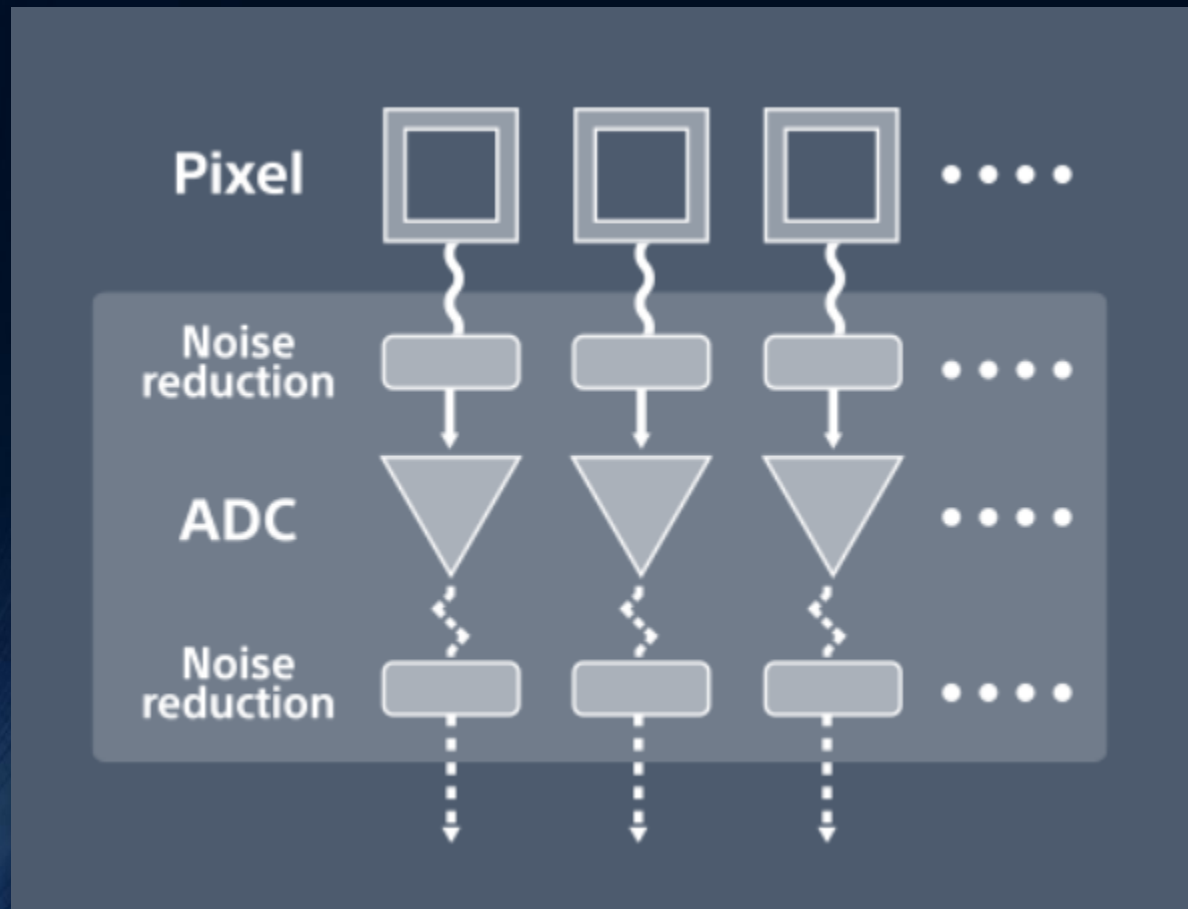
Low Light 10lx



High Light 1000lx



Column A/D Converter



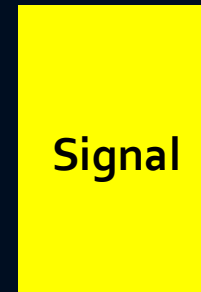
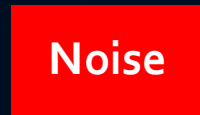
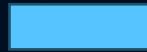
Noise Reduction by CDS: Correlated Double Sampling



Light Sampling



Dark Sampling



CDS Frequency Performance

Dark Sampling

Light Sampling

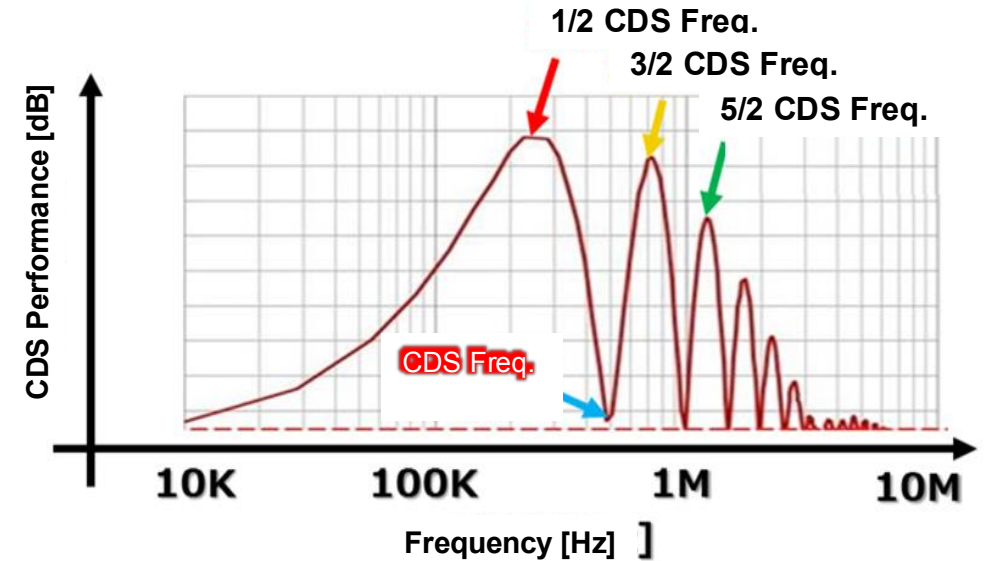
Time

Noise

CDS Freq.

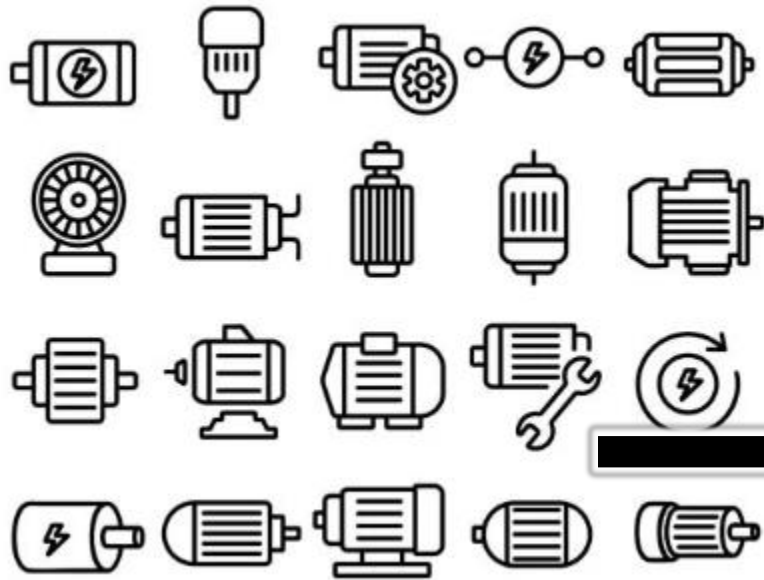
3/2 CDS Freq.

1/2 CDS Freq.

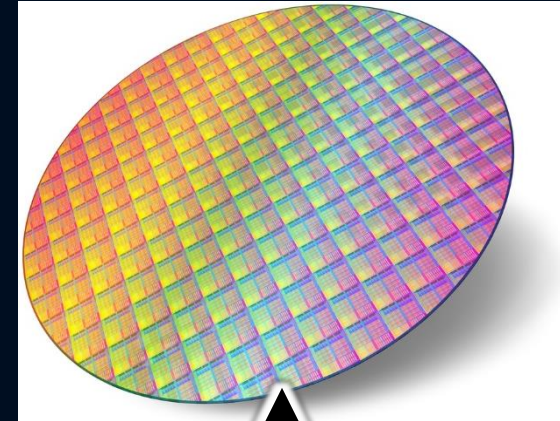


Noise from Water Test Equipment

Wafer Test Equipment



**AC/DC
Converters
Motor Drivers
etc**



Wafer Chuck Top Noise

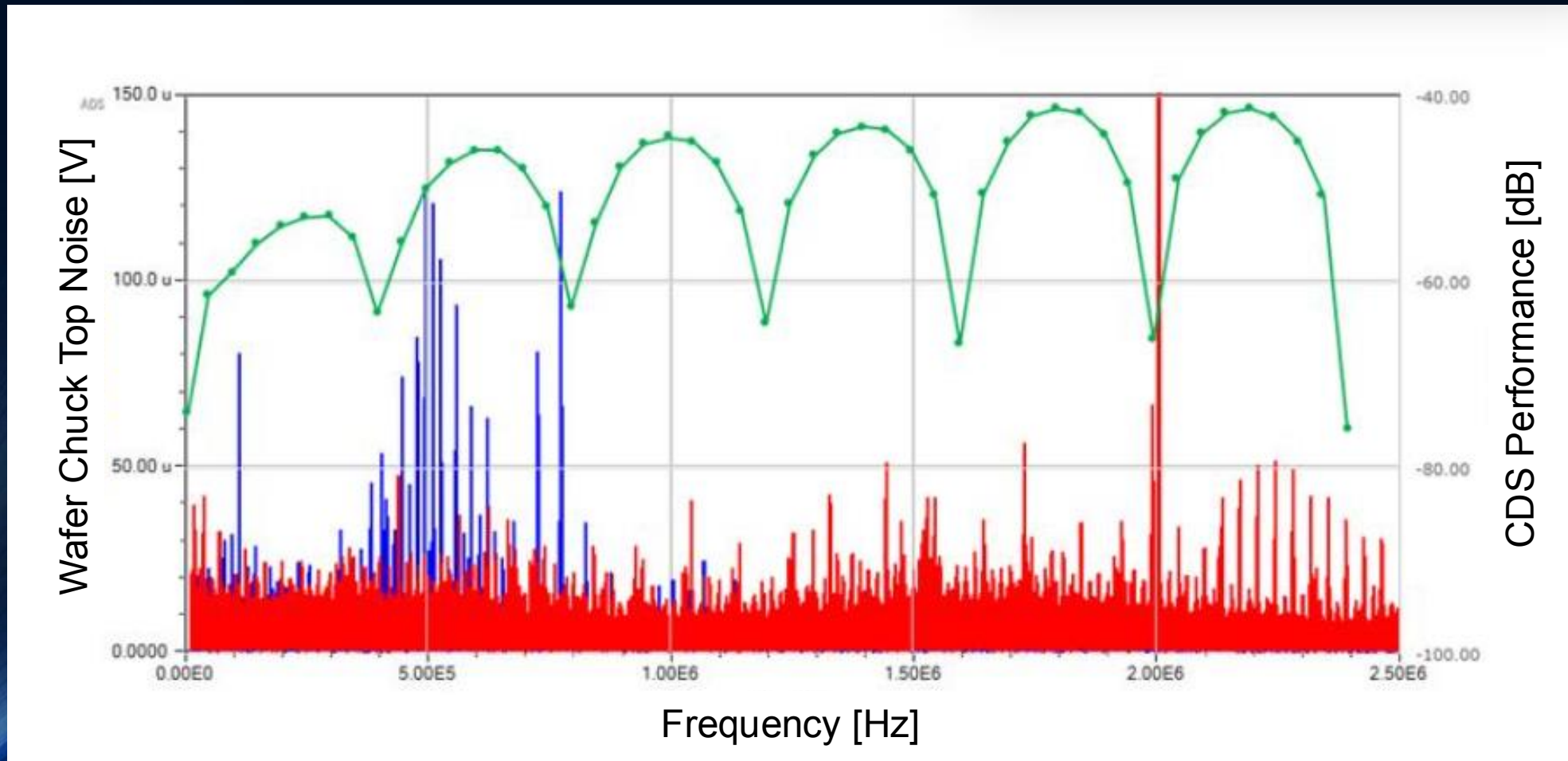
Noise attacks Wafer via Wafer Chuck Top

CDS vs Wafer Chuck Top Noise

Green : CDS Performance

Blue : Wafer Chuck Top Noise @ System A

Red : Wafer Chuck Top Noise @ System B



Noise Issues @ Parallel Test

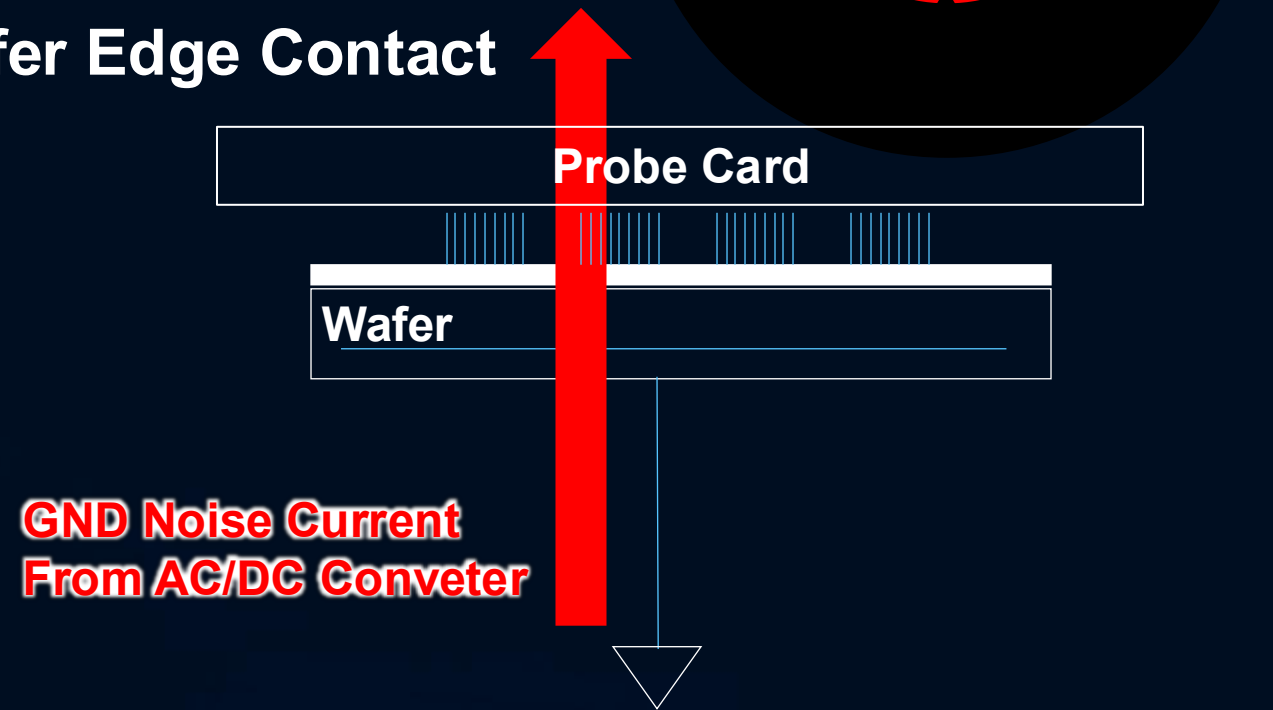
GND Noise Current per DUT

@Wafer Focus 20DUT : 1/20

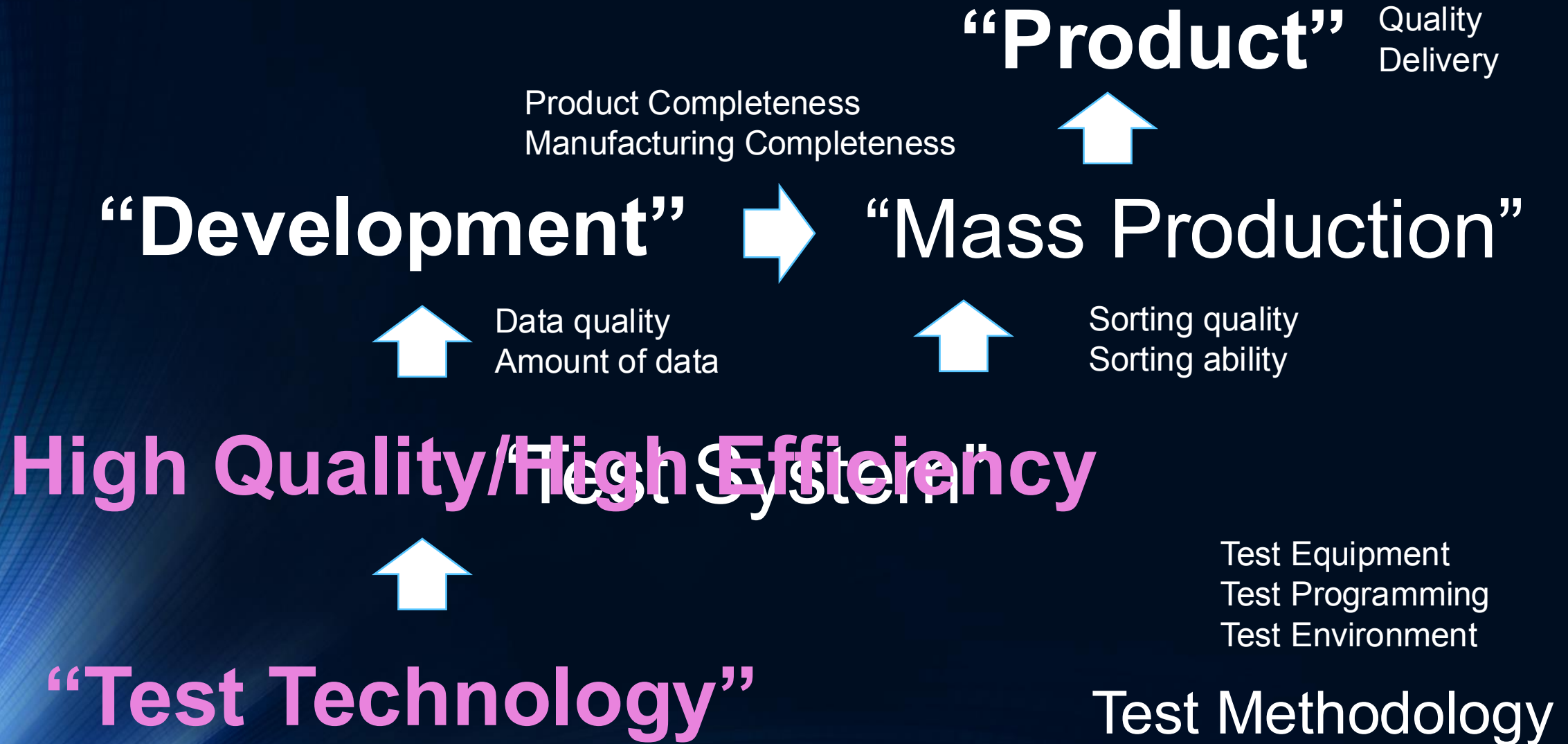
@Wafer Edge 10DUT : 1/10

Dark Noise Worse @ Wafer Edge

@ Wafer Edge Contact



Critical Role of Testing For Image Sensor Development



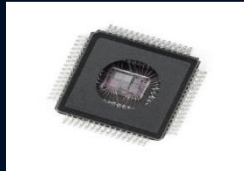
Summary

Types and characteristics of semiconductors



Organizing
information

【Logic】
Microprocessor



Information storage

【Memory】
DRAM, SRAM, Flash
Memory



Power
Control & Supply

【Power Devices】
SiC Modules



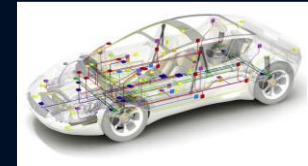
Converting light into a
digital signal

【Image Sensor】
CIS



Controlling
the car

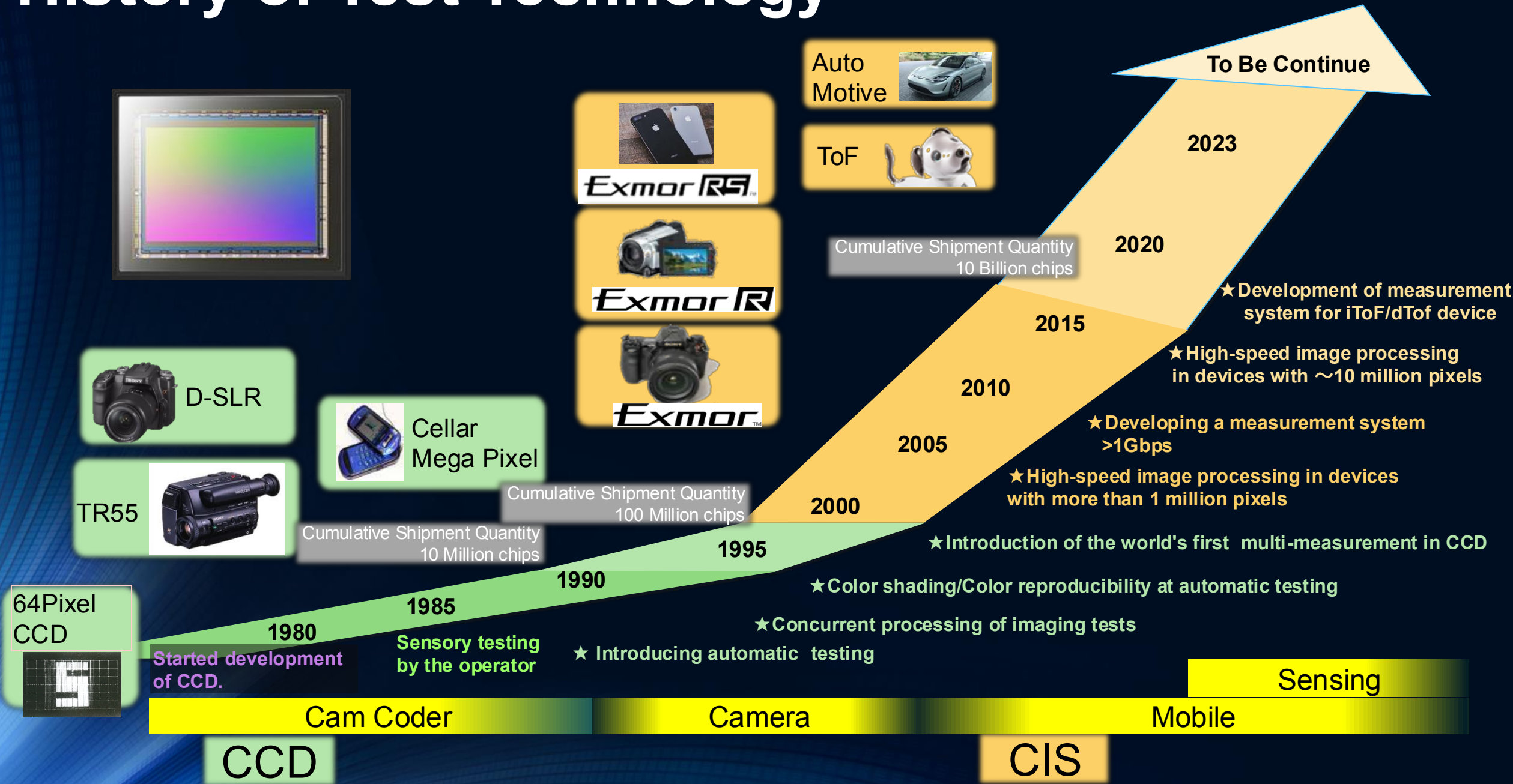
【Automotive
Semiconductors】
Microcomputer, ADAS



There are test technologies suitable for the characteristics of semiconductors.

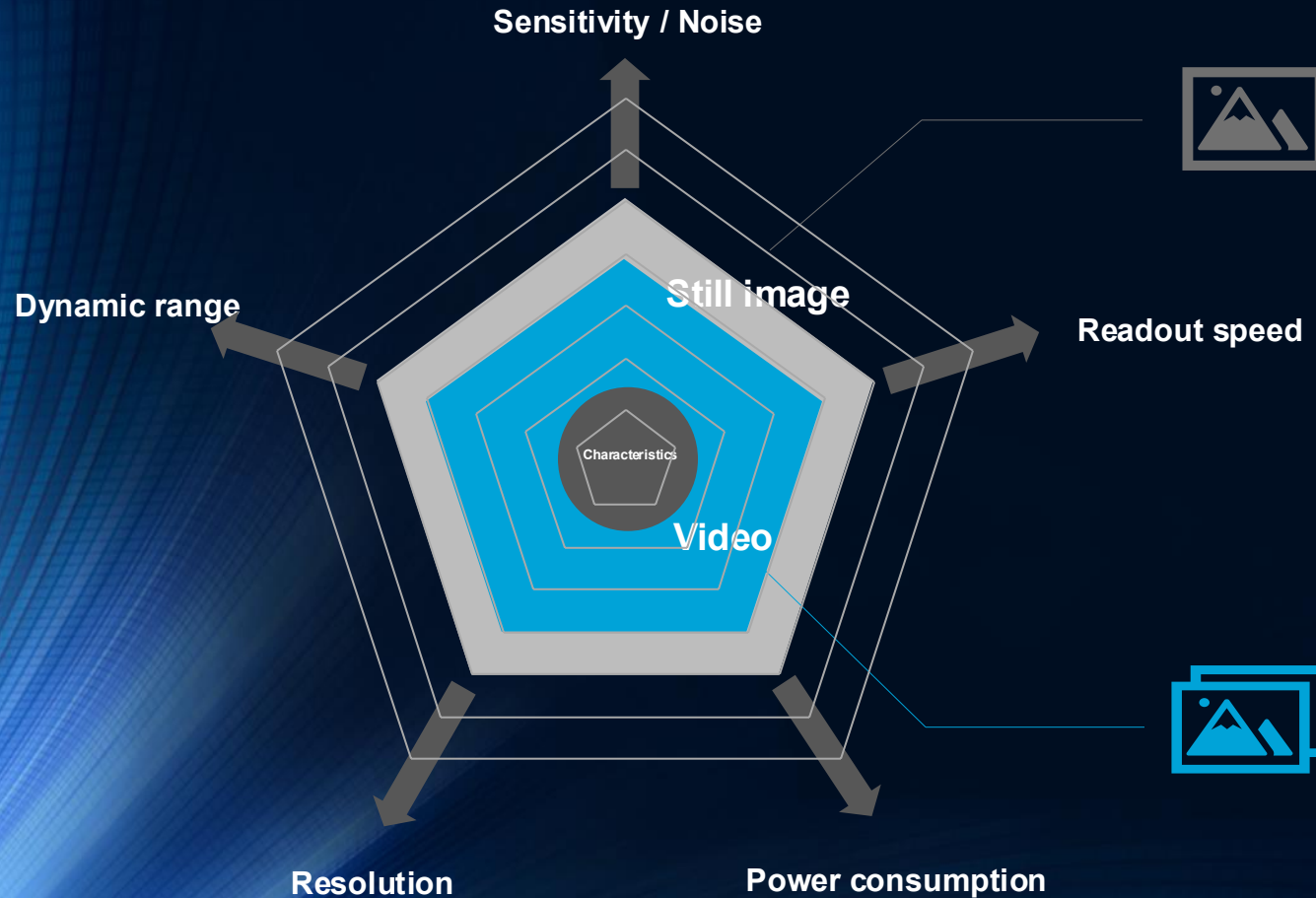
As devices evolve, test technology are also evolving.

History of Test Technology

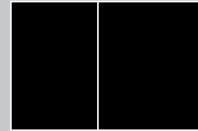
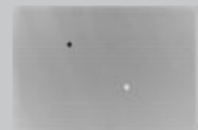
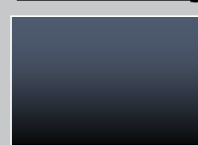
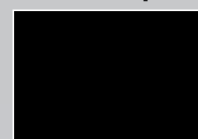
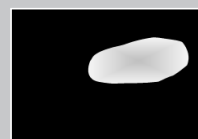


Test technology stand out strengths and eliminates weaknesses

CIS Strong Point



CIS Weak Point

Defective line  Origin Colum circuit Transistor malfunction	Sunspot  Origin An omission of electric charge to FD by the High brightness light
Light time black/Brightness pixels  Origin Transistor malfunction of vertical transfer	Pear place 
Vertical line  Origin Colum circuit Transistor malfunction	Dark shading  Origin Heat static current
Defective pixels  Origin Dust Colum circuit malfunction	Brightness irregularity  Origin Micro lens Non-uniformity of color filter

Test Engineering Sprints and Connections

Noise Busters



Form Factor Corporation
Noise Consulting
Mr. Masahiro Sameshima



“EN”joy



Workplace connections, human connections,
and emotional connections

[What I want to convey]

Product First

To develop a product is essential for changing the world.

Test Technology is crucial

To deliver that product to the world.

Test Engineers and connection are the most important factors

To produce New Test Technology.

Testing itself has Value

“The Evolution of Testing” and “The Evolution of Products”
are an inseparable relationship.

Thank you for your attention