Lens Design Optimization/ Estimator
Product Requirements Document
University of Rochester, Institute of Optics
OPT 310 Senior Design

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Authentication Block

Rev	Description	Date	Authorization
A	Release	27 October 2014	NP/JLC
B	Update	10 November 2014	NP/JLC
C	Updated document with specifications chart	1 December 2014	NP/JLC
D	Updated with timeline, project scope, and resources needed	12 December 2014	NP/JLC

The Lens Design Optimization/ Estimator project is a senior design driven microscope objective lens system. As such its design inputs were derived from our interactions with our project advisors, Dan Brooks, Gustavo Gandara- Montano, Wayne Knox, Julie Bentley, and Rick Plympton.

Vision:

The product vision is a compact, attachable microscope objective for a femtosecond micromachining system. This microscope objective will be part of a larger system [1] that can write a GRIN structure into corneal tissue. Several designs will be drafted to determine the effect of different performance specifications as a function of cost using Optimax Systems Inc.'s Estimator software.

Environment:

As a laboratory instrument, it needs to operate in the following environment:

Temperature

55-85 °F - safe operation

65-75 °F - meets specifications

Relative Humidity

Non-condensing – safe operation

30% Nominal - meets specifications

During normal operation the last surface of the microscope objective will potentially come into contact with biological specimens. Microscope surfaces that contact biological specimens must be cleanable.

Microscope objective should be not be damaged by splashing of biological fluids, standard laboratory cleaning compounds or optical matching fluids such as mineral oil, cellulose gel, normal saline, sugar water and water.

The microscope objective should be compact and must be able to fit into the larger laser system.

The lens system should be resistant to catastrophic failure under exposure to a 0.5 Watt pulsed femtosecond Ti:sapphire laser operating at wavelength of 400nm with a bandwidth of 10nm (± 5 nm).

Regulatory Issues:

None, this is a design project. There will be regulatory issues associated with the larger system, but that is out of the scope of our project.

[1] "Lateral gradient index microlenses written in ophthalmic hydrogel polymers by femtosecond laser micromachining,", Lisen Xu;, Wayne H. Knox, OPTICAL MATERIALS EXPRESS Volume: 1 Issue: 8 Pages: 1416-1424 (Published: DEC 1 2011)

Fitness for use:

First Order Specifications	The System Will Have	It is Desirable That	Comments
Aperture	Image NA= 0.7	Image NA= 1.0	The last surface will be immersed in water
Field	± 0.1 degrees		
Wavelengths	400 ± 5 nm		0.5 W Ti:Sapphire Laser Source

Packaging/Manufacturing Specifications	The System Will Have	It is Desirable That	Comments
Working Distance	>0.5 mm		To prevent contact with corneal tissue
Full Aperture	>5mm, <12mm		
Clear Aperture of first surface	>10mm		To accommodate beam width
Overall Length	>5mm, <35mm		Length of the lens Assembly from First Lens Surface to Last Lens Surface
Object	Collimated 0.5 W Pulsed Femtosecond Ti:Sapphire Laser with approx. 10mm beam width		
Final surface	Flat or Convex		For the prevention of bubbles when immersed in water
Cemented Doublets		None	For ease of manufacturing
Hemispherical Lens Surfaces		None	For ease of manufacturing

Material Specifications	The System Will Have	It is Desirable That	Comments
Glass Types	Fused Silica*		Optimax Systems Inc. preferred glasses column (http://www.optimaxsi.com/preferred-glass/) *another glass type may be needed to correct for chromatic aberrations
Surface Types	Spherical Only		No Aspheres, GRINs, or DOEs due to limits of Optimax Estimator Software
Maximum Number of Elements		<4	

Anti-Reflection Coating	V-coat centered at 400nm	Standard Optimax Systems Inc. anti- reflection V- coat

Performance Specifications	**The System Will Have**	**It is Desirable That**	**Comments**
Transmission	90% at 400 ± 5 nm	>90% at 400 ± 5 nm	
Ray angles of incidence and refraction on all *coated* surfaces	<50 Degrees	<40 Degrees	Needed to Simplify the Coating Design
Wave front error	Less than 0.05 Waves		
Diffraction Limited	200µm behind the surface of the cornea to 300µm behind the surface of the cornea		
Vignetting	None		To increase transmission

The designs will be optimized for price as a function of various performance parameters in collaboration with Optimax Systems Inc. and their Estimator software. Such parameters will be:

- Numerical aperture (range of 0.7 to 1 when immersed in water)
- Number of elements
- Different design forms
- Tolerances

Project Scope:

Responsible for

- Determining the lens specifications with customers
- Designing the lens system using CodeV software (possibly Zemax)
- Comparing designs versus price using Estimator software
- Presenting the collected design and cost metrics to customers
- Having the customer choose a design that meets all performance specifications at the lowest cost
- Making any final revisions to the chosen design
- Passing the design to Optimax Systems Inc. for fabrication
- Investigating possible optomechanical design mounting options with Dan Brooks if time permits

Not Responsible for

- Manufacturing the lenses
  - Manufacturing will be done by Optimax Systems Inc
- Testing manufactured lenses
  - Testing of optical and mechanical properties of the lenses is done by Optimax Systems Inc as part of their manufacturing process
- Designing the optomechanical mounting
  - Optomechanical mounting will be designed by Dan Brooks
- The larger system that will incorporate the microscope objective
  - We are only designing the microscope objective that the larger system will use, and are not responsible for assembling the system, testing the system, or any safety or regulatory issues associated with it

Budget

- Rick Plympton told us that Optimax Systems Inc. will cover the cost of manufacturing the lenses after a design has been agreed upon
- No target budget was given, but as part of the scope of our project, we will design a system that meets all performance specifications at the lowest cost possible.

Timeline

- Mid- January: begin lens design process
- March 7 (before Spring Break): Draft initial designs in conjunction with Estimator software

  Optimized for price as a function of:

  - Numerical aperture

  - Number of elements

  - Different design forms

  - Tolerances
- Week of March 16: Meet with customers to choose design that meets specifications at the lowest cost
- March- April: Investigate possible optomechanical design mounting options if time permits
- Mid- April: Finalize designs; submit lenses for fabrication to Optimax Systems Inc.