Unlocking the Hidden Spectrum: Sony SWIR™ Imaging Solutions with Macnica

Executive Summary

Short-wave infrared (SWIR) imaging is opening new frontiers in inspection, sensing, and monitoring. Operating in the 1100 nm to 2,500 nm spectrum, SWIR imaging enables visibility into features invisible to conventional silicon-based sensors, whether detecting cracks in semiconductors, sorting agricultural products, or visualizing heat and moisture patterns.

Sony has advanced this field with its **SenSWIR™ family of sensors**, which combine visible and SWIR sensitivity in a single device. With broadband coverage from 400 nm to 1,700 nm, SenSWIR eliminates the need for dual-camera systems and simplifies integration. It delivers higher resolution and reliability through innovations like Cu-Cu bonding and low read noise architectures.



In the image above, note how the shoreline below stands out, and captures more detail than a visible camera.

Source: https://www.sensorsinc.com/applications/general/imaging-through-haze

As the strategic distribution partner for Sony image sensors in the Americas, **Macnica Americas** goes beyond supplying components. We provide a complete solution ecosystem sensor evaluation, optical, and processing integration, design services, and supply chain reliability. Customers can benefit from faster time-to-market, reduced engineering risk, and the assurance of building on proven technologies.

Call to Action:

For organizations developing machine vision systems, industrial inspection platforms, or advanced imaging applications, Macnica is the ideal partner to bring together all the elements of a successful solution. Contact Macnica Americas today to learn how we can help you leverage Sony SWIR sensors and our expertise to achieve your goals.

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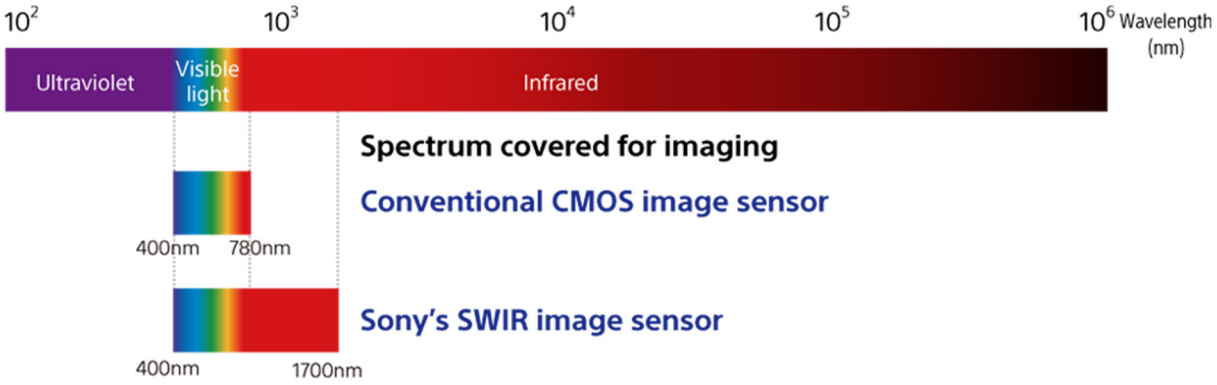
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1. Understanding SWIR Imaging

What is SWIR?

Short-wave infrared (SWIR) light lies just beyond the visible spectrum, spanning roughly from **1100 nm to 2,500 nm**. While invisible to the human eye, SWIR offers unique imaging capabilities because of the way these wavelengths interact with different materials. Unlike visible light, which is either absorbed or reflected at the surface, SWIR can penetrate certain substances—revealing features hidden from standard imaging systems.



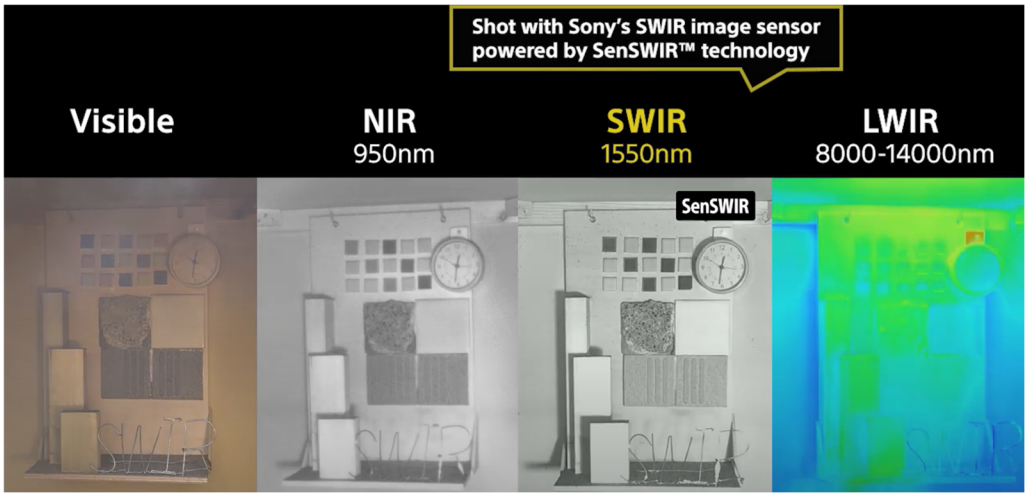
** Source – Sony Semiconductor - https://www.sony-semicon.com/en/solution-proposal/swir-for-firefighting.html?utm_source=chatgpt.com*

For example:

- **Silicon wafers** appear opaque to visible light, but SWIR wavelengths pass through, enabling inspection of internal structures and defects.
- **Plastics, glass, and packaging films** can become semi-transparent in the SWIR range, allowing cameras to confirm package contents or detect contaminants.
- **Moisture and organic compounds** have distinct absorption peaks in the SWIR spectrum, which enables applications such as food quality inspection or vegetation health monitoring.

Short vs. Long SWIR

- **Shorter SWIR (1,100–1,700 nm):** Behaves similarly to visible light by reflecting off surfaces, making it ideal for inspection, material sorting, and agricultural imaging.
- **Longer SWIR (1,700–2,500 nm):** Overlaps with the thermal emission spectrum, enabling detection of heat signatures and providing visibility through smoke, haze, or fog.



Source: https://www.sony-semicon.com/en/products/is/industry/swir.html

This dual capability, reflective imaging at shorter wavelengths and emissive imaging at longer wavelengths, makes SWIR one of the most versatile sensing technologies in the electromagnetic spectrum.

Why SWIR Imaging Matters Now

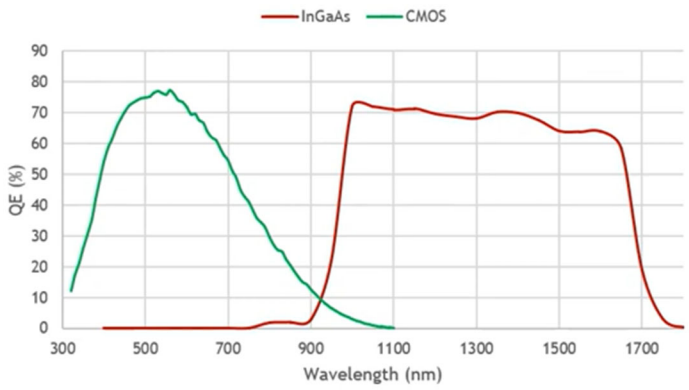
Historically, SWIR sensors have been bulky, expensive, and limited to specialized markets like defense or aerospace. However, advances in sensor design, led by Sony's SenSWIR™ technology, are bringing SWIR imaging into mainstream industrial and commercial applications. Higher-resolution, lower-noise sensors combined with improved affordability are enabling new use cases in **semiconductors, food safety, automotive, medical, and security**.

2. Sony SenSWIR™ Technology: Industry-Leading Performance

The Challenge with Conventional SWIR

Traditional SWIR sensors are based on Indium Gallium Arsenide (InGaAs). While effective in certain ranges, they come with challenges:

- **Limited spectral coverage:** Standard InGaAs sensors are typically sensitive from about 900–1,700 nm, leaving a gap in visible and near-IR regions.
- **Complex integration:** Conventional SWIR systems often require a dual-camera setup—one silicon-based sensor for visible and one InGaAs sensor for SWIR—driving up cost and size.
- **Pixel limitations:** Older bump-bonded InGaAs sensors suffer from large pixel sizes, dead pixels, and limited resolution.
- These constraints have historically limited SWIR imaging to high-cost, specialized applications.

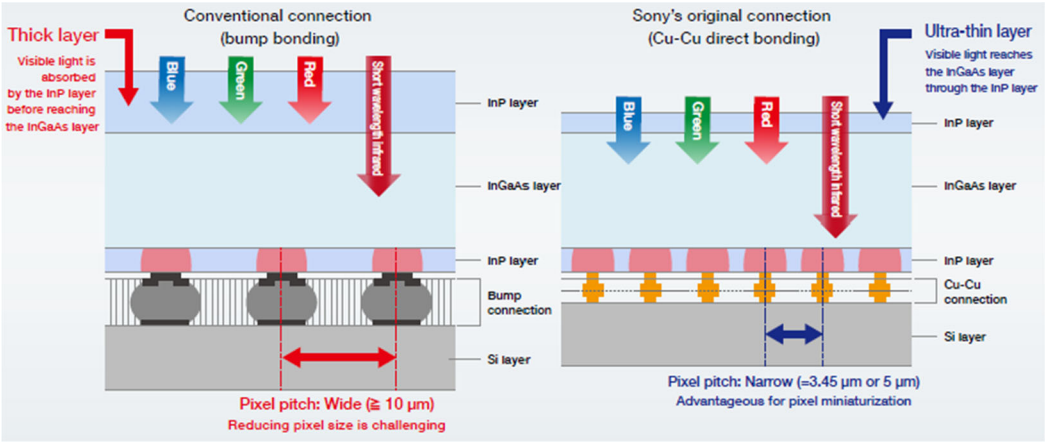


Source: Lucid Vision Labs

Sony's SenSWIR Breakthrough

Sony has redefined the SWIR sensor market with its **SenSWIR™ CMOS image sensor family**, addressing these challenges through key innovations:

1. **Broadband Sensitivity (400–1,700 nm)**
    - A single sensor that covers visible, NIR, and SWIR, reducing system complexity.
    - Eliminates the need for dual-camera setups.
    - Enables new multi-spectral imaging capabilities with simple filter configurations.
2. **Cu-Cu Bonding Technology**
    - Instead of indium bump bonding, Sony employs **copper-to-copper bonding**.
    - Allows for smaller pixel pitch (down to **3.45 µm** in IMX992/IMX993).
    - Results in higher resolution sensors (up to **5.32 MP**) while maintaining compact sensor formats.
    - Improves operability and reliability with >99.5% effective pixels.



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3. **Lower Noise and Better Image Quality**
    - Built-in features like **Dual Read Rolling Shutter (DRRS)** reduce read noise at the sensor level.
    - Minimizes the need for heavy post-processing.
    - Provides clearer images in low-light and high-dynamic-range conditions.
4. **Digital Integration**
    - SenSWIR outputs **digital signals directly**, reducing camera design complexity compared to analog-based SWIR sensors.
    - Easier system integration into modern FPGA, SoC, or AI-based platforms.

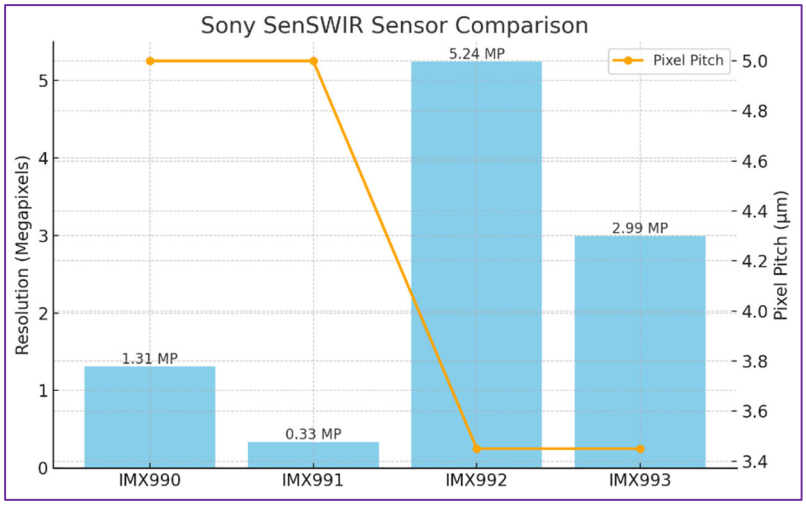
Sensor Lineup

- **IMX990 & IMX991:**
    - 5 µm pixel pitch, resolutions up to 1.3 MP.
    - Compact options for cost-sensitive or space-constrained designs.
- **IMX992 & IMX993:**
    - 3.45 µm pixel pitch, up to 5.32 MP resolution.
    - Ideal for high-precision inspection and advanced imaging systems.

Why This Matters for Customers

Sony SenSWIR sensors enable a new class of applications by delivering **compact, cost-efficient, high-resolution imaging across visible to SWIR**. For customers, this means:

- **Smaller cameras with broader capability.**
- **Fewer components and simpler designs.**
- **Lower overall system cost.**
- **Improved image quality and operational reliability.**

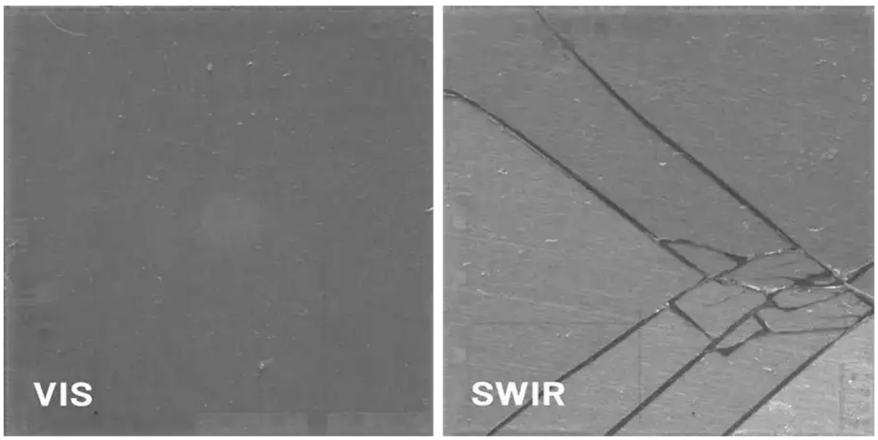


3. Applications of SWIR Imaging

Semiconductor Inspection

Semiconductors are a natural fit for SWIR because **silicon becomes transparent at wavelengths beyond 1,100 nm**. This allows inspection of wafer thickness, crack detection, and analysis of buried structures invisible to visible light.

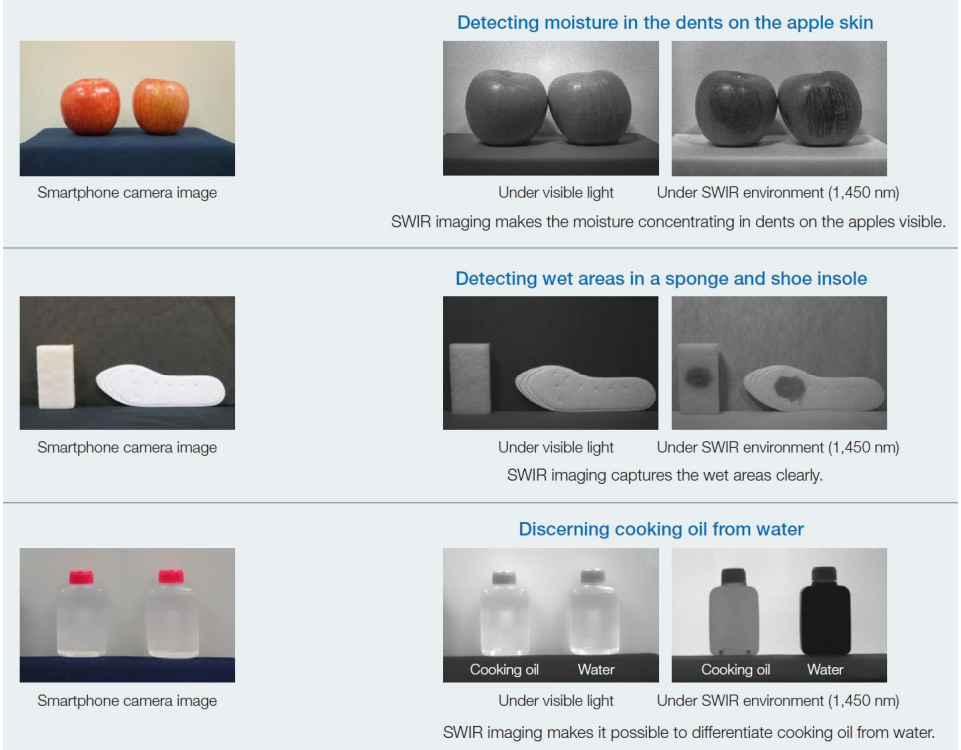
- **Sony SenSWIR Advantage:** With resolutions up to **5.32 MP** (IMX992), manufacturers can achieve finer defect analysis, improving yields and reducing costly scrap.
- **Macnica's Role:** We provide evaluation kits and SLVS-EC receiver IP to accelerate sensor integration, while also offering optical design support for precise wafer inspection tools.



Food & Agriculture

Moisture content, bruises, or contaminants in food often go undetected in visible light but stand out clearly in SWIR.

- **Use Cases:**
  - Identify bruises beneath fruit skins.
  - Detect foreign objects like stones, dirt, or plastic.
  - Monitor crop health using reflectance signatures (healthy plants reflect more SWIR than stressed vegetation).
- **Sony SenSWIR Advantage:** Single-camera systems that span visible and SWIR enable simultaneous visual inspection and moisture/contaminant detection.
- **Macnica's Role:** We help design complete machine vision solutions, including lenses, lighting, and processing modules, to simplify food-safety automation.



Safety, Security & Environmental Monitoring

SWIR has unique capabilities for safety and environmental monitoring:

- **Fire Detection:** Alcohol flames, often invisible in daylight, glow brightly in SWIR.
- **Haze/Smoke Penetration:** SWIR's longer wavelengths cut through scattering, enabling vision in wildfire monitoring and foggy environments.
- **Night Vision:** SWIR sensors detect "night glow" (natural infrared background light) and can visualize invisible lasers at 1,550 nm
- **Sony SenSWIR Advantage:** Low-noise sensors with broad sensitivity improve clarity in these demanding conditions.



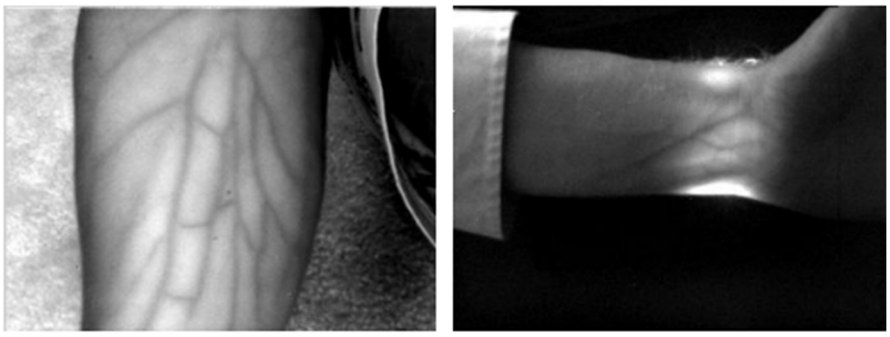
Source: EU Space Imaging - https://www.euspaceimaging.com/wp-content/uploads/2018/06/EUSI-SWIR.pdf

- **Macnica's Role:** We collaborate with OEMs and integrators to adapt Sony SWIR sensors into surveillance systems, drones, and environmental monitoring platforms.

Medical & Life Sciences

Biomedical imaging benefits greatly from SWIR's ability to penetrate tissue and enhance contrast.

- **Applications:**
  - Vein visualization for surgery or diagnostics.
  - SWIR fluorescence imaging using FDA-approved dyes
  - Small animal imaging for research.
- **Sony SenSWIR Advantage:** Broadband sensitivity enables multimodal imaging—visible plus SWIR—without needing multiple sensors.



On the left is a broadband top-illuminated forearm image taken with SWIR InGaAs camera showing surface veins; on the right is a trans-illuminated image of a wrist showing veins and arteries (bones can be relatively transparent at these wavelengths).

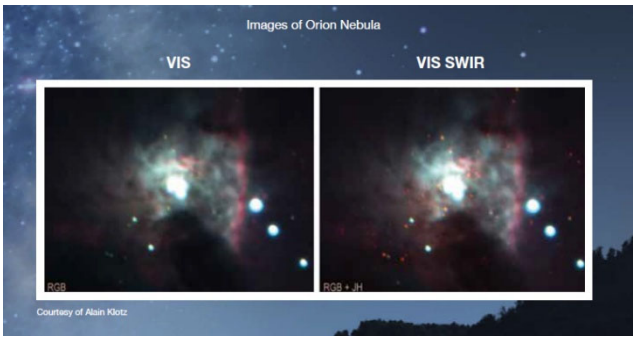
- **Macnica's Role:** Beyond supplying sensors, we advise on optical path design and processing integration to accelerate research and device development.

Laser & Industrial Applications

Astronomy & Research

SWIR imaging is increasingly used in astronomy to study cool stars, dust-obscured galaxies, and exoplanets.

- **Sony SenSWIR Advantage:** Broadband sensitivity allows overlap with visible data while adding deep insights at the J-band and H-band.
- **Macnica's Role:** Providing academic and commercial researchers with access to Sony's sensors and the integration expertise needed for specialized instruments.



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4. Macnica Americas, More Than a Distributor

Macnica helps customers **design, integrate, and launch** complete SWIR imaging solutions, not just select a sensor. Think of us as the glue between Sony's SenSWIR technology and your finished product.

How we help

- **Application scoping**, map your inspection or sensing task to the right wavelength bands, optics, and sensor
- **Sensor selection and evaluation**, IMX990, IMX991, IMX992, IMX993, with eval guidance, ROI modes, trigger and interface setup
- **Optics and filters**, lens guidance for 400 to 1700 nm, multiband filters for simple multispectral capture, illumination advice for LEDs or halogen
- **Processing and interfaces**, help with SLVS or MIPI bring-up, data pipeline, frame grabbers, FPGA or SoC selection, SDK integration
- **Calibration and image quality**, NUC, bad pixel map, linearity and gain tuning, DRRS usage strategies
- **Prototyping to production**, BOM hardening, supply planning, warehousing, and ongoing support

Why it matters

- One partner for sensor, optics, processing, and integration
- Faster time to a working demo, then to production
- Lower design risk and cleaner scaling as you add new features

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SWIR camera design considerations, practical checklist

Lenses and coatings. Select glass types and coatings designed for 400 to 1,700 nm. Verify MTF at your wavelengths and f-number, confirm focus shift between visible and SWIR if using the same lens across bands.

Filters. Short pass, bandpass, long pass to control contrast. Examples, 1,550 ± 50 nm for laser work, 1,500 nm long pass for Si wafer backlighting, multi-band cover glass for simple multispectral acquisition, paired with multi-frame ROI on SenSWIR.

Illumination. SWIR LEDs or halogen for inspection lines, manage ambient light, for indoor benches consider darkened environments with controlled SWIR sources.

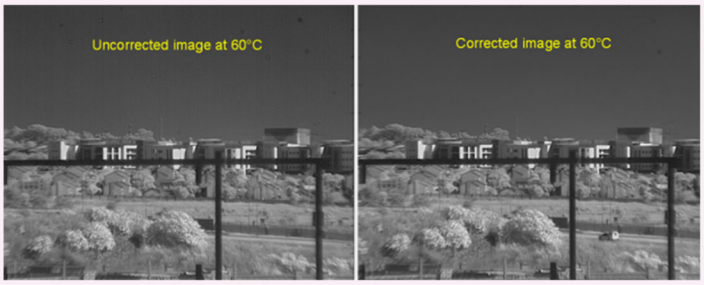
Thermal management. Sony SenSWIR sensors may come with built-in TEC to support on-sensor features that reduce noise, where system cooling still matters.

Image signal processing. Plan for NUC, bad pixel replacement, fixed pattern noise handling. Calibrate gain, offset, and linearity for your band and exposure. Use DRRS correctly where applicable to reduce read noise.

Windows and cover glass. Visible sensors often use BK7, SWIR systems commonly use sapphire or materials specified for SWIR to maintain transmission and durability.

Interfaces and data path. Validate SLVS or MIPI bring-up, ensure frame grabber or FPGA bandwidth for your resolution and frame rate, verify ROI strategies for multispectral capture.

Safety. For laser work, account for attenuation and ND filters to protect the sensor, follow eye-safety practices around laser sources.



Sample images before and after Non-Uniformity Corrections. Source: Goss, T, et.al. SWIR sensor design considerations. Hensoldt Optronics

Macnica's role. Selection of lenses and filters, illumination design, thermal and ISP recipes, interface support, evaluation to production support.

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5. End-to-End Solution Example

Case Scenario: Semiconductor Inspection

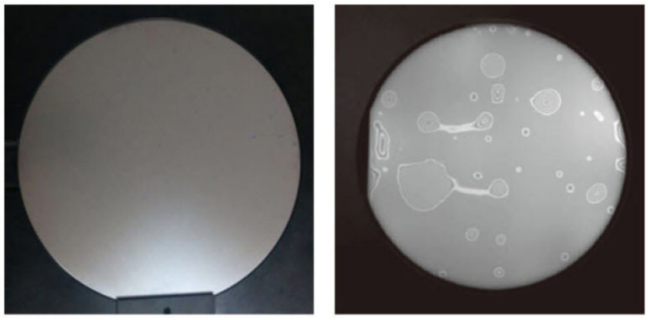
A global semiconductor manufacturer needed to improve wafer defect detection and metrology. Traditional visible-light systems could not see internal cracks or bonding defects, leading to lower yields and costly scrap.

The Solution:

- **Sensor Selection:** Macnica recommended the **Sony IMX992 SenSWIR sensor**, offering 5.32 MP resolution with 3.45 µm pixel pitch.
- **Evaluation & Integration:** Using Macnica's evaluation kit, the customer rapidly validated the sensor in a prototype inspection system.
- **Optics & Illumination Guidance:** Macnica advised on lens coatings and SWIR backlighting optimized for 1,550 nm, enabling defect visualization inside stacked silicon wafers.
- **System Optimization:** Our engineering team advised with calibration and noise reduction, applying best practices in non-uniformity correction and DRRS utilization.

The Result:

- Defects and micro-cracks previously missed were identified with clarity.
- Wafer yields improved by measurable percentages, reducing waste and increasing throughput.
- The customer accelerated deployment by months, saving both development cost and time-to-market.



SWIR through a good wafer | Void inside

Source: https://rjwilson.com/swir-imaging-101-what-can-it-do-for-you/

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6. Call to Action

SWIR imaging is no longer limited to high-cost, niche applications—it is rapidly becoming essential across industries like semiconductors, food safety, agriculture, medical imaging, and environmental monitoring. **Sony SenSWIR image sensors** deliver unmatched performance across the Visible-to-SWIR spectrum, while **Macnica Americas ensures you have the expertise and ecosystem to succeed**.

Why Partner with Macnica?

- Access to the **latest Sony SenSWIR technology**.
- **Solution-focused engineering support** from evaluation to production.
- **Complete ecosystem guidance**—sensors, optics, filters, processing, and integration.
- **Reliable fulfillment** with U.S.-based warehousing and supply chain confidence.

Next Steps:

Contact Macnica Americas to explore how Sony SWIR technology and our solution-driven approach can help you accelerate innovation, reduce development risk, and achieve your imaging goals.



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