Light-responsive microvalve for flow control in a novel glaucoma implant

Master thesis project

Introduction

Glaucoma is the leading cause of preventable blindness worldwide, with over 70 million people affected and 10% being bilaterally blind [1]. A rise in the intraocular pressure (IOP) is considered to be the major risk factor for glaucoma, and is associated with an unbalance between the production and drainage of aqueous humor (AqH) due to an abnormal increase of resistance to AqH outflow from the anterior chamber.

Glaucoma drainage devices (GDDs), which are typically hollow tube-like shunts surgically implanted in the eye, provide an alternative pathway through which AqH can effectively exit the anterior chamber, thereby lowering IOP (Fig. 1) [2]. However, postoperative IOP is unpredictable and current GDDs often lack in maintaining it at optimal levels, which can lead to serious postsurgical complications such as hypotony (i.e. low IOP).

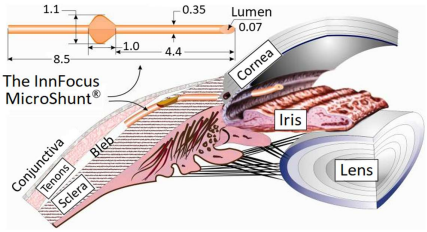

Figure 1: An example of a GDD: the InnFocus MicroShunt including its dimensions (mm) and placement in the eye [2].

Project description

The aim of this project is to fabricate a novel glaucoma implant with an integrated light-responsive microvalve, which will be made of a photoresponsive liquid crystal polymer. Upon irradiation with light of a specific wavelength region (color), the microvalve will change its shape to close or open microfluidic channels inside the device. This will enable to modulate the hydrodynamic resistance of the GDD in a non-invasive way. Thus, the final device will not only drive the AqH from the anterior chamber into a filtering bleb (Fig. 2) [3], but will also enable to effectively maintain the IOP within the normal range (10-15 mmHg). An example of how a light-responsive film actuates under light irradiation is illustrated in Fig. 3.

The main goals of this project are:

- Fabrication of a microfluidic device with a light-responsive valve integrated: new strategies to integrate the responsive valve into the microdevice will have to be developed;
- Test the flow control properties of the light-actuated device and adjust its design whenever necessary to achieve the desired flow modulation.

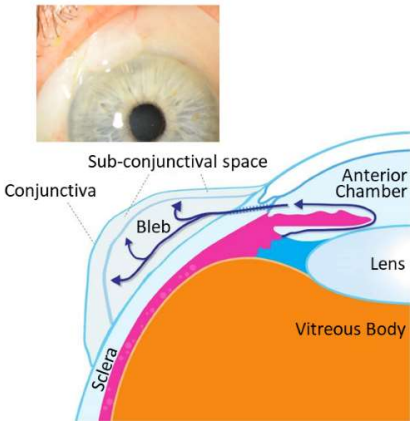

Figure 2: Bleb formed by subconjunctival drainage of AqH [3].

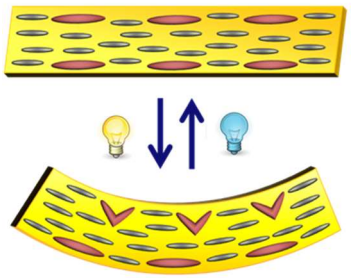

Figure 3: Schematic depiction of the shape change of a photoresponsive film under light irradiation.

References

1. H.A. Quigley and A.T. Broman, "The number of people with glaucoma worldwide in 2010 and 2020", *Br J Ophthalmol*, 2006.
2. J.F. Batlle, *et al.*, "Three-Year Follow-up of a Novel Aqueous Humor MicroShunt", *J Glaucoma*, 2016.
3. B.S. Gardiner, *et al.*, "Computational Modeling of Fluid Flow and Intra-Ocular Pressure following Glaucoma Surgery", *PLoS One*, 2010.

Interested? Contact: Microsystems Group
Hans Wyss (h.m.wyss@tue.nl, GEM-Z 3.127, www.mate.tue.nl/~wyss)