White Paper

Prototyping to Production

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INTRODUCTION

CVI Laser Optics' quick turnaround prototype services smooth the transition from prototype to production. We start by understanding your application and needs, then back it with expert engineering knowledge and world-class manufacturing capabilities. By providing you with better technical support than you can find anywhere else, we help you optimize the price to performance ratio of your optics at the beginning of the product development cycle.

The Benefits of Prototyping with CVI Laser Optics

Unparalleled Support

We see prototyping as an opportunity to provide the engineering support that is so essential to the success of a new product development. Our highly qualified technical sales team will walk you through prototyping, providing honest answers to the questions most relevant to your product development and timelines.

Our application engineers will help you define which specs are most important, optimizing tradeoffs between competing specifications and balancing performance with cost. Armed with research and fabrication experience, they understand the full process through to testing and inspection. At CVI Laser Optics, we know how to design optics with volume manufacturability in mind, giving us an advantage that most prototype houses can't offer.

Time- and Cost-Efficient

As a full-service volume optical component supplier, we can accelerate your design to implementation cycle. The prototypes we provide are already designed with consideration to our volume production capabilities and quality yield metrics, allowing us to quote optical performance, volume costing and lead times with high confidence. Transition to volume production is supported and facilitated by the same engineers involved in prototyping.

When a number of our customers told us they were turning to independent prototyping houses for cost or leadtime reasons, we listened. In response, we created our own prototyping lines capable of delivering the quality for which CVI Laser Optics is known – at similar leadtimes, and often at lower cost! By offering you the same comprehensive design and engineering support at the prototype stage as we do for volume components, the cost-intensive step of re-testing and requalifying a new vendor for volume production can be avoided, cutting up to 4 weeks from your product development schedule.

CVI Laser Optics

Copy-Exact Option

Many of our customers in the defense, semiconductor and medical device industries have copy-exact requirements, forcing them to requalify each time a vendor is changed. While this is often expected in going from prototype to production, it can be avoided through careful planning. If you have copy-exact requirements, we can adapt our prototyping process to meet those criteria from prototyping through to volume.

Premium Performance

As a world-class optical component supplier, we can offer higher performance specifications and more thin film coating options than most rapid prototyping lines or small optics companies. We guarantee this performance using state-of-the-art metrology, inspection, and environmental testing capabilities in our ISO 9001:2008 certified facilities. Whether you need laser grade or standard grade optics, or even an optical assembly, we have the performance you need at a competitive price and leadtime.

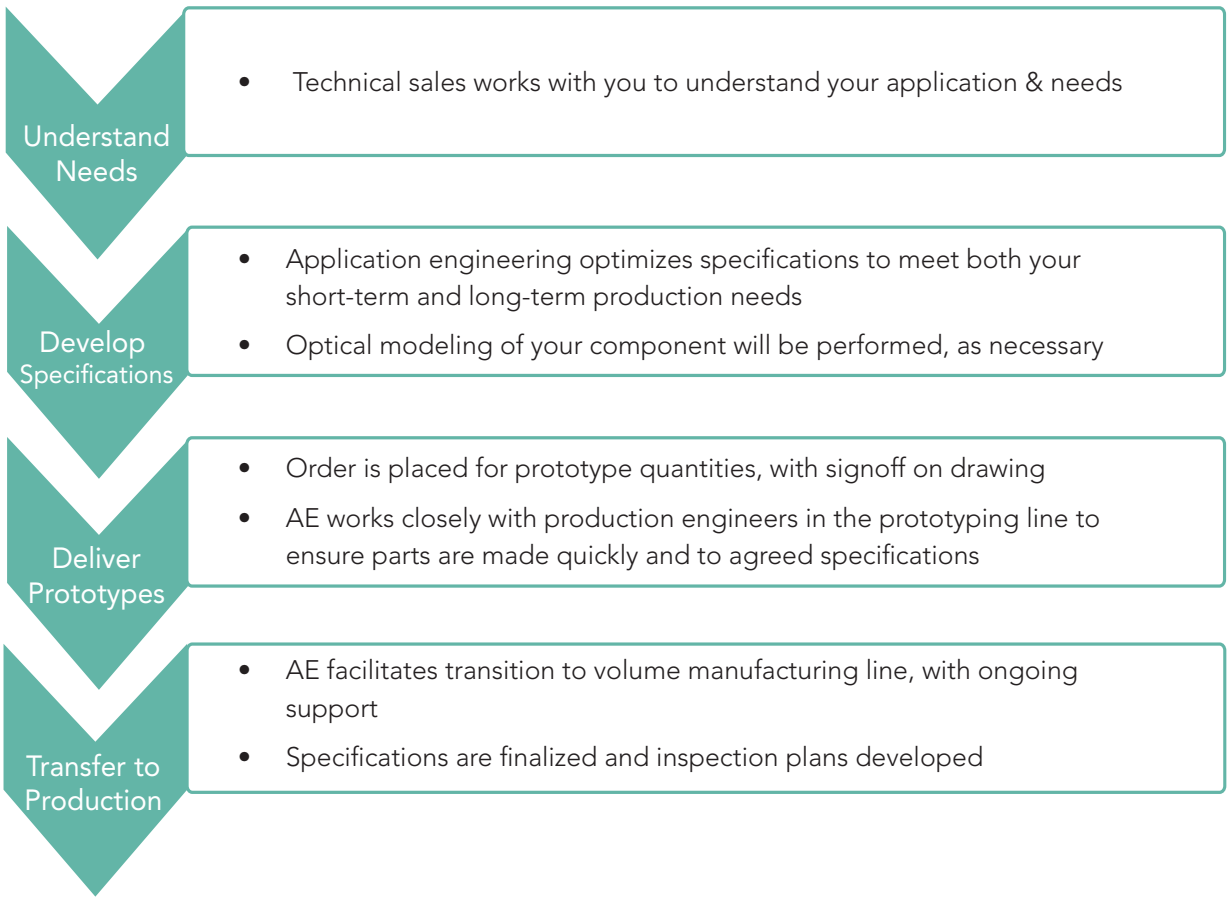
Reduced Risk

Transitioning from prototype to production with CVI Laser Optics reduces your risk in several ways. Not only do you avoid designing your product around performance that can only be delivered in small volumes or with poor yield, but you also gain a partner who is invested in the long-term success of your product from the beginning.

Our prototyping line can help to fill the gap in supply often seen in the weeks between prototype and volume ramp, providing a steady flow of components with repeatable performance throughout your product development. Once in production, you have access to large capacity under one roof, supported by a global network of affiliates and suppliers. If we are unable to manufacture your components at our primary laser optic manufacturing facility in Albuquerque, we have access to manufacturing facilities spanning three continents to deliver a solution.

The Prototyping Process: How it Works

Your technical salesperson will be your point of contact all the way through the prototyping process, with support from application engineering. Together, they will determine how best to use the prototyping line to achieve the optical component you require long-term.



Product Types

Our prototyping line can quickly create fully customized versions of many of our optical components. Both spherical lenses and flats can be provided with any of the CVI Laser Optics coatings. Limited assembly or additional testing is also available on an as-needed basis. We can build to print, or provide engineering design services to assist with design of optics, coatings and mounts.

- Spherical lenses: plano-convex, plano-concave, biconvex, biconcave, bestform
- Optical flats/windows: parallel, low-wedge, large wedge; round, square, or rectangular
- Beamsplitting cubes

Stocked Materials

An application engineer will work with you to identify the best material for your application, considering spectral requirements and design factors, as well as hardness, CTE (coefficient of thermal expansion), environmental resistance and cost. Our on-hand selection of crown glass, flint glass, and crystalline materials span the ultraviolet to near infrared, from 193 nm to 3000 nm. They include various refractive indices and dispersion options appropriate for pairing of glasses for doublets, as well as low expansion options.

Material	Index (at 633 nm)	Max Diameter
7980 1-D	1.457	3.0″
7979 1-C	1.457	2.0″
N-BK7	1.5151	3.0″
CaF2	1.4329	1.0″
N-SF5	1.66846	1.0″
N-SF6	1.7988	1.0″
N-SF11	1.7786	1.0″
Zerodur	1.5403	1.0″

Manufacturing Capabilities

At CVI Laser Optics, we're known for precision fabrication. From economical standard grade components to premium laser grade optics offering low surface defects and high surface figure, we manufacture, test and inspect every component to demanding specifications. We've outfitted our prototyping line with many of the same high-end capabilities available on our production lines, including centering and shaping not available from most manufacturers.

Automated High Speed Spherical Generator/Polishers

With high speed spherical 5 axis CNC generation and polishing, we can create high quality optics with λ/10 surface figure and 10-5 surface quality. The same equipment also allows for competitive manufacturing of standard grade optics with λ/4 surface figure and 20-10 surface quality. This process is highly automated and repeatable, enabled by in-process metrology.

Conventional/Pitch Polishing

We employ more conventional polishing methods to achieve certain conformations or performance:

- Higher specifications: λ/20 surface figure, plano or spherical, as well as roughness considerations
- Generating/polishing combinations: spherical surfaces, block on spindle; also ideal for tighter specifications
- Double-sided polishing: well-suited to competitive, high capacity flats manufacturing; also ideal for waveplate production

Centering and Shaping

Our centering and shaping capabilities are industry-leading. We utilize a high speed automated spherical centering process that is very repeatable. Spherical centering of less than 30 arc seconds is achieved with ease, sometimes better (depending on material, curvature, etc.). In fact, we offer a unique ability to improve beam walk due to centration on laser grade optics using our Schneider etching tool.

We can also produce creative edge shapes with micro scale precision using a highly automated, repeatable process. This allows us to create faucets or edge beveling so that mechanical and glass pieces can be better fit quickly, reducing your assembly time.

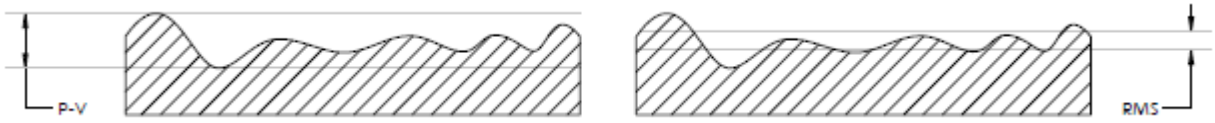
Tech Note: PV vs RMS

The surface figure (also known as surface quality) of an optic is an expression of the deviation of an optic from its ideal shape. It is an important metric, as it impacts aberrations and quality of focus. There are two methods by which surface figure is typically described:

Peak to valley (PV) error: Calculated using the distance between the highest and lowest points on an optical surface, relative to the ideal surface. It does not quantify the number of defects, only compare those most extreme in amplitude.

RMS (Root Mean Square) error: Calculated using the standard deviation of the optical surface relative to the ideal surface, using measurements from many points on the optic. It thus takes into account the number of defects, as well as their amplitude.

In both cases, the actual number reported is twice the calculated value in nanometers, divided by the wavelength of light being used. Both values are most often reported at 633 nm.



Two optics can have the same peak-to-valley amplitude, but a very different number and severity of defects.

Which is better?

Many optics manufacturers will argue that RMS error is a better indicator of surface quality, pointing out that a single, large defect on an optic can result in a high PV error, yet impact only a small fraction of the transmitted light. RMS error, in contrast, considers the number of defects as well as their sizes.

When working with high-performance optics, however, a low PV measurement (i.e., λ/10) is a far more powerful indicator of surface quality than an equivalent RMS value. Why? Both measurements are performed using the same method – interferometry – and are calculated using hundreds of points across the optic's surface. The difference lies only in the calculation. The RMS value is a measure of the standard deviation from the ideal surface, while the PV value indicates the absolute difference from the ideal surface.

Although RMS error provides a good overall average sense of surface quality, the mathematics of its calculation dictate that it will always be lower than the PV error for the same surface, typically by a factor of three to four. A λ/10 PV error specification is more difficult to meet when manufacturing optics than a λ/10 RMS error specification.

Let's consider a few different scenarios in which PV and RMS are both reported, and consider what those values say about the surface and implications for use.

CVI Laser Optics provides optics with both low PV error and very low RMS error to meet the needs of high power, laser and optically demanding applications. We provide our surface figure error values in PV simply because it is more difficult to meet, and it assures our customers of higher quality.

PV	RMS	Surface Characteristics	Recommended Use
High	Low	Smooth, but with one to several large defects	May be adequate for some applications, like astronomy optics
Low	High	No large defects, but highly irregular	May be adequate for low power or routine applications
Low	Low	No large defects, very smooth	Good optical performance for all applications; best for high power and sensitive systems

How can we manufacture optics with such low PV and RMS error values simultaneously? Through carefully designed and controlled manufacturing processes. We remove material to shape the optics in different steps, progressing from a rough removal (milling), to fine removal (grinding), and then very fine removal (polishing) to minimize the sub-surface damage in the optical surface. Each step minimizes the peaks and valleys to ensure that we can create optics that are both consistently smooth across their surface, and also free of large defects. The result is less image distortion, and higher power handling.

Thin Film Coating

Drawing on a wide range of metal and dielectric coating technologies, we can coat any custom spherical lens or optical flat for use at wavelengths from the UV to NIR.

- Coating Technologies: advanced plasma source (APS), ion assisted deposition (IAD), electron beam (e-beam) deposition
- Coating Types: Anti-reflection, high reflector, polarizing, filter (longpass, shortpass, bandpass, blocking)

Assembly

Basic assembly capabilities are available at prototype quantities, including optically contacted or cemented optics, as well as optomechanical assemblies. An in-house machine shop allows for prototyping of some metal components, while assembly is performed in class 100 cleanrooms. This also enables us to provide cleanroom specific packaging and cleaning methods at prototype quantities.

Quality Assurance

Our metrology capabilities are extensive, and include a 12" Fizeau interferometer for measurement of large aperture optics. We assess surface quality using machine assisted surface quality inspection, with significantly brighter light sources and higher magnification than is required by the industry. We developed this inspection method to meet our customers' laser induced damage requirements, underscoring our commitment to high performance laser optics. Full documentation can be provided, including AS9102 first article inspection reports.

Environmental Testing & LDT

The strong base of existing MIL and ISO standard testing data for our optical components allows you to prototype with the confidence that qualification of production quantities will be successful. In-house environmental testing can be supplemented as needed by sourced testing to meet all your requirements. We also have extensive experience with laser damage testing, both for bare optics and our full suite of thin film coatings.

Summary

Now at CVI Laser Optics, we can take your concept from prototype to production under one roof. Our prototyping line gives you access to comprehensive engineering support as you develop your product, and ensures the best price to performance ratio. Not only can we provide premium performance backed by world class metrology and coating capabilities, but we can pave the way for a seamless transition to volume. Contact us today to get started!

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