THERMAL IMAGING OPTICS
FOR DEFENSE APPLICATIONS
YOUR OPTICS PARTNER FOR MISSION SUCCESS
Ophir IR Optics is a leading provider of high-performance IR optical elements and assemblies for advanced defense thermal imaging applications. Ophir offers over 40 years of experience in the most advanced Electro-Optics programs, developed by the leading global defense OEMs. These partnerships have resulted in unmatched capabilities, reliability, knowledge, and solutions that serve major defense platforms worldwide.

With decades of knowledge and experience, having designed and delivered thousands of thermal imaging optics for multiple defense applications, Ophir has earned its reputation as a world-leading, one-stop-shop designer and manufacturer of Infrared thermal imaging components for defense OEMs.

Our R&D engineering team works in collaboration with defense customers to develop, design and deliver high-performance optics, delivering solutions for high precision and environmentally challenging applications, answering the strict demands of defense customers worldwide, enabling today’s most advanced aerospace and defense solution deployments.

Applications served

- **Ground-based**: Enhanced Vision Systems (EVS), Driver Vision Enhancement (DVE), Situation Awareness Systems (SAS), Remote Controlled Weapon Stations (RCWS), Tank Gunner/ Commander Sight, Thermal Goggles, Thermal Weapon Sight (TWS), Hand-held Thermal Imagers (HHTI)
- **Airborne**: Unmanned Aerial Vehicles (UAV), Payloads and Forward-Looking IR Cameras (FLIR)
- **Naval**: Surveillance, Targeting
- **Missiles**: Optical build-to-print components for IR guided missiles, including domes, mirrors and Cassegrain telescopes.

**Your Optics Partner for Mission success**

- **Build to Print (BTP)**
  - Customized Infrared Optical Components

- **Build to Spec (BTS)**
  - Customized Infrared Optical Components

- **Widest Selection of Catalog Products (COTS)**
Build-To-Spec (BTS) & Build-to-print (BTP) expertise

With decades of knowledge and experience, having designed and delivered thousands of infrared components in the LWIR, MWIR or SWIR wavebands for multiple defense applications, Ophir has earned its reputation as a world-leading, one-stop-shop designer and manufacturer of Infrared thermal imaging components for defense OEMs.

Advanced optical design technologies and innovative engineering are applied to our build-to-specification (BTS) development processes, allowing us to reach efficient design results with fewer elements, lighter components, and reduced-cost.

These same advanced capabilities and expertise are combined with cutting-edge manufacturing technologies such as MRF technology, diamond-turning machines, CNC generators and polishers, automated coating chambers, and advanced metrology and test equipment, to create our build-to-print (BTP) component and assemblies, including aspheric, diffractive and spherical lenses, mirrors, domes, windows and prisms.

Widest IR assemblies product range

Our range of long-lasting products includes IR complex lens assemblies with various focus mechanisms:

- Fixed
- Manual
- Motorized focus
- Continuous zoom

From LWIR, MWIR to SWIR we excel in the production of the following product configurations:

- Single Field-of-view (FOV)
- Multiple FOV
- Zoom

Our knowledge and experience in motorized continuous zoom lens systems is recognized by customers around the world.

Meeting defense market strict demands

We harness innovative designs to provide largest-portfolio products with field-proven performance, answering the strict demands of global defense customers for:

- Lightweight, compact designs answering the strict SWaP restraints
- Ruggedized design for durability in harshest environmental conditions
- Outstanding detection, recognition, and identification (DRI) ranges >28km
- Accurate Line on Sight (LOS)
- High precision optics with MTF close to the diffraction limit
- Focal length ranges from 1.8mm to 1350mm

STRICT QUALITY ASSURANCE (QA) PROCESSES

With rigorous QA testing throughout the production process, we ensure that any finished product is optimized for the defense market requirements with the highest performance requested.

From design to delivery, our material control, in-process testing, operator inspections and final inspections all ensure that Ophir products meet the highest specifications and quality standards.

<table>
<thead>
<tr>
<th>SupIR 80-1200mm f/5.5</th>
<th>SupIR 50-1350mm f/5.5</th>
<th>SupIR 60-1200mm f/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 26km detection range</td>
<td>&gt; 26.5km detection range</td>
<td>&gt; 28km detection range</td>
</tr>
<tr>
<td>* For 15μm pixel pitch</td>
<td>* For 15μm pixel pitch</td>
<td>* For 10μm pixel pitch</td>
</tr>
</tbody>
</table>
Our in-house testing tools are encompassing all required specifications and include the following:

**Standard Compliance**

- AS9100 Rev. D and ISO 9001:2015 certified
- Compliant with RoHS standards
- QMS SAP Information System
- LEAN management methods across all company functions

**Radiation**
- Test glass
- IRS
- Computerized SAG Device

**IRR**
- Interferometers 0.633, 3.39 and 10.6μ
- CGH
- Twyman Green
- Aspheric Interferometer VFA
- Lumpho Scan
- Profilometers technology

**Roughness**
- Optical Profiler New View
- Profilometers Talystrat

**Angle**
- Goniometer Prism Master
- FTIR Perkin Elmer Cary
- UV, VIS and NIR

**Environmental**
- Humidity
- Salt spray
- Salt Solubility
- Adhesion
- Abrasion
- Wiper
- Temperature cycles
- Chemical Attack

**Production & Engineering**
- First Article Inspection (FAI)
- Suppliers management & STS (ship to stock) status
- Quality processed and manuals
- Self inspection of production process & quality validation
- Final inspection based on SAP

**Capability Improvement & RMA**
- Six Sigma Green Belt problem-solving method
- Define, Measure, Analyze, Improve, Control (DMAIC) problem-solving method
- 8D failure analysis
Detection, Recognition & Identification (DRI) performance

Cooled MWIR, 10µm pixel size detector*

Cooled MWIR, 15µm pixel size detector*

* Assumptions: 23mK NETD (f/4 & f/5.5) | 30Hz frame rate | 50% detection probability
Uncooled LWIR, 17 µm pixel size detector

Note: Calculation used are based on "Johnson Criteria" | Real world performance may vary depending on the weather conditions
* Assumption: 50mK NETD (f/1.2 – f/1.6) | 30 Hz frame rate | 50% detection probability
COMPONENTS MANUFACTURING EXPERTISE MEETING ANY SPECIFICATION

- Manufacturing large size mirrors, lenses, mirrors, domes, windows, and prisms, supporting multispectral optics and emerging applications.
- VIS to LWIR wavelengths.
- Spherical, aspherical, diffractive, flat, and free-form shapes.
- Doublets or triplets
- Substrates: BK7, Fused-Silica, Zerudor, Chalcogenides, Germanium, Silicon, Calcium Fluoride, Zinc selenide, Zinc sulfide cleartran, Copper, Aluminum and more

Core capabilities
- In-house, cutting-edge manufacturing technologies:
  - MRF technology
  - Lupho Scan Profilometers technology
  - Diamond turning
  - CNC polishing
  - Coating
  - Metrology
- Highest development standards including Design for Manufacturability and Assembly (DFMA) as well as highest production standards including risk analysis.
- Complete control of production processes
- Statistical Process Control (SPC) over full production cycle
- Innovative engineering
- Large volume high-end production capabilities
- Manufacturing sites in Israel and Europe (Romania) with a clean room for the coating, inspection and packing processes.

Superior components manufacturing
- 5-400mm diameter components fabrication and coating
- Free form optics manufacturing and metrology
- Variety of Chalcogenide glasses
- Large Silicon lenses > Ø300mm
- Large Aluminum mirrors for Cassegrainian telescopes
- Tolerances (Typical | high-end):

<table>
<thead>
<tr>
<th></th>
<th>Windows</th>
<th>Lenses</th>
<th>Mirrors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensional</td>
<td>± 0.05mm</td>
<td>± 0.01mm</td>
<td>± 0.05mm</td>
</tr>
<tr>
<td>Surface figure (P-V)</td>
<td>Flatness 0.5</td>
<td>0.2Fr</td>
<td>Spherical Power 2Fr</td>
</tr>
<tr>
<td></td>
<td>Irregularity 0.2</td>
<td>0.1Fr</td>
<td>Irregularity 0.5Fr</td>
</tr>
<tr>
<td>Parallelism</td>
<td>3</td>
<td>5 arc sec.</td>
<td>3</td>
</tr>
<tr>
<td>Surface quality (S-D)</td>
<td>80-50</td>
<td>10-5</td>
<td>80-50</td>
</tr>
<tr>
<td>Roughness nm, RMS</td>
<td>2</td>
<td>0.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 3: Ophir’s selected components: mirrors, domes, truncated shapes, prisms
Advanced optical coatings

Coating types:
- Anti-reflective (AR), Mirrors and Filters
- UV, VIS, NIR, SWIR, MWIR, LWIR
- Multispectral coatings
- High efficiency and high durability coatings
- DLC (HC) coatings and Low Reflectance HC (LRHC)
- Laser coatings for 1.064µ and 10.6µ
- EUV coatings

Coating performance:
- Broadband AR:
  - Ref<0.5% to 0.2%
  - Tra >98% to 99%
- Broadband mirror: Ref>98% to 99%
- Windscreen Wiper Test TS1888 / P 5.4.3 – DLC coatings

Figure 4: Ophir’s 1,000 clean room coating chambers
About Ophir IR Optics
With decades worth of knowledge and experience, Ophir Optronics Solutions LTD., Infrared Optics, an MKS Company (NASDAQ: MKSI), is a world-leading designer and manufacturer of high performance IR thermal lenses and optical elements for SWIR, MWIR & LWIR imaging. Using advanced technologies, innovative engineering, and design configurations, Ophir provides a global solution for homeland security, surveillance, commercial and defense applications: IR Components and complex lens assemblies with fixed or motorized focus and zoom lenses.