A NIR-spectroscopy-based approach for detection of fluids in rectangular glass micro-capillaries

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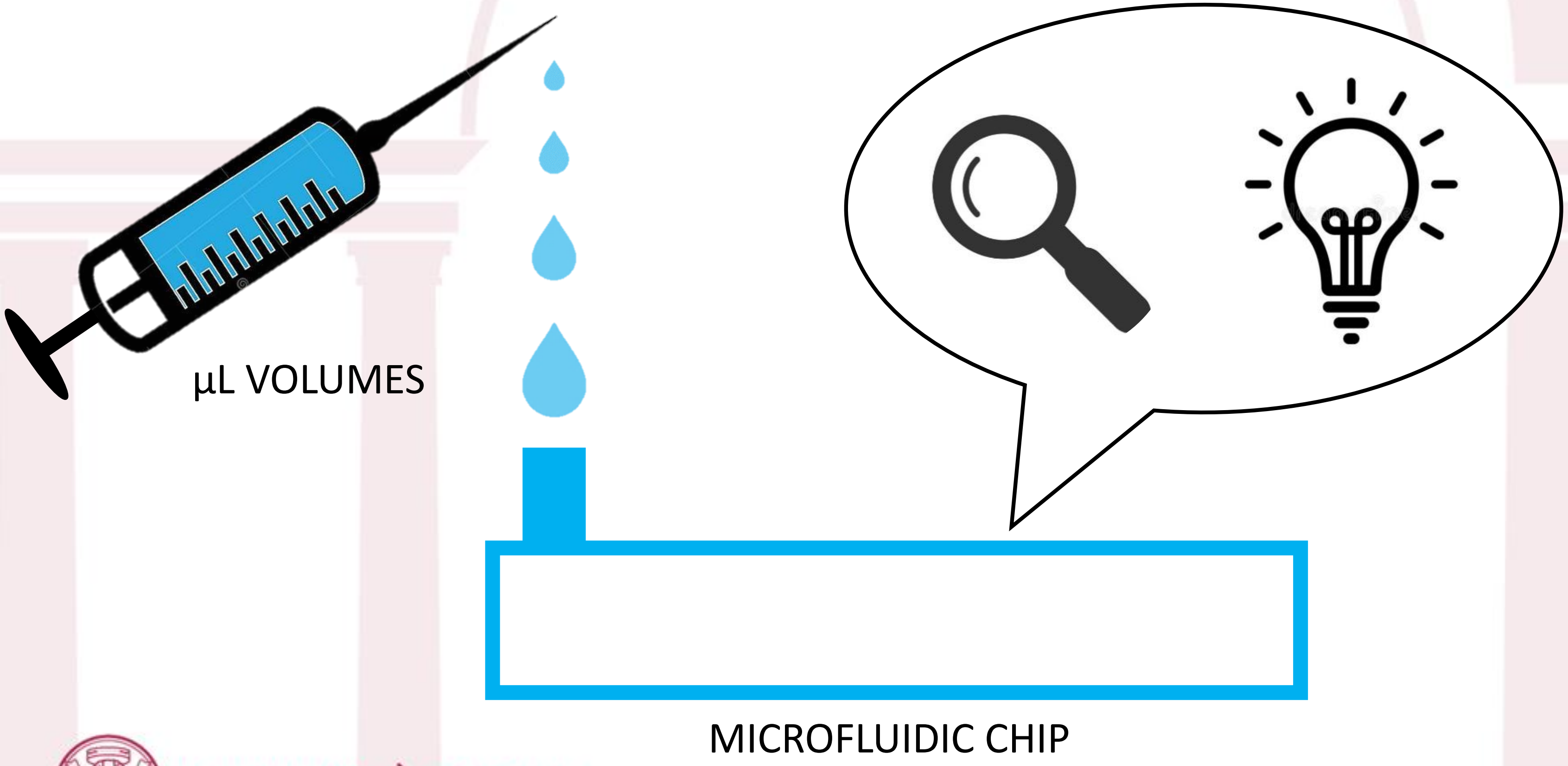
Outline

- What is microfluidics?
- Goal of the work
- Micro-opto-fluidic setup
- Theoretical model
- Results
- Conclusions
- Future perspectives: what’s next?

What is microfluidics?

Microfluidics is the science of manipulating and controlling fluids, usually in the range of microliters to microliters, in networks of channels with dimensions from tens to hundreds of micrometres.



APPLICATIONS

- BIOLOGY
- HEALTHCARE
- CHEMISTRY
- DRUG DISCOVERY

… AND MANY OTHERS!

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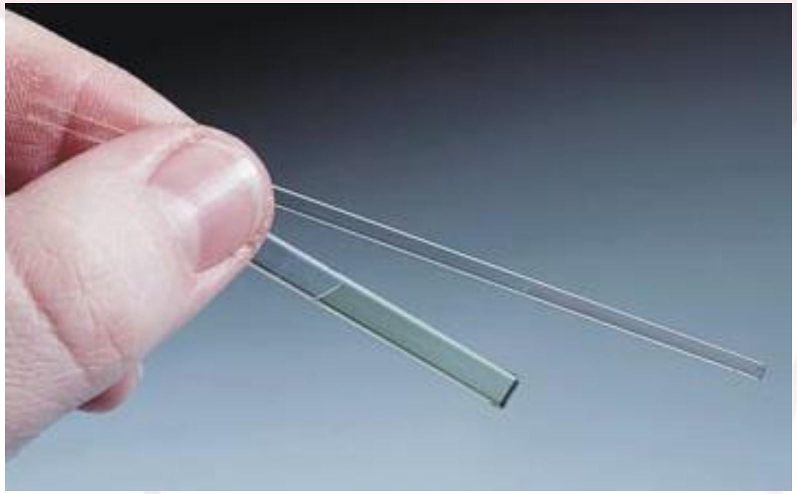
Goal of the work

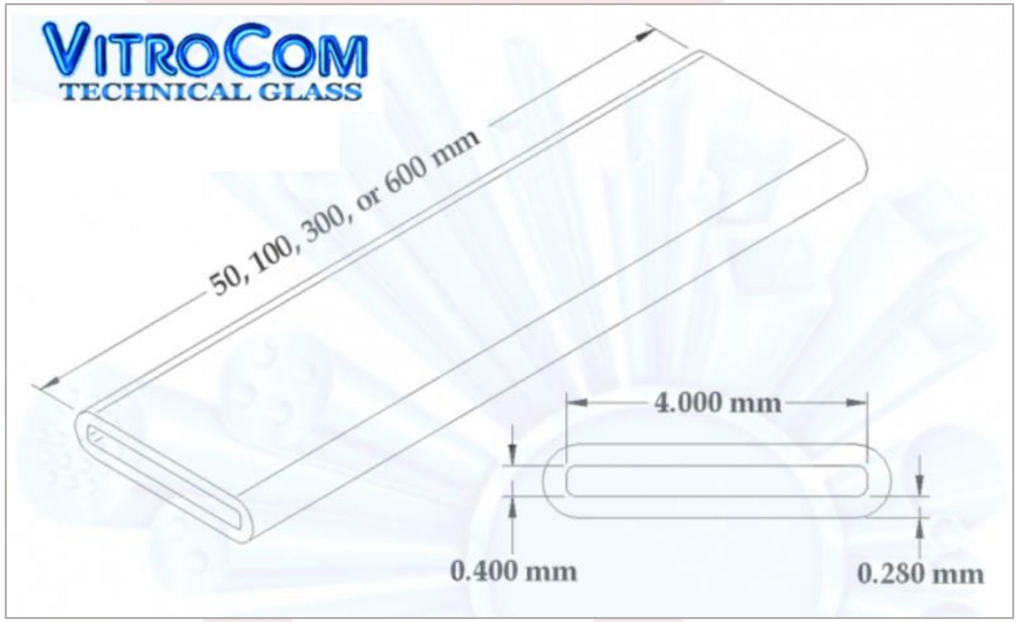
Rectangular glass micro-capillaries: features

- Commercially available low-cost devices.
- Reduction of light scattering.
- Transparency → optical detection.
- Micrometric dimensions → ultra-low volumes of sample.

⇩

PERFECT DEVICES
FOR MICRO-OPTO-FLUIDIC SENSING!





In previous works, we exploited micro-capillaries to measure the real part of the refractive index:

- spectral reflectometry# (detection of optical resonances)
- spectral shift interferometry$

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#Rigamonti et al., *Biomed. Opt. Express* **2017**, *8*, 4438
$Bello et al., *Sensors* **2020**, *20*, 1043

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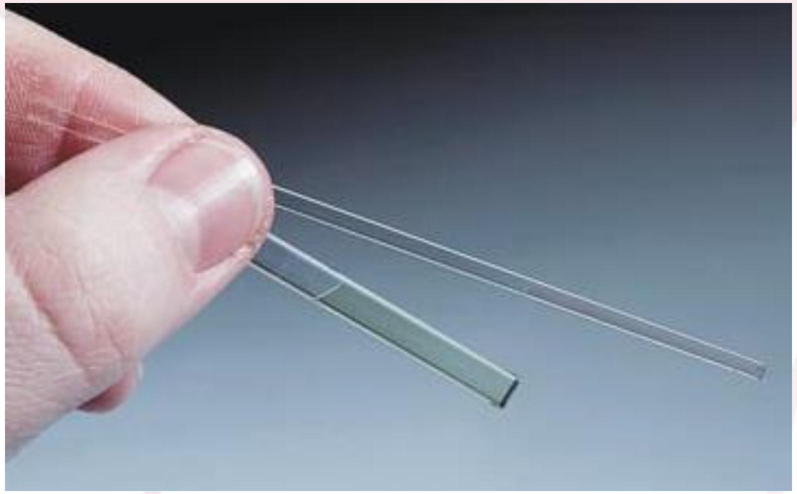
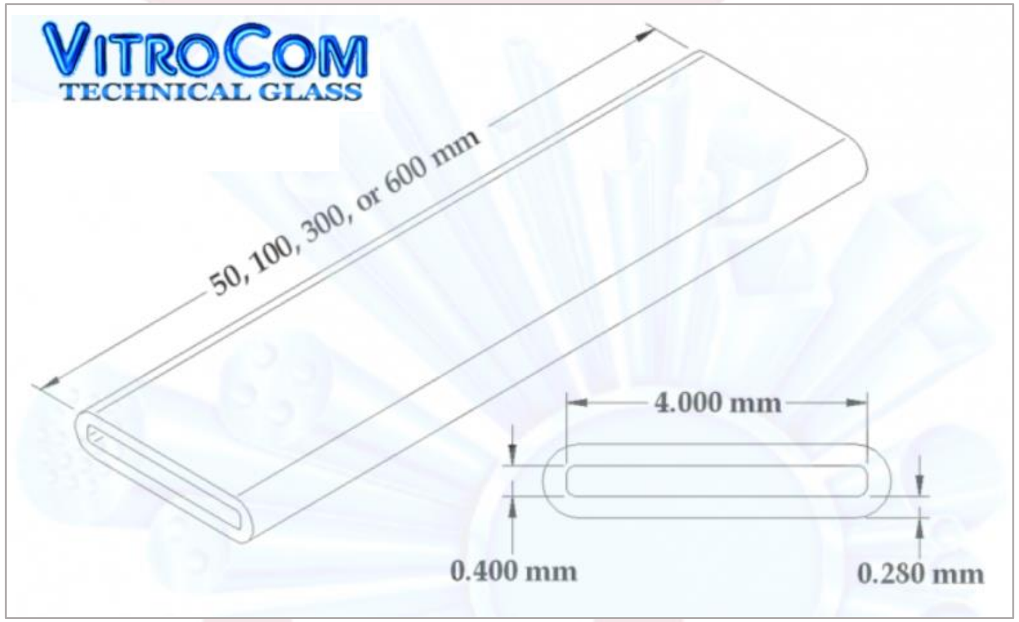
BUT <u>refractive index sensing is non-specific!</u>

Hence, in this work ⇨ we exploit micro-capillaries for recognition of fluids based on spectroscopy in the near infrared region





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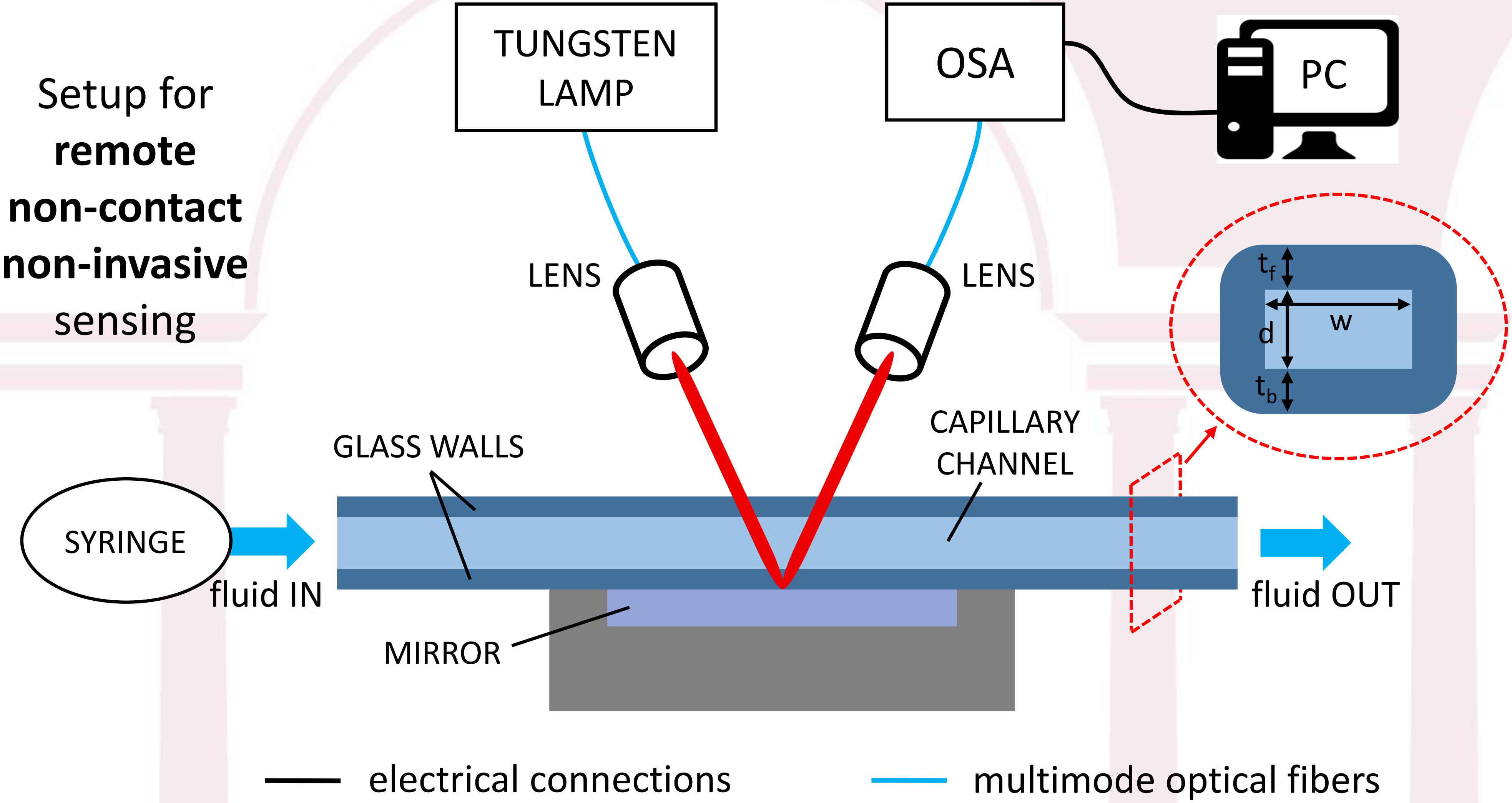
Micro-opto-fluidic setup

Setup for
remote
non-contact
non-invasive
sensing



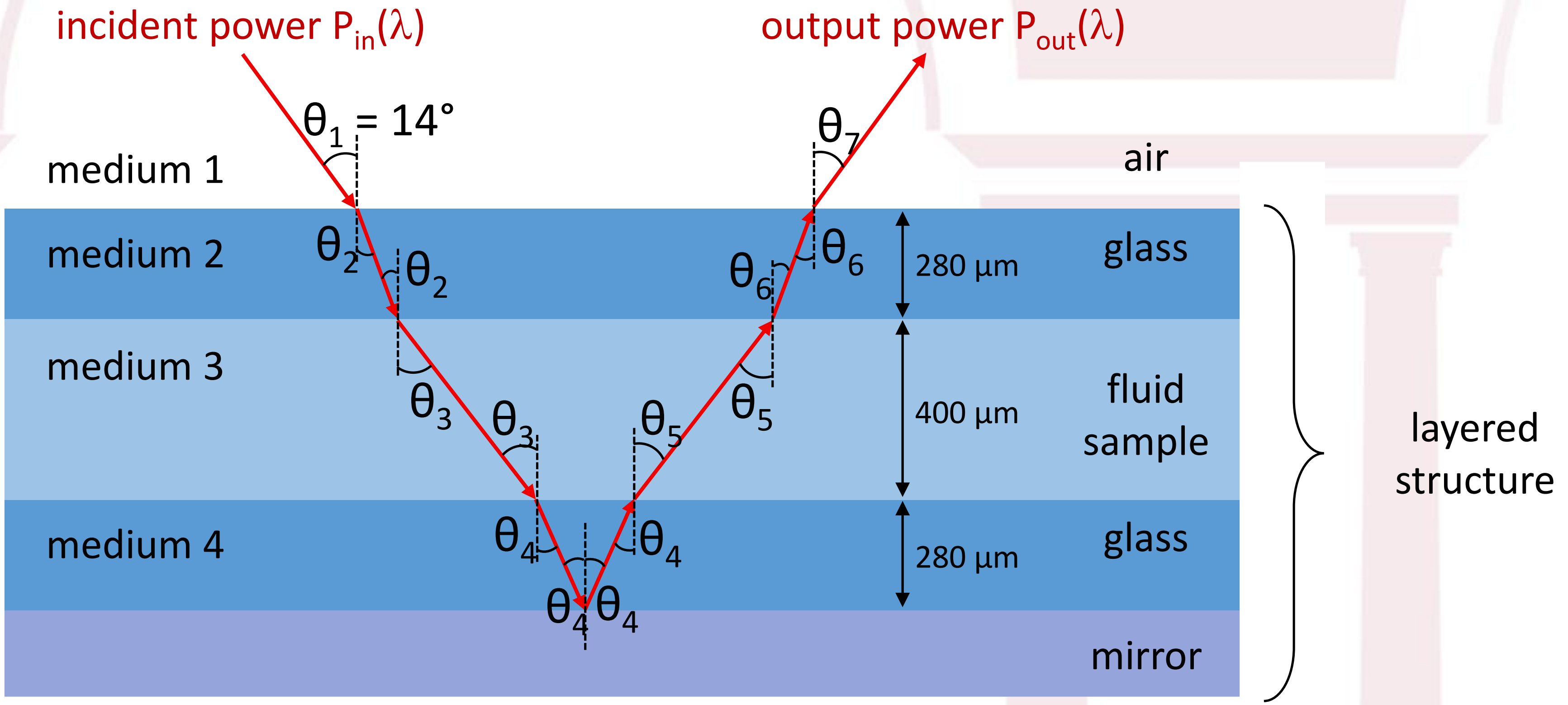
Theoretical model

effect of absortpion → Beer-Lambert law

$T_{air} = P_{out\ air}(\lambda)/P_{in}(\lambda)$ (with empty channel) $T_{sample} = P_{out\ sample}(\lambda)/P_{in}(\lambda)$ (with fluid in channel)

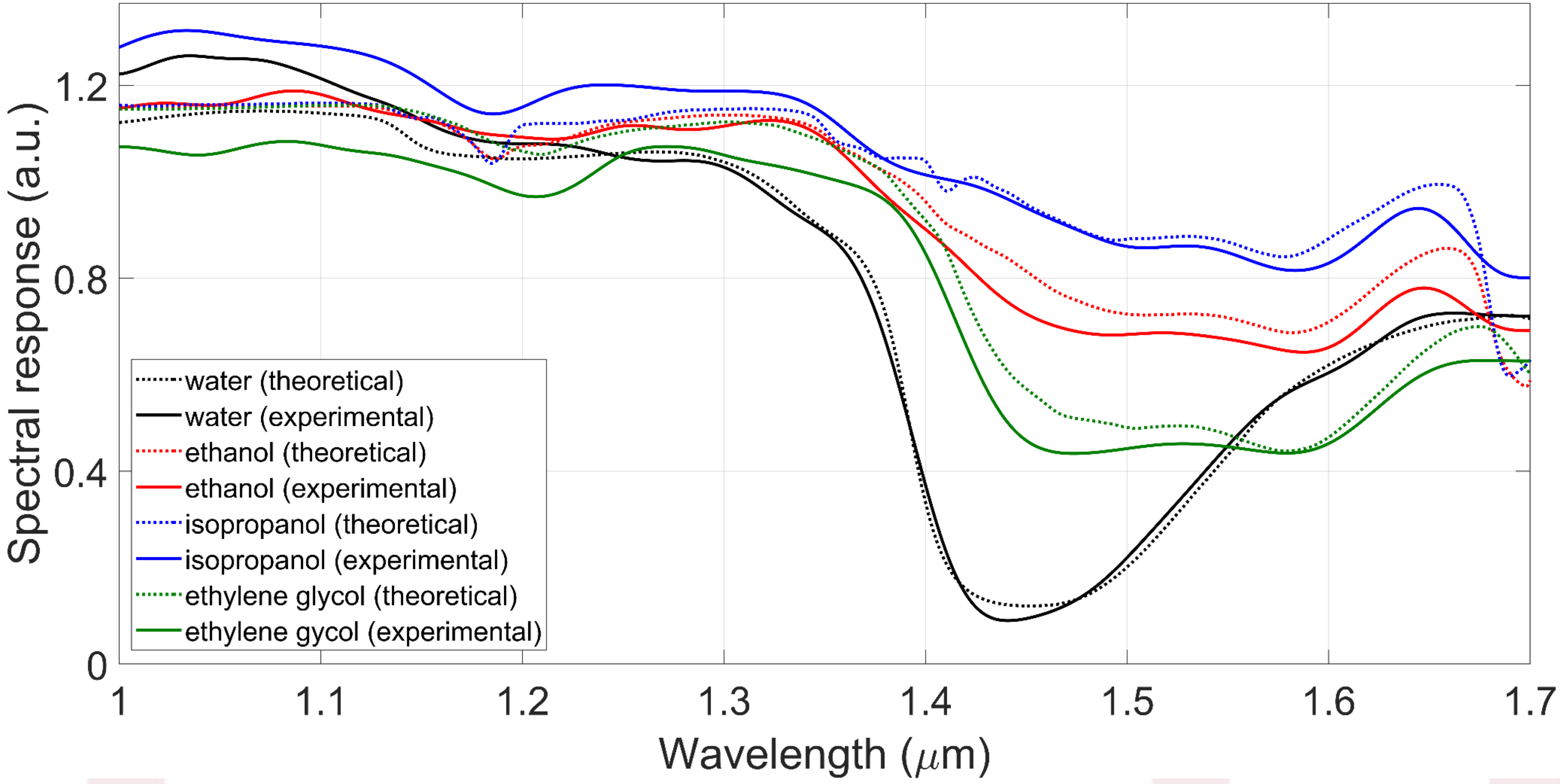
spectral response: $SR(\lambda) = T_{sample}/T_{air} = P_{out\ sample}(\lambda)/P_{out\ air}(\lambda)$ → depends on the absorption features of the sample

Model implemented in MATLAB



Results – 1

Experimental spectra, in good agreement with theoretical predictions, allowed to distinguish water from several types of alcohol thanks to their different absorption features.



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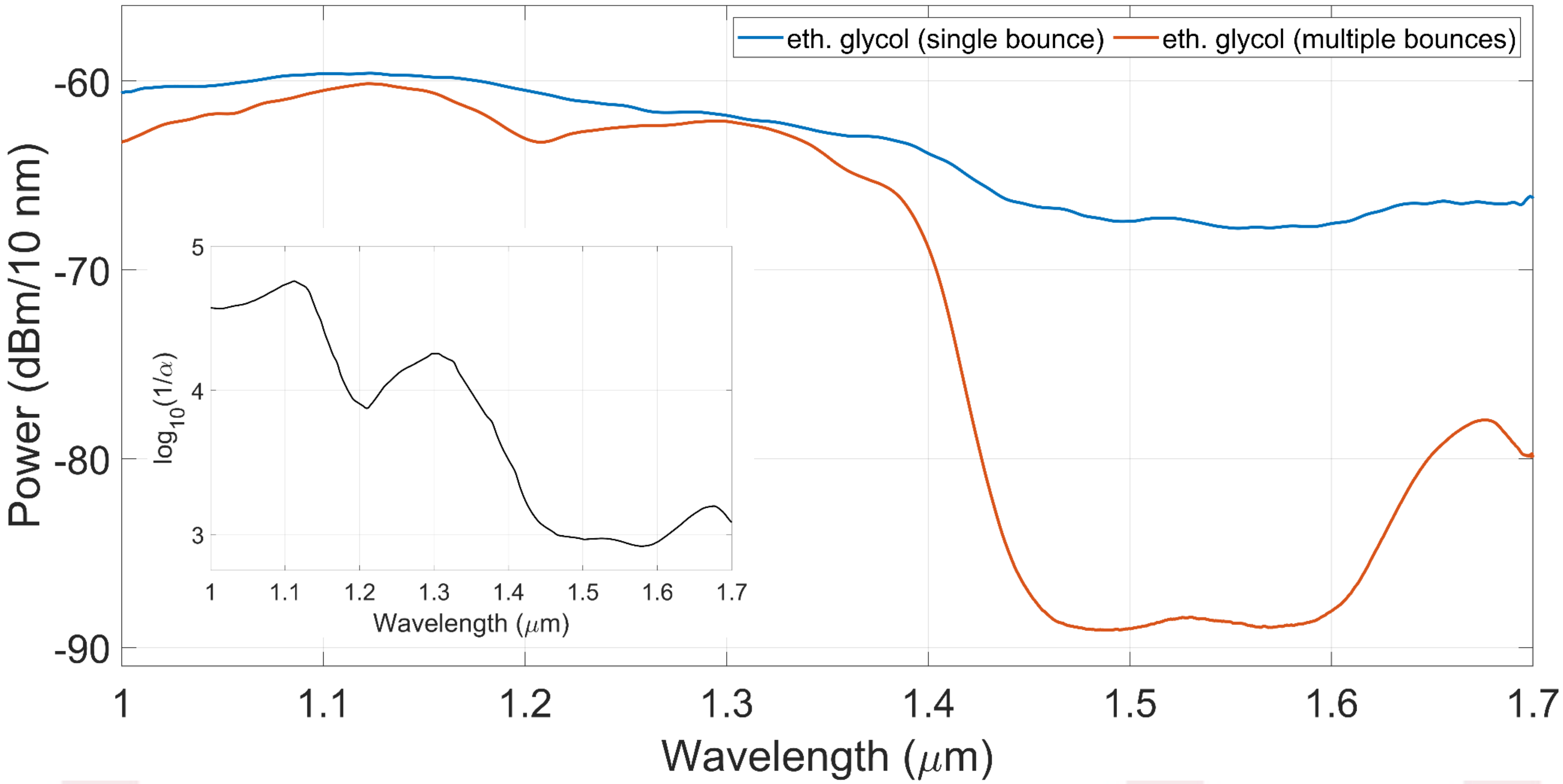
Results – 2

By extending the path length travelled by the light in the channel, spectra of sample can be reconstructed with a higher level of detail.



Conclusions

In this work, we have reported a **micro-opto-fluidic platform** based on **rectangular** glass **micro-capillaries** for detection of fluids based on their **spectroscopic features**.

The micro-capillary is laid onto a bulk **mirror** and light emitted by a **tungsten lamp** crosses the channel containing the sample twice.

A **theoretical model** was implemented in MATLAB® environment.

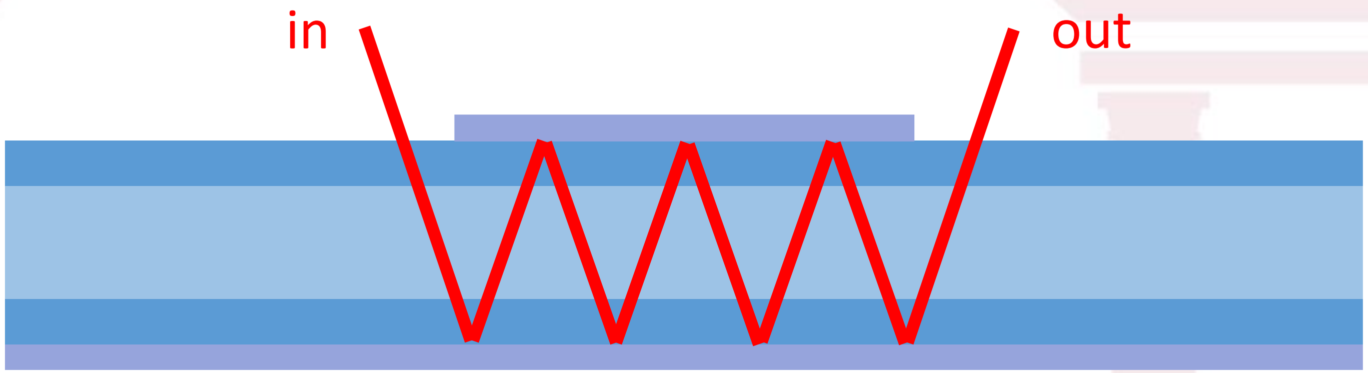
Experimental results are in good agreement with the theoretical study. In particular, **water and** three types of **alcohol were** tested and **distinguished** thanks to their absorption profiles.

Moreover, by **extending the light-path** inside the channel, absorption profiles of fluids can be reconstructed with a **greater level of detail**.

Future perspectives: what's next?

Future work will be devoted to the realization of a **more compact setup** including a laser diode, a photodetector and a metallization coating instead of the bulky mirror.

Moreover, both sides of the capillary can be coated to obtain a "**multiple-bounce**" configuration.



The system could be exploited also for the analysis of **biological fluids**.

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