Lens System for Photoacoustic Imaging of Prostate

Product Requirements Document

OPT 310 - Acoustic Imaging Team

Document Number 001

Revision Level	Date
D	12 December 2014

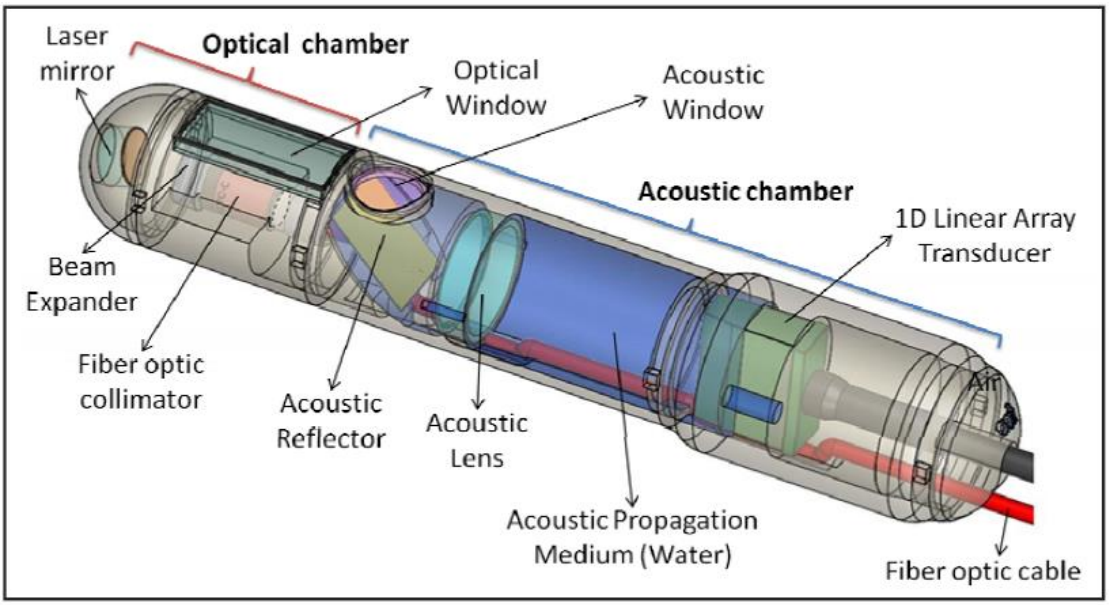
Revision History

Revision	Major Changes	Date
A	Initial Release	10/27/14
B	Refined requirements from customer feedback	11/9/14
C	Added scope section, added specification table	11/30/14
D	Formatting, added revision history*, added system diagram	12/12/14

** Constructed from highlighted changes in previous revision documents*

Vision:

A lens subsystem for imaging the acoustic response of prostate tissue exposed to laser radiation. This subsystem will be implemented within a greater device for performing photoacoustic imaging of in-vivo human prostates (pictured below).



Scope:

The team is responsible for:

designing a floating, i.e. no mounting mechanics, lens system and delivering a full schematic of the system to the customer. The report should include mechanical tolerancing and sensitivity analyses.

choosing the materials used for the acoustic lenses.

overseeing that the designed lenses are manufactured according to the desired specifications.

testing and validating the manufactured floating lens system in the test setup provided by the customer.

If time permits, a basic stray “light” analysis of the final system should be performed and delivered to the customer. This report should include recommended actions that the customer might take to maximize their signal to noise ratio.

The team is NOT responsible for:

any portion of the design that is not directly relevant to the imaging subsystem of the device

choosing an acoustic sensor or acoustic mirror.

the mechanical mounting of the lens system or any mechanics required move the lens element during zooming.

Environment:

The lens system:

must meet performance specifications over a range of 55 – 110 ºF.

should be able to sustain minimal mechanical impacts and maintain required performance.

needs to fit within a previously designed housing with a 22mm internal diameter. This is the maximum allowable lens diameter. (See System Diagram)

will be immersed in water between lenses.

Regulatory Issues:

There are no regulatory concerns.

Fitness for use:

The system will:

image acoustic waves onto to 22.4 mm x 1 mm sensor with a rectangular pixel pitch of 0.7 mm x 1 mm. The acoustic signal has a center wavelength of 300 µm. Wavelengths between 150 µm and 450 µm should be considered in the design.

able to image 2 cm section of the prostate along the 22.4 mm axis of the sensor.

minimize the loss in acoustic signal amplitude as it propagates through the system. Lenses will be immersed in water instead of air to minimize loss of signal. Materials with acoustic impedances matching that of water should be used to avoid loss of

signal at lens interfaces. Lenses should be kept thin if they attenuate the acoustic signal more than water.

be capable of deterministically measuring the size of the region being imaged. This should be known across system zoom positions (described later in document).

have lenses that are long-lasting (i.e.do not degrade over time).

the lens system can change it object plane between 0 and 2 cm from the entrance window of the system. It should be noted that the full depth of the prostate from the entrance window of the system is 5 cm. (See System Diagram)

the first element in the lens system must be at least 32 mm away from the entrance window of the system.

It is desirable that:

the lens system has the ability to magnify a region of interest in the prostate image. It is desirable that the system is able to view a region of interest as small as 5mm onto the entire detector. The lens system also has the capability to zoom out and image the entire diameter of the prostate, about 4 cm, onto the entire detector. Performance only need to be maintained for 4-5 zoom position within this range, not throughout the entire range. The sensor position may be allowed to change if necessary however moving elements is preferred.

the field curvature aberrations of the lens system be minimized. This will allow images to be processed and displayed more rapidly.

low cost manufacturing techniques for rapid prototyping of multiple designs. Manufacturing volume will be extremely low, i.e. 1-5 systems.

Specification Table:

Summary of specification provided in previous sections.

Aperture	< f/3
Field	5 mm – 40 mm object diam. (22.4 mm primary)
Wavelength	150, 300 (primary), and 450 µm
Zoom Range	8x field zoom
Sensor Size	22.4 x 1 mm (32 x 1 pixels)
Pixel Size	0.7 x 1 mm
Nyquist	0.714 lp/mm
MTF (as-built)	> 30% at 0.7 lp/mm
Distortion	< 4%
Telecentricity	n/a
Relative Illumination	No vignetting
Elements	≤ 3 (pending testing)
Diameter	< 22 mm
Length	< 1.5 ft
Object Clearance	32 mm from entrance window
Image Clearance	> 1 cm
Airspace Material	All airspaces are water immersed

System Diagram:

Cross-sectional side view displaying physical constraints of the system.