Optical Precision in the Field: Tactical Targeting Operations Source: FISBA

Andreas Kunz / Roman Szatkowski

EMERGENT TECHNOLOGIES ENABLING NEW SWIR APPLICATIONS

Short-Wave Infrared (SWIR) imaging is a rapidly advancing technology operating in the wavelength range of approximately 1400 nm to 2500 nm, bridging the visible (VIS) / near infrared (NIR) and thermal infrared spectra. By capturing light beyond the visible range, SWIR sensors reveal details invisible to standard CMOS sensor-based cameras, making them indispensable for military and defense applications. SWIR cameras play an increasingly important role in ISTAR (Intelligence, Surveillance, Target Acquisition, and reconnaissance). This is thanks to the ability to see through fog and smoke, imaging in low light conditions (using "night glow"), and the capability to differentiate substances through their unique absorption characteristics.

Enhancing multispectral imaging with AI: Weighted fusion from VIS to LWIR for tactical superiority

More recently, two major steps in technology enhanced the application space: quantum dot sensors and AI in image processing. While long-established InGaAs sensors cover the range of wavelengths from 900nm to 1700nm, quantum dot sensors can cover a much broader range from visible up to wavelengths beyond 1700nm.

The challenge is how to use that much information from three different wavebands: VIS, NIR, and SWIR, each having its specific advantages. And how to even integrate the image information from a thermal infrared (LWIR, long wave infrared) camera?
For this task, artificial intelligence (AI) comes into play. AI significantly enhances multispectral imaging by expertly integrating and analyzing data across spectral bands from VIS to LWIR. AI meticulously sifts through these bands, assigning weighted importance to each based on its unique contribution, to efficiently extract precise, mission-critical information.

In military applications, AI uses VIS for contour and color recognition, SWIR for material-specific reflectance patterns, and LWIR for thermal signatures. Fusing these inputs creates a high-fidelity environmental image that reveals subtle anomalies like chemical residues or hidden objects. The SWIR channel sensors also detect hostile laser emissions beyond the CMOS range while overlaying visible-spectrum imagery.

From VIS to SWIR in one assembly: Challenging Optical Requirements

The recent advances in SWIR sensors regarding performance and costs lead to an ever-increasing demand of specific lens assemblies in the SWIR range. Small form factor and low weight are often crucial in defense applications. That's why it is an advantage if one lens system can be used to cover all wavebands from VIS to LWIR.

Such ultra-broadband lens assemblies are applied in two different setups: 1. In combination with a quantum dot sensor, which covers VIS to SWIR. 2. In front of a beam splitter, which splits the image from the lens assembly between VIS+NIR and SWIR. The VIS+NIR image is then projected onto a CMOS sensor while the SWIR image is projected onto an InGaAs sensor. In this case, the many years of experience with beam splitters at FISBA come into play. However, defense applications demand more than just high image quality across broad spectral ranges. Key requirements include:

- Temperature stability
- Shock resistance
- Robustness and durability
- Compact size and low weight (particularly for airborne and soldier-carried systems)

Manufacturing technologies and capabilities for SWIR optical systems

FISBA develops high-precision optical systems tailored to customer requirements. Close collaboration ensures a clear understanding of specifications, while integrated engineering and manufacturing teams drive technical innovation.
Producing high-performance assemblies relies on a broad spectrum of design and manufacturing technologies, including:

- **Optomechanical design**, translating application requirements into optical specs and designing color-corrected, and athermalized diffraction limited systems.
- **Grinding and polishing** of optical glass for flat optics and lenses, both spherical and aspherical.
- **Precision glass molding** technology, allowing high precision glass aspheres at economically feasible costs in mid to high-quantity applications.
- **Advanced coating technologies**, allow for durable coatings acting as anti-reflective-, filter-, mirror, or beam splitter coating.
- **Cementing** of lenses and prisms
- **High-precision mechanical housing**, plays a very specific role, especially when it comes to the athermalization of optical assemblies.
- **Assembly process** including active alignment and alignment turning

The package of all these capabilities enables optical assemblies that use the full potential of today's SWIR sensors, optionally combined with VIS and NIR sensors. As a result, they allow the required DRI (Detection, Recognition, Identification) values in harsh environmental conditions. SWIR is and will continue to be a game changer in drones, handheld devices, and land-based systems.

FISBA AG, CH
https://www.fisba.com

Making the Invisible Visible
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