Optimax
SBIR Commercialization
Enabling customer satisfaction, revenue growth and job creation utilizing SBIR developed technologies

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Outline

• Company overview
• SBIR commercialization strategy
• Review Phase II SBIR projects completed at Optimax
  – Report resulting revenue and job creation due to SBIR developed technologies
• Successful technology transition from R&D to production
• Summary
  – Highlighting customer satisfaction due to SBIR developed technologies
• Future work
Optimax Overview
Profile

- Founded 1991
- Ontario NY
- 60,000 ft² facility
- 250 employees
- ISO 9001:Certified
- ITAR compliant
Optimax Systems, Inc. – Custom Precision Optics
Committed to Small Volume, High Quality, Quick Delivery

- **Materials**
  - Glass Materials
  - Ceramics
  - Crystals
  - Fused Silica
  - Low Expansion

- **Shapes**
  - Aspheres
  - Conformal & Freeform
  - Cylinders
  - Domes
  - Flats
  - Prisms
  - Spheres
Optimax Overview

Markets We Serve

- Semiconductor
- Aerospace & Defense

- Medical
- Commercial
Standard Processes
Cylindrical, Plano, and Spherical Optics

- Lean manufacturing
- CNC generation for speed
- Traditional pitch & deterministic polishing
- Application specific processing – HEL, UV, high strength
Standard Processes
Asphere, and High Precision Optics

- Deterministic processing – sub-aperture tools
- Iterative processing – metrology ↔ fine finishing tools
Optimax Coatings
Coating Capability

• Antireflection, mirrors, filters, beamsplitters
• Thermal and e-beam evaporation, IAD technologies
• 4,000ft² class 10,000 facility: optics cleaned in class 1,000 space under class 100 benches
• 193nm to 5µm
• Large apertures
• High laser damage thresholds
• Coating uniformity on flat and curved surfaces
SBIR strategy at Optimax

- Optimax business model: Service industry
  - Provide high precision custom optics
- Early adopters of novel technology
- SBIR and R&D projects at Optimax fill gaps in technology
  - Projects focus on processes to enable higher precision, more complex geometries and ability to work with novel materials

General Optical Manufacturing Process

- CNC Generate
- Pre-Polish
- Measurement
- Deterministic Figure Correction
- Smoothing
Optimax Completed Phase II SBIRs

<table>
<thead>
<tr>
<th>Federal Agency</th>
<th>Project Title</th>
<th>Year Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOD/NAVY</td>
<td>Aerodynamic Infrared Dome</td>
<td>2011</td>
</tr>
<tr>
<td>NASA</td>
<td>Removing Mid-Spatial Frequency Errors with VIBE</td>
<td>2013</td>
</tr>
<tr>
<td>DOD/NAVY</td>
<td>Optically Precise Conformal Sensor Window</td>
<td>2013</td>
</tr>
<tr>
<td>DOD/NAVY</td>
<td>Fabrication of Corrective Optics for Aerodynamic Domes</td>
<td>2014</td>
</tr>
<tr>
<td>DOD/NAVY</td>
<td>Reduced-Cost Grinding and Polishing of Large Sapphire</td>
<td>2014</td>
</tr>
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Current SBIRs:
- Five Phase I SBIRs
- Three Phase II SBIRs
- One Phase II STTR (in contracting negotiations)

Please check out Optimax presentations tomorrow by Kate Medicus, highlighting current NASA Phase I work
Aerodynamic Infrared Dome (2009 – 2011)

• **Summary:** The goal of this SBIR Phase II was to produce a polished PCA tangent ogive dome using VIBE.

• **Key Technology Enabler:** VIBE polishing freeform optics and hard ceramic materials
Removing Mid-Spatial Frequency Errors with VIBE (2011 – 2013)

- **Summary:** Utilizing VIBE finishing process to rapidly reduce or eliminate mid-spatial frequency (MSF) errors created by deterministic polishing.

- **Key Technology Enabler:** VIBE finishing to reduce MSF errors on spheres and aspheres.

  Fringe pattern from before (left) and after (right) the VIBE smoothing process.

  Zernike Residual map for asphere with 300 µm of departure with 128 mm clear aperture, rms = 0.003 wv.
Optically Precise Conformal Sensor Window (2011 – 2013)

• **Summary:** Phase II goal was to combine novel optical generation and high speed polishing along with deterministic finishing to produce optical quality spinel conformal windows.

• **Key Technology Enabler:** Implementing ultrasonic generation in combination with VIBE polishing to fabricate spinel conformal windows.

Spinel window 140 mm x 164 mm clear aperture
No visible grain decoration
Surface Roughness: 2 nm to 3 nm

The grain boundary is visible, but not pronounced.
Fabrication of Corrective Optics for Aerodynamic Domes (2012 – 2014)

• **Summary**: Goal was to manufacture a corrector element that was a bilaterally symmetric arch with aspheric terms using a suite of manufacturing technologies.
  - The material chosen for the corrector optic was difficult to produce aspheric components due to its incompatibility with sub-aperture polishing techniques.

• **Key Technology Enablers**: VIBE polishing and smoothing of soft polycrystalline ceramic materials, plus initial work on sub-aperture polishing tools to minimize grain decoration.

![Flowchart](image-url)
Summary: This Phase II project focused on high speed polishing to result in high strength large sapphire windows.

Key Technology Enabler: High speed polishing of sapphire and new polishing slurries for optimized sapphire polishing.
### Optimax SBIR commercialization success

- **Total Revenue 2011 - 2014 due to SBIR enabled processes: $5,388,839**
  - 2015 Estimate Additional Revenue: $4,000,000
- **Number of new employees due to SBIR developed technology: 25**
  - 2015 Estimate Additional Jobs Created: 10

#### Federal Agency | Project Title | Total Revenue (through CY 2014)
--- | --- | ---
DOD/NAVY | Aerodynamic Infrared Dome | $561,750
NASA | Removing Mid-Spatial Frequency Errors with VIBE | $3,149,260
DOD/NAVY | Optically Precise Conformal Sensor Window | $387,170
DOD/NAVY | Fabrication of Corrective Optics for Aerodynamic Domes | $1,004,386
DOD/NAVY | Reduced-Cost Grinding and Polishing of Large Sapphire Windows | $286,273

Approximately $4M initially invested through SBIR programs
2015: Official roll out of Freeform manufacturing from R&D to Production

- Successful commercialization of several SBIR funded technologies
  - New Manufacturing Lean Cell dedicated to freeform manufacturing

Common Freeforms

<table>
<thead>
<tr>
<th>Toroid</th>
<th>$z = \frac{C_x X^2 + C_y Y^2}{1 + \sqrt{1 - C_x X^2 - C_y Y^2}}$</th>
<th>$C_x = \frac{1}{R_x}, C_y = \frac{1}{R_y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atoroid/Bicone</td>
<td>$z = \frac{C_x X^2 + C_y Y^2}{1 + \sqrt{1 - (1+k)C_x X^2 - (1+k)C_y Y^2}}$</td>
<td>$C_x = \frac{1}{R_x}, C_y = \frac{1}{R_y}$</td>
</tr>
<tr>
<td>Acylinder</td>
<td>$z = \frac{C_x X^2}{1 + \sqrt{1 - (1+k)(C_x X^2)}} + a_0 X^2 + a_1 X^2 + a_2 X^2 + a_3 X^2 + a_4 X^2 + a_5 X^2 + a_6 X^2 + a_7 X^2$</td>
<td>$C_x = \frac{1}{R_x}$</td>
</tr>
<tr>
<td>Off-Axis Parabola (OAP)</td>
<td>$z = \frac{C_x X^2}{1 + \sqrt{1 - (1+k)(C_x X^2)}} + a_0 X^2 + a_1 X^2 + a_2 X^2 + a_3 X^2 + a_4 X^2 + a_5 X^2 + a_6 X^2 + a_7 X^2$</td>
<td>$C_x = \frac{1}{R_x}$ Where $k = -1$</td>
</tr>
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What is a Freeform?

An optical surface with little to no symmetry.

Why design with freeforms?
- Designing with freeforms will make your project have:
  - Fewer elements
  - Lighter weight
  - Increased flexibility
- And in the end overall better performance.
Optimax SBIR Commercialization Success Story

Optimax SBIR Commercialization Accomplishments:
- Commercialization Index: 90 (out of 100)
- First SBIR awarded in 2009
- Five Phase II contracts completed
- Three current Phase II contracts (One new Phase II contract currently in negotiation)
- Jobs created at Optimax since 2009: 90 (~25 directly due to SBIR developed technology)
- Successful SBIR technology transfer from R&D to production
  - Optimax officially introduced custom freeform optics to the market in 2015
  - Example customer request ($400,000 project)
    - Specific Customer Need
      - Two freeform optics with dimensions 240 mm x 200 mm and 140 mm x 150 mm
        - Asphere on Side 1: Manufactured using standard processes
        - Freeform on Side 2: Manufactured using Optimax SBIR developed processes

Deterministic Surface Form Correction

VIBE Smoothing

Final Freeform Optics After Coating
## Future commercialization success
Currently funded SBIR projects at Optimax

<table>
<thead>
<tr>
<th>Project title</th>
<th>Funding Agency</th>
<th>SBIR Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive Manufacturing for Lightweight Reflective Optics</td>
<td>NASA</td>
<td>Phase I</td>
</tr>
<tr>
<td>Manufacture of Monolithic Telescope with a Freeform Surface</td>
<td>NASA</td>
<td>Phase I</td>
</tr>
<tr>
<td>Freeform Optics: A Non-Contact “Test Plate” for Manufacturing</td>
<td>NASA</td>
<td>Phase I</td>
</tr>
<tr>
<td>Low Cost Finishing of Optical Ceramic Domes with Embedded Grids</td>
<td>Army</td>
<td>Phase II</td>
</tr>
<tr>
<td>High Precision Conformal Sensor Window</td>
<td>Navy</td>
<td>Phase II</td>
</tr>
<tr>
<td>Corrective Optics Manufacturing for Aerodynamic Infrared Domes and Conformal Sensor Windows</td>
<td>Navy</td>
<td>Phase II</td>
</tr>
<tr>
<td>Manufacturing of Visibly Transparent Large Conformal Window</td>
<td>Navy</td>
<td>Phase I</td>
</tr>
<tr>
<td>Metrology of Visibly Transparent Large Aspheric Optics</td>
<td>Navy</td>
<td>Phase I</td>
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</tbody>
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Thank you for the challenges!
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