IR Optics for Long Range Security & Surveillance Applications

EPIC Photonics Technology Summit, San-Francisco 2020
Ophir Optics Group
Dr. Kobi Lasri, GM
Outline

• Introduction
  • Company Overview
  • IR Thermal Imaging trends and application drivers
• Advanced IR Long-Range Continuous Zoom Lens Solutions
  • Lightweight zoom lenses
  • Folded-optic, long focal-length zoom lenses
• Summary
MKS helps the most innovative companies in the world

**SOLVE COMPLEX PROBLEMS**

**MARKET LEADER**

MKS is a leading global provider of process control solutions for

- Semiconductor
- Industrial Technologies
- Life & Health Sciences
- Research & Defense

**STRATEGIC GROWTH**

- Q1 2019 – acquired Electro Scientific Industries (ESI)
  - Leader in laser-based manufacturing for the micro-machining industry
- Q2 2016 – acquired Newport Corporation
  - Leader in sophisticated laser, light and motion products

**INNOVATIVE SOLUTIONS**

- Vacuum Processing
  - Pressure measurement & control, flow, power, reactive gas analysis, automation
- Laser Solutions
  - Precision laser applications
- Motion, Photonics & Optics
  - Vibration & performance motion control, gratings & optics, laser measurement
- Laser-Based Process Equipment
  - Advanced PCB, Semi & component manufacturing

**KEY FACTS**

- Founded: 1961
- HQ: Andover MA
- IPO: 1999 (NASDAQ MKSI)
- Selling in 60+ countries
- In 2018*
  - Sales: $2.45B
  - Employees: 5,600+
  - R&D: 900+
  - R&D Spend: $170M
  - Worldwide Patents: 2,500+
Ophir Optics – World Class Infrared Optics

**COMMERCIAL**

- Ophir’s IR optical components and assemblies for thermal imaging are integrated in a variety of commercial applications.
- Offering innovative cost-effective solutions for high-volume, lightweight, infrared optics

**DEFENSE**

- Leading provider of high quality IR optical components and assemblies for sophisticated military applications.
- Decades of experience in meeting manufacturing defense standards

**INDUSTRIAL**

- Industrial laser customers include laser processing machine manufacturers and end users.
- Providing optical components and assemblies with high damage threshold capabilities for high-power 1µm and CO₂ laser processing

**AUTOMOTIVE | SECURITY & SURVEILLANCE**

**AERIAL | MARITIME**

**SECURITY & SURVEILLANCE | WEAPON SIGHTS**

**MISSILES**

**LASER MATERIAL PROCESSING**
Ophir Optics Solutions

IR THERMAL IMAGING OPTICS

IR Optical Components:
- Lenses, mirrors, prisms, windows

IR Optical Assemblies:
- Manual and Motorized zoom IR lenses
- Lenses for SWIR, MWIR and LWIR cameras

LASER OPTICS

- **Optics for CO2 lasers**: focusing lenses, mirrors
- **Optics for 1μm lasers**: protective windows, spherical and aspheric lenses, collimating and focusing assemblies
<table>
<thead>
<tr>
<th>Technology Leader</th>
<th>Comprehensive Portfolio</th>
<th>Vertical Integration</th>
<th>Quality &amp; Testing</th>
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<tr>
<td>• Recognized leader in delivering innovative, high quality and reliable optomechanical solutions</td>
<td>• Diversity of optical components and assemblies for the commercial, defense, and industrial markets</td>
<td>• A one-stop-shop from design, diamond turning, polishing, coating, assembly, and testing</td>
<td>• Recognized for the highest quality products</td>
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<td>• With over 40 years of experience</td>
<td>• Multiple FOV &amp; continuous zoom lenses for SWIR, MWIR &amp; LWIR</td>
<td>• Capacity to deliver at high volumes</td>
<td>• Testing and inspection at every phase of the process to ensure full customer satisfaction</td>
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<tr>
<td>• Cutting-edge design and manufacturing capabilities</td>
<td>• Spherical, aspheric, flat, diffractive, and free-form</td>
<td></td>
<td>• AS 9100 Rev. D and ISO 9001-2015 certified</td>
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<tr>
<td>• Military credibility highly valued in commercial markets</td>
<td>• UV to LWIR wavelengths</td>
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IR Commercial Applications

Surveillance

Homeland Security • Border Control • Perimeter Security

Maritime

(25-150mm f/1.4)
(26-105mm f/1.6)

(7.5mm f/1.4)

(20-275mm f/5.5)
(26-105mm f/1.6)

Enhanced vision systems
(15.5mm f/1.5)

Drones
(20-275mm f/5.5)

Aerial

MKS CONFIDENTIAL
Ophir is a leading provider of high volume optical assemblies for automotive thermal sensing cameras.

Such cameras excel in driving situations where other sensor technologies are challenged, including low-visibility, high-contrast conditions, and challenging weather conditions including fog.

Excellent for detecting pedestrian and wildlife.
IR Defense Applications

Unmanned aerial vehicles (20-275mm f/5.5)

Forward looking IR camera (28-850mm f/5.5)

Remote control weapon station (45/135mm f/1.6)

Thermal weapon sight (40mm f/1.0)

Tank gunner/ commander sight (19-275mm f/5.5)

Thermal goggles (25mm f/1.0)

Targeting (15-300mm f/5.5)

Surveillance (48.5-700mm f/5.5)
IR Thermal Imaging Trends and Application Drivers (1/2)

- Growing use of small UAVs and Drones
  - Security & Surveillance, HLS, Border Control, ...
  - Requirements for reduced Size, Weight, and Power (SWaP)
  - Increased operational ranges

- Growing use of hand-held lightweight thermal imaging systems

- Growing demand for long-range all-weather security & surveillance

- Need for increased camera resolution and format
  - Sensors have gone to HD
  - Pixels are shrinking to 10μm and the systems become optics-limited
  - Lower SWaP FPAs

- Increased need for multi-spectral capabilities
  - SWIR+MWIR
  - MWIR+LWIR
  - VIS+ IR bands
IR Thermal Imaging Trends and Application Drivers (2/2)

- Self driving cars and ADAS are potentially killer applications for Commercial IR
  - High volume, high performance IR optics
  - Demanding requirements

- Autonomous drones will be the next driver ...
  - Environmental monitoring
  - Infrastructure inspection
  - Emergency services
  - Security
  - ...
How do we address the challenges for IR Optics?

- **Continuous zoom lens design**
  - Can keep high performance with reduced size and weight
  - Smaller and lighter compared to multiple single filed-of-view (FOV) lenses
  - Better mission flexibility, by allowing changes in magnification during operation

- **Innovative optical design**
  - Advanced IR materials with reduced number of elements (athermalization, achromatization, size, and weight)
  - Folded-optic configuration (size and weight)
  - Diffraction-limited design
  - Multi-spectral design

- **Innovative mechanical design**
  - Advanced materials (athermalization, size, and weight)
  - High accuracy
  - Durability to harsh environmental conditions

- **Cutting-edge optical components production**
  - Spherical, aspheric, flat, diffractive, and free-form
  - Large optics manufacturing capabilities
  - High durability (HD) or low reflection hard carbon (LRHC) AR coatings
  - Multis-spectral coating capabilities
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Lightweight Zoom Lenses

- The LightIR continuous zoom lenses incorporate unique, low SWaP design, with reduced number of opto-mechanical elements

- Unique athermalization and achromatization concepts

- Wide operating temperature range -35°C to +70°C

- The F#, focus and MTF characteristics are maintained through the entire zoom and temperature ranges with tight thru-zoom boresight

- Our 20-275mm f/5.5 (264 gr) and 15-75mm f/1.2 (320 gr) zoom lenses enable long operational ranges on constrained platforms with high performance detection, ranging, and identification (DRI) capabilities.

- For example, the detection range of a 2.3m vehicle using the 20-275mm lens would be around 15km(!) when integrated with a 15um pixel detector
Optical performance close to the diffraction limit in the NFOV along the entire image frame. For the WFOV, the image slightly degrades in the peripherals.

High level MTF performance is maintained over the entire zoom range and over the entire operating temperature range.
Folded-Optic, Long Focal-Length-Zoom Lens

Motivation:

- Shorten system overall length while maintaining a long EFL
- Long optical length for reduced sensitivity to tolerances
- Efficient volume utilization
- Compact design
- Ideal for airborne gimbals / constrained platforms

Key Products:

- 16-180mm f/3.6 for MWIR with 640 x 512, **10μ pixel pitch**
- 28-850mm f/5.5 (x30 zoom ration) for MWIR 1280x1024 (HD), 15μ pixel pitch. Optimized for stabilized payloads with accurate LOS capabilities of less than 2 pixels and **>20km detection range**
- 50-1350mm for MWIR 1280x1024 (HD), 15μ pixel pitch. Performance close to the diffraction limit over a detection range of **>25km**
50-1350mm f/5.5 Folded-Optic Continuous Zoom Lens

- MWIR spectral range 3 to 5μ
- HD format 1280 x 1024, 15μ pixel pitch
- The longest focal-length and zoom ratio capabilities for high resolution imaging in harsh environmental conditions and constrained platforms
- Performance close to the diffraction limit with a detection range of >25km over the entire temperature range
- Addresses the need for persistent IR surveillance over long distances, constrained platforms, and harsh environmental conditions
Summary

➢ Advanced low-SWaP IR zoom lenses based on innovative lightweight and folded optomechanical concepts suitable for small pixel FPAs and long-range detection

➢ Lightweight continuous zoom lenses with the highest level of performance over a wide zoom range

➢ Longest focal-length and zoom ratio capabilities for high resolution imaging in harsh environmental conditions and constrained platforms

➢ Such lenses open-up new opportunities in next generation UAVs and small gimbals thermal imaging applications
Thank you!

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