



# Coating High Quality Custom Optics: Risk Reduction Through Supplier Evaluation

## INTRODUCTION

Risk mitigation is vital when procuring optics for use in critical applications such as defense, aerospace, semiconductor, research, and life/health sciences. Risks are events affecting cost, timeline, and technical performance. This article examines four key capabilities to look for in optical coating suppliers to minimize program risks.

### 1. VERTICALLY INTEGRATED MANUFACTURING

#### Timeline and Transportation

The fabrication, coating, testing, and assembly of optics by a single manufacturer provides many benefits. The most obvious advantage is an overall reduction in project completion time. A single supplier takes full responsibility for completion of the project by coordinating all activities. This eliminates the need to transport optics to a coating supplier, then back to the originator for final acceptance testing and perhaps a third supplier for assembly, saving both time and expense. After receiving the optics from Supplier A, you are ultimately responsible for ensuring damage does not occur when sending the optics on to Supplier B. Insuring high quality optics is a prudent choice in these cases. Most optics represent a significant financial expenditure, so any delays in reimbursement by the insurance company will only increase the project delays, completely derailing your program schedule.

#### Technical Performance: Taking Responsibility

When working with multiple suppliers, a risk that is not immediately apparent is determining who is at fault when an optic fails to meet the specifications. As an example, consider a high aspect ratio optic with a demanding surface figure. Did the fabricator fail to meet specifications, or did coating stress distort the optic? Assigning responsibility and taking corrective action is not possible when the root cause of the failure is ambiguous or unknown. Even if one supplier is willing to take

responsibility, the substrate will need grinding, polishing, and recoating services from additional suppliers.

At ZYGO, we've been fabricating cutting-edge optics for over 45 years. Prior to developing our own coating capabilities in the 1980s, we learned this painful lesson first hand. These situations inspired us to develop the broad and deep coating capabilities ZYGO has today. Our customers know they can rely on a single supplier who possesses the technical expertise to select the most appropriate substrate material and then fabricate, coat, assemble, and perform metrology on their unique optics.

#### Keeping it Clean

A high quality, durable coating design is subject to failure if applied to a substrate that is not properly cleaned. When reviewing potential coating suppliers, it is important to ask about their cleaning processes, facilities, and packaging capabilities. ZYGO's facilities include Class 1000 and Class 100 cleanrooms that are set up to process optics sensitive to Airborne Molecular Contaminants. Cleaning standards are per MIL-STD-1246 and certified by the National Ignition Facility (NIF). We can ship completed optics and assemblies in vacuum or nitrogen purged packaging.

### 2. EXPERIENCED IN-HOUSE DESIGN TEAM

#### Theory vs. Real Life

When designing sophisticated coatings, it is standard practice to model initial designs using various software applications. However, will these coatings perform as expected when real-world variables clash with textbook theories? If your application requires a high performance coating, it is important to ask prospective suppliers about their prior experience in applying similar coatings to similar substrates. When coating very large optics, for example, it is critical to understand the supplier's level of experience in handling, cleaning, and controlling coating uniformity. Understanding the variables involved is the key to ensuring the finished product meets or exceeds specifications.

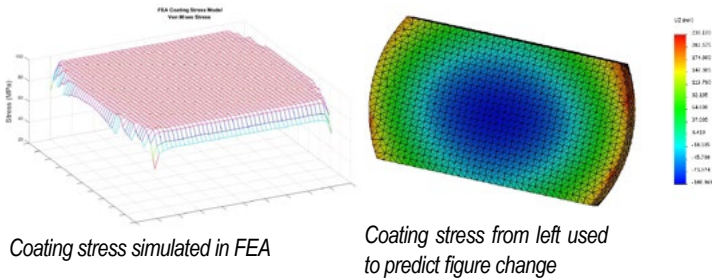
Decades of experience allow our design team at ZYGO to apply out-of-the-box thinking to solve unique, complex problems. In addition to designing coatings, our in-house research and development engineers have the skill set to design and fabricate proprietary fabrication equipment



*A single source supplier of coated optics and optical assemblies takes full ownership of all manufacturing processes.*

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and fixtures for optics. Our production staff has methods in place to control post-coating figure, surface quality, and uniformity — even with large or unusually shaped optics.



Coating stress simulated in FEA

Coating stress from left used to predict figure change

## Environmental and Durability Factors

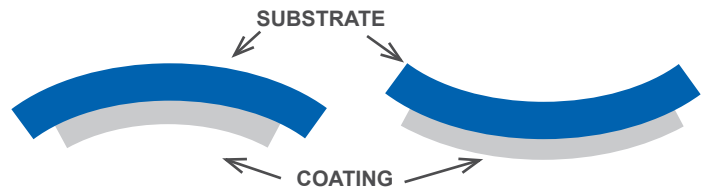
A custom coating design may be required to meet the environmental and durability specifications for your application. The end users of coated optics are typically not interested in the type of deposition technology used to apply a coating onto a substrate. Nevertheless, a strong case can be made that top tier coating suppliers must have multiple deposition technologies at their disposal to balance the needs of a coating's spectral performance and durability with cost and schedule. ZYGO employs a variety of deposition technologies that allow us to optimize our manufacturing processes. We utilize enabling technologies such as ion assisted deposition and resistive sputtering, in addition to more conventional processes.

It is essential that you select a coating supplier that has in-house testing capabilities for your environmental and durability requirements. Coating designs are tested using witness samples during the development phase and during production for performance verification. Outsourcing these tests significantly slows down the coating design and production processes and increases costs. Common requests include ISO and military specifications for

temperature cycling, humidity, salt fog, adhesion, and abrasion. At ZYGO, we maintain the capability to perform all of the testing listed here, allowing us to develop advanced coatings in an efficient and cost-effective manner.

## Stress Affects Optics – Not Just Engineers

An optic is at risk for deformation when certain types of coatings are applied. This risk is dependent on the coating materials and layer count, deposition technique utilized, substrate material, and aspect ratio. The stress applied can distort an otherwise perfect substrate so that it will no longer meet transmitted wavefront or flatness requirements. When selecting different suppliers for fabricating and coating an optic, the proprietary coating design is almost never shared with the fabricator. Without that information, the fabricator cannot anticipate and compensate for the stress induced on the optic by the coating. Selecting a single supplier, such as ZYGO, to fabricate and coat an optic allows the engineering and manufacturing teams to share coating design information freely to produce an optic that meets specifications both before and after coating is applied. Always be sure to ask suppliers if they have established techniques for coating stress compensation and whether or not they will verify specifications both before and after coating is applied.



ZYGO utilizes various techniques to prevent substrate deformation due to tensile or compressive coating stress.

## 3. SOPHISTICATED METROLOGY

### If You Can't Measure An Optic, You Can't Produce It

It is vitally important to understand the metrology capabilities of potential coating suppliers. Your coating supplier must have a spectrophotometer available to measure reflectance and transmission at various angles of incidence and polarizations. In order to ensure an optic meets all specifications before and after coating, your chosen supplier must have interferometric testing equipment on hand. It is especially desirable that the interferometer be large enough to test the optic at full aperture. To ensure accurate results are obtained, ask suppliers if their equipment is in a climate controlled environment. Can the supplier design appropriate holding fixtures and provide an error budget based on your testing requirements? ZYGO's metrology equipment and expertise are recognized worldwide. Our equipment includes



High reflective, antireflective and specialty coatings are applied in 72-inch coating chambers.

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*Large aperture interferometry ensures optics meet specifications before and after coating.*

interferometers up to 32 inch [813 mm] diameter, allowing us to make full aperture measurements on large optics without the need to use stitching.

## 4. REFURBISHMENT SERVICES

### Repolishing and Recoating at One Location

Program risks do not end with the delivery of a new optic or assembly. A premier coating supplier needs to be able to support their optics after they leave your facility and face the wear and tear of the real world, whether from the battlefield or after extended use in an ultra-high power laser system. By definition, high-durability coatings cannot simply

be chemically stripped and reapplied. Rework requires grinding the substrate to remove the damaged coating and repolishing to meet specifications prior to recoating. Ensure your chosen coating supplier has the in-house capabilities to perform all of the required refurbishment steps. When working with a coating supplier that does not have ZYGO's full in-house capability to manufacture substrates, extensive delays typically occur when the substrate requires transportation to different facilities to complete the rework process. Choosing the right coating supplier ensures support is available over the life of your program.



*Refurbishing highly durable coated optics requires in-house grinding and polishing capabilities.*

### ABOUT THE AUTHOR

**Michael Albrecht** is the Product Manager for Zygo Corporation's Precision Optics business segment. He possesses extensive knowledge of optical materials and the processes involved in creating cutting-edge plano optics. Albrecht has been involved in numerous high-profile, complex optics development programs. To learn more about ZYGO's coating, fabrication and assembly capabilities, contact Michael at [michael.albrecht@ametech.com](mailto:michael.albrecht@ametech.com). He would like to acknowledge ZYGO team members Mike Bohac, Rich Deluca, Mike Gentile, Reed A. Schmill, and Katy Zdrovicz for their contributions to this article.



[www.zygo.com](http://www.zygo.com)  
(860)347-8506

At Zygo Corporation, we have experienced engineers, well-established processes, advanced equipment, and highly trained technicians to fabricate substrates, apply a wide variety of coatings and assemble components into complete systems. ZYGO works from raw stock to produced finished optics and assemblies, validating performance at the optical component and system level. Our specialties include high reliability optics with challenging specifications that operate in extreme environments. Our services also include design, rapid prototyping, and OEM manufacturing.