MAGNETICALLY ACTUATED GLAUCOMA DRAINAGE DEVICE WITH ADJUSTABLE FLOW PROPERTIES AFTER IMPLANTATION

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Inês C.F. Pereira[1,2,*], Hans M. Wyss[1,2], Henny J.M. Beckers[3], and Jaap M.J. den Toonder[1,2]

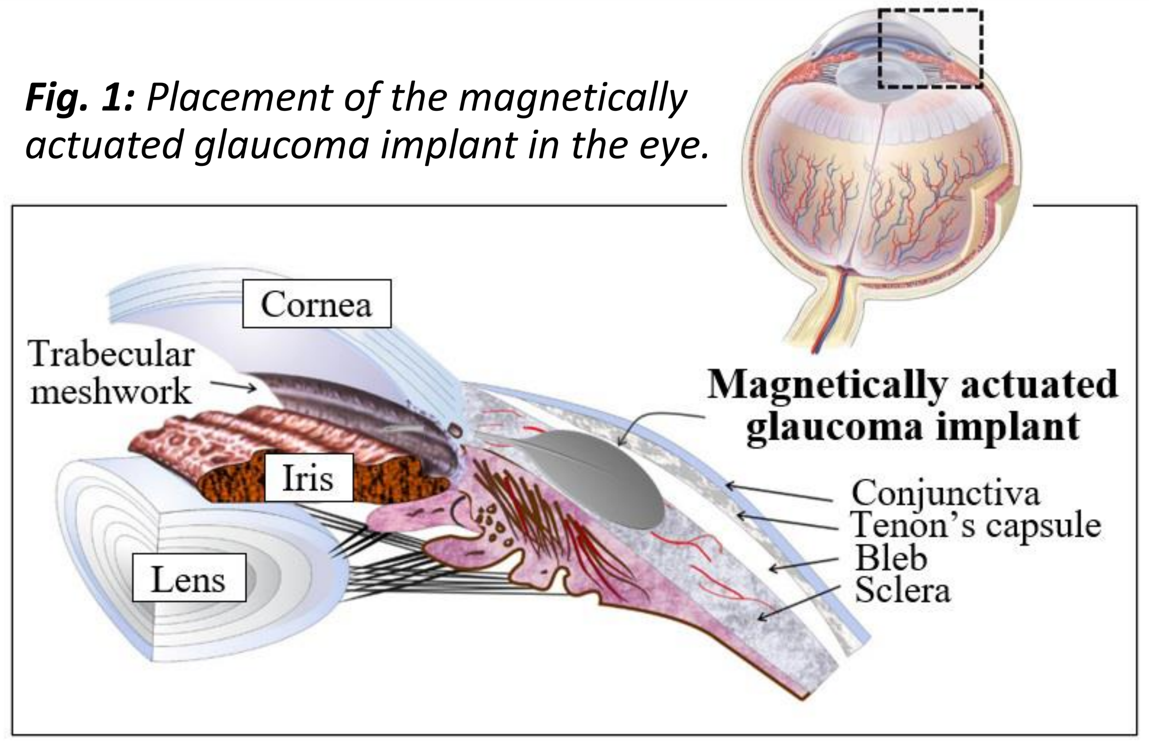
[1]*Microsystems, Eindhoven University of Technology, The Netherlands*
[2]*Institute for Complex Molecular Systems, Eindhoven University of Technology, The Netherlands*
[3]*University Eye Clinic Maastricht, Maastricht University Medical Centre+ (MUMC+), The Netherlands*

*Contact: i.c.figueiredo.pereira@tue.nl

Motivation

Glaucoma is a group of eye conditions that damage the optic nerve, the health of which is vital for good vision. The key risk factor for this disease is increased intraocular pressure (IOP)[1]. Implantable glaucoma drainage devices have been developed as an alternative means to divert fluid out of the eye to reduce the IOP[2]. However, postoperative IOP is unpredictable and current implants often fail in maintaining it at optimal levels[3]. To achieve better control of the IOP, we are developing an innovative magnetically actuated glaucoma implant with a hydrodynamic resistance that can be adjusted following surgery.

Fig. 1: Placement of the magnetically actuated glaucoma implant in the eye.



Implant design

Our smart implant is comprised of a drainage tube and a housing element in which a magnetic "micro-pencil" valve is integrated. The implant is made from poly(styrene-*block*-isobutylene-*block*-styrene), or 'SIBS'.

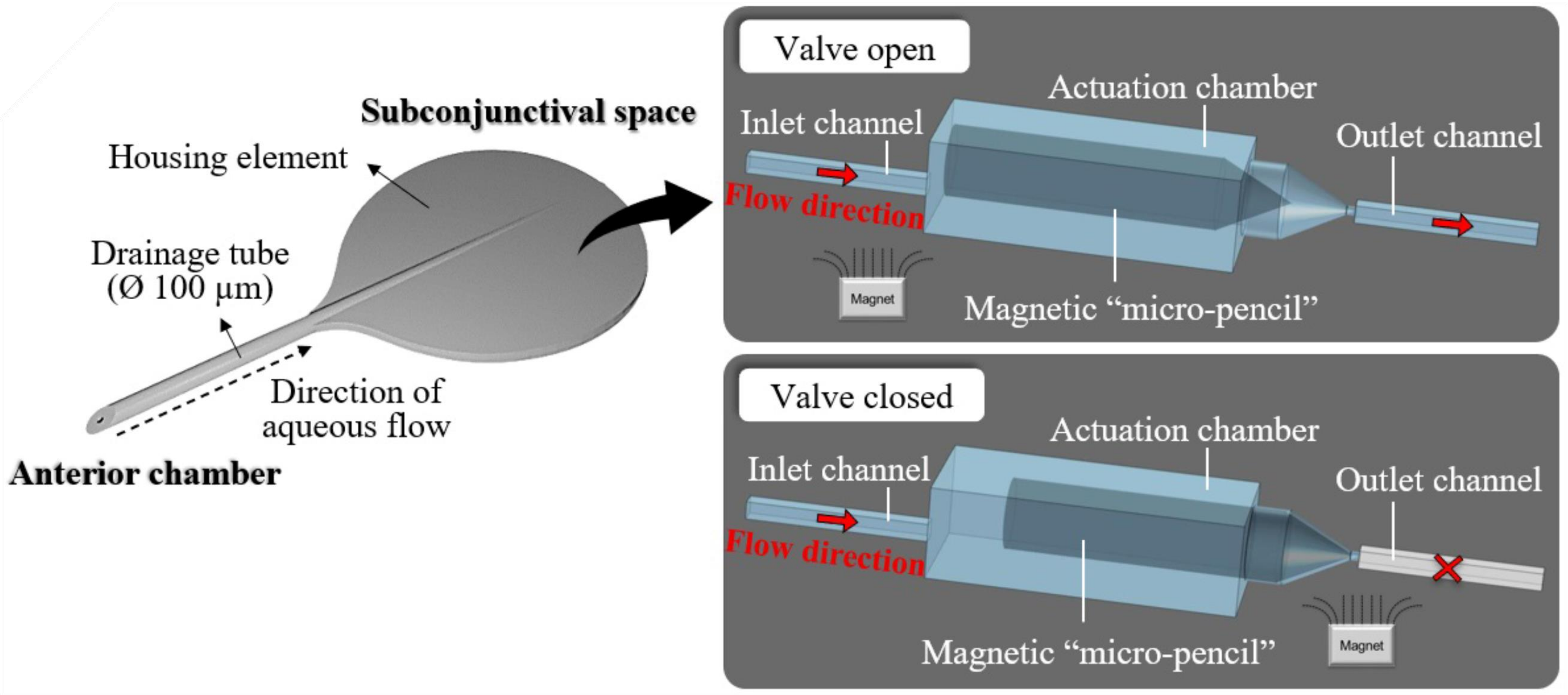


Fig. 2: Schematic depiction of the magnetically adjustable glaucoma implant design and actuation mechanism of the integrated micro-pencil valve.

Fabrication

The magnetic microvalve was made from SIBS with homogeneously dispersed iron microparticles. Micro-pencil valves of this material were fabricated by replica molding using hot embossing, using femtosecond laser-machined fused silica glass molds. The same technique was used to fabricate the housing element.

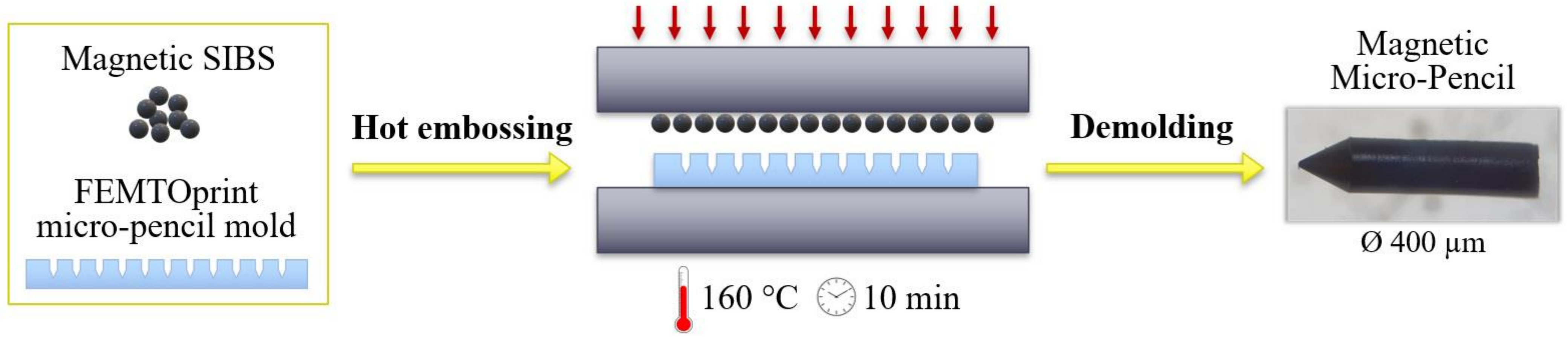


Fig. 3: Schematic illustration of the micro-pencil valve fabrication process.

Microfluidic experiment

1. Microfluidic experiments involving actuating the magnetic micro-pencil with a moving external magnet were carried out to confirm the valving function. The pressure upstream the implant was measured while the microvalve was switched between open/closed states.

2. A pressure difference up to 6 mmHg was achieved which is sufficient to overcome hypotony (i.e. too low IOP) – one of the most common post-operative complications following glaucoma filtration surgery.

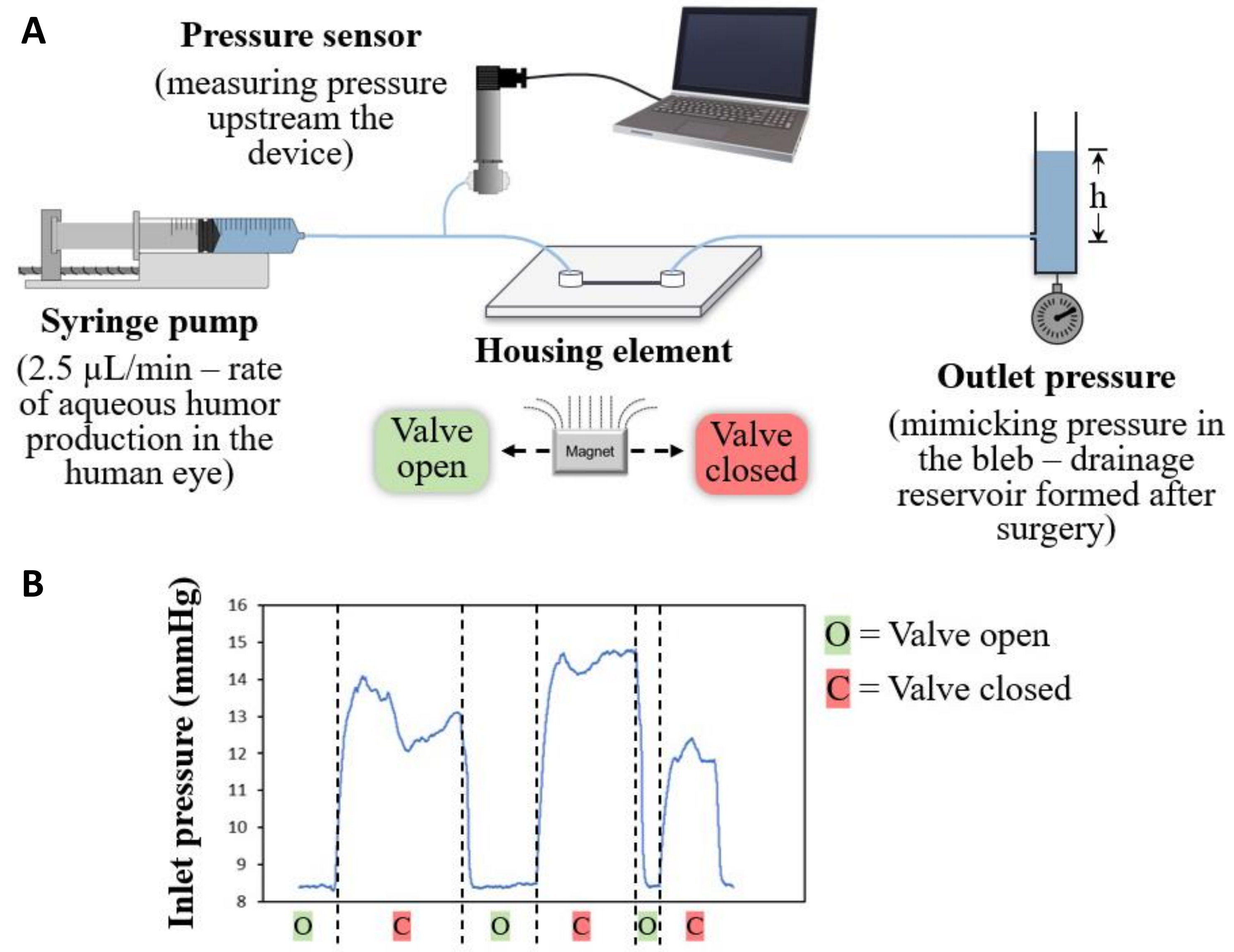


Fig. 4: A – Setup used for the microfluidic experiment. B – In vitro measurement of the pressure variation upstream the device as a result of the valve operation.

Conclusion

- ✓ The femtosecond laser machining process has proved to be an effective technique to fabricate the molds for both the microvalve and the glaucoma device;
- ✓ The features in these molds were successfully transferred to the thermoplastic material SIBS by replica molding using a hot embossing machine;
- ✓ Microfluidic experiments showed that, when in the closed state, the microvalve can provide a sufficient hydrodynamic resistance that can help to overcome hypotony.

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TU/e MICRO SYSTEMS
Maastricht UMC+
Santen
INNFOCUS
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