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WHITE PAPER

Globalization and new manufacturing technologies have transformed the optics industry, allowing customers more choices, higher precision, better quality, and lower prices for the products they buy. However, lead time improvements for custom optical components have been slow to develop. Optics suppliers usually rationalize their long lead times by pointing to their limited glass availability, long manufacturing cycles, and queue times at different stages of the manufacturing process. In the meantime, time to market is increasingly becoming one of the most important metrics for a competitive manufacturing company's product development process. Often it means the difference between success and failure of the new product launch.

Long lead times for obtaining optical components may affect end-user product success at all stages of a product's lifecycle. Despite best efforts of the buyers to plan component purchases in advance, any clerical mistake, MRP system output error, or sudden change in demand can create major disruptions in the production process and result in lost revenue and eroding customer confidence. Most optics suppliers, especially overseas suppliers, simply cannot react fast enough to mitigate these risks.

Market uncertainties make accurate long-term production planning a challenging if not impossible endeavor. Inventory and possible cancellation costs associated with committing to blanket orders for component supply counter the benefits in cost reduction, and spot purchases become the most advantageous procurement option. Manufacturers who operate in this mode desperately need agile suppliers who can meet the demand for quick delivery without exorbitant fees and specification waivers.

Advances in high-productivity optics fabrication equipment, particularly CNC systems, enabled significant reduction in the fabrication cycles for low- to medium-precision optics. However, the ability to produce higher precision products still remains out of reach for the majority of merchant optics manufacturers due to the low productivity and yields of traditional manufacturing methods and business management systems. Also, in many cases the lead time for obtaining higher performance coatings remains long; most optics shops possess only rudimentary (if any) coating capabilities and most specialized coating houses capable of producing high-performance coatings are unable to respond quickly. Splitting the responsibility for quality between multiple suppliers always adds to the overall costs and risks of procuring precision optical elements and systems.

CVI Melles Griot

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As the leading supplier of optical components, CVI Melles Griot acutely understands the need to achieve higher agility to meet its customers' needs. Over the last 30 years, CVI Melles Griot has developed extensive technical capabilities for manufacturing high precision optical elements and high-performance coatings to support its advanced optical system products. These capabilities include:

- High speed CNC lens generating, polishing, and centering systems
- Conventional pitch polishers
- Magneto-Rheological Finishing (MRF™)
- Digital phase-measuring interferometers, including a QED Sub-Aperture Stitching Interferometer (SSI™) featuring absolute spherical reference and automatic radius of curvature verification
- Coating technologies include ion beam sputtering, magnetron sputtering, APS utilizing the Leybold SYRUSpro™ deposition system, E-beam, ion-assisted E-beam, thermally deposited soft films, and chemical vapor deposition.Important typical specifications such as laser damage threshold and scatter can be found in *Figure 1*.
- High-performance spectrophotometers including N_2DUV purged systems
- Veeco white light interferometer RMS surface roughness measuring system
- Class-100 clean rooms

Our mission was to develop business processes and manufacturing practices that would allow achieving 2-week lead time for expedited deliveries. We analyzed each step of the business process from quotation to final shipment in order to identify opportunities for cycle time reduction. (*see Figure 2*).As a result of this end-to-end manufacturing process analysis, we developed a streamlined process that allows us to achieve industry-leading cycle times for optics manufacturing.

The time it takes for a manufacturer to respond to a customer's request-for-proposal is an important element of the total procurement cycle. Through eliminating redundant and non-value added steps we have been able to develop a robust quotation process capable of responding to customer inquiries, for a custom optical elements, within two business days.

Similar improvements have been made to the order processing, planning, fabrication, and coating processes. As a result, a 2–4 week lead time for the complete manufacturing of custom, coated optical elements became a reality.

One of the most challenging issues in optic fabrication lead time reduction is glass material availability. This issue has been addressed by creating a stock for commonly used materials and securing a commitment from leading vendors to make their preferred glasses available within 24 hours. (see Material Selection Guide table).

These capabilities along with the industry-leading cycle time for optics manufacturing allow CVI Melles Griot to meet the needs of its customers for high-precision rapid-time-to-market optical components. This enables the customer to gain a competitive edge by reducing new product development cycles and achieving the production planning flexibility required to react to end-user demand fluctuations.

	E-beam	IAD	APS	IBS	Magnetron Sputtering
Laser Damage Threshold*	>20 J/cm^2	>27 J/cm^2	>27 J/cm^2	>27 J/cm^2	>27 J/cm^2
Absorption (%)	<0.1	<0.02	<0.02	<0.02	50 PPM
Scatter (%)	<0.1	<0.15	<0.15	<0.1	50 PPM
Surface Roughness (Å rms)	5	7	7	<5	<9
Wet/Dry Shift (range) (%)	<0.8	<0.3	0.00	0.00	0.00

These values may be slightly higher or lower depending on deposition conditions and other process-related parameters. Overall plasma processes have lower absorptions than conventional e-beam technologies.

**Laser-Induced Damage Threshold (LIDT) depends on test wavelength, pulse width, repetition rate, and inspection method. Data from 1064 nm, 10 ns, 20 Hz.*

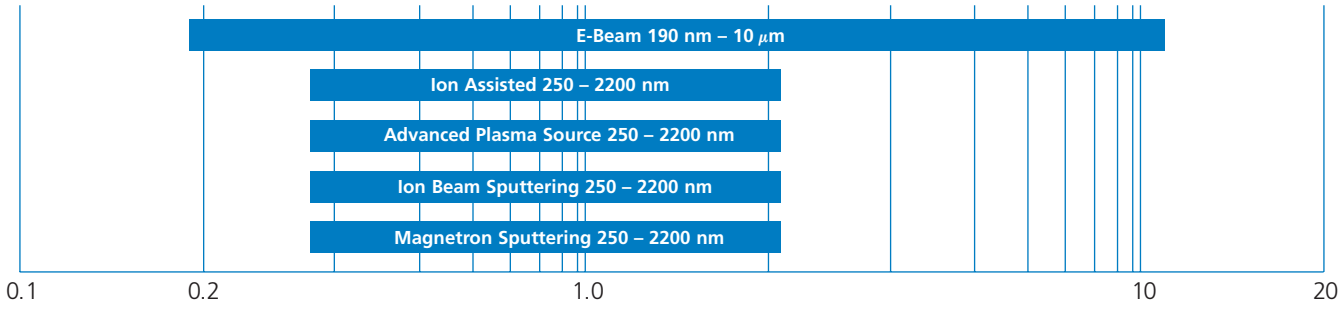

Figure 1 *General coating specifications, for coating options contact CVI Melles Griot*

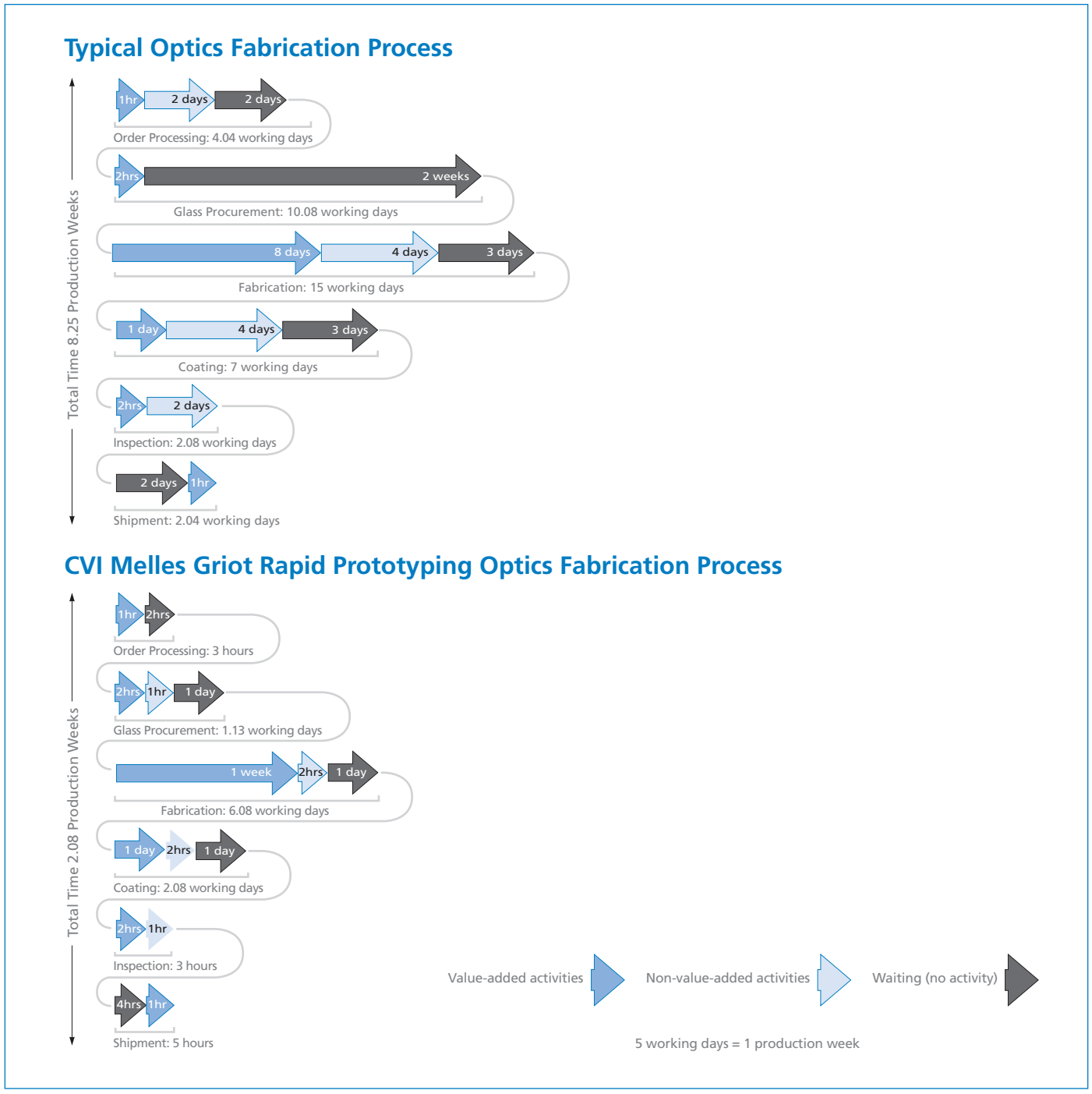

Figure 2 *Comparison of typical optics fabrication process with CVI Melles Griot rapid prototyping optics fabrication process*

Spherical Optics

Specification	Commercial Quality	Precision Quality	Laser Grade Quality	Manufacturing Limit
Surface Figure Accuracy, PTV @ 633 nm	λ/2	λ/8	λ/20	λ/100
Surface Roughness, Angstroms RMS	50	20	5	2
Cosmetic Quality, Scratch–Dig	60–40	40–20	10–5	5–2
Center Thickness Tolerance (mm)	±0.150	±0.050	±0.010	+0/–0.005
Centration (Edge Thickness Variation) (mm)	0.05	0.015	0.007	0.003
Radius Accuracy, Fringes @ 633 nm	10	5	3	1*
Diameter Accuracy (mm)	+0/–0.1	+0/–0.025	+0/–0.01	+0/–0.005

* *or ±0.005 mm*

Tighter tolerances are available on a special basis.

Flat Optics (windows and mirrors)

Specification	Commercial Quality	Precision Quality	Laser Grade Quality	Manufacturing Limit
Surface Figure Accuracy, PTV @ 633 nm	λ/2	λ/8	λ/20	λ/100
Surface Roughness, Angstroms RMS	50	20	5	2
Cosmetic Quality, Scratch–Dig	60–40	40–20	10–5	5–2
Center Thickness Tolerance (mm)	±0.150	±0.050	±0.010	+0/–0.005
Wedge	3′	1′	10″	0.5″
Diameter Accuracy (mm)	+0/–0.1	+0/–0.025	+0/–0.01	+0/–0.005

Tighter tolerances are available on a special basis.

Material Selection Guide

Coating	Windows	Lenses	Mirrors	Beamsplitters	Polarizers
BK 7	•	•	•	•	•
CaF_2	•	•	•	•	•
Calcite					•
Crystal Quartz	•	SR			
F2		•			
Ge	•	•		•	
Infrasil 301	SR	SR	SR	SR	SR
Infrasil 302	•	•	SR	SR	
LaKL21		•			
MgF_2	•	•	SR	SR	SR
SF10	SR	•			
SF11 (N-SF11)	SR	•			•
SF2	SR	•			
Silicon	•	•	•	•	
Suprasil 1	•	•	SR	SR	SR
Suprasil 2	•	•	•	•	SR
UV Fused Silica	•	•	•	•	•
Zerodur			•		
ZnS	•	•		•	
ZnSe	•	•			
Chalcogenides	•	•			
Sapphire	•	•		•	
GaAs	•	•		•	

• - *Standard Optical Materials*
SR - *Special Request*