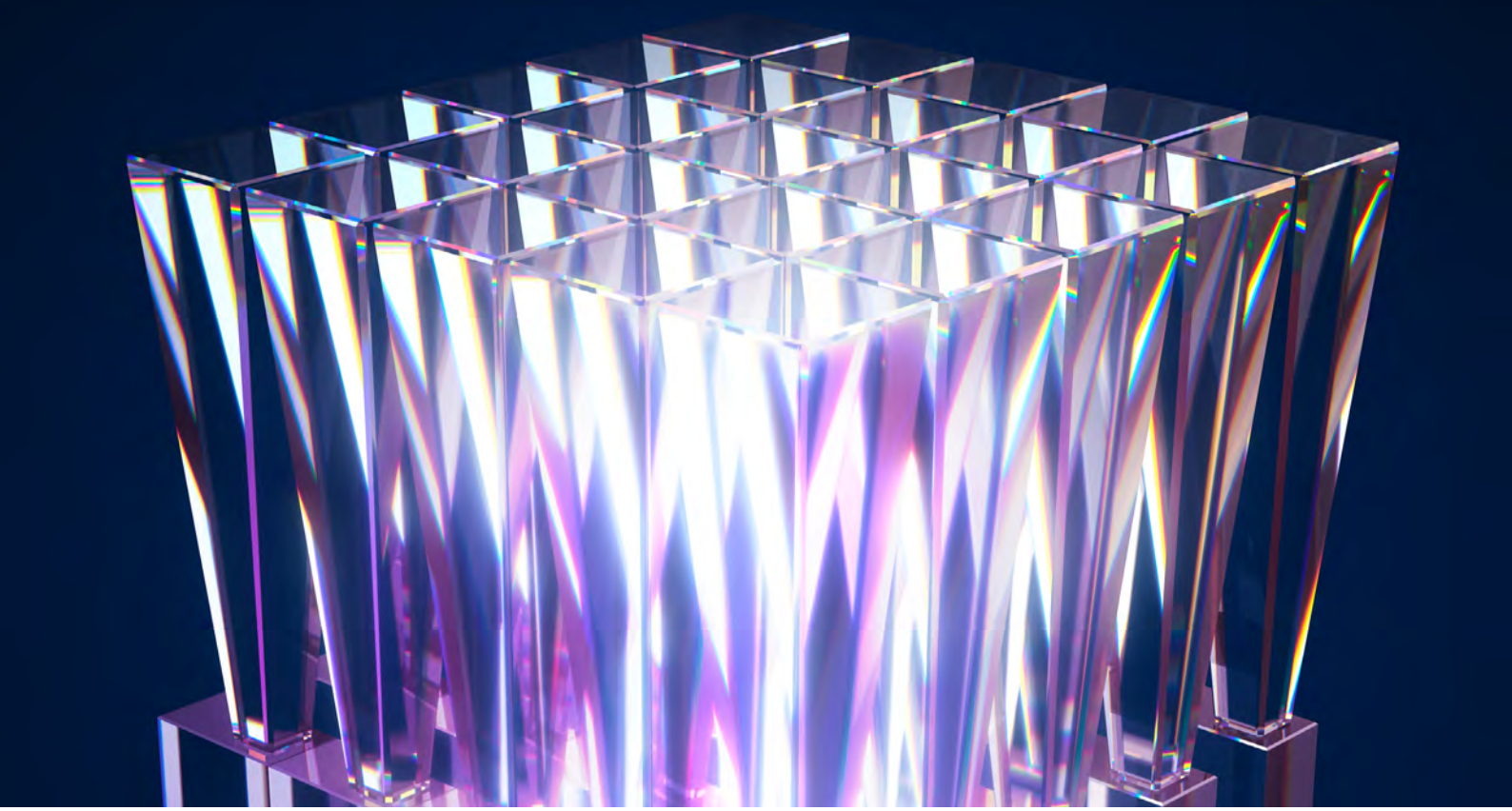
eyeo the future of imaging



whitepaper

nanophotonic color-splitting (NCOS®) enables the next generation of image sensors

eyeo-imaging.com

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1. Executive summary

Light is everything in an image, yet every image sensor built today throws away 70% of the light it receives.

Color imaging has relied on the same fundamental principle for more than half a century. The Bayer color filter array, present in virtually every CMOS image sensor today, covers the sensor with a mosaic of red, green, and blue filters. Each filter lets only one color through and absorbs the rest. This means two thirds of the light never reaches the sensor. No amount of software, AI, or post-processing can recover what was never captured. This is a structural, persistent penalty that affects the 7 Billion cameras sold each year from smartphones to industrial inspection systems.

eyeo takes a different approach. Rather than filtering light, eyeo's sensors feature NCOS® (Nanophotonic Color Splitting), which includes a layer of precisely engineered nanostructures that split light by wavelength and guide each color directly to the right pixel. No light is absorbed. No color information is discarded. And the architecture works with standard semiconductor manufacturing, making it a practical path to volume production.

Developed over 7 years of research & development at imec, Europe's leading semiconductor research center, and protected by 26 patents, the result is a new baseline for what image sensors can deliver: 3x more light, within the same physical footprint.

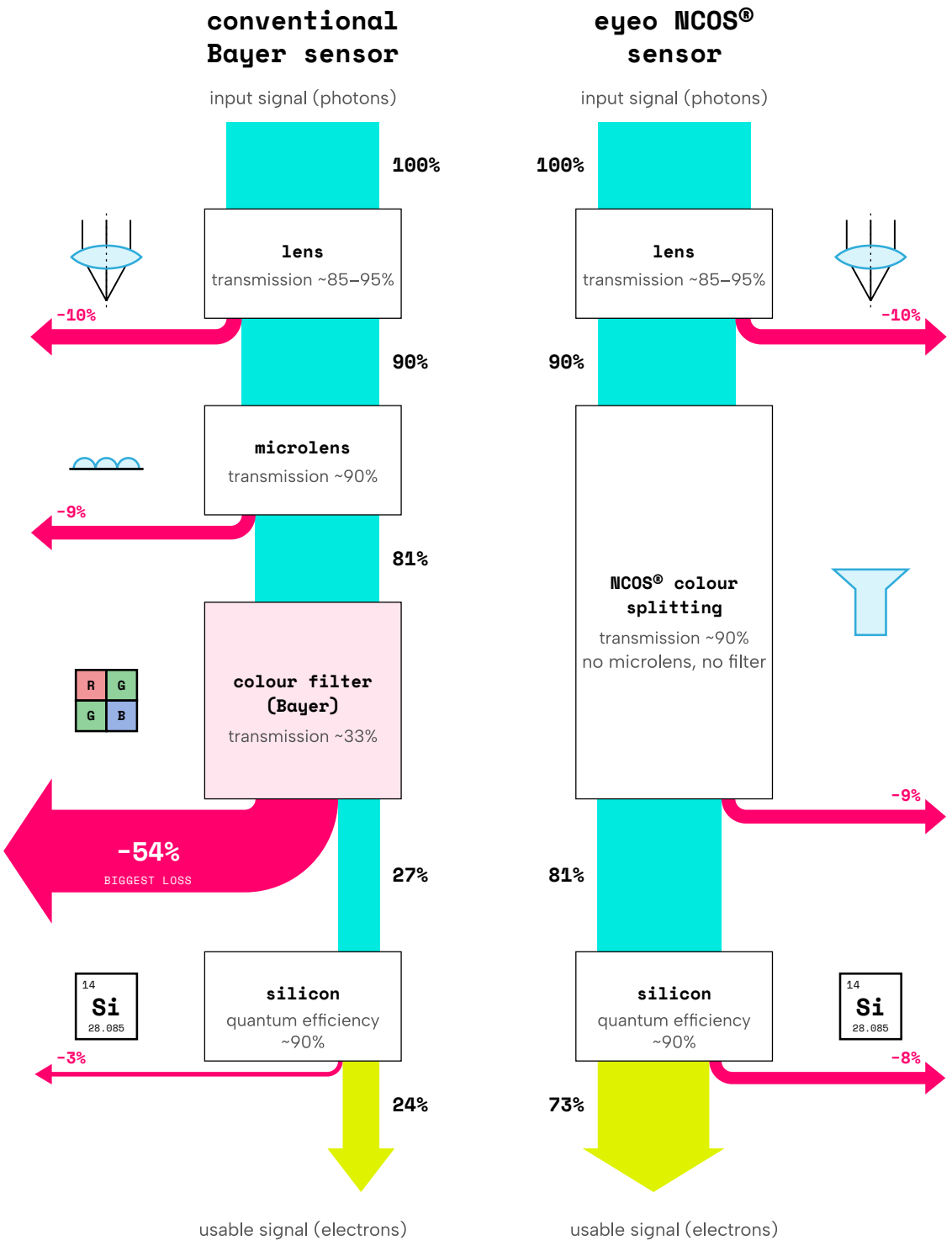
This whitepaper explains the science, the architecture, and the implications, for engineers evaluating new sensors and for product and strategy teams asking what becomes possible when light itself is no longer the constraint.

2. Breaking the photon efficiency barrier in color imaging

The evolution of image sensors has reached a point where incremental improvements are no longer sufficient. Optical designs, sensor fabrication, and system integration have collectively eliminated most avoidable losses between the lens and the silicon. Color extraction represents the last major inefficiency in this otherwise mature imaging pipeline.

Absorptive color filters impose a hard limit on photon efficiency. Replacing them with a high-transmission color-splitting architecture redefines what sensors can do with the same light. By preserving photons that are currently lost, this approach enables a step change in system performance, without requiring larger sensors, expensive optics, or longer exposure times.

Figure 1 below compares photon transmission through a conventional Bayer sensor and an eyeo NCOS® sensor under identical conditions. Lens transmission and silicon quantum efficiency are the same in both cases. The difference is entirely at the color separation stage: Bayer filters reduce transmission to roughly one third of incident light, a loss that no upstream optimization can recover. eyeo's color-splitting architecture performs wavelength separation with no absorption. This approach delivers a 3x higher end-to-end photon count, by purely eliminating the dominant architectural loss in conventional color imaging rather than optimizing around it.



~3× more light

Figure 1 | End to end photon transmission from lens to usable signal for eyeo NCOS® color splitting (right) and conventional Bayer color filtering (left).

3. The problem with how cameras see color today

3.1. How conventional sensors sense colors

The Bayer color filter brought digital color imaging to life for the last 50 years. It made it possible to filter light in a red, green and a blue component, similar to how colors could be displayed on digital screens. This made color reconstruction, and with it, imaging possible.

There is a limit to what can be done with the three color filters that form the core of Bayer filters. Each filter absorbs a substantial amount of light, light that cannot be used for imaging. Less signal reaches the sensor than the same camera without this color filter.

In recent years, image sensors have shrunk their pixel sizes. It is getting close to the size where light itself becomes the limiting factor, as the pixel size gets closer and closer to the diffraction limit.

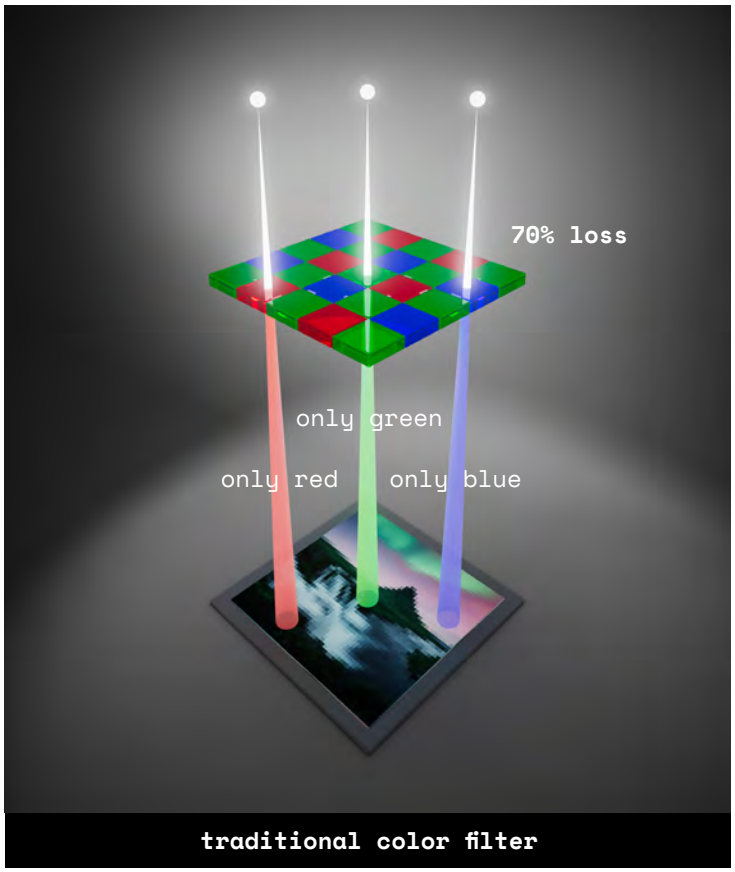


Figure 2 | Existing image sensors are practically blind

3.2. Why this matters more now

The global image sensor market is projected to grow from $23 billion in 2024 to over $30 billion by 2030, with shipments rising from 7 to 9 billion units annually*. That growth is driven by simultaneous demand acceleration across smart city infrastructure, industrial inspection, XR headsets, smart glasses, physical AI and consumer mobile devices. Each of these applications pushes sensors harder on the same three dimensions simultaneously: resolution, low-light performance, and power consumption.

As pixel sizes shrink below 1 micron, these constraints compound precisely as performance requirements intensify. The industry has been trading one against another for decades because no solution has addressed the root cause.

AI makes a change more urgent. Vision is the primary sensing modality for edge intelligence, from autonomous systems to on-device inference in consumer hardware. The quality of AI output is bounded by the quality of sensor input. A model cannot recover detail, dynamic range, or low-light performance that the sensor never captured. As AI moves closer to the physical world, the sensor becomes the bottleneck the industry can no longer defer.

The physics of conventional filters and the demands of next-generation applications have reached an irreconcilable point.

**Yole Group, Status of the Camera Module Industry, 2024.*

4. A different approach: NCOS® - Nanophotonic Color Splitting

4.1. What is Nanophononics

Nanophotonics is the discipline of redesigning the interaction between light and matter at its most fundamental level, structuring materials at scales measured on the nanometer scale unlocking optical behaviors that conventional lenses, filters, and coatings cannot replicate.

4.2. How eyeo's sensors work – Color splitting instead of filtering

eyeo's NCOS® sensors behave differently from traditional RGB sensors. Instead of filtering light, it splits it: separating light into its colors and guiding every photon directly to the pixel where it belongs. The NCOS® platform triples light sensitivity and breaks resolution limits. This breakthrough approach unlocks picture quality, color accuracy, resolution, and cost-efficiency, which was never-before possible.

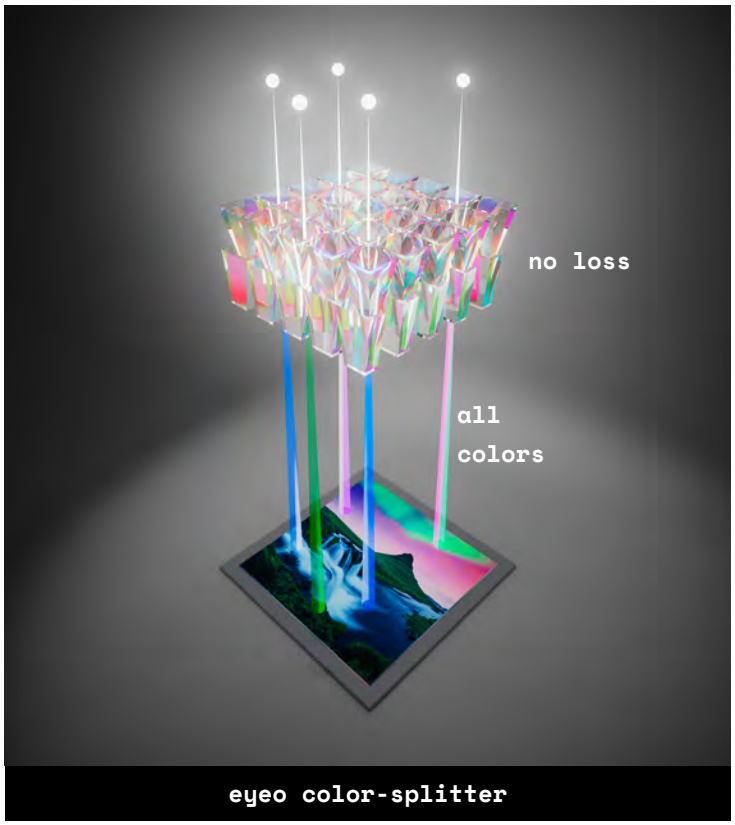
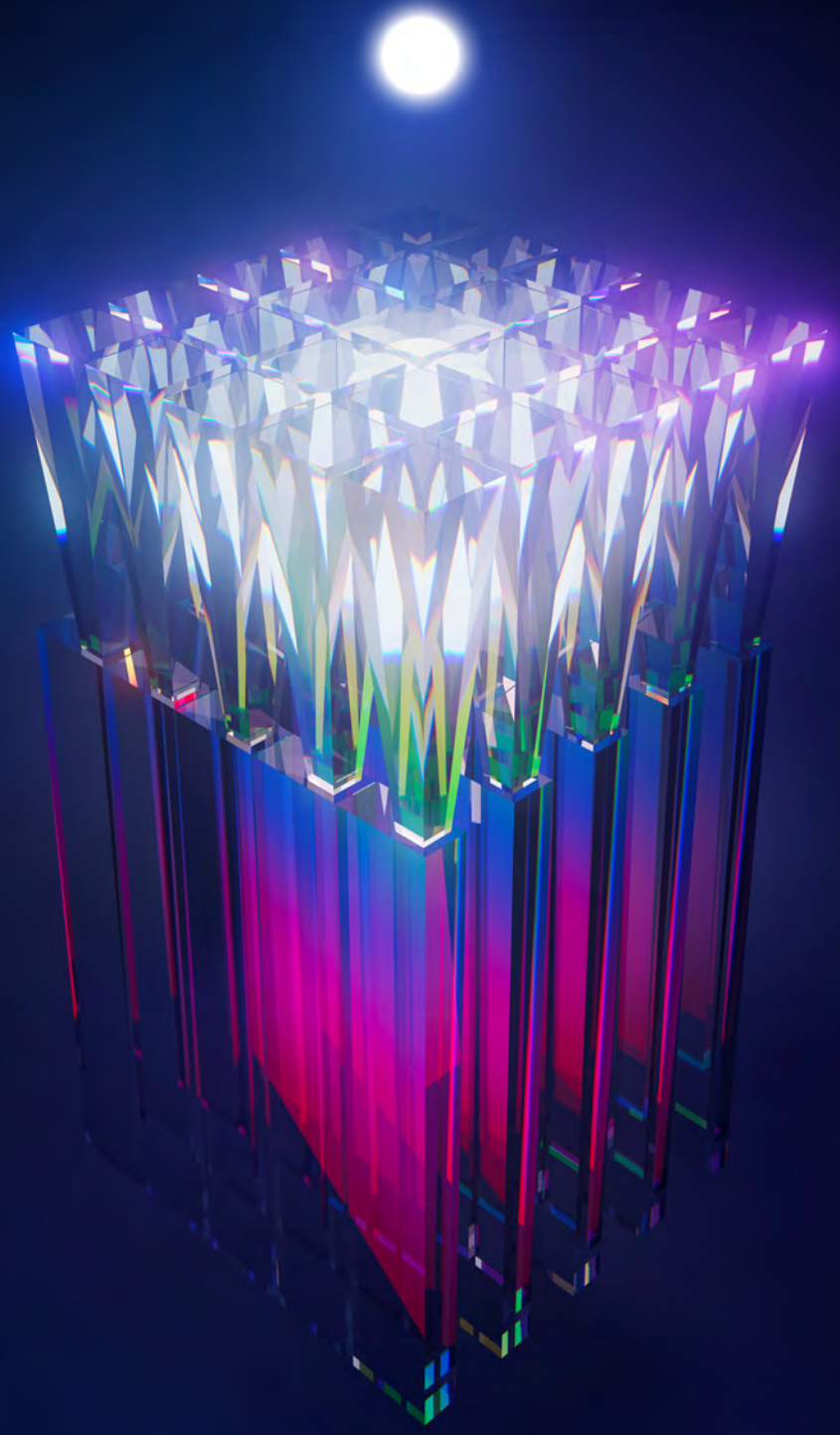


Figure 3 | eyeo image sensors see 3x more light

eyeo image sensors see 3x more light



Compatible with existing CMOS sensor platforms, eyeo's technology unlocks sub-micron pixels with 3x the light for ultra-compact, high-performance imaging, removing the trade-off between image quality and sensor size that has constrained product design for decades.

1↘

Enhanced sensitivity

By eliminating absorptive filters, our sensors capture more light, delivering superior performance in low-light conditions.

2↘

Improved color accuracy

Precise control over light diffraction ensures accurate color reproduction, essential for applications demanding high fidelity.

3↘

Higher resolution

Increased light efficiency allows for smaller pixel sizes, enabling higher-resolution imaging without compromising quality.

At the core of each eyeo sensor is an array of precisely engineered nanostructures that perform the color-splitting function through four integrated stages.

Nanophotonic color splitting structure

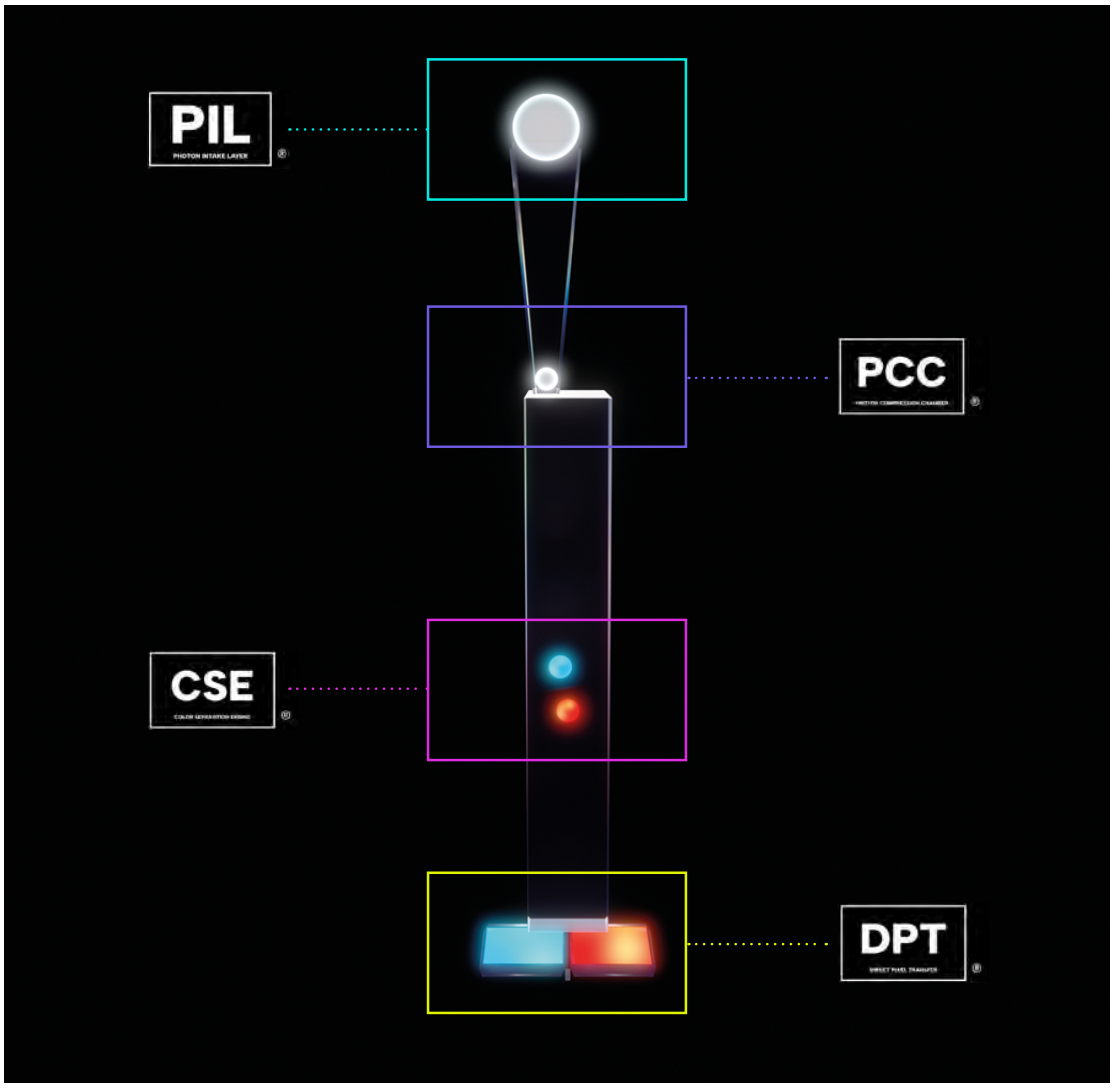


Figure 4 | Nanophotonic Color Splitting Structure representation

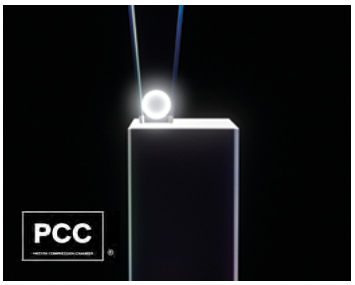
Principle of color splitting

Each splitter consists of a vertical waveguide with a rectangular cross-section. It has a tapered section at the top that acts as an entrance funnel for incident light. The tapered waveguide section forms an adiabatic funnel for the incoming light. The light is then squeezed into a single mode in the waveguide. The light is asymmetrically guided in the rectangular waveguide below. Because light travels at different velocities for each wavelength, the shape of this waveguide can be designed such that a desired color composition difference is attained between a “left” and a “right” exit.



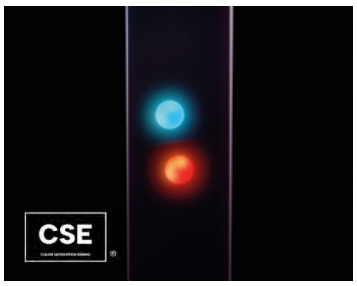
PIL® - Photon Intake Layer

The entry point of the vertical waveguide nanostructure. PIL© captures incoming photons across the full spectrum without filters to block them or microlenses to approximate them. Every photon that arrives, enters.



PCC® - Photon Compression Chamber

Light enters wide, at 1 µm. PCC© compresses the optical mode 3 times, concentrating the photonic energy into the core of the nanostructure where wavelength separation becomes possible. A precisely engineered transition that unlocks sub 0.5 µm pixels.



CSE® - Color Separation Engine

After preconditioning by the PCC®, the nanoscale CSE® geometry creates multi-mode interference that separates light by wavelength.



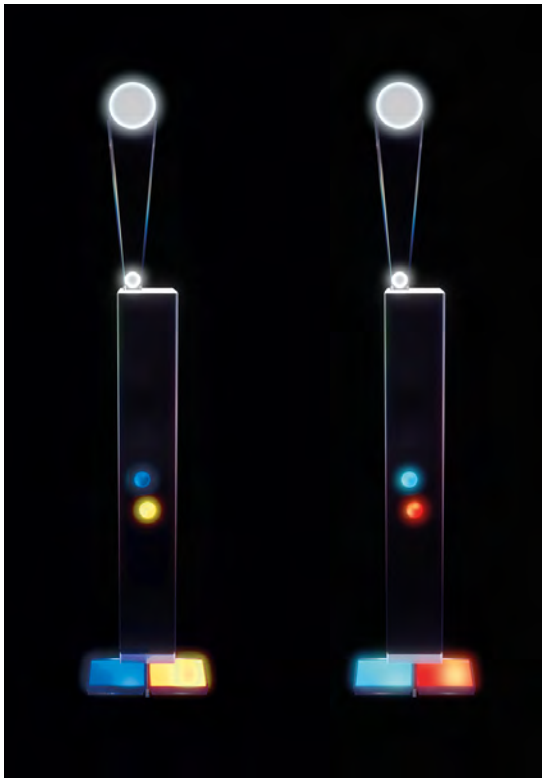
DPT® - Direct Pixel Transfer

The final stage delivers on the stack's core promise. DPT© guides each separated wavelength directly to one of two dedicated pixels, without crosstalk or loss. What entered as raw light exits as precise color information, pixel-ready.

4.3. Colors as humans see

The light output of the splitters is not modelled on the filtering of the red, green and blue of traditional color cameras. Instead, it splits the light. For most applications, the optimal splitting is based on the human vision. Based on the human cone spectral sensitivities, the light is split in a blue, a yellow, a cyan and a red component.

The nanophotonic color splitters are implemented in two complementary variants: yellow–blue and red–cyan.



2 structures
4 color channels

With 2 nanostructure designs, we extract 4 color channels:

- Blue and yellow
- Cyan and red

The closest colors to what the human eye actually sees.

Each splitter directs incoming light to two adjacent pixels, with the separation at the outputs depending on wavelength. The spectral transfer functions of the splitters are designed such that their crossing points align with transition regions in the human visual system. This alignment ensures efficient color discrimination by matching the natural sensitivity regions of the eye.

The resulting differential signal between pixel pairs enables accurate color reconstruction while preserving a significantly larger fraction of the incident light compared to conventional RGB filtering. Therefore, more photons reach the photodetectors, leading to a higher signal level and improved overall sensitivity.

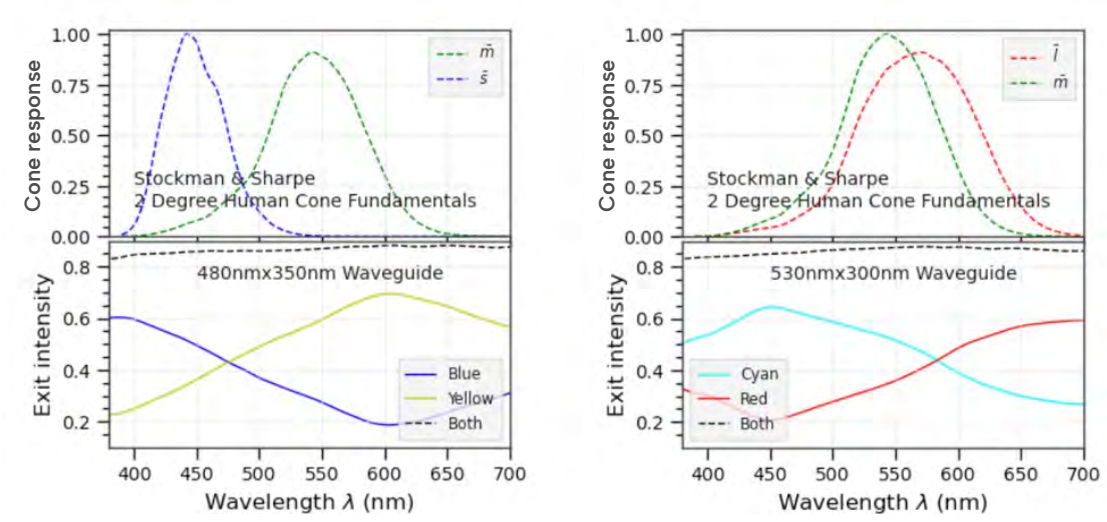


Figure 5a | (top) standard CIE observer blue and green human eye response with crossing point at 480 nm. (bottom) Lumerical FDTD simulation of the left and right detector signal.

Figure 5b | (top) standard CIE observer red and green human eye response with crossing point at 580 nm. (bottom) Lumerical FDTD simulation of the left and right detector signal.

The YBCR (Yellow-Blue-Cyan-Red) signal is close to the conventional YCbCr color space. That color space is used in the MPEG video file compression. Because fewer conversion steps are theoretically needed to get to this color space, the nanophotonic color splitting technology opens up new possibilities to efficient compression.

4.4. Fabrication

The waveguides are fabricated using well-established semiconductor processes. No exotic materials are needed to achieve color splitting. The splitters consist of an optical stack with SiN waveguides inside a simple SiO_2 matrix. Light is collected into the splitter via the PIL (Photon Intake Layer) at the inverse knotted pyramid shape at the top and compressed in the PCC (photon compression chamber). Then, the light enters the CSE (Color Separation Engine) and the DPT (Direct Pixel Transfer) will inject the light either on the left or the right side, based on the color composition of the light. Pixels are located at both exits of the waveguide, ready to collect all the photons.

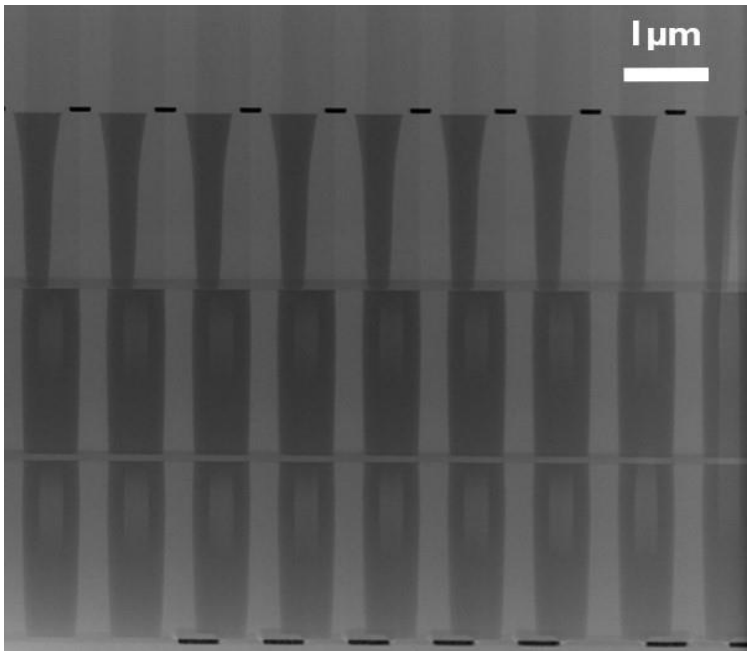


Figure 6 | Early TEM cross section of first prototype splitter waveguides. Comprising (left) two waveguides with both-sides aperture exits, five waveguides with right side aperture exits and (right) two waveguides with left side aperture exits. From the original paper on which the color splitter principle is based, read more here: https://eyeo-imaging.com/knowledge/research/vertical-waveguide-color-splitter/.

4.5. Color processing

Traditional color cameras use a Bayer filter mosaic pattern on their pixels. The output of these pixels is entered in the Image Signal Processor (ISP) where they are interpolated and combined into an image with a value for red, green and blue for every pixel. These values still need some further processing by multiplying it with a color correction matrix, a 3x3 matrix that corrects the colors so the output matches human eye perception.

For color splitters, the pixel pattern will consist of a yellow, blue, cyan and a red pixel. This output is similarly interpolated in the ISP, where in the demosaiced image each pixel consists of a yellow, a blue, a cyan and red value. To get to the life-like screen-ready RGB image, a 4x3 color correction matrix is used, similarly to the traditional RGB. This ensures a perfect-colored image.

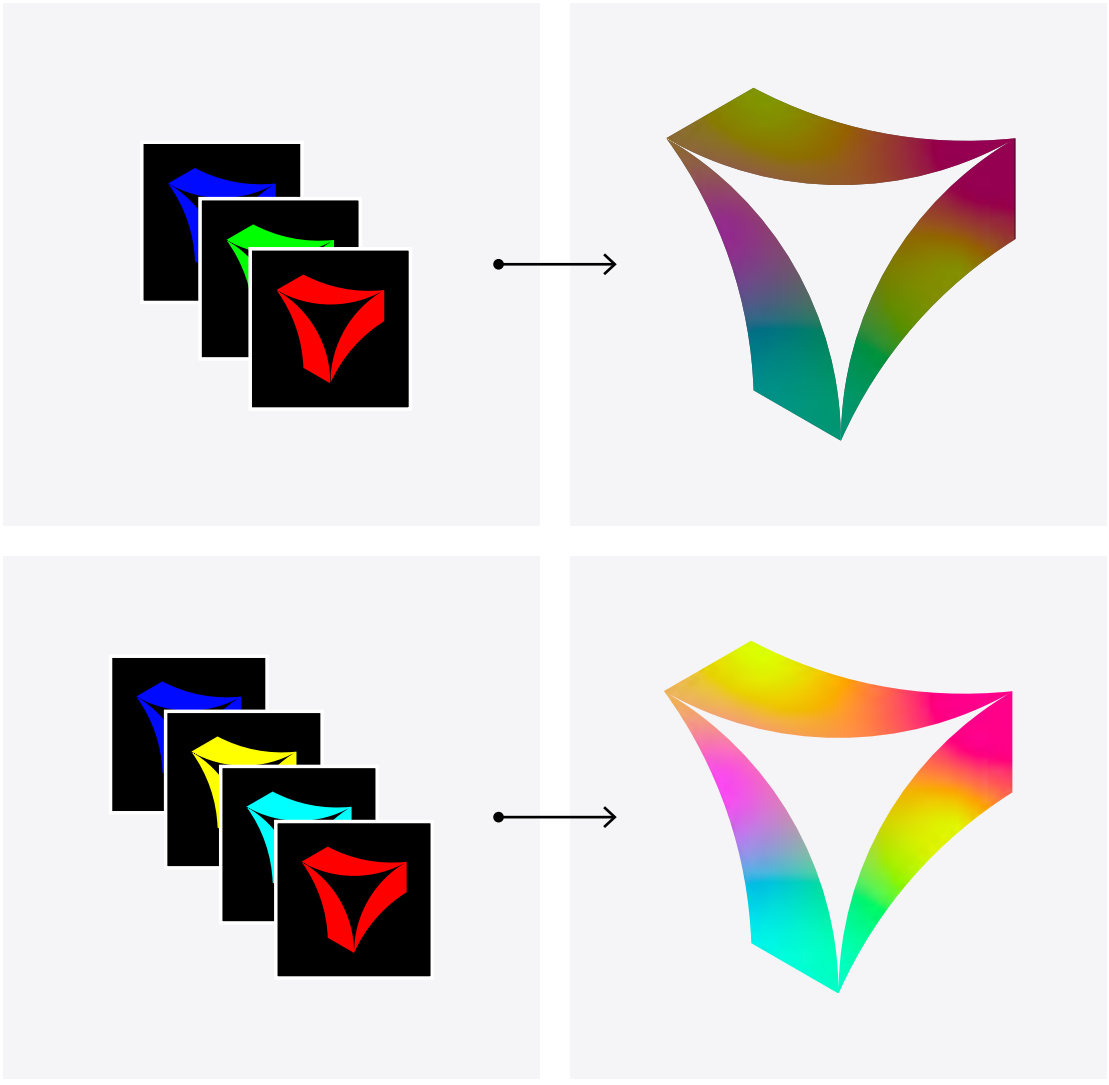


Figure 7 | RGB vs YCBR at same illumination level

5. Applications and markets

eyeo's NCOS® architecture directly addresses the dominant constraints of modern imaging systems: low-light performance, compact form factors, power consumption and cost-sensitivity. By preserving photons that are conventionally discarded, eyeo sensors deliver higher signal quality under identical system conditions, without increasing sensor size, lens aperture, exposure time, or power consumption. This enables reliable imaging in challenging lighting conditions while supporting continued pixel scaling and cost-efficient system designs across a wide range of imaging markets.

More light disrupts a 23B$ industry

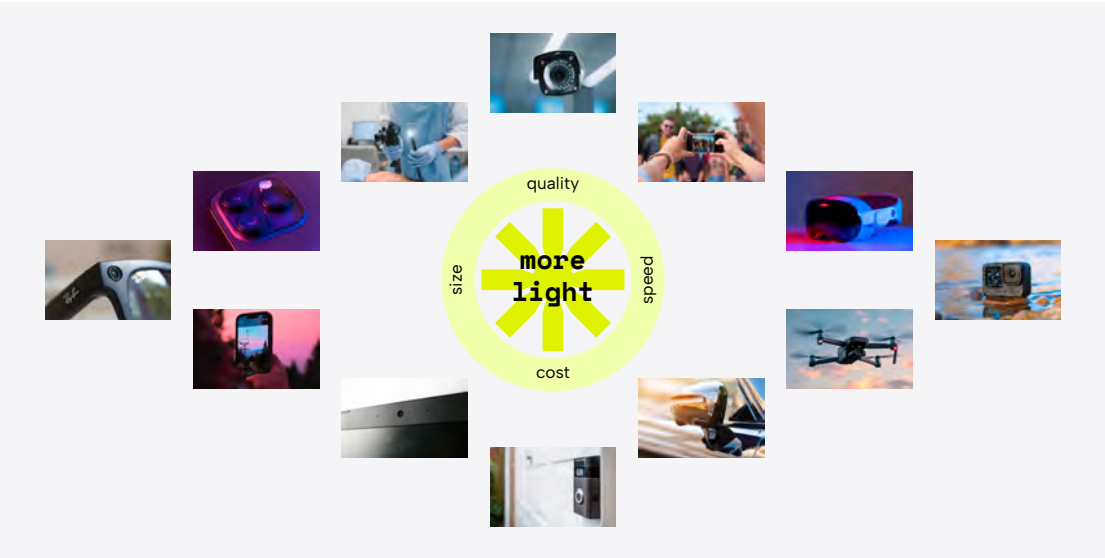


Figure 8 | eyeo core Markets

5.1. Security and smart city

Security and smart city deployments operate in environments that are dark, low-contrast, and uncontrolled by design. When signal degrades, the details that matter most go first: vehicle color, license plates, clothing. eyeo's sensors preserve substantially more of that light, maintaining usable signal in near-darkness where conventional systems fail. Key visual evidence stays recoverable for monitoring, forensic analysis, and incident investigation. AI analytics get better input, which means higher detection rates, more accurate classification, and fewer missed events or false alerts.

5.2. Machine vision and industrial inspection

Machine vision and industrial inspection systems must deliver reliable image data in environments where speed and precision are critical. Limited illumination and short exposure times reduce signal, causing fine defects and low-contrast features to be missed first.

eyeo's sensors preserve more of the light, keeping those features detectable even in demanding production conditions. This means higher detection rates and throughput, better AI-based classification, and fewer false rejects. They can also bring color to applications where today only monochrome can be used, adding a new dimension of information to the process.

5.3. Automotive and ADAS

Automotive and ADAS systems must deliver reliable image data in environments where safety depends on consistent perception. Low-light driving, tunnel transitions, and low-contrast scenes reduce available signal, causing critical information such as pedestrians, lane markings, and obstacles to be missed first.

This matters most at night: most fatal pedestrian crashes happen in the dark, precisely where today's camera-based ADAS is least effective. eyeo's sensors preserve substantially more of that light, raising signal-to-noise ratio and maintaining usable signal in conditions where conventional systems degrade.

Key visual information remains detectable for driver assistance and autonomous functions, helping close the perception gap that limits today's safety systems at night, without increasing sensor size, exposure time, or system cost.

5.4. AR/VR and spatial computing – smart glasses

Smart glasses and spatial computing devices operate under extreme size and power constraints. Limited sensor size and short exposure times reduce available signal, causing motion blur, temporal noise, and loss of detail in low-light scenes, which directly impacts tracking stability and scene understanding.

eyeo's sensors maintain usable signal in conditions where conventional systems degrade. This ensures more stable visual input for pictures and films, inside-out tracking and SLAM, reducing drift and improving environment reconstruction, while enabling smaller form factor and cutting power consumption and overall system complexity.

5.5. Medical and life sciences imaging

In photon-limited imaging environments, signal quality determines what is observable. Fluorescence, low-level emission, and faint biological structures are easily lost to noise when illumination is constrained. eyeo's sensors preserve the light, keeping weak signals above the detection threshold. Measurement sensitivity, signal-to-noise performance, and reproducibility all improve across microscopy, diagnostics, and analytical imaging.

5.6. Drones & action cameras

Fast motion, vibration, and rapidly changing light are standard operating conditions for drones and action cameras. Short exposure times already push signal to its limit, and the result shows up as motion blur, temporal noise, and rolling shutter artifacts. eyeo's sensors deliver sharper frames, better low-light video, and more stable image quality through rapid scene changes.









5.7. Mobile imaging

Mobile sensors operate under the tightest constraints in the industry: small pixels, limited optics, and strict cost and power budgets. In low-light and high dynamic range conditions, those constraints compound into noise, lost detail, and degraded image quality.

eyeo's sensors deliver more signal from the same pixel footprint, improving low-light photos and video, extending HDR performance, and raising image quality at small pixel sizes. The gains are most striking where light is scarcest: in telephoto cameras, where long zoom optics and tight space starve the sensor of light, or under the display, where the screen absorbs too much light for conventional RGB filters to produce good images.

With 3x more light, eyeo makes low-light photos and videos possible, sharp zoomed shots and high-quality under-display front cameras a reality.

5.8. Physical AI

Robots, autonomous machines, and smart devices have to work reliably in places they do not control. In low light, fast motion, or high dynamic range scenes, less signal reaches the sensor, and the fine details are the first to go: the ones that tell a person from a shadow or a defect from a reflection. No algorithm can recover information that was never captured.

eyeo's sensors split light by wavelength instead of filtering it, capturing 3x more light than any RGB color sensor. That gives every layer of Physical AI, from perception to decision to action, a stronger foundation to build on





6. The team and the company

eyeo was founded in late 2024 by imaging specialists with combined expertise across nanophotonics research, semiconductor engineering, imaging system design as well as C-level expertise in new product market introduction and scaling, and general management.

The team has grown to more than 30 people – as of September 2026 – spanning research, engineering, and commercial functions across two locations: High Tech Campus Eindhoven and a sensor design center in Antwerp.

The company has raised 55 million euros across two funding rounds, a 15-million-euro seed and a 40-million-euro Series A led by Innovation Industries, with participation from existing investors imec.xpand, Invest-NL, QBIC, HTGF, and BOM.



6.1 Headquarters

High Tech Campus 41, 5656 AE Eindhoven, The Netherlands



6.2 Design center

Posthofbrug 6/8, 2600 Berchem, Antwerp, Belgium



7. Frequently asked questions

If your output is not standard RGB, how is it used in existing imaging pipelines?

eyeo sensors produce four spectral components that can be mapped to standard color spaces such as RGB or YCbCr with a 4x3 color matrix. If this is supported by the ISP, integration is straightforward, with flexibility to optimize for specific application requirements.

Do eyeo sensors require demosaicing?

Yes. eyeo sensors use demosaicing principles similar to conventional image sensors, but adapted to the different way color information is captured at the pixel level. The processing leverages the structure and spectral properties of the nanophotonic color splitters.

Do eyeo sensors require microlenses?

No. The nanophotonic color-splitting architecture directs incoming light to the appropriate pixels without relying on microlenses, removing associated losses and sensitivities while maintaining high photon efficiency and color fidelity.

Are standard lenses compatible with eyeo sensors?

Yes. eyeo sensors operate with standard imaging optics and do not require changes to lens design, aperture, or system configuration.

Does this require a new manufacturing process or specialized fabs?

No. The nanophotonic structures are fabricated using CMOS-compatible processes and materials, and are already setup in a dedicated commercial foundry.

What pixel sizes are supported with this technology?

eyeo's architecture is inherently compatible with pixel scaling and is particularly advantageous at smaller pixel sizes (especially below 2µm and going beyond 0.5µm), where conventional approaches face increasing efficiency and crosstalk challenges.

Do eyeo sensors require Quad Bayer, Tetra cell, or similar pixel binning architectures?

No. In eyeo's nanophotonic color-splitting structures, the effective Airy disk of the photon is reduced, allowing light to be confined to a smaller spatial footprint thanks to the PCC (Photon Compression Chamber). This enables the use of smaller pixel sizes, going even below 0.5µm, without the need for Quad Bayer, Tetra cell, or other binning approaches. As a result, smaller pixels can achieve higher sensitivity, while full resolution is preserved and MTF remains much higher compared to binned architectures.

Is this based on nano-prisms, meta-surfaces or other similar diffraction-based effects?

No. eyeo's technology relies on nanophotonic waveguide principles to spatially separate light by wavelength, at sub-diffraction level. Diffraction-based techniques suffer from higher color cross-talk, a lower effective resolution (MTF) and still require color filters.

Do you build sensors or license the technology?

The company designs and sells complete image sensors for integration by device manufacturers and does not license its core technology independently.

Why can't software or AI compensate for the photon loss?

Photon loss at the sensor level reduces the fundamental signal-to-noise ratio. While software and AI can enhance captured images, they cannot recover information that was never detected. With richer color capture and a stronger signal, eyeo sensors give AI more detailed and accurate data to work with, delivering greater performance and unlocking new possibilities.

How does the quantum efficiency and spectral response compare to Bayer sensors?

In eyeo's NCOS® architecture, the underlying silicon quantum efficiency remains unchanged. However, because color separation is performed through high-transmission splitting rather than absorption, the effective spectral response approaches that of a monochrome sensor in terms of photon utilization, while still enabling color reconstruction through optical separation.

Does the color-splitting structure introduce optical crosstalk between pixels?

The nanophotonic splitter is vertically aligned with the underlying pixel and directs light to individual pixels, minimizing lateral propagation. Unlike conventional architectures, it avoids crosstalk sources such as color filters and microlenses.

How does the technology handle large chief-ray angles from the lens?

The optical response of the color splitter is designed to accommodate the angular distribution of incoming light. Chief-ray angle requirements can be incorporated into the splitter design, enabling the most stringent and space constrained environments in which a large chief-ray angle is required.

How sensitive is the performance to angle of incidence?

The nanophotonic structure is designed to operate across a defined angular range, allowing stable performance under off-axis illumination. The acceptable range depends on the specific design and can be adapted to match system requirements.

Does the architecture introduce vignetting or color shading effects?

As with any imaging system, lens-induced shading and angular effects may be present. These can be characterized and corrected using standard calibration techniques. The color-splitting architecture does not introduce additional dominant shading mechanisms beyond those already present in the optical system.

How does the architecture impact dynamic range and exposure behavior?

By increasing the number of photons reaching the pixel, the architecture improves signal levels across the operating range, which can support improved effective dynamic range under many conditions. The exact impact depends on pixel design parameters such as full-well capacity and readout characteristics, which remain part of the underlying sensor implementation.

Does the architecture impact full-well capacity or intrinsic pixel noise?

full-well capacity and intrinsic noise characteristics are determined by the underlying pixel design and remain unchanged. The advantage of eyeo's architecture comes from increasing the number of photons converted into signal, which improves effective signal-to-noise performance without modifying the fundamental pixel properties.

8. Conclusion: Rethinking the sensor

For 50 years, every image sensor ever built has been 70% blind.

eyeo changes that. Nanophotonic Color-Splitting is the first filter-free architecture to recover the light that conventional sensors have always discarded.

90% of what the human brain processes is visual, and for physical systems and AI, the same logic applies. What the sensor captures sets an absolute limit on everything that follows.

3 times more light and smaller sensors mean fundamentally more accurate diagnoses, memories preserved, defects caught, safer roads, life-changing discoveries. It means AI that perceives the world as it is, not an approximation of it.

The next generation of smart cities, drones, XR devices, medical devices, mobile phones, and physical AI systems can be built without the compromises that have defined the category until now.

7 years of R&D at imec, Europe's leading semiconductor research center. 26 granted patents. Process established at commercial foundries. eyeo's sensors are now coming to market with a vision to advance humanity with perfect visual intelligence.

Get in touch

eyeo the future of imaging

eyeo is redefining imaging with the world's most advanced nanophotonic color-splitting technology. For the first time, image sensors can capture all incoming light, overcoming the 70% light loss imposed by decades-old color filter technology. Instead of filtering photons, eyeo's technology guides them directly to individual pixels, unlocking full light sensitivity and native color fidelity in any condition. Compatible with any CMOS sensor platform, eyeo enables sub-0.5-micron pixels for ultra-compact, high-performance imaging where image quality is critical. eyeo is headquartered at High Tech Campus Eindhoven (NL), with a sensor design center in Antwerp (BE).

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