GOING POLARIZED: ADDING A NEW PERSPECTIVE TO INDUSTRIAL IMAGING

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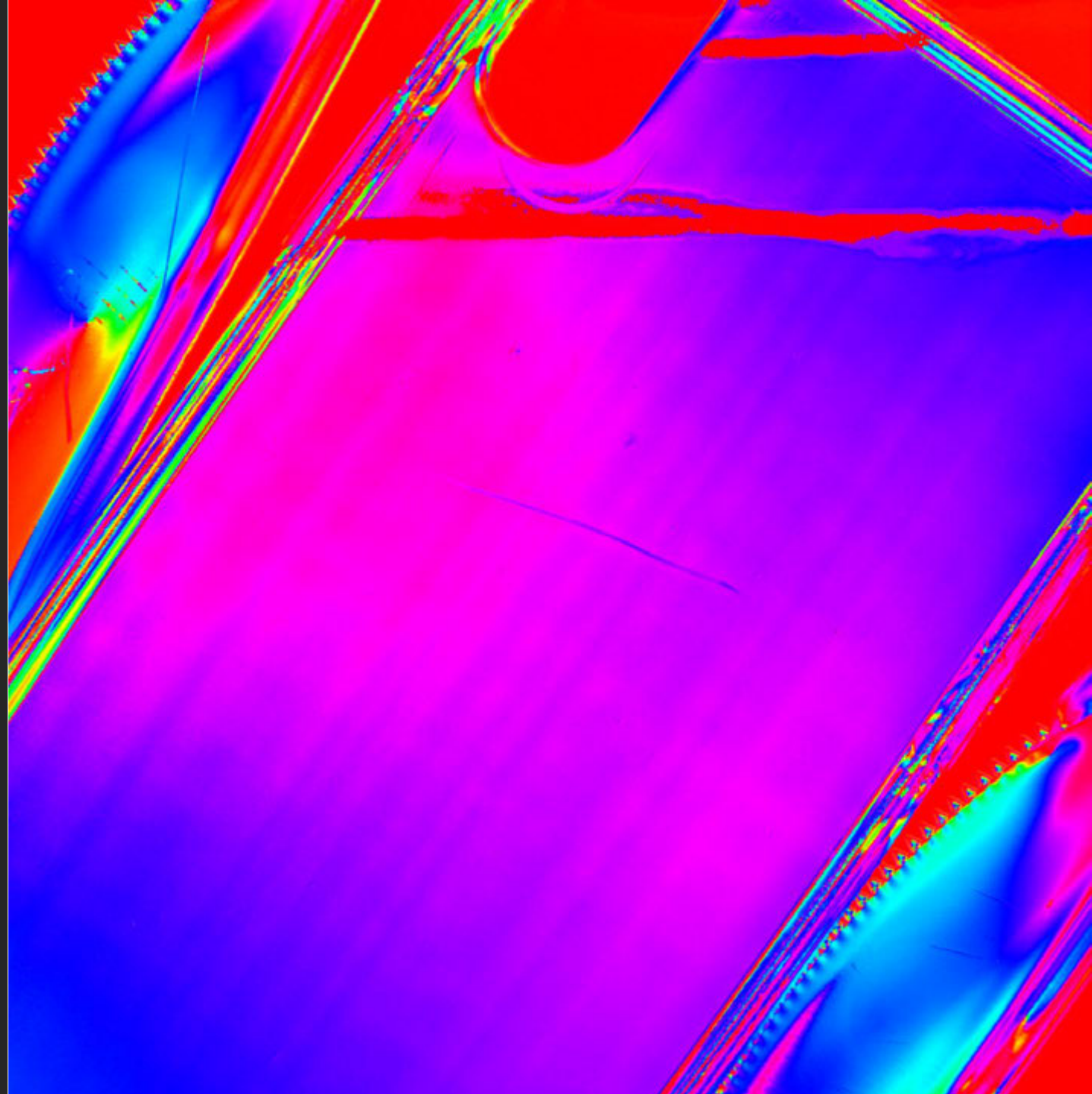
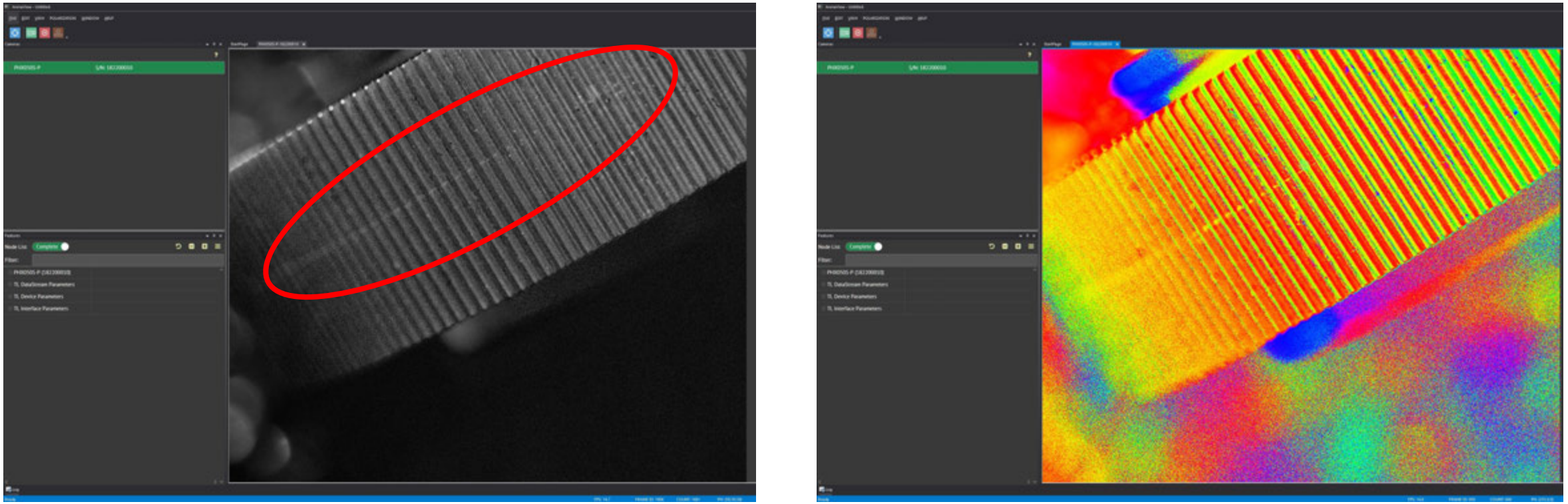


INSPECTION WITH POLARIZATION IMAGING

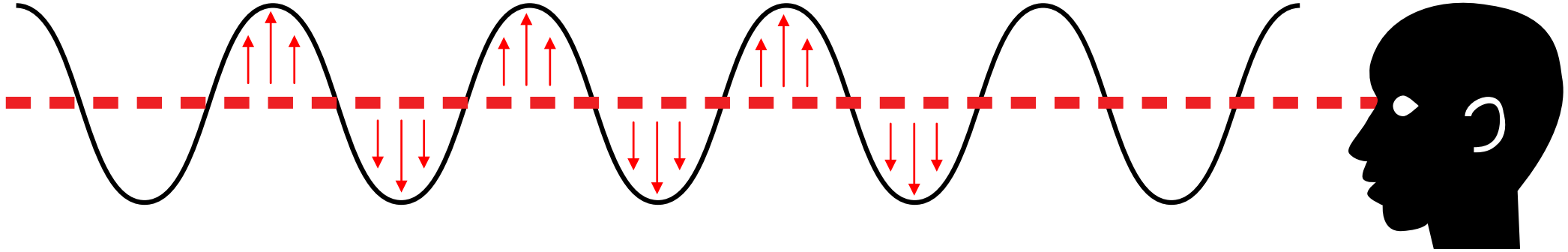
Inspection tasks which require measuring fine mechanical detail can be challenging with traditional cameras – such as this intricate gear used in automotive or aerospace applications. In this case, the accuracy of the measurement is required to be within a few um. Metallic parts also suffer from specular reflection which may further complicate inspection and measurement.

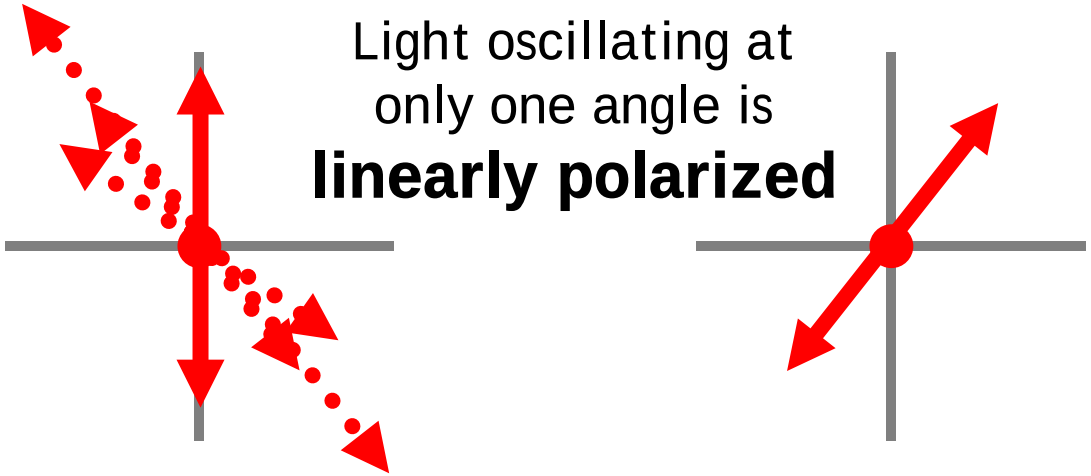


Scratch mark on gear in Degree of Linear Polarization & Angle of Linear Polarization images

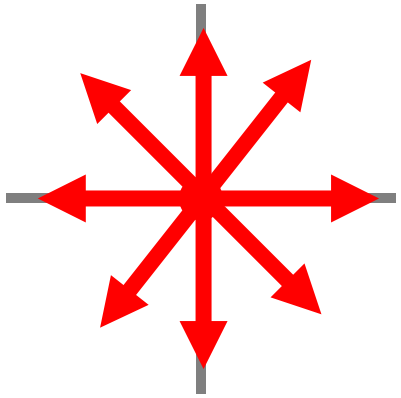
POLARIZED LIGHT, WHAT'S THAT?

Light oscillates at angles perpendicular to the direction of propagation





Light oscillating at only one angle is **linearly polarized**

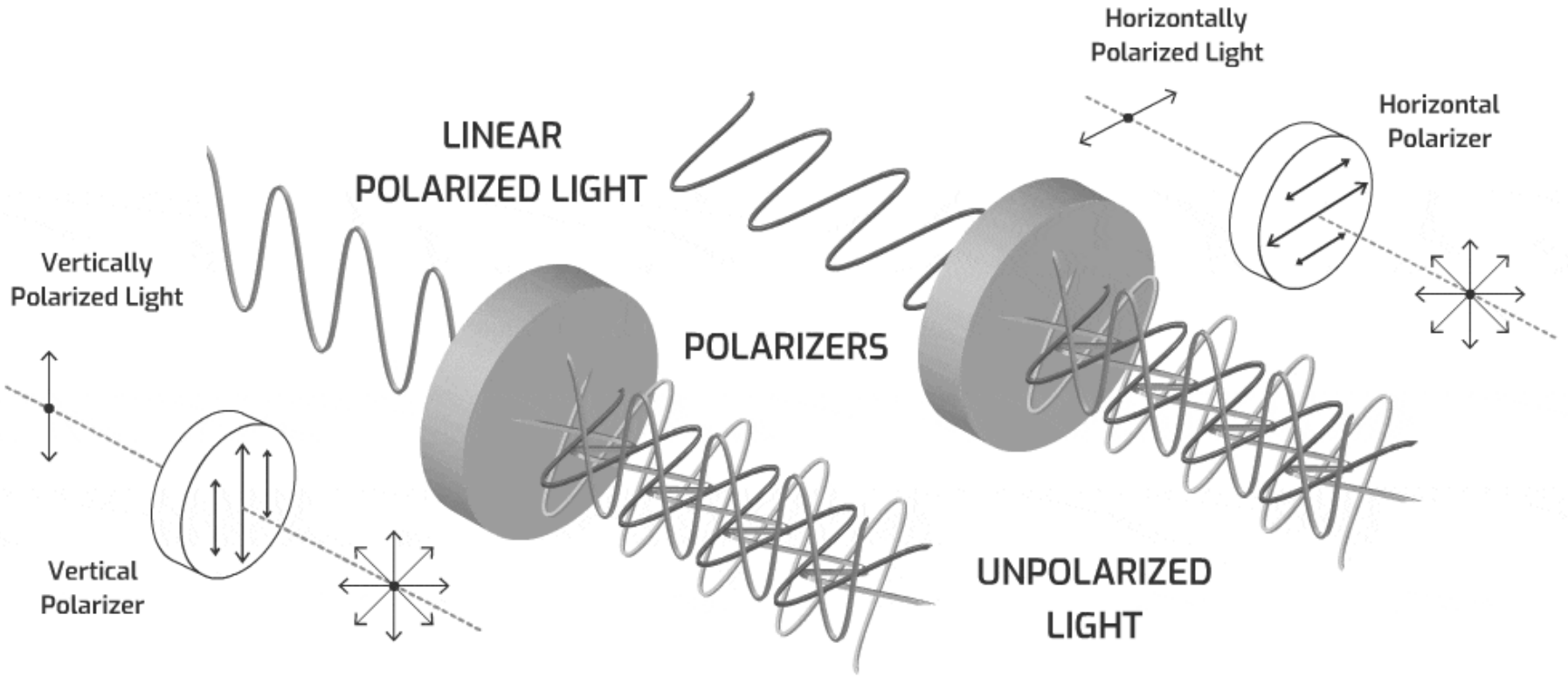


When light oscillation is omnidirectional – **not polarized**

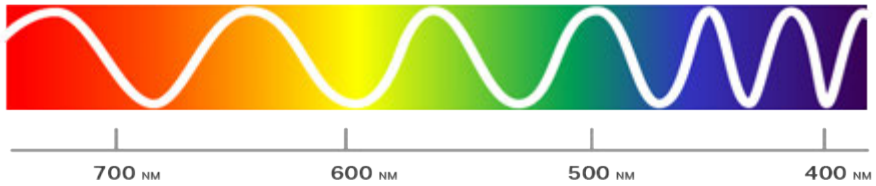
Angle of linear polarization – Angle of the polarized light
Intensity of linear polarization – Strength of the light signal
Degree of linear polarization – How well the light is polarized

} There properties can be captured by **Stokes' Parameters**

HOW LIGHT BECOMES POLARIZED



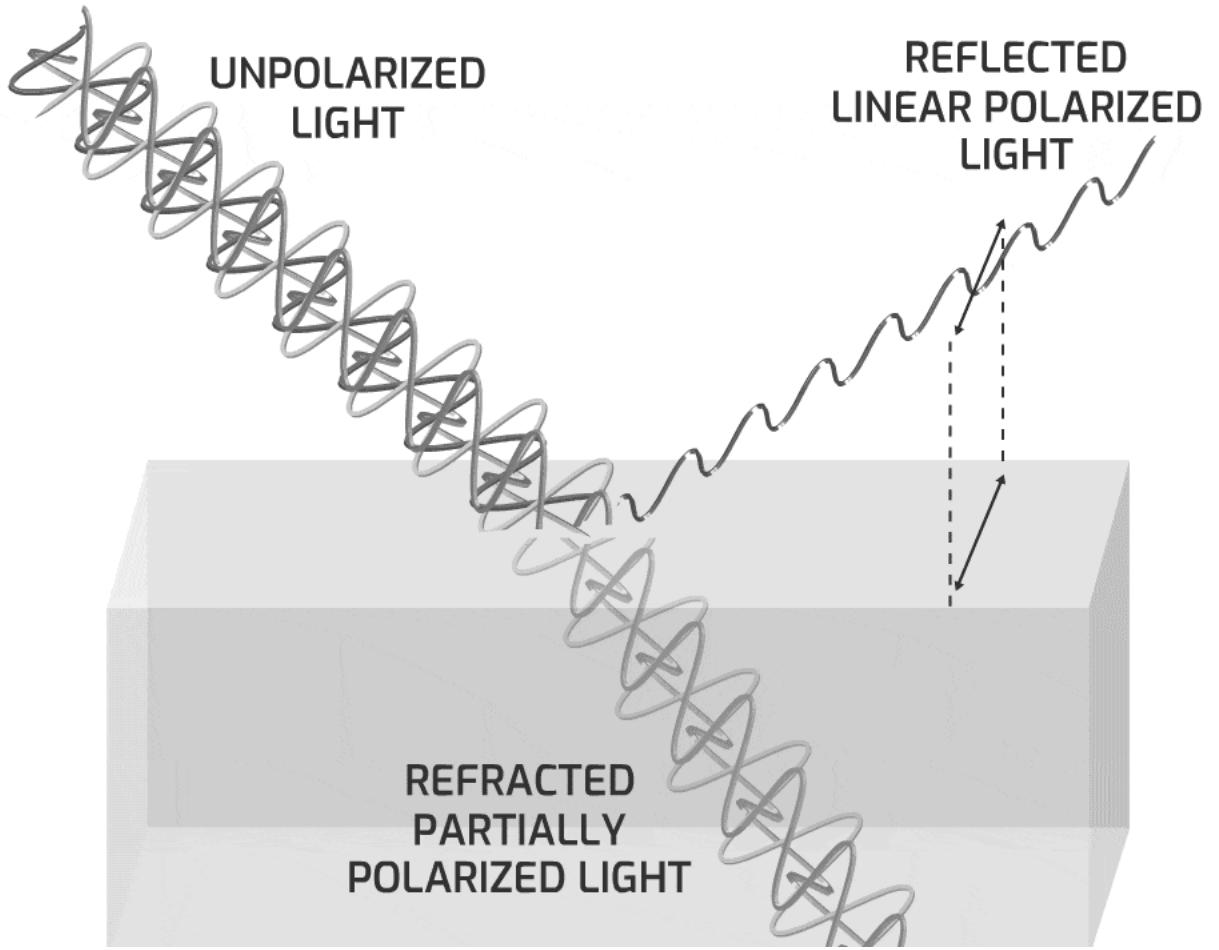
Color = Wavelength



Brightness = Intensity

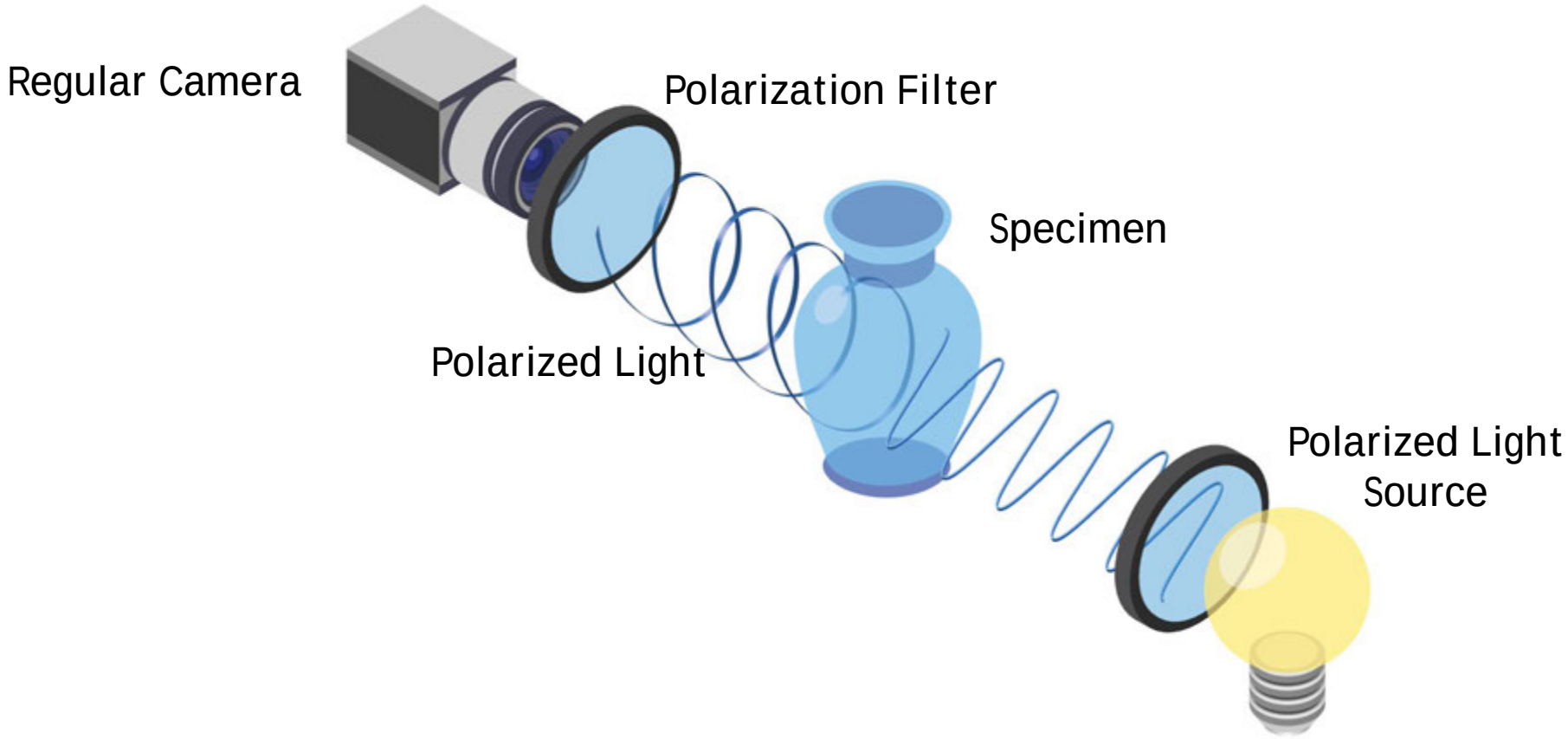
HOW LIGHT BECOMES POLARIZED

Light can also be polarized through reflection or refraction

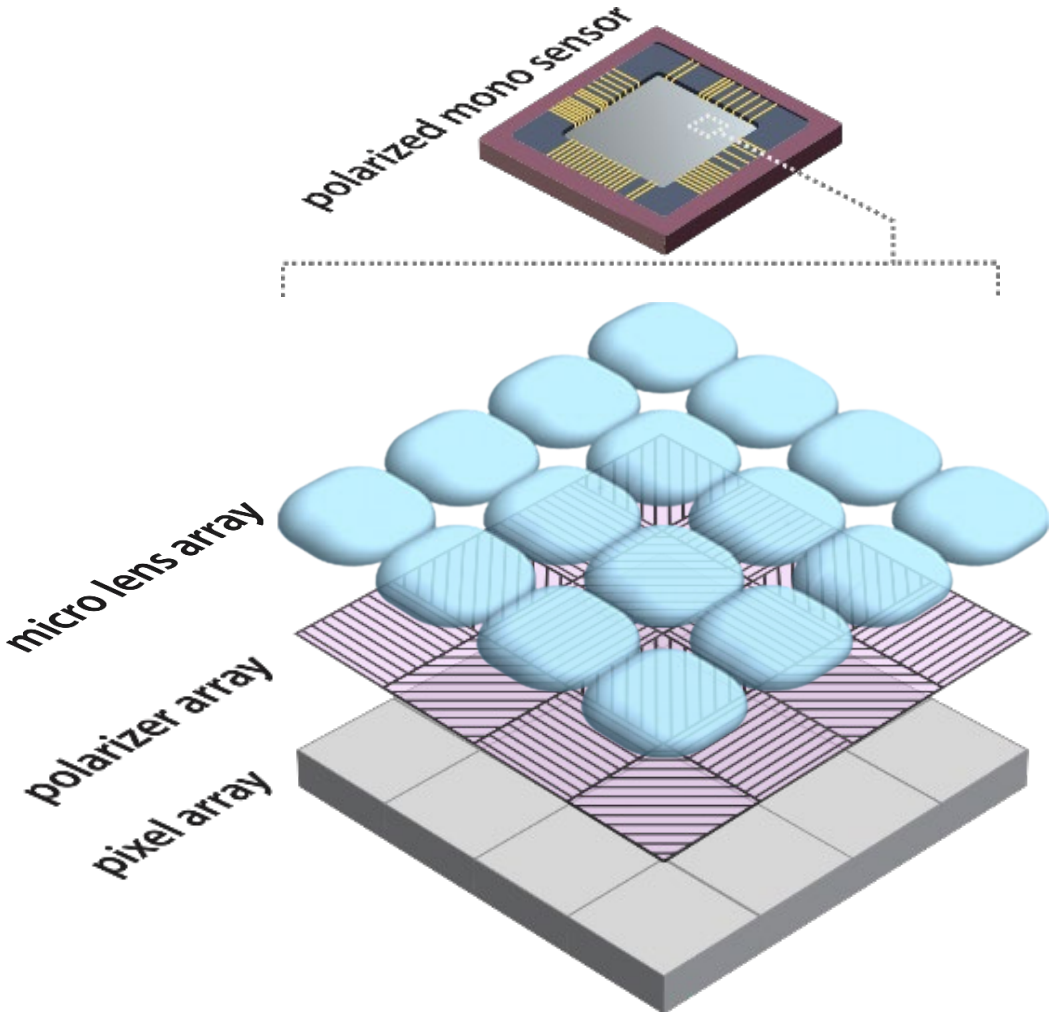


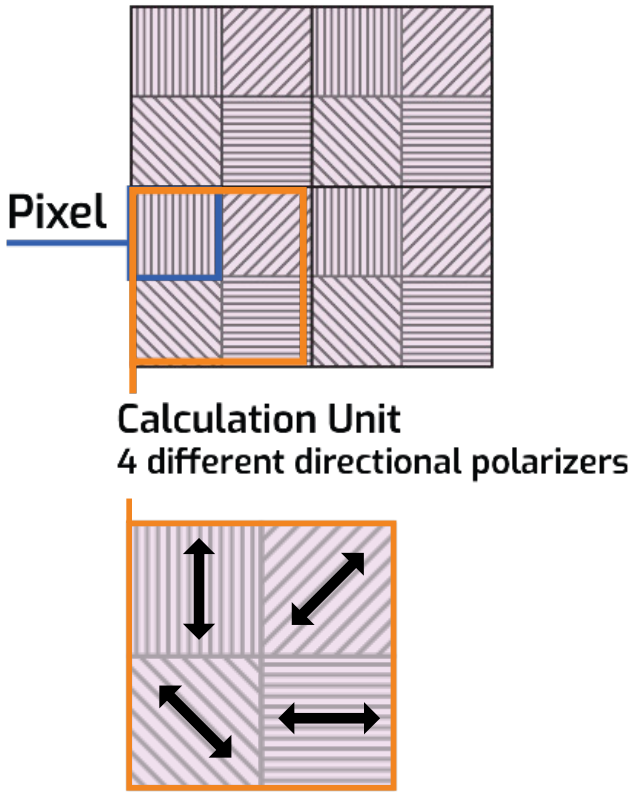
DETECTION OF POLARIZED LIGHT

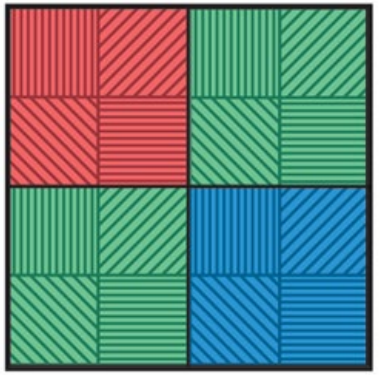
Traditional polarization imaging require placement of a polarizing filter in front of the camera to capture light in the angle of polarization consistent with the filter.



SONY Polarsens POLARIZATION TECHNOLOGY



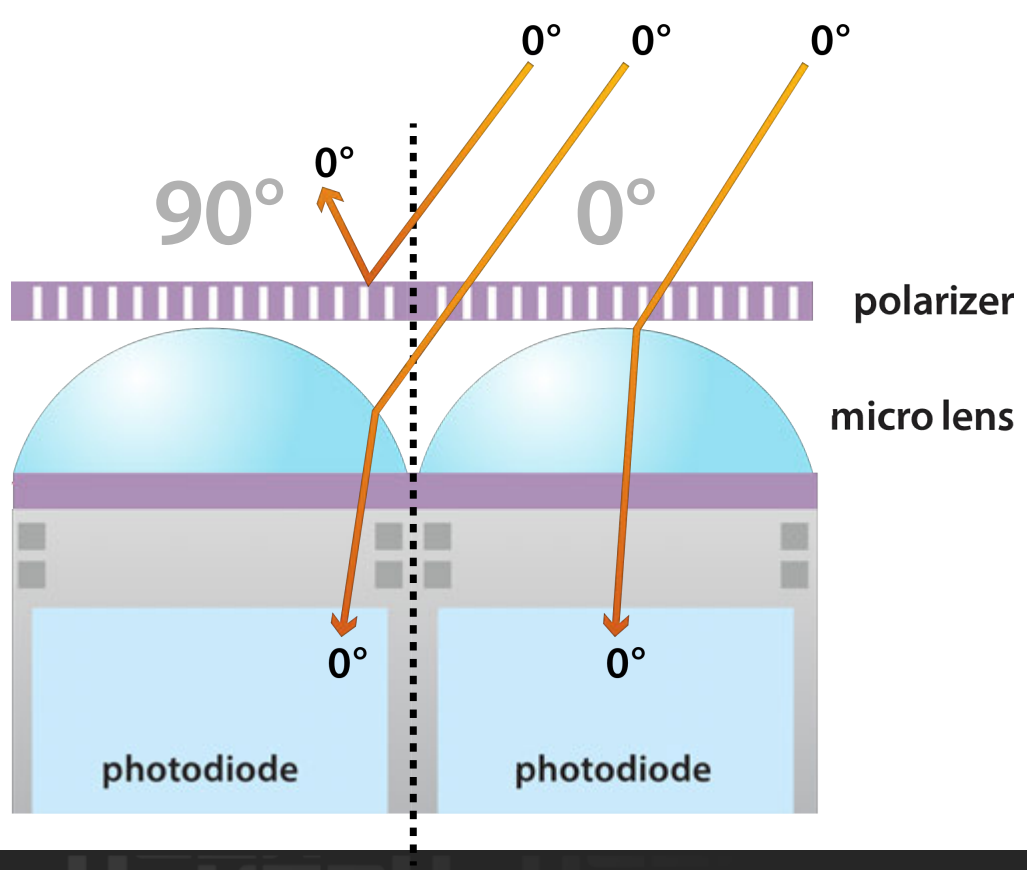


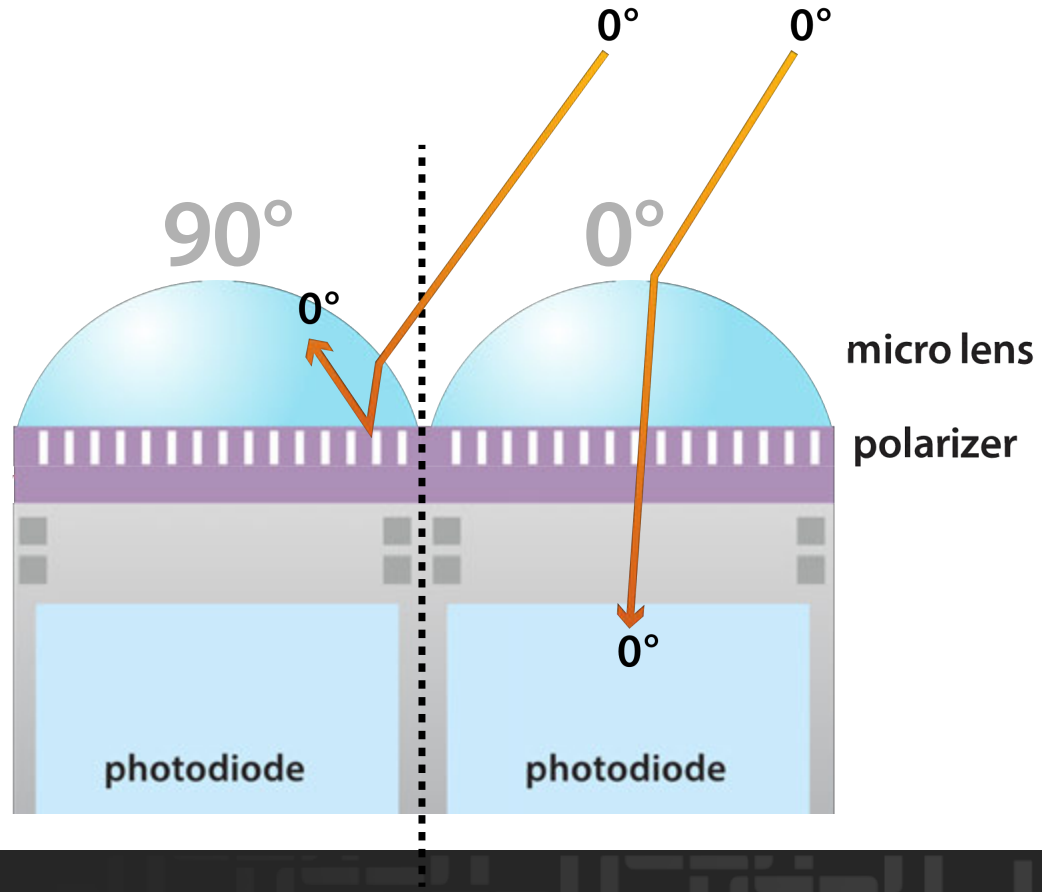


On the color polarization sensor, there is an additional RGB Bayer filter

SONY IMX250MZR POLARIZATION TECHNOLOGY

This design reduces pixel cross-talk compared to other polarization sensors that places the wire-grids above the micro lens array

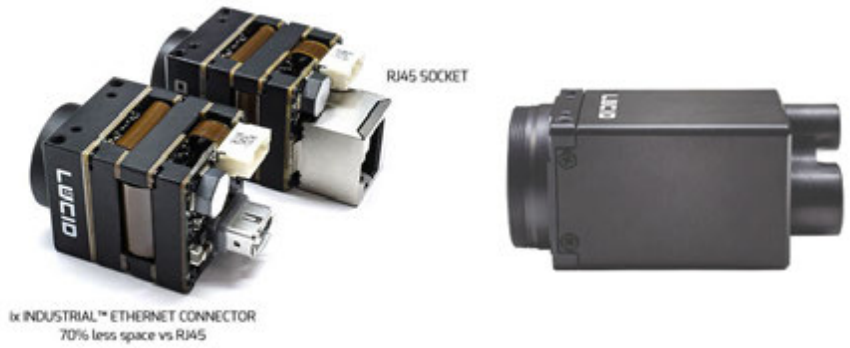




SONY Polarsens POLARIZATION SENSORS

Sensor Name	IMX250MZR/IMX250MYR
Resolution	5MP, 2448 x 2048
Pixel size	3.45µm
Sensor format	2/3”
Sensor framerate	163.4fps (8bit)
Extinction ratio	Greater than 300:1 (500nm)

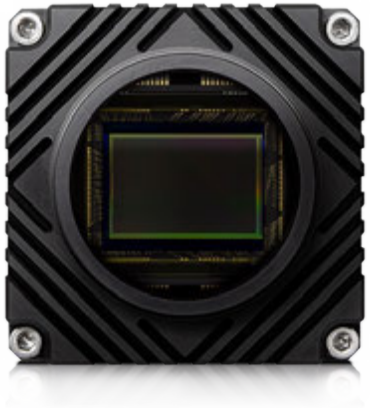
Sensor Name	IMX253MZR/IMX253MYR
Resolution	12.3MP, 4096 x 3000
Pixel size	3.45µm
Sensor format	1.1”
Sensor framerate	68.3fps (8bit)
Extinction ratio	TBD



When integrated into LUCID’s cameras, the polarization camera can achieve up to 5MP at 120 fps or 12MP at 50fps.

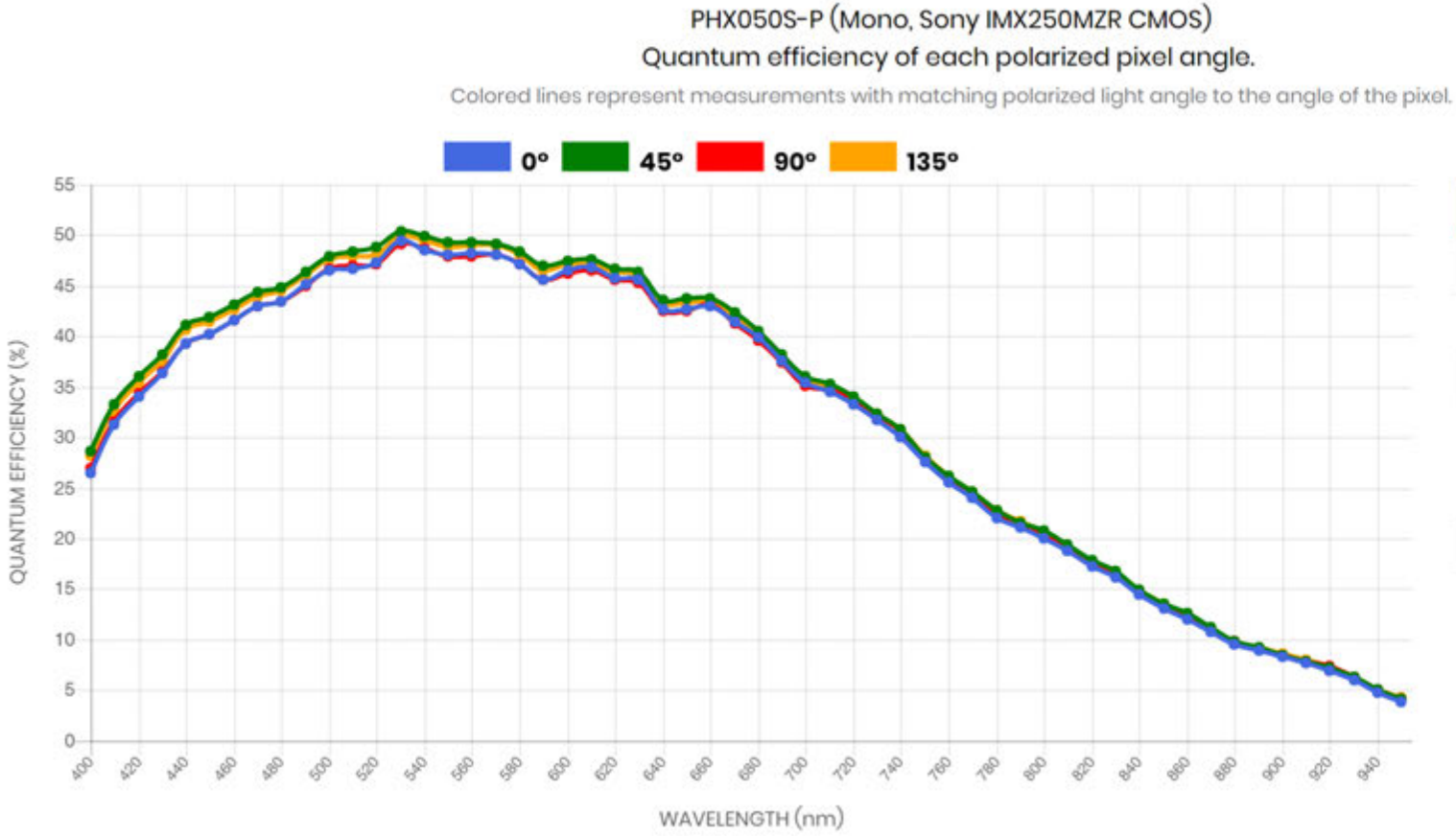
Current available models:

- PHX050S-P/Q (5MP, 24fps)
- TRI050S-P/Q (5MP, 24fps)



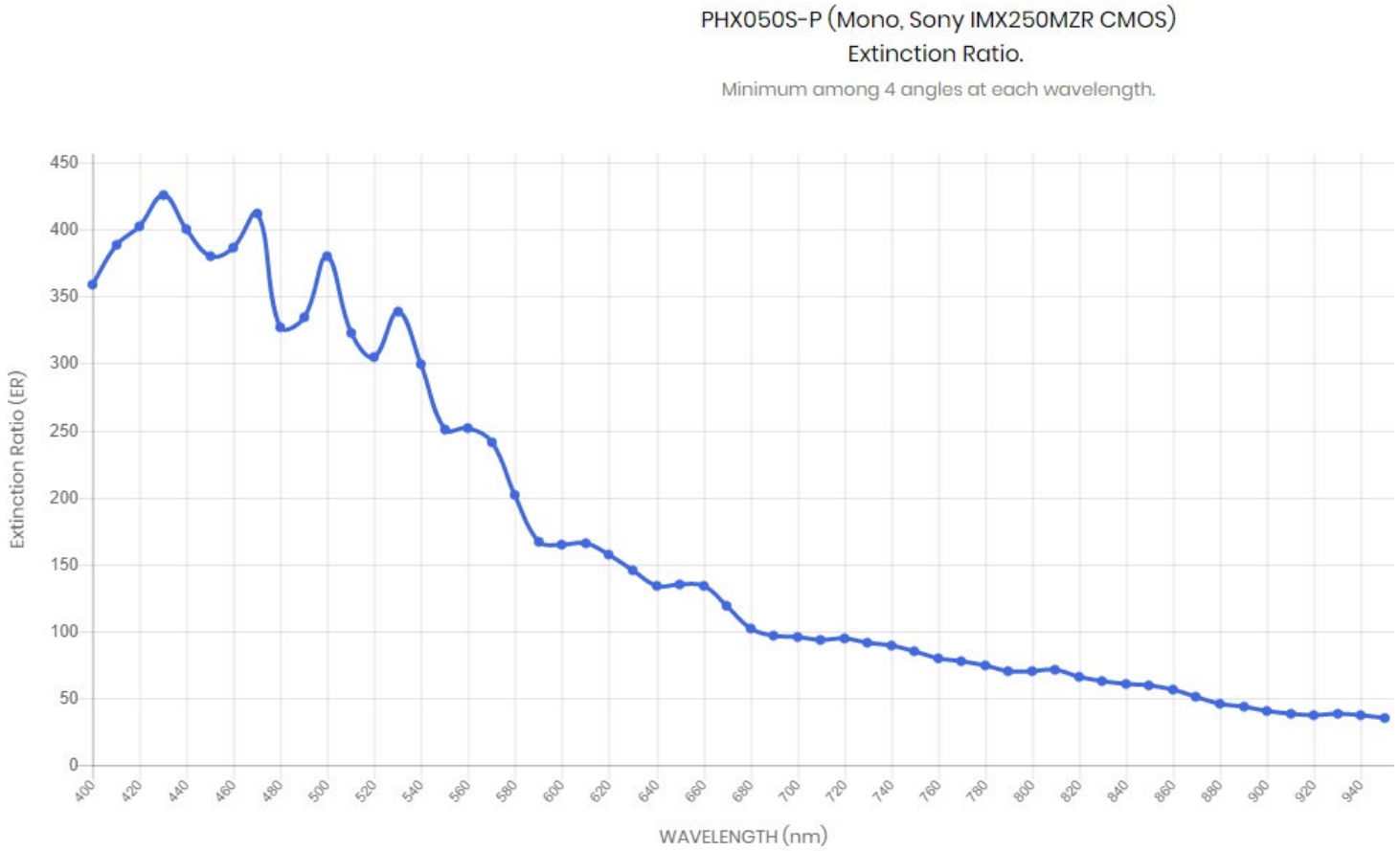
SENSOR PERFORMANCE – QUANTUM EFFICIENCY

LUCID measures sensor performance in adherence to the EMVA 1288 standard. Quantum efficiency per polarization channel as well as key sensor performance metric such as dynamic range are published on thinklucid.com.



EVMA 1288 RESULTS	
Dynamic Range	71.34 dB
SNR (Max)	40.14 dB
Saturation Capacity	10318 e-
Absolute Sensitivity Threshold (Measured at 527.5nm)	5.28 γ
Temporal Dark Noise	2.16 e-
Gain	0.369 DN / e-

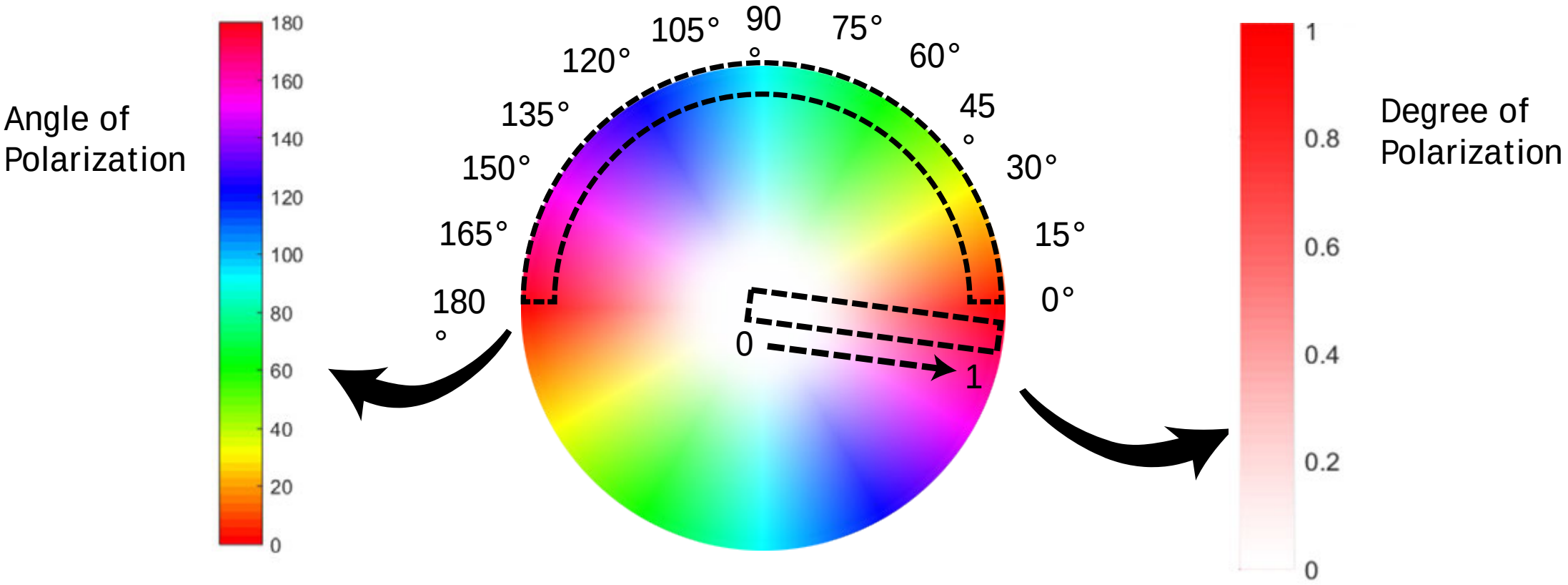
SENSOR PERFORMANCE – EXTINCTION RATIO



Extinction Ratio (ER) is the ratio between the maximum and minimum signal detected by a particular polarization pixel channel for a linearly polarized input. The quality of ER affects many applications and is a key parameter optical engineers care about –ER affects how well the degree of polarization can be measured.

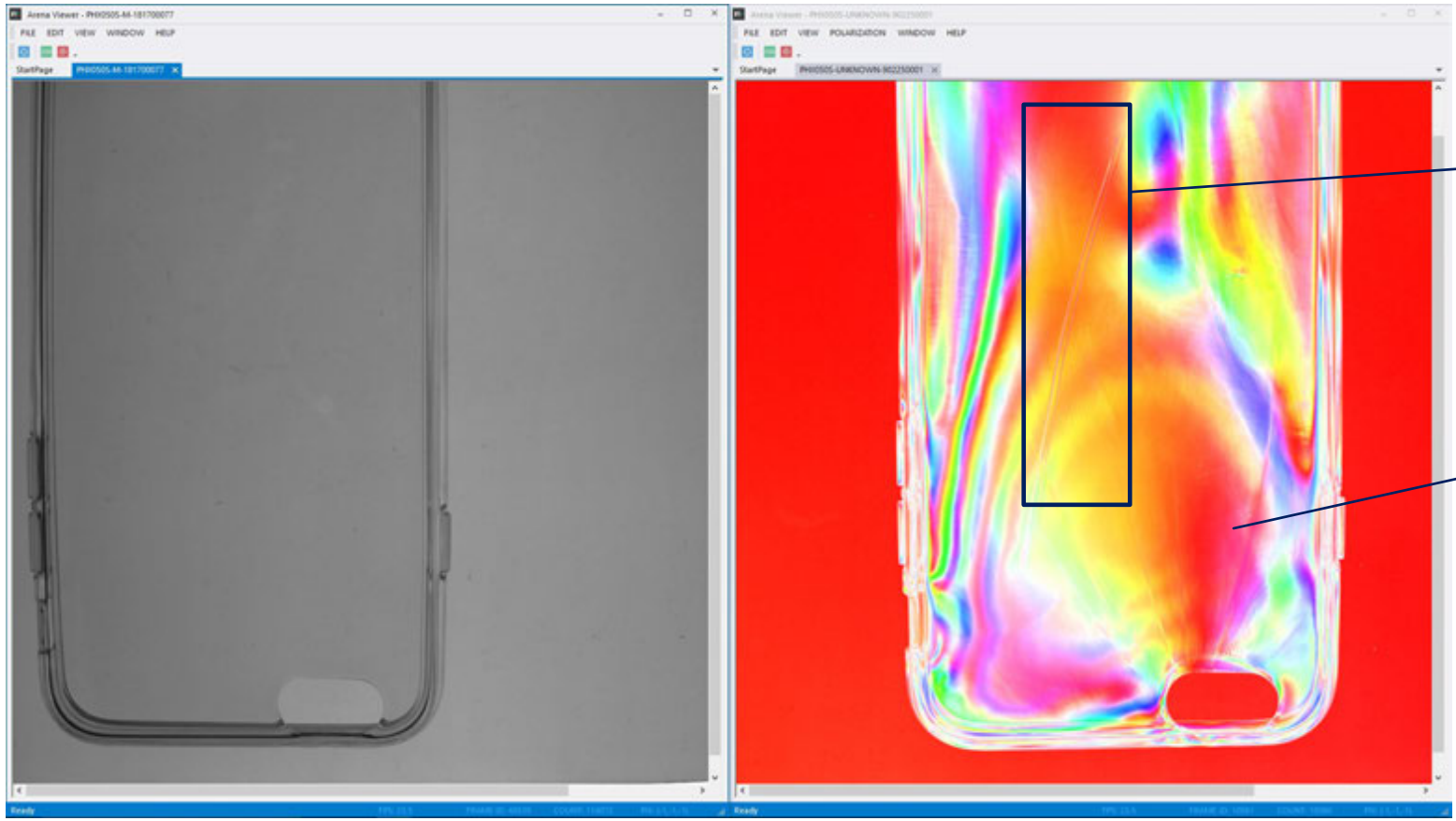
POLARIZATION IMAGING WITH LUCID'S CAMERA

All images are taken with PHX Polarization camera and processed using a color wheel to represent polarization information



POLARIZATION IMAGING WITH LUCID'S CAMERA

Plastic Inspection – Clear Cellphone Case



Monochrome image

Polarized image

CHALLENGES IN INSPECTION TASKS

Hidden stress in materials

Strong reflective surfaces

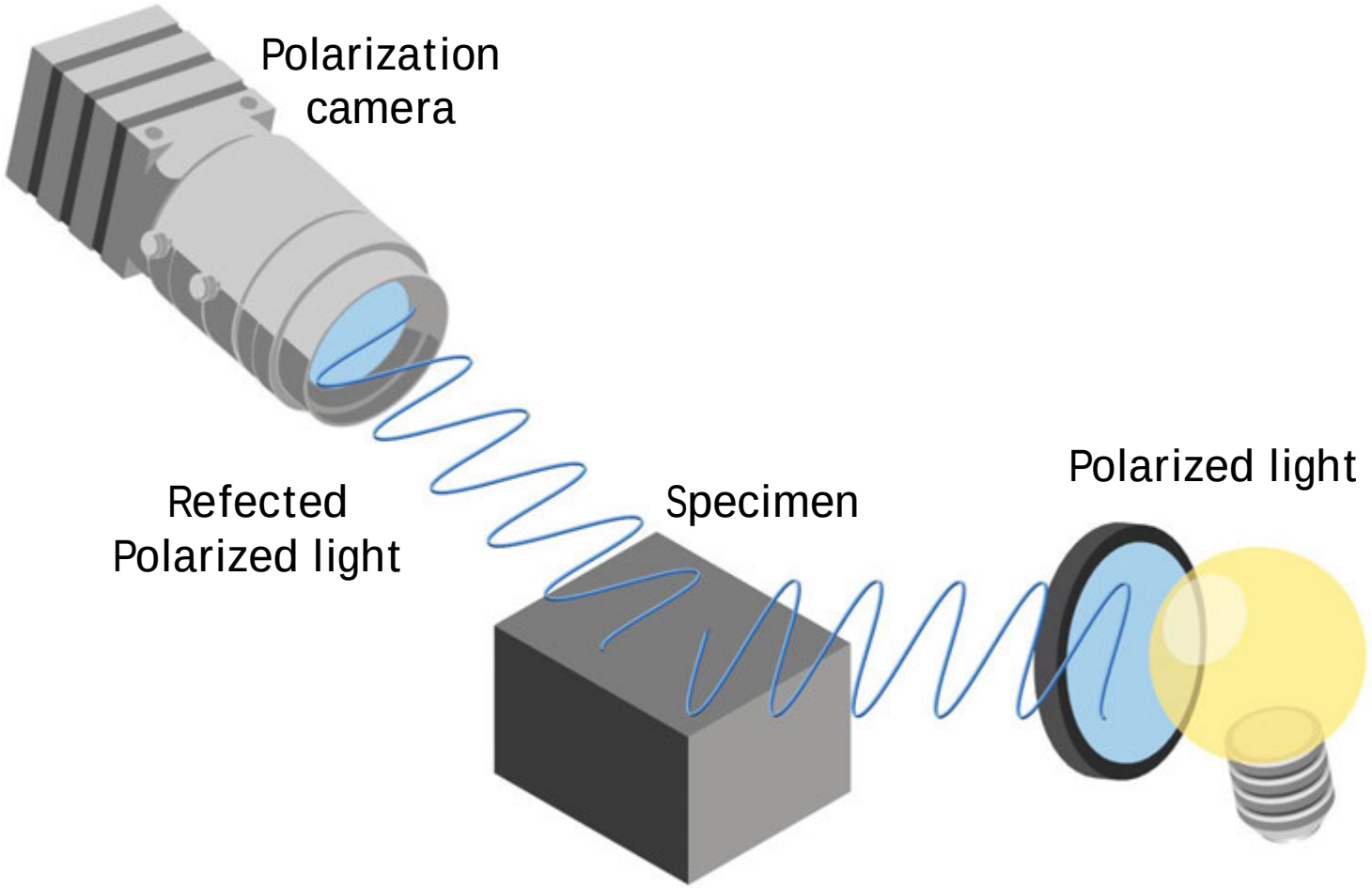
Low contrast objects/surfaces

https://www.yourmechanic.com/article/symptoms-of-a-bad-or-failing-door-mirror
https://www.edmundoptics.com/resources/application-notes/optics/introduction-to-polarization/
https://images-na.ssl-images-amazon.com/images/I/61zmqV9CpgL._SL1170_.jpg

INSPECTING USING REFLECTION TECHNIQUE

Effective in detecting:

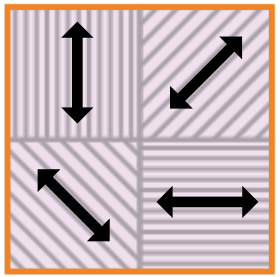
- **Surface damage**
- **Surface flatness**
- **Scratches**



INSPECTING PLASTIC SHRINK WRAP

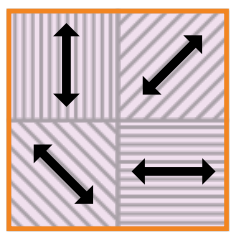
DAMAGE - STICKER - DAMAGE

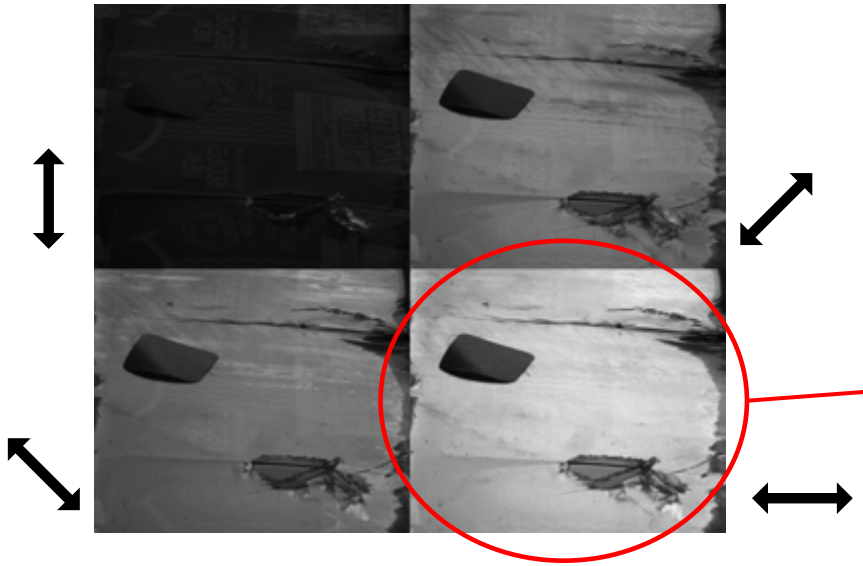
INSPECTING PLASTIC SHRINK WRAP

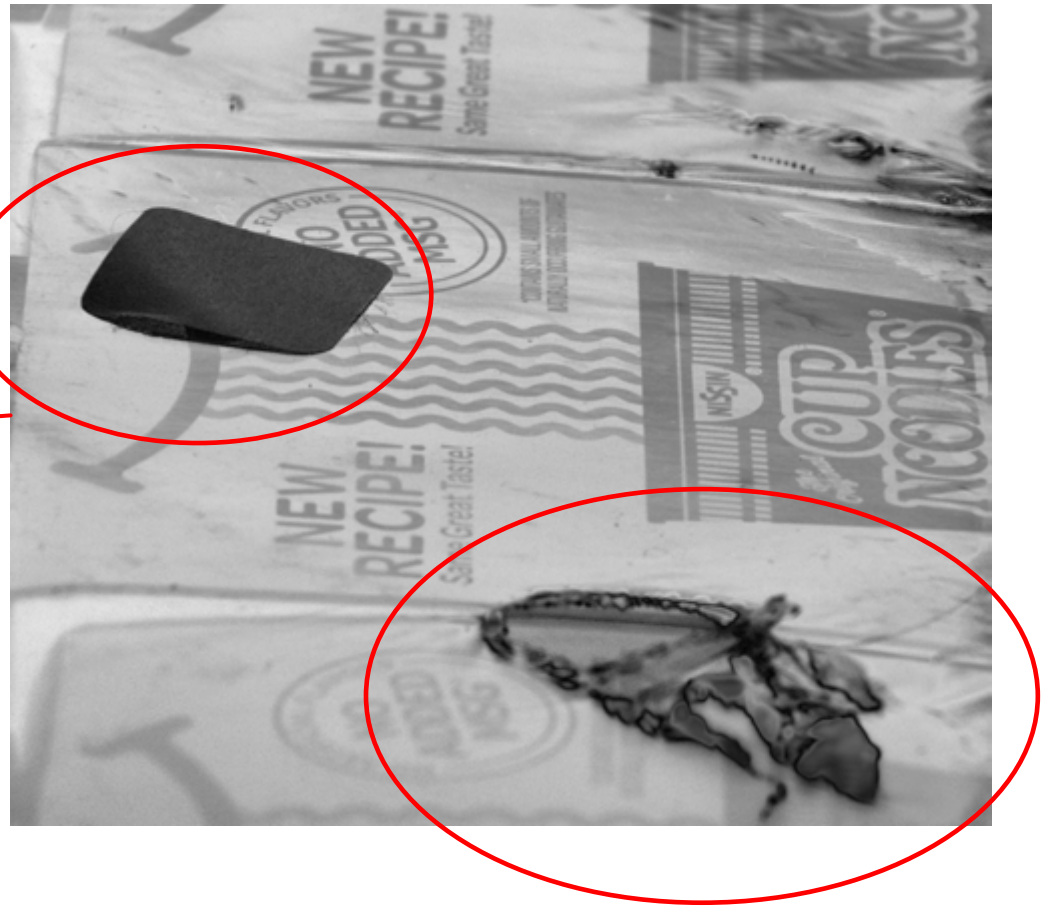


Each quadrant represents a polarization channel from the Polarsens 4 pixel calculation unit. Reflection can be removed as one polarization channel can minimize the polarized reflected light.

INSPECTING PLASTIC SHRINK WRAP







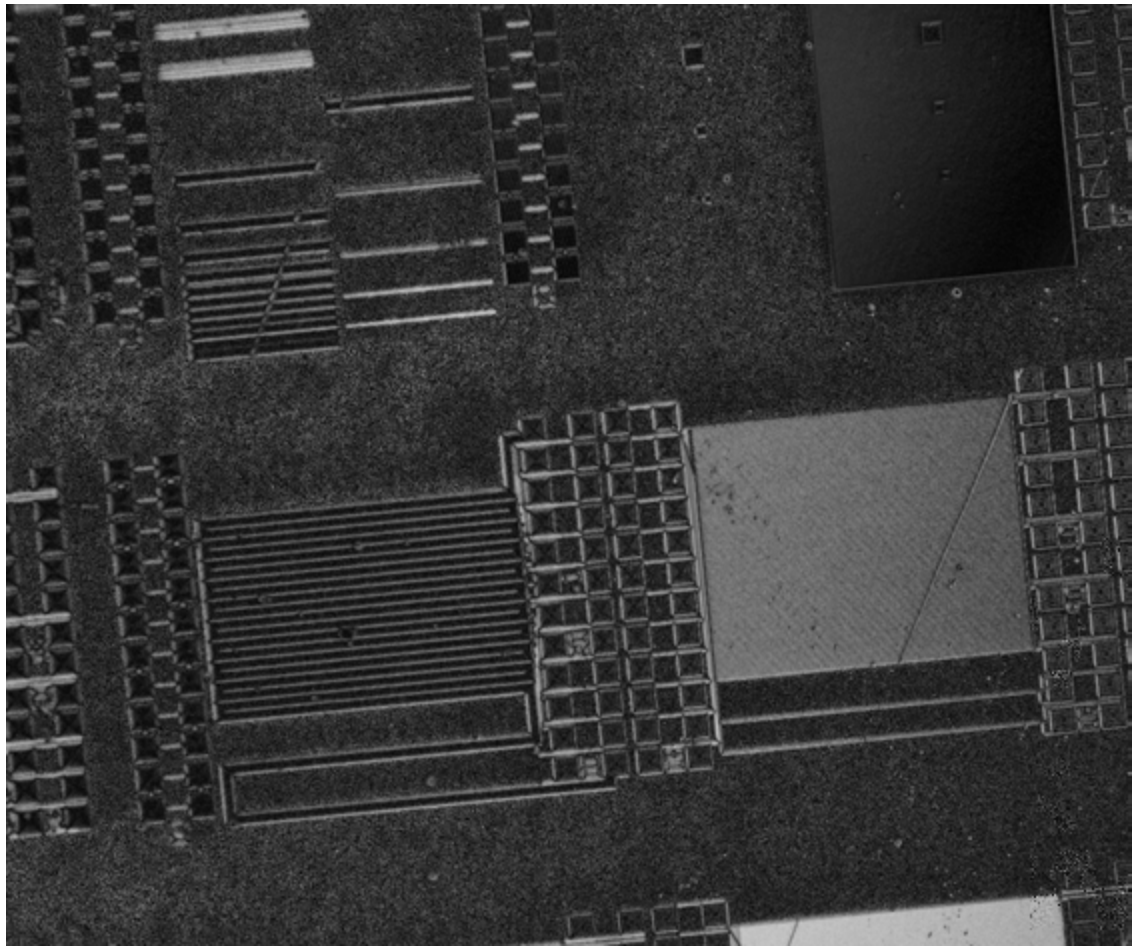
Here is another example of images visualized in the 2x2 grid. One polarization channel catches the most amount of polarized reflected light off of the plastic wrap. Any de-polarization by the sticker or a rip in the package can be easily identified.

INSPECTION OF WELDING SPOT

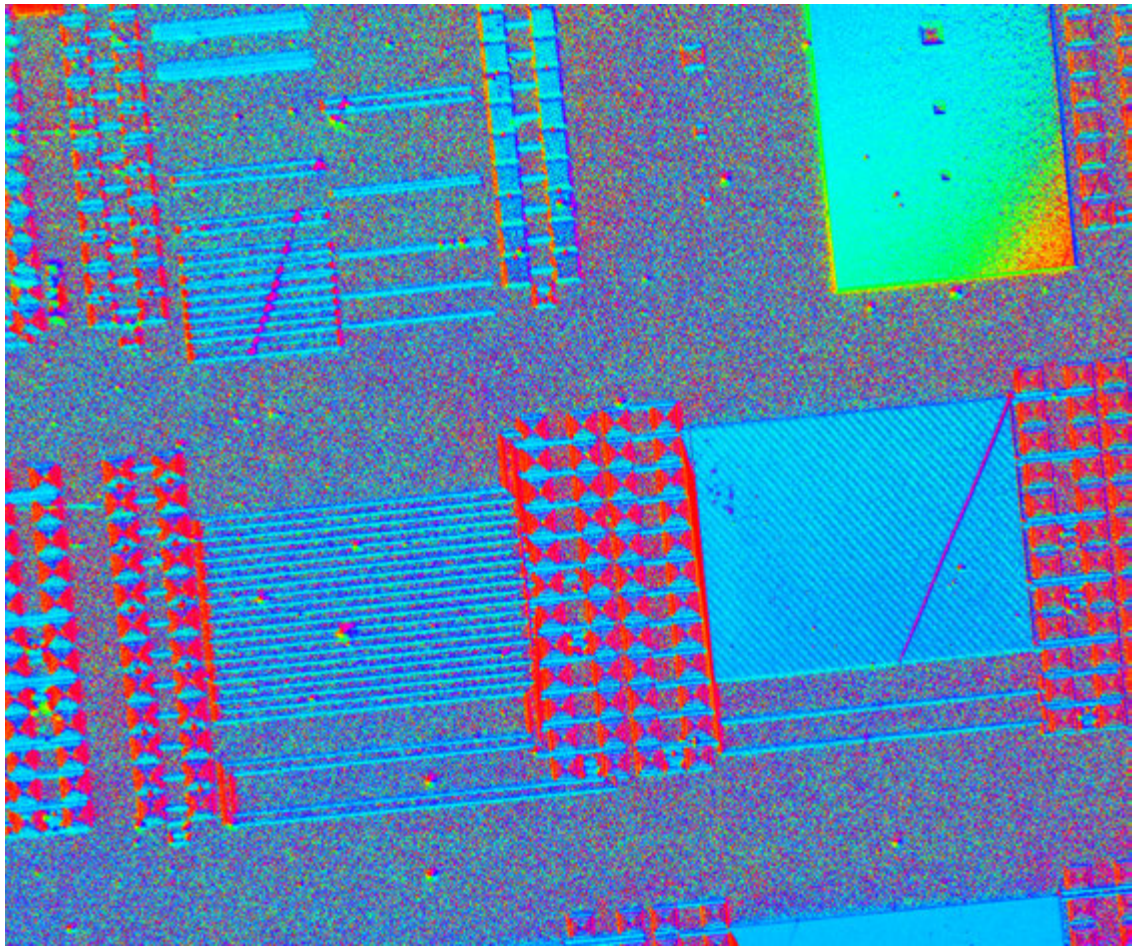
DOLP image of welding spots

- welding project which is difficult to detect the target with mono camera
- Measure of welding consistency, spot location, size and quality.

INSPECTING SEMICONDUCTOR WAFER



DOLP image of semiconductor wafer



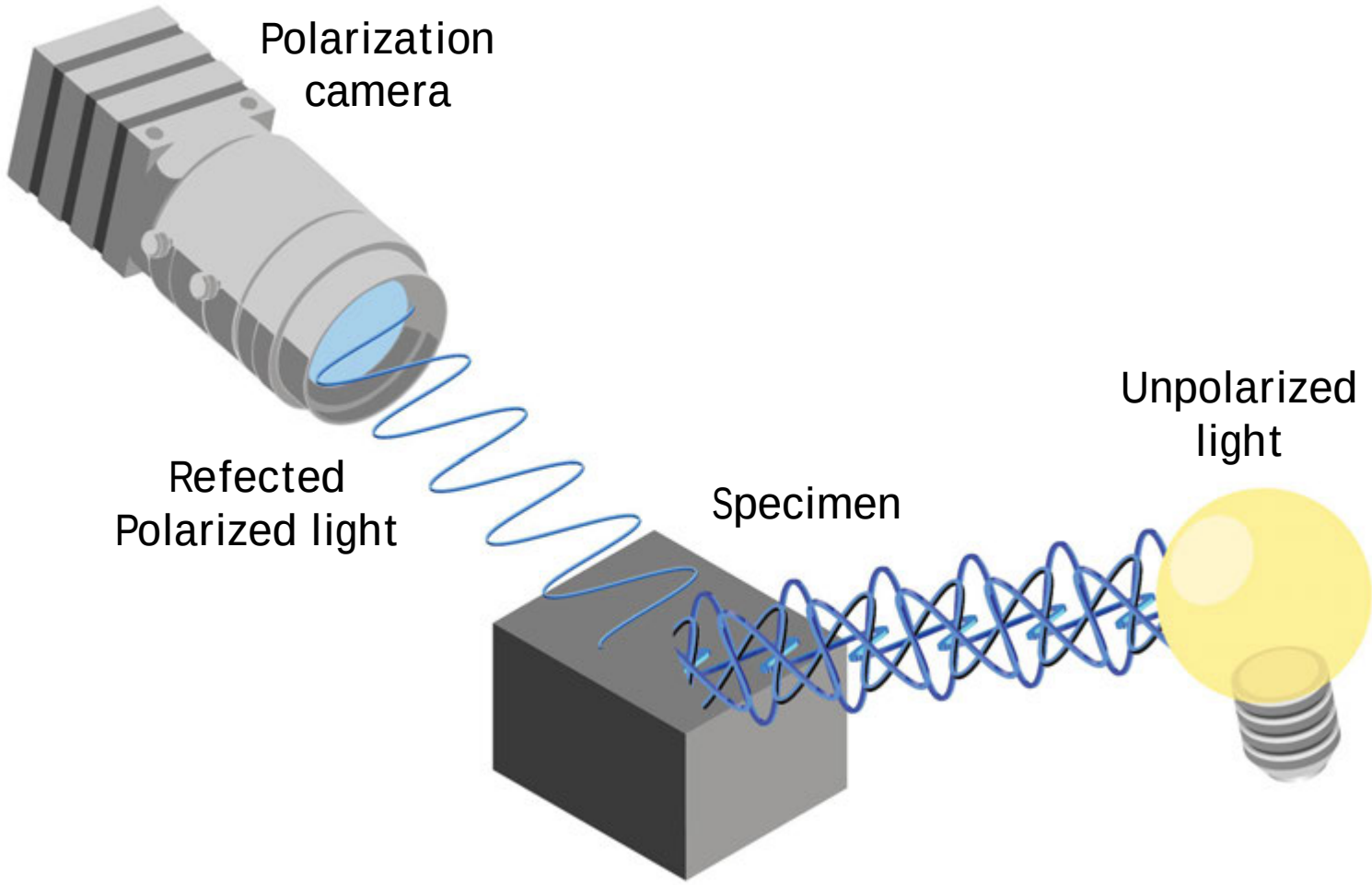
AOLP image of semiconductor wafer

INSPECTING USING REFLECTION TECHNIQUE

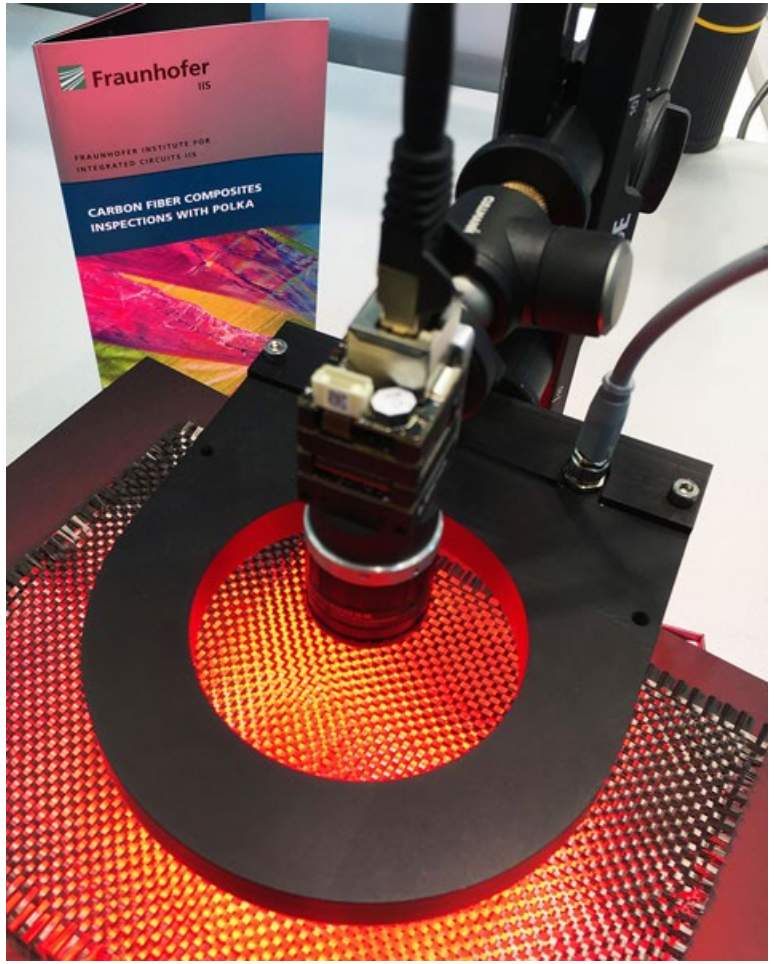
WITH UNPOLARIZED LIGHT

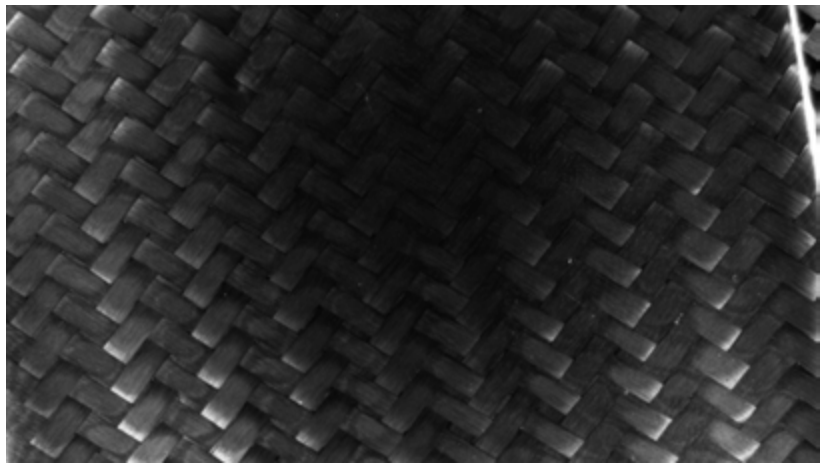
Effective in dedecting:

- **Surface damage**
- **Surface flatness**
- **Scratches**

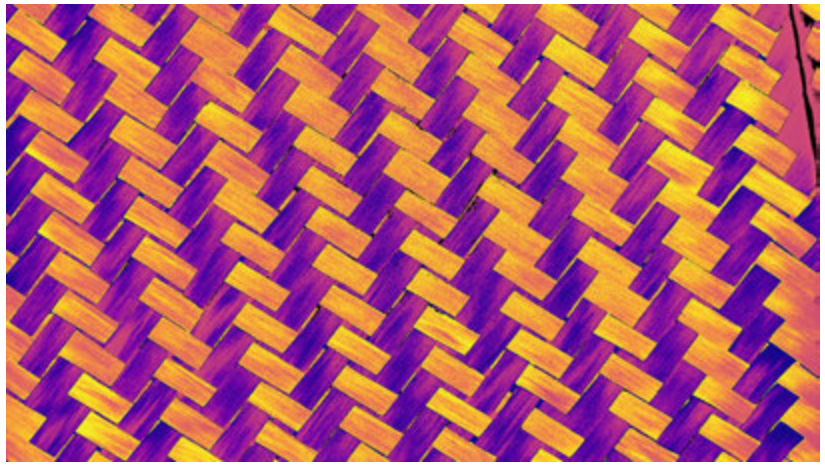


CARBON FIBER INSPECTION





Intensity image of a region of a finished part. Not much of the fibers can be seen - the fiber orientation is not discernible in the intensity image.



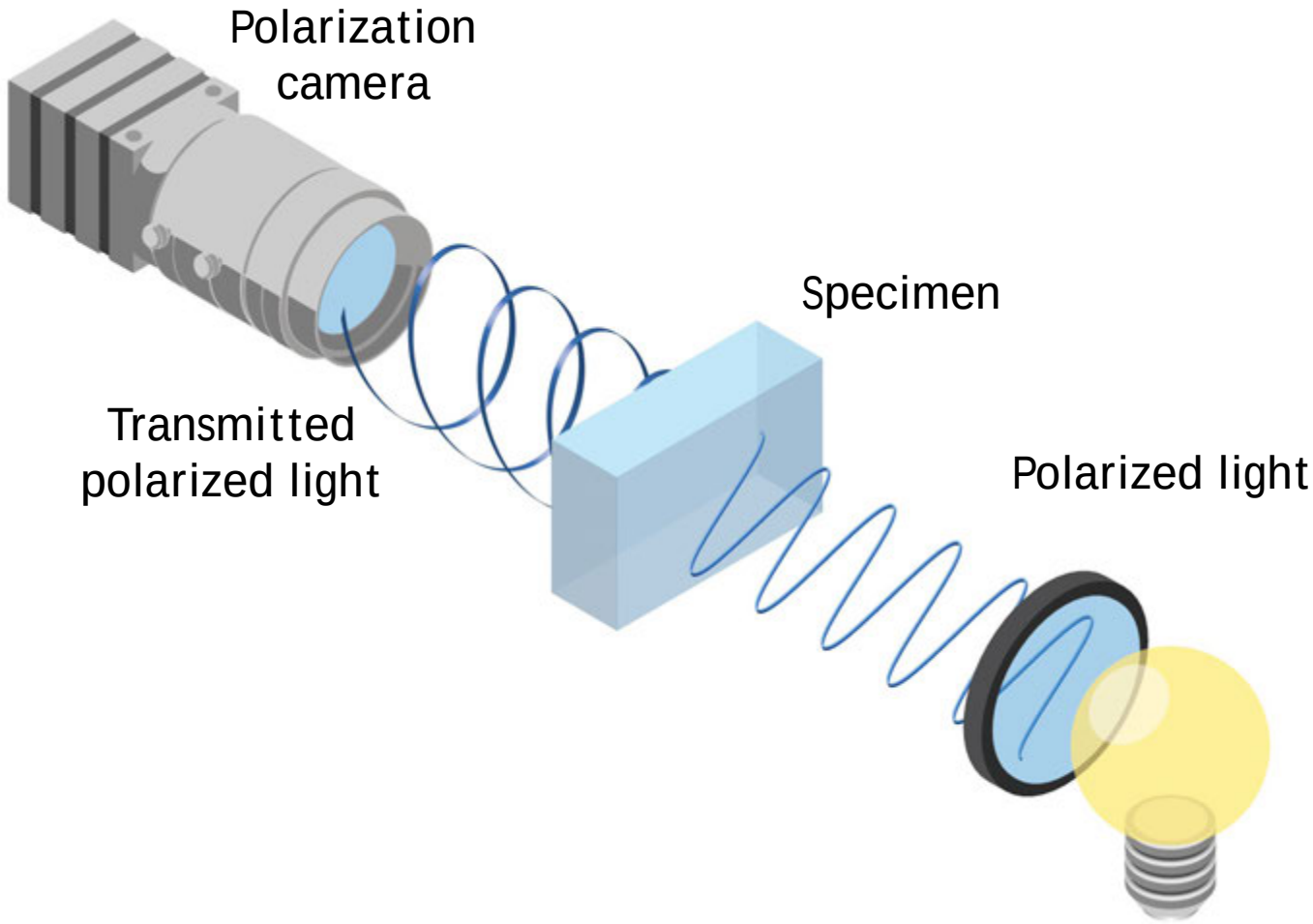
False color image to represent fiber orientation. Some areas can easily be identified in which the fibers are not perfectly straight.

https://www.iis.fraunhofer.de/en/ff/sse/ims/tech/polarizationimaging.html

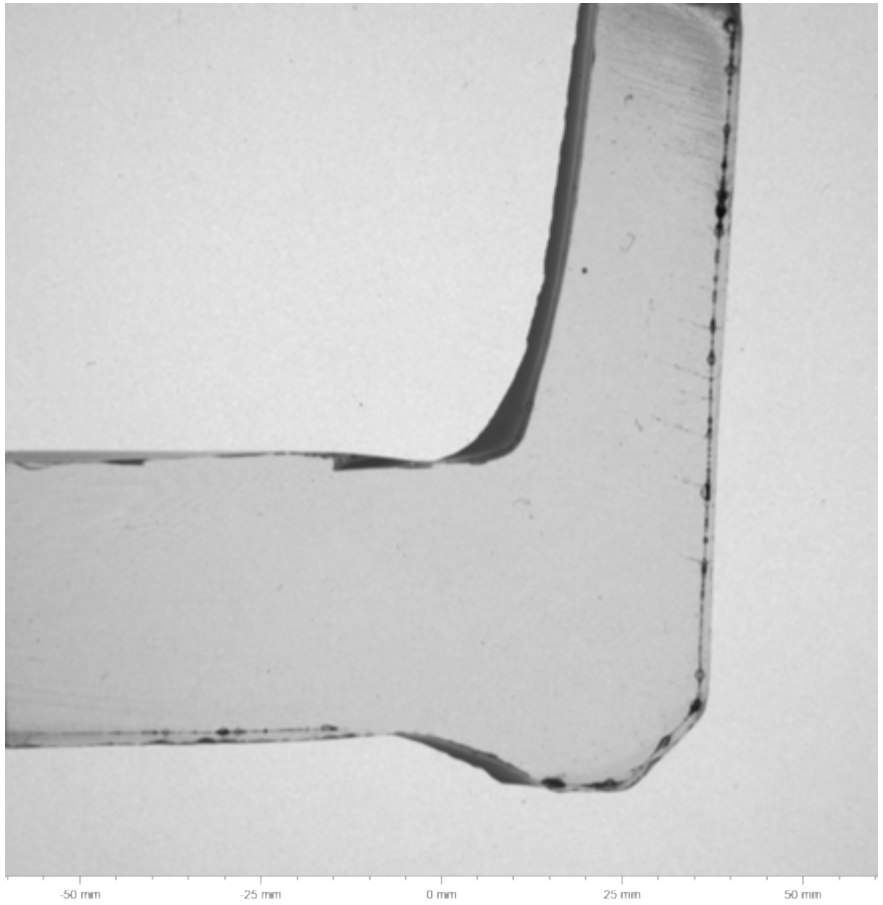
IMAGING USING TRANSMISSION TECHNIQUE

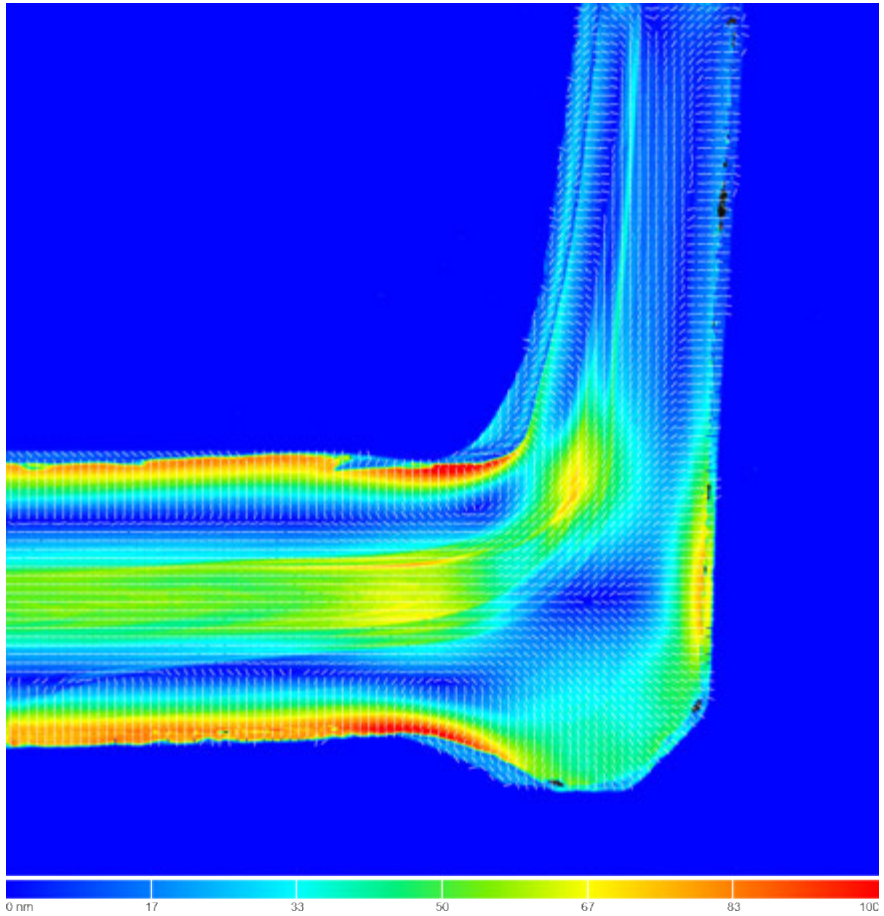
Effective in detecting:

- **Internal stress**
- **Transparent debris**
- **Scratches**



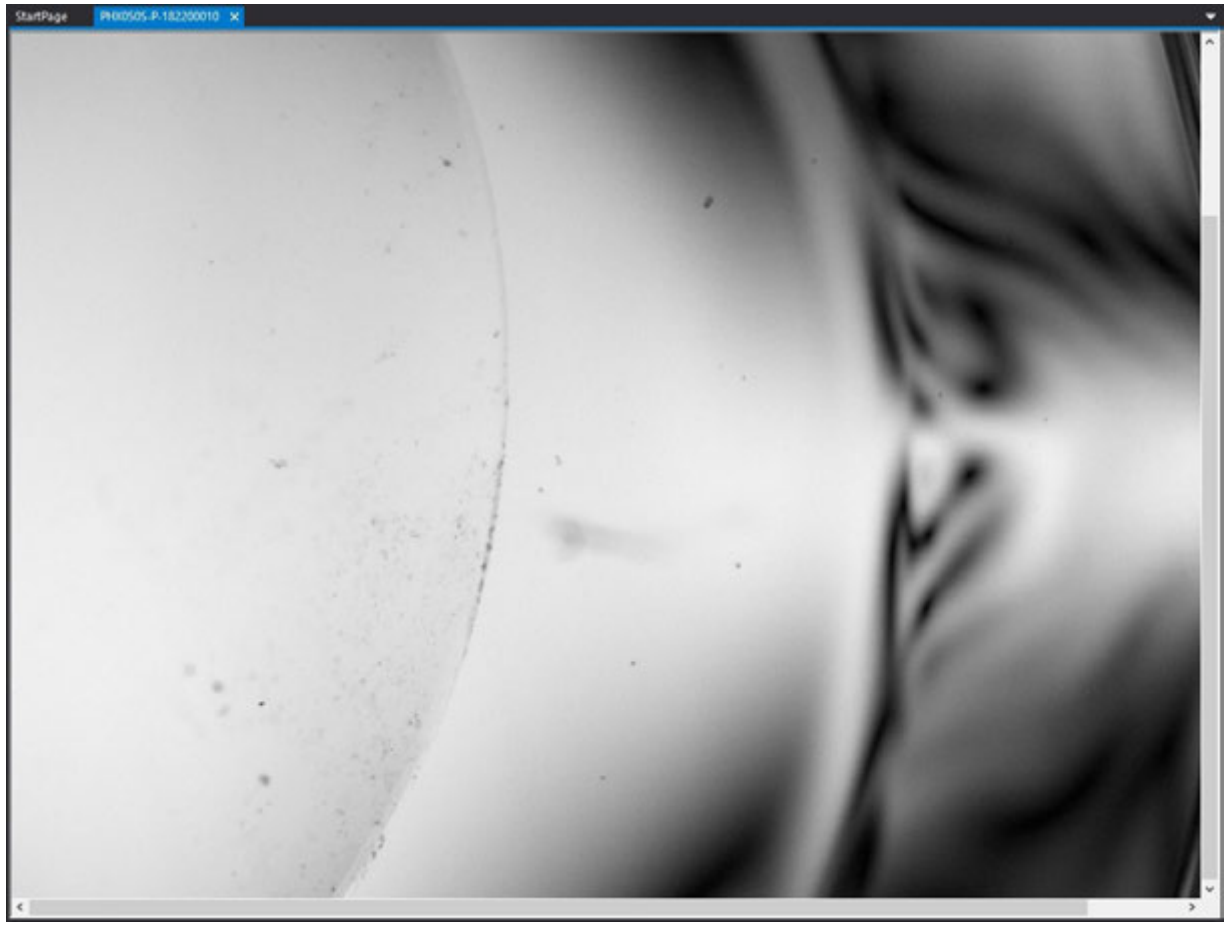
MEASURING STRESS



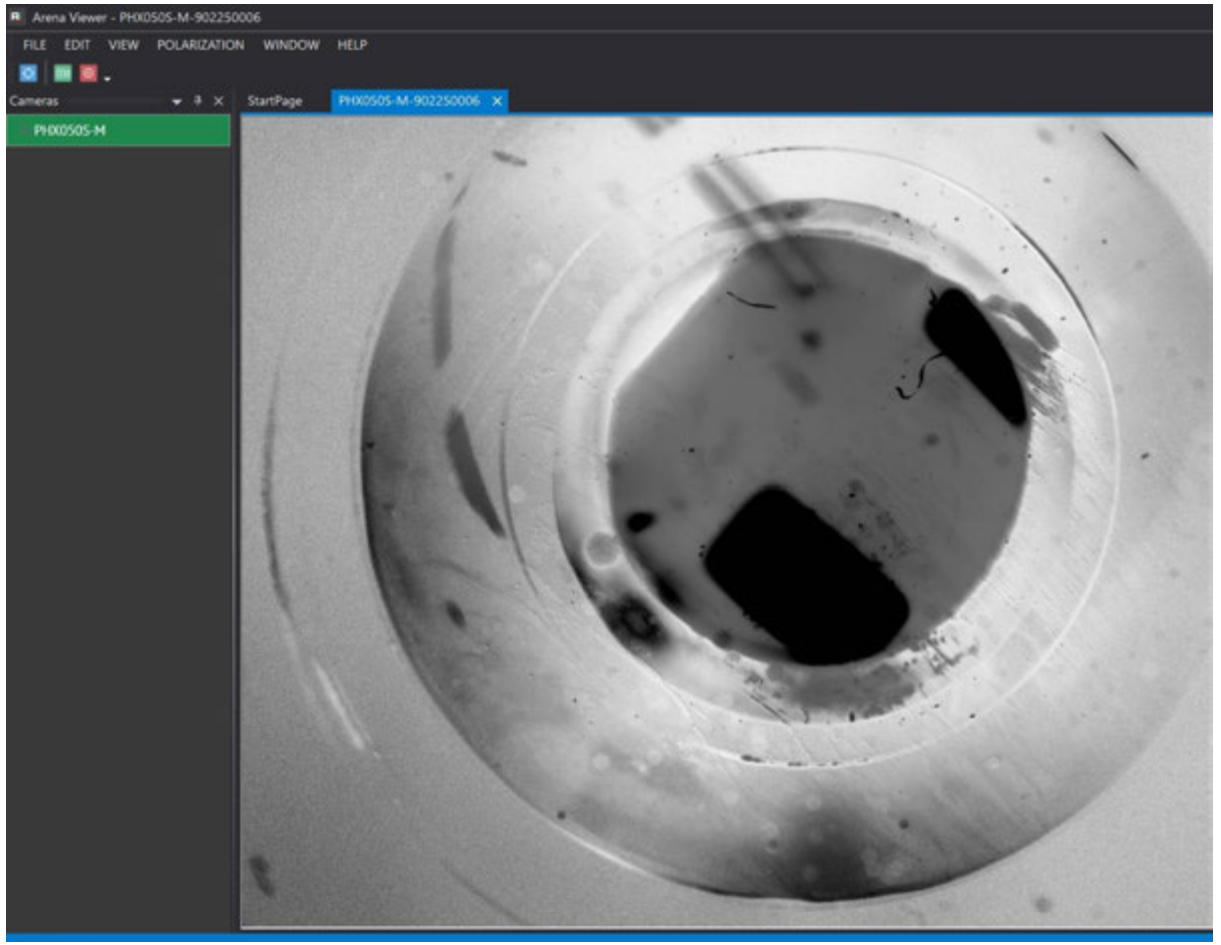


images courtesy of ilis (https://www.ilis.de/) with PHX050S-P camera

INSPECTING CONTACT LENS



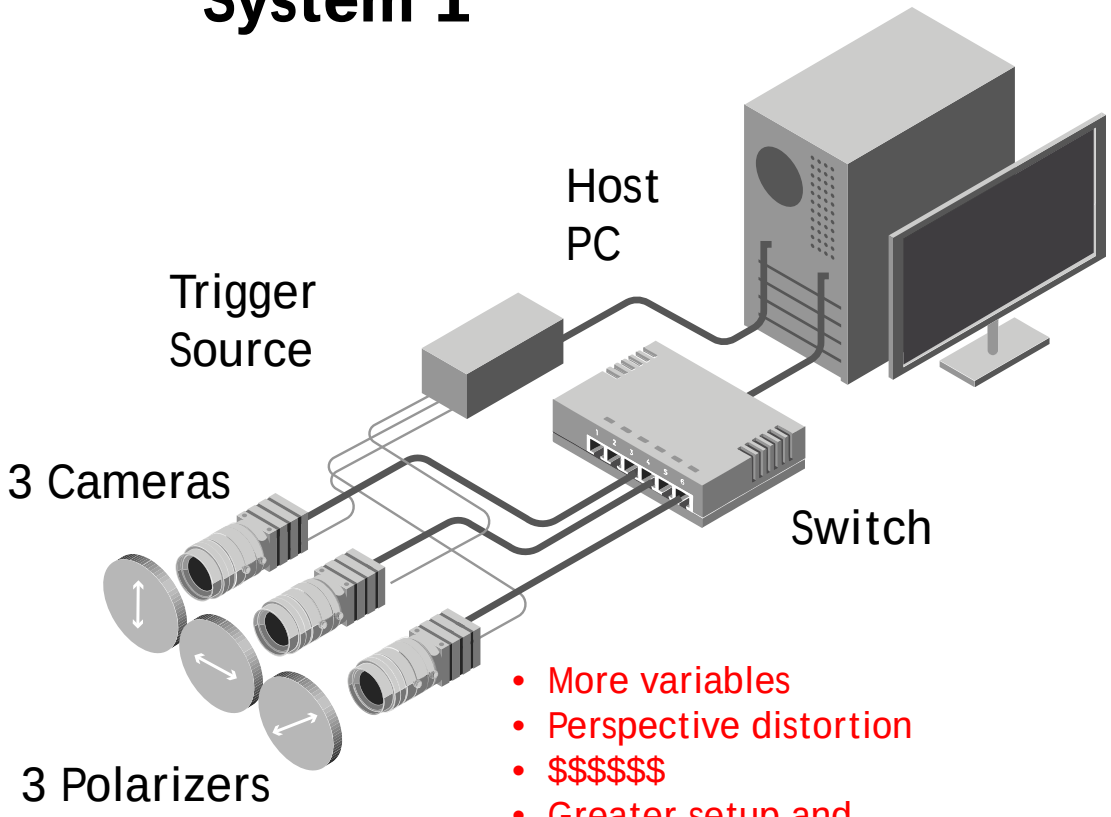
Detecting the edge of contact lens for non-uniformity



Inspection of contact lens for defects and abnormalities

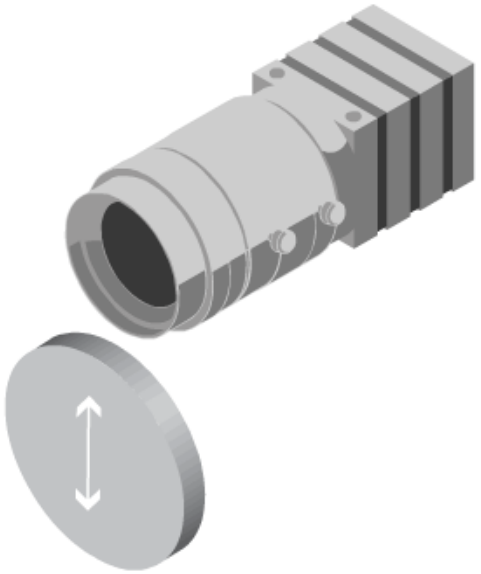
EXISTING POLARIZATION SOLUTIONS

System 1



- More variables
- Perspective distortion
- $$$$$$
- Greater setup and development effort

System 2



- Flip between filters very fast
- Time delay in filter rotation
- Moving mechanical parts
- $$$

System 3

- No moving part, simple setup
- Complete linear polarization data with one camera
- Overall system cost-saving
- Low effort for development

PHOENIX: INDUSTRY'S SMALLEST GIGE POE CAMERA

NF MOUNT

NF mounting and lens options provide even smaller footprint, up to 40% less space compared to c-mount. Supports up to 2/3" sensor sizes.

IX CONNECTOR

70% less space than RJ45 sockets. High EMC immunity and snap-in locking

TRANSFORMABLE

The camera can be mounted in various configurations such as flat or right angle.

GiGE VISION

GEN<i>CAM

TRITON: NEW PERFORMANCE STANDARD

ACTIVE SENSOR ALIGNMENT

All cameras are actively aligned to minimize image sensor tilt, rotation, and to place the center of the image sensor at the lens optical axis.

M12/M8 CONNECTORS

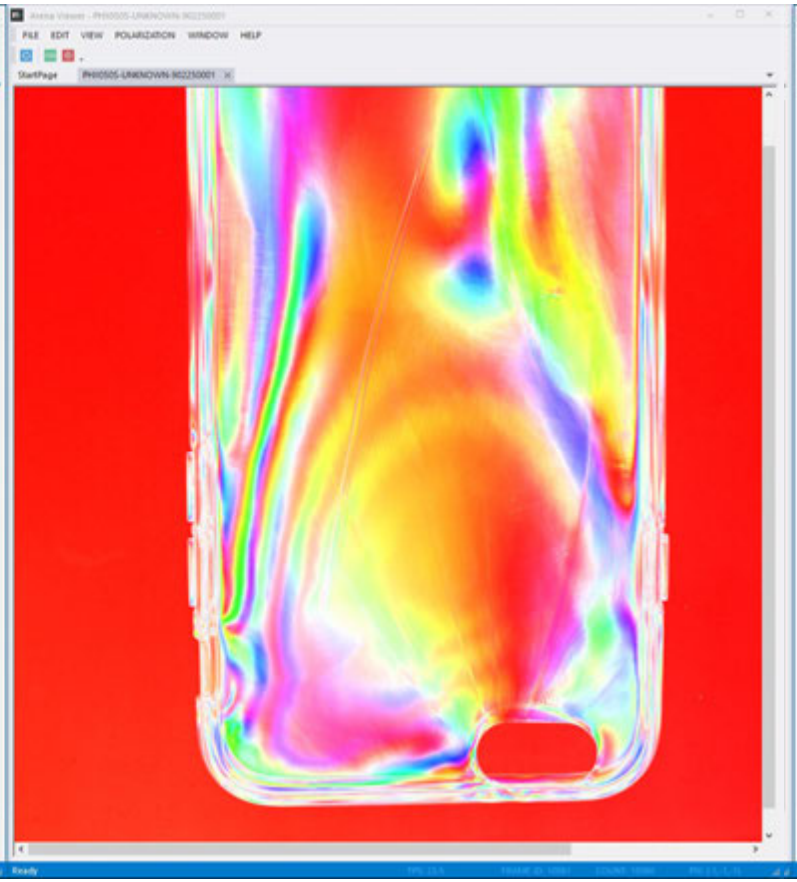
The M12 Ethernet and M8 GPIO connectors provide robust and secure cable connection with ingress protection against dirt, dust, and water.

IP67 OPTION

LUCID's sealed lens tube and attachment ring makes the camera dustproof and water resistant for harsh working environments.

POLARIZATION PROCESSING IN ARENAVIEW

Monochrome



HSV Overlay

Degree of Linear Polarization

WHO IS LUCID

- LUCID Vision Labs is a new company that designs and manufactures innovative machine vision products that creatively leverage new technology to deliver exceptional value to our customers.

- Founded in January 2017 in Canada, first product shipped in March 2018

- Headquartered in Canada, with regional sales and support offices in Germany, Japan and China

Headquarter in Richmond, BC, Canada
Engineering, sales, support, and manufacturing

European office in Ilsfeld, Germany
Sales and support

CONTACT

LUCID VISION LABS

http://www.thinklucid.com

http://www.linkedin.com/company/lucid-vision-labs/

Visit us at Booth 1C62