Clark Optical Consulting and Prototyping, LLC

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Opto-Mechanical Design

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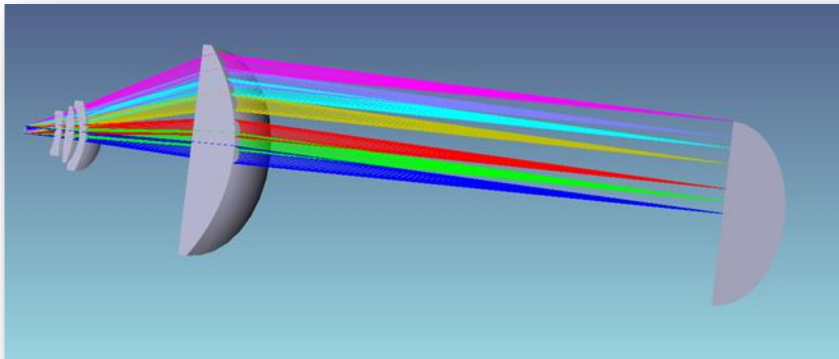
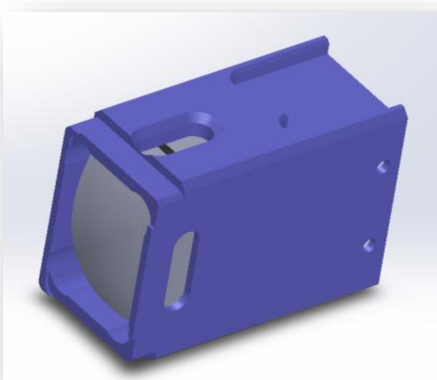
From my 20+ years of Optical Mechanical design experience, I have come to recognize the benefits of a preliminary "whole package" evaluation of any optical system. The space/packaging requirements, the alignment requirements, the fabrication method, the component lock down/fixing method, the testing method, the environmental constraints and shock and vibration specifications and cost all go into this "whole package" look. Simple "whole package" reviews can allow for a quick convergence to the needed optical system design structure. To do this "whole package" review, I usually start by looking at the packaging requirements.



F-Theta scanning lens---after the initial optical design is completed this system will need the "whole package" review to ensure that the components have the proper clear apertures, there is room for the appropriate lock down method, that the alignment can be held with the chosen housing and that the system will be stable under its desired operating conditions.

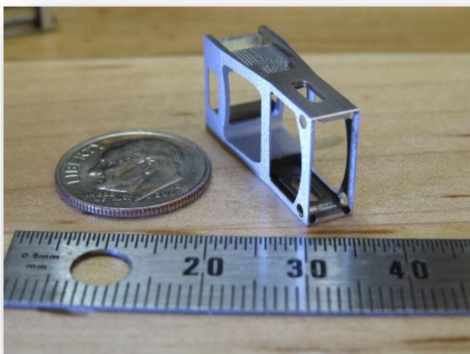
For many of today's small and/or light weight optical systems, such as cell phone cameras, packaging volume can come at a premium. These small-volume designs often require thin wall housings and automated precisely aligned optics tooling. The optics assembly often utilizes some kind of epoxy or other adhesive attachment means. This foreknowledge accelerates the design process to the correct design space, allowing for the correct packaging design from the beginning.



Thin wall design option—utilizing adhesive lock down means yielding less than +/-35micron decenters and less than 0.3deg tilts

Another element of the "whole package" review is the alignment means. Is this to be an active alignment, pick and place, or a by-hand install? Can alignment datums be fabricated right into the part? Will the alignment be stable? What is the tolerance budget to determine which alignment method I can use? Very tight tolerances can often be realized, but may be complicated by the available space and cost limitations for the project. Environmental constraints and shock or vibration must also be taken into account to make sure the alignment will be sound over different operating conditions. Several prototype runs may be necessary to perfect the alignment for these conditions. Standard alignment tolerances of +/- 0.05mm decenter and +/-1deg are common for by-hand installations. Tight tolerances of +/- 0.025mm and 0.5deg are achievable with additional tooling and mechanical part optimization. Very tight tolerances of +/- 0.005mm and 0.1deg or less can be done with special alignment tooling and custom fitting of the individual components.

The fabrication means is another element of the "whole package" review process. Fabrication is one area that is often overlooked during the design cycle and can lead to costly redesign efforts after a problem is found. Knowledge of fabrication methods and limits allow for more effective designs to be created. Incorrect assumptions on fabrication limits can cause parts to fail to operate at the desired specification, making system alignment difficult and in some cases, impossible. One important thing to keep in mind is that each fabrication house may have its own fabrication limits, meaning some parts may only have one or two fab houses that can manufacture the piece. This may cause issues in the long-term and should be avoided if possible.



Small optics housing—with experience even very intricate mechanical parts can be made-0.2-0.5mm wall thicknesses are possible

For the "whole package" review a mounting/lock down method must be chosen. Adhesives, retaining rings, UV curable cements, flexures are a few among many options for locking down optical components. These methods all have differing space and setting requirements. Each method also has different position-holding strength and accuracy limits. For example, epoxies may have high strength, but may shrink a lot and cause part motion when curing. Epoxies may also need to have heat applied to cure, causing challenges due to CTE mismatch and/or other material properties. When using retaining rings, there may be issues with centration of the parts if the rings are not concentric or made to a tight enough fit. Previous review steps may lead toward a particular lock down/component fixing option.

The environmental and shock and vibration are often couple in this review. The moisture control, temperature requirements and shock and vibration specs are often met by a single opto-mechanical module and must ideally be looked at as a whole unit. Gaskets/O-rings, seals all most work under the shock and vibration specs. Material selection for temperature specs and seals must be looked at together.

The final "whole package" review area is testing. When designing any optical system, it is important to know how or if the unit will need a final or during-assembly test. These tests will always be benefited by thoughtful consideration up front, allowing for datuming to be integrated into the system and to allow space for needed test equipment. This upfront work will make these full or part system checks run much faster.

This initial review moves designs into the final design space faster and keeps the whole system picture in place so that fewer gaps are found in the final design. This initial "whole package" review does not replace the bulk of the opto-mechanical design work, it simply steers into a good starting point quickly.

My experience has been that opto-mechanical system design can be done effectively and make optical assembly consistent and reliable with proper planning and modeling. At Clark Optical Consulting and Prototyping, LLC, we have the knowledge and ability to get the job done with precision.

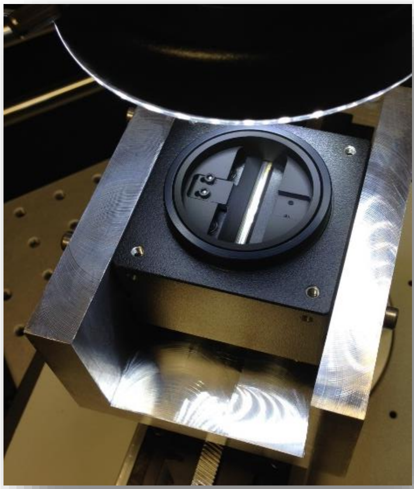


Image Sensor—some tests require additional tooling to accurately determine optical system component locations. Microscopes or other imaging devices can be a great help here.