



**HAL**  
open science

## Toward hybrid polymer-porous silicon waveguides for Vernier-effect optical biosensors

Paul Azuelos, Nathalie Lorrain, M. Guendouz, Parastesh Pirasteh, Jonathan Lemaitre, Isabelle Hardy, Joël Charrier, Monique Thual

► **To cite this version:**

Paul Azuelos, Nathalie Lorrain, M. Guendouz, Parastesh Pirasteh, Jonathan Lemaitre, et al.. Toward hybrid polymer-porous silicon waveguides for Vernier-effect optical biosensors. 11th Porous Semiconductors - Science and Technology 2018 Conference (PSST 2018), Mar 2018, La Grande Motte, France. hal-01891918

**HAL Id: hal-01891918**

**<https://hal.science/hal-01891918v1>**

Submitted on 18 Oct 2018

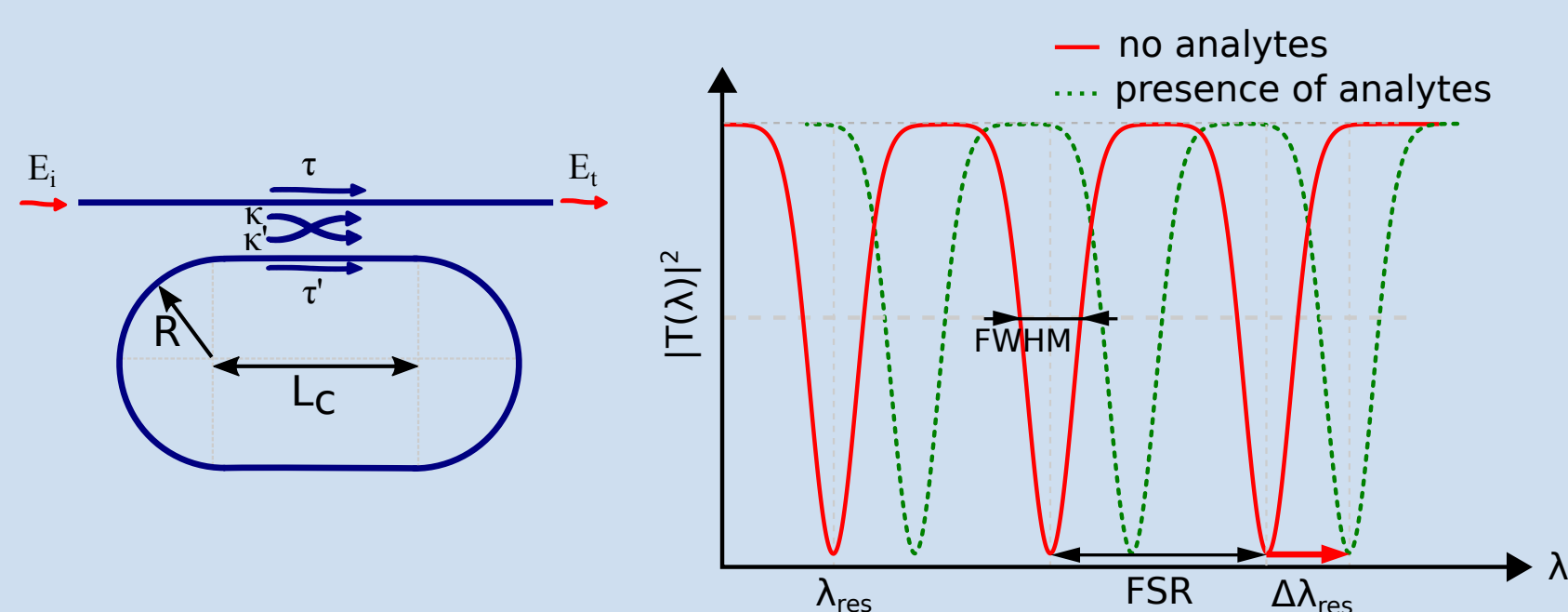
**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Toward hybrid Polymer-Porous silicon waveguides for Vernier effect optical biosensors

## Introduction on integrated MR

### • Microresonator sensing

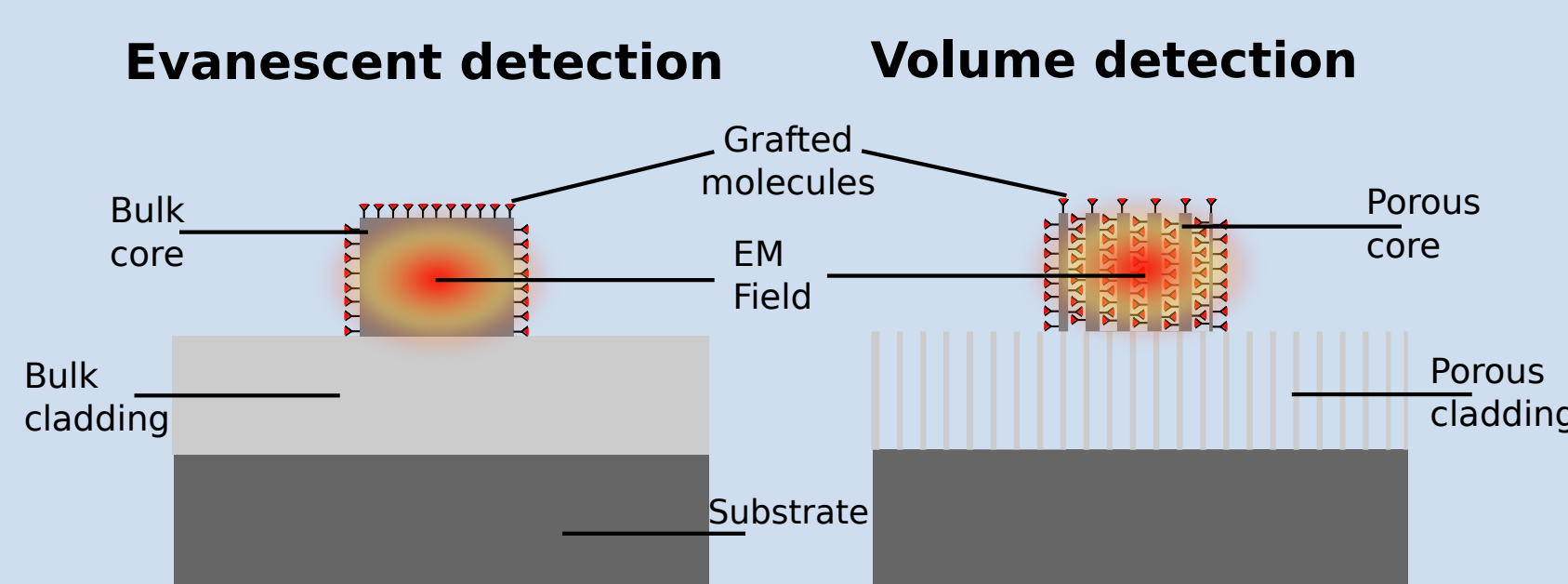


Sensor performance evaluation with **Sensitivity** and **Limit of Detection** :

$$S = \frac{\Delta\lambda_{res}}{\Delta C_{analytes}} \quad LOD = \frac{Noises}{S}$$

Main economic field : Health, Research, Industrie, Biodefense, Environnemental

### • PSi for surface sensing



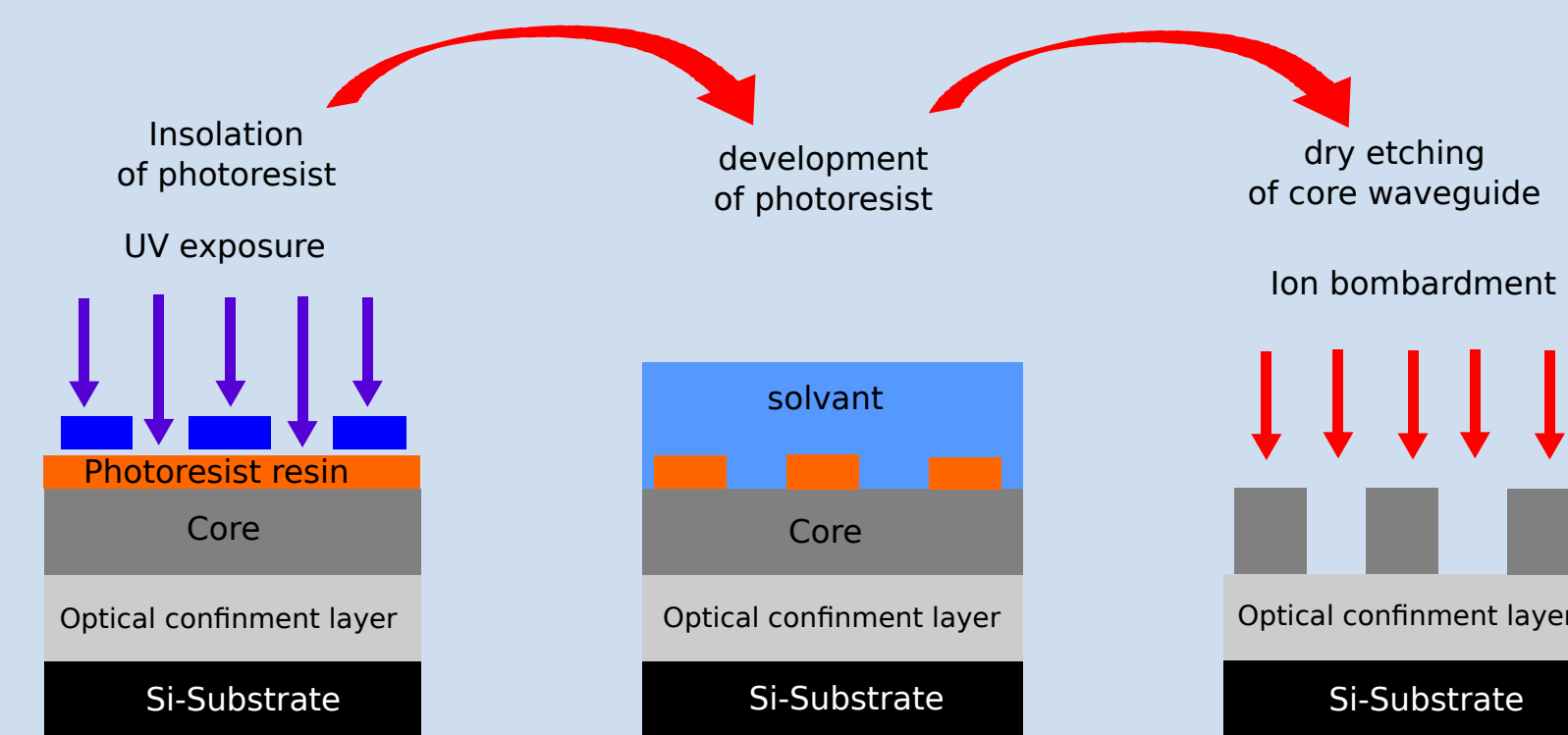
**PSi advantage** : High sensing sensitivity  
**Bulk material advantage** : Low propagation losses

## Porous silicon MR fabrication

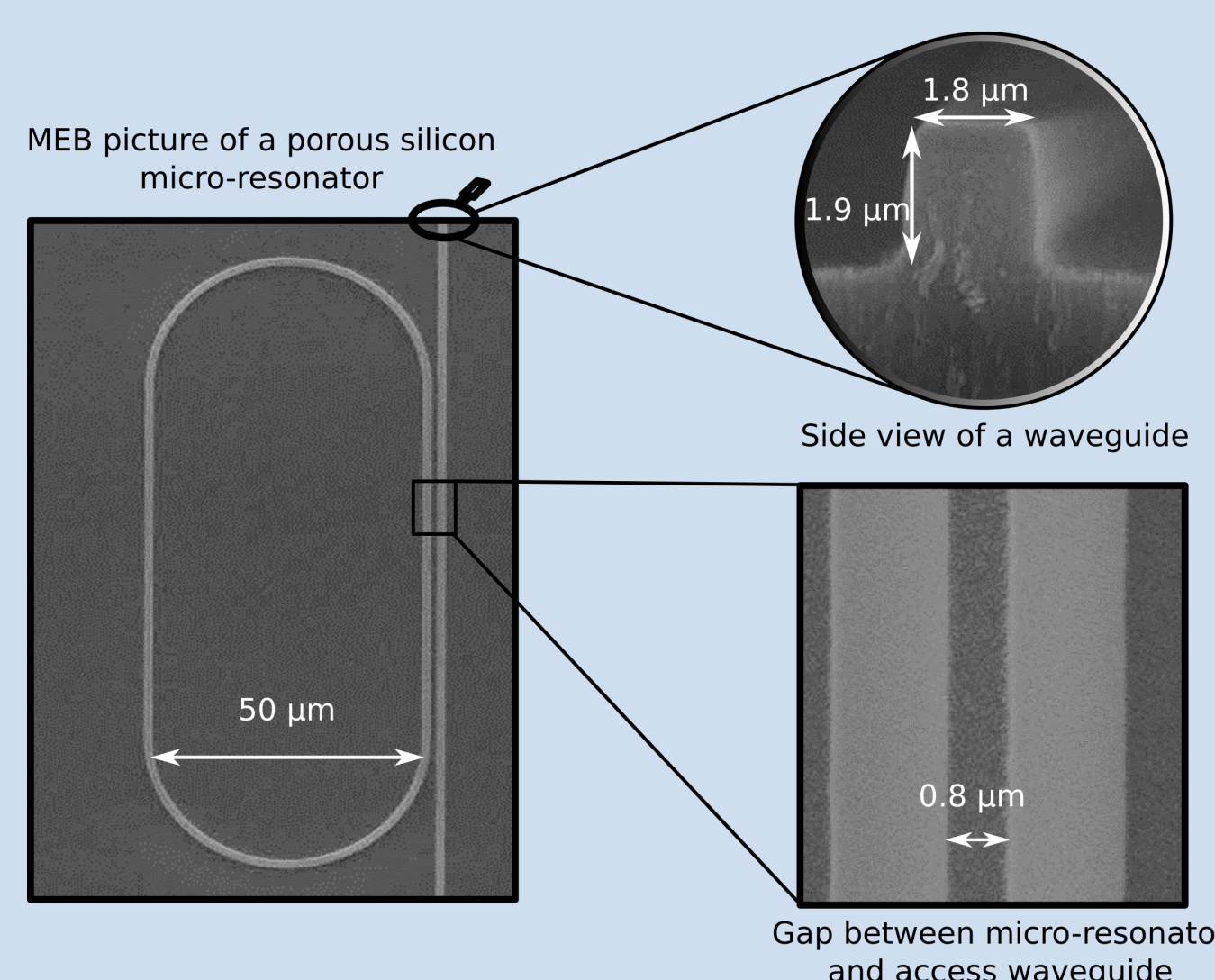
### • Thermal treatment of PSi

Partial oxidation remove native hydrophobicity, improve PSi layers stability in time and tune RI

### • Photolithography and etching



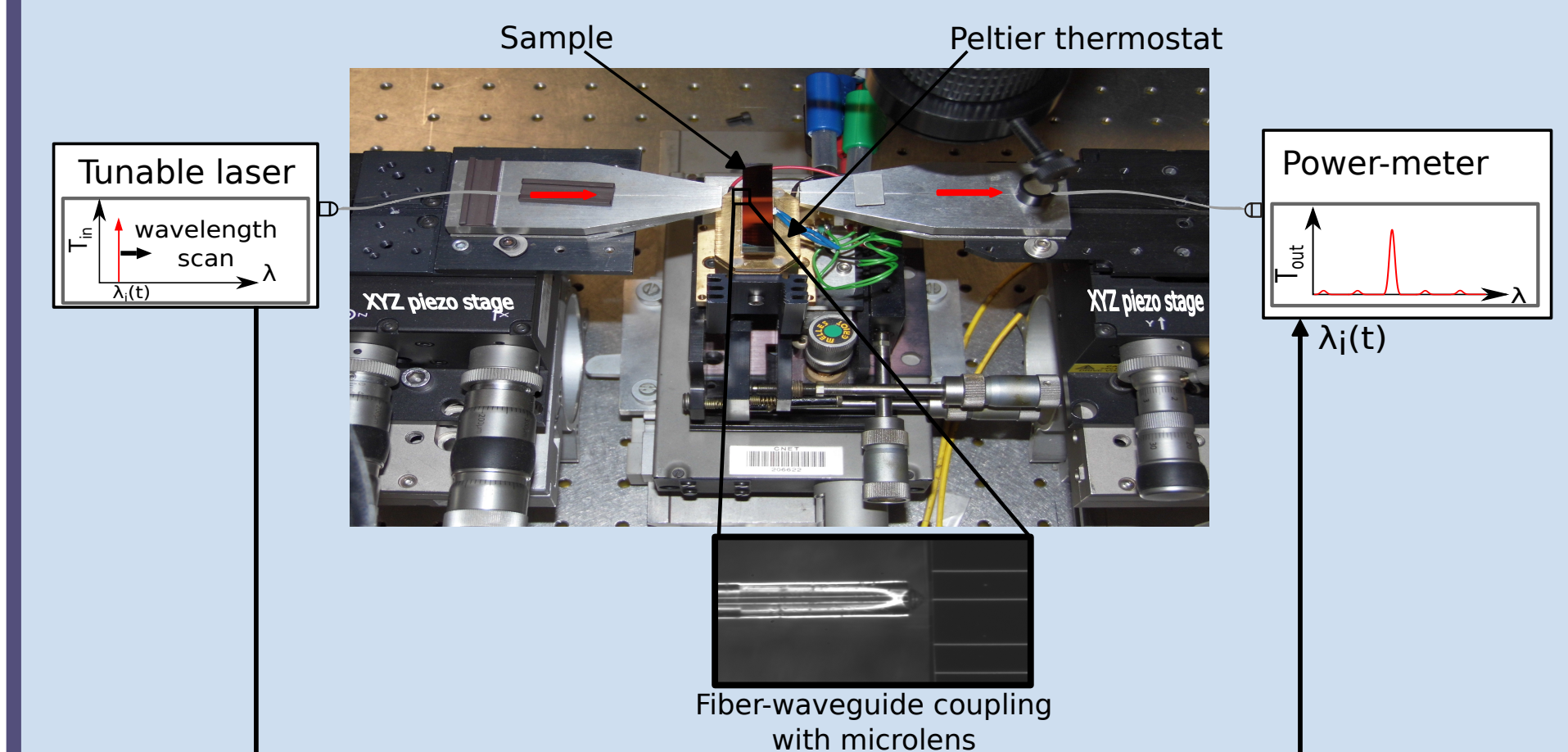
### • PSi MR sensor



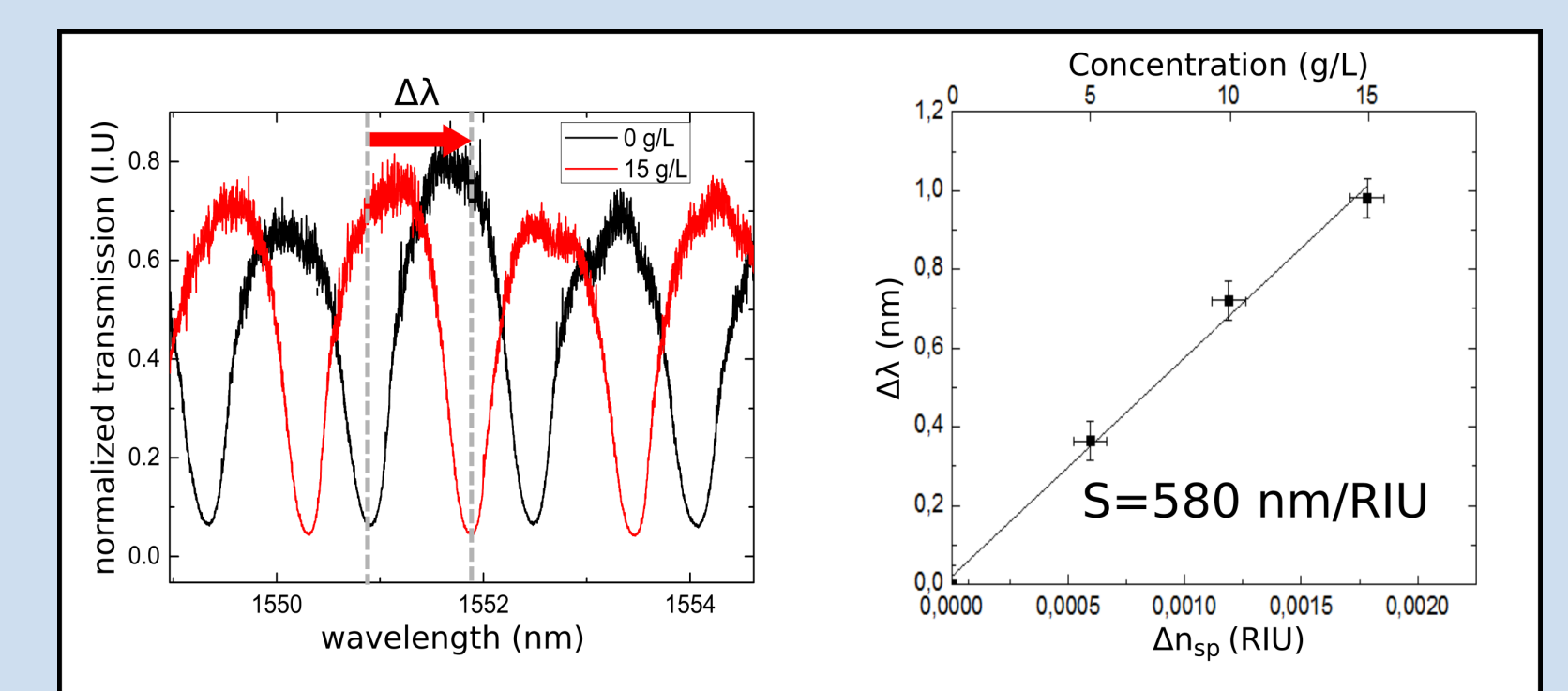
P+ Boron doped Si ( $5m\Omega.cm^{-1}$ ) ; Current density applied : (Core/Cladding) ( $50/80$ )  $mA.cm^{-2}$  ; HF sol. prop. HF(50%)/ethanol/water : 2:2:1.

## Sensor characterisation

### • Experimental setup

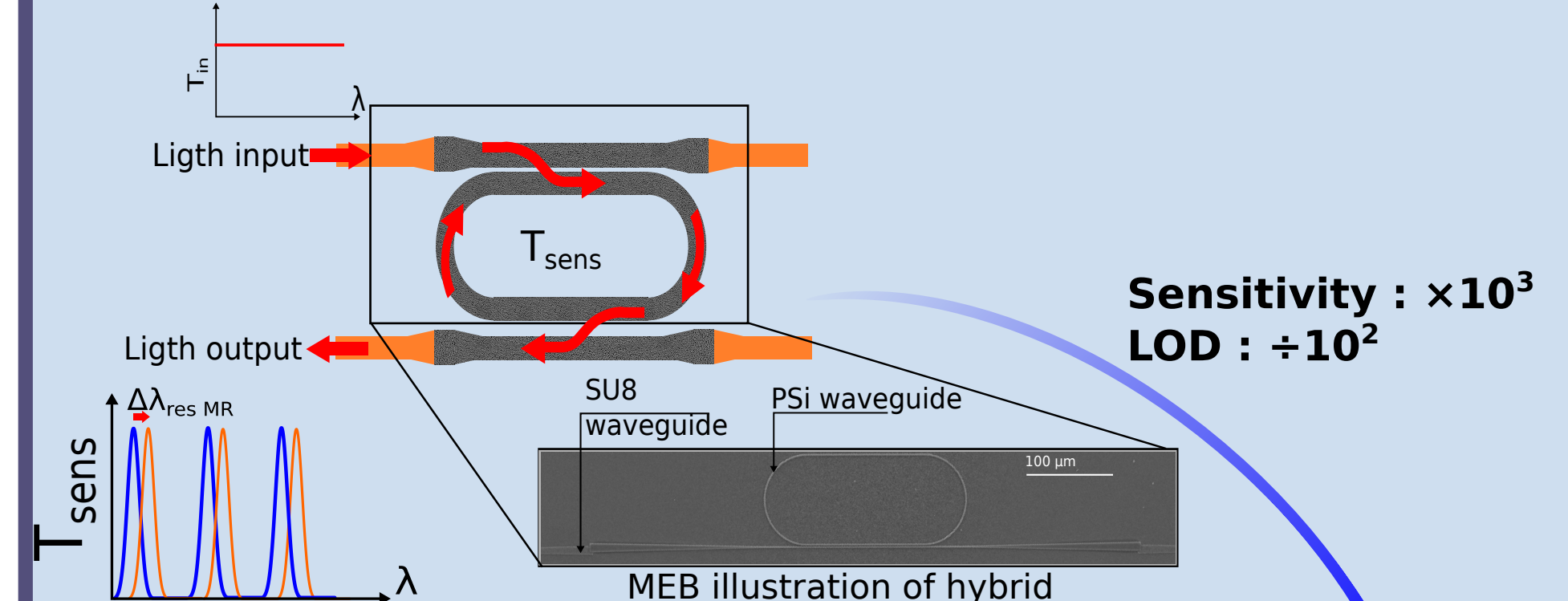


### • PSi MR homogeneous sensitivity characterisation

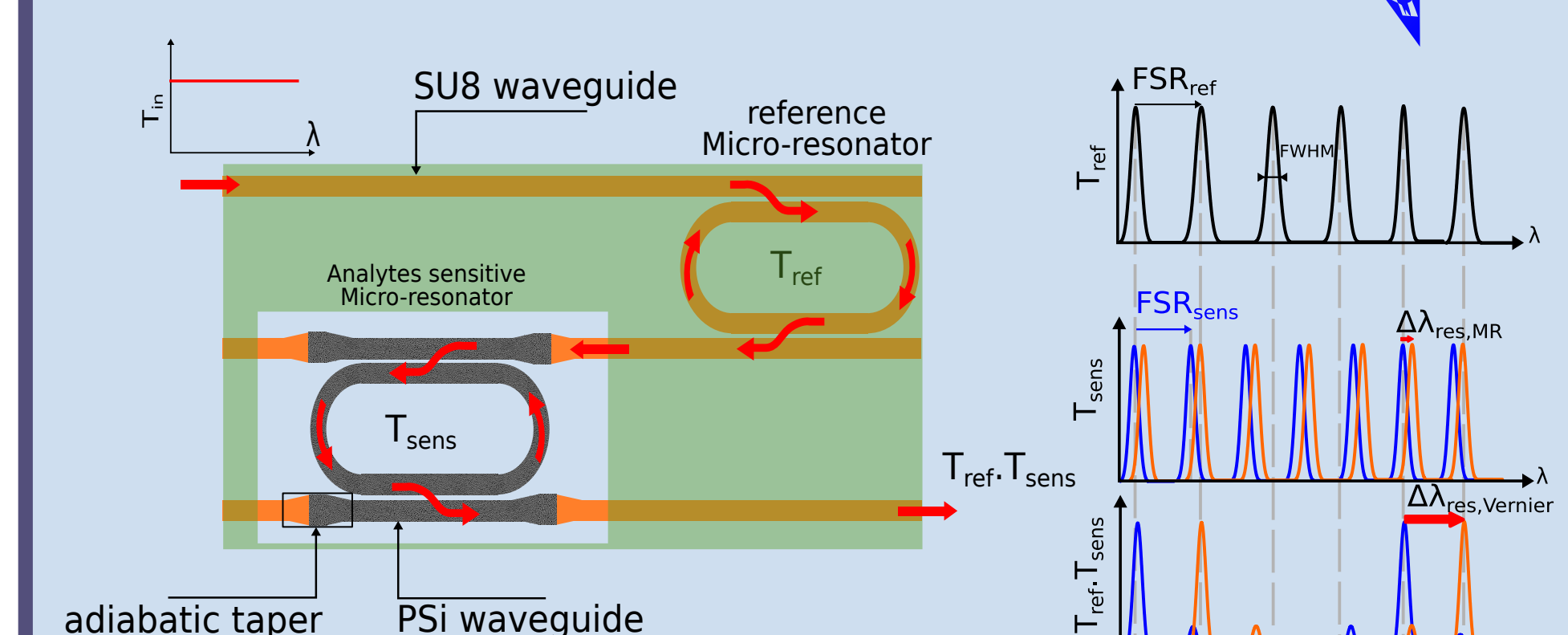


## Toward hybrid Vernier effect

### One micro-resonator



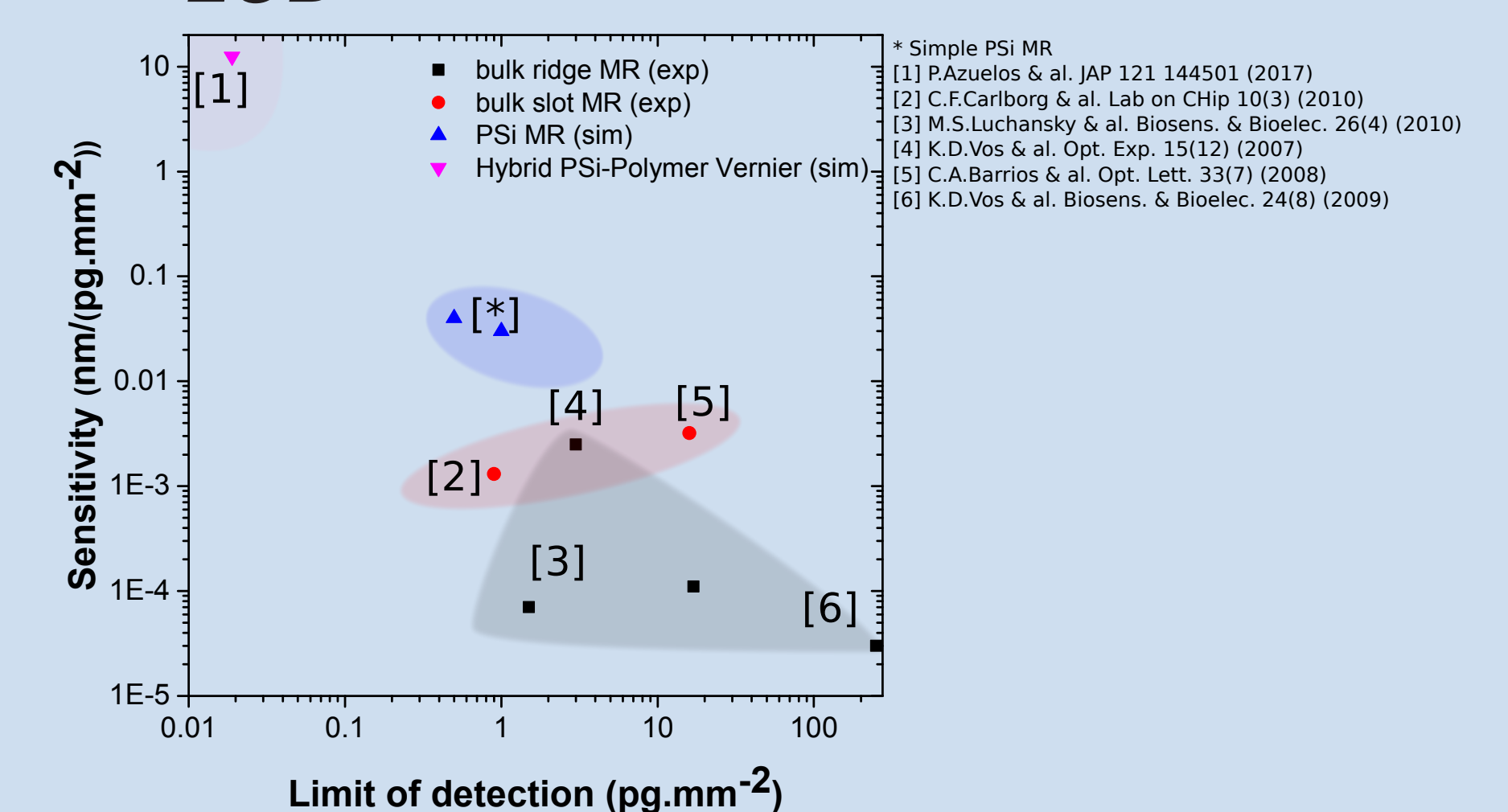
### Vernier effect : Cascaded micro-resonators



Vernier effect can improve sensor performances with a reference interferometer

## Conclusion and Perspective

### • MR integrated sensor sensitivity and LOD



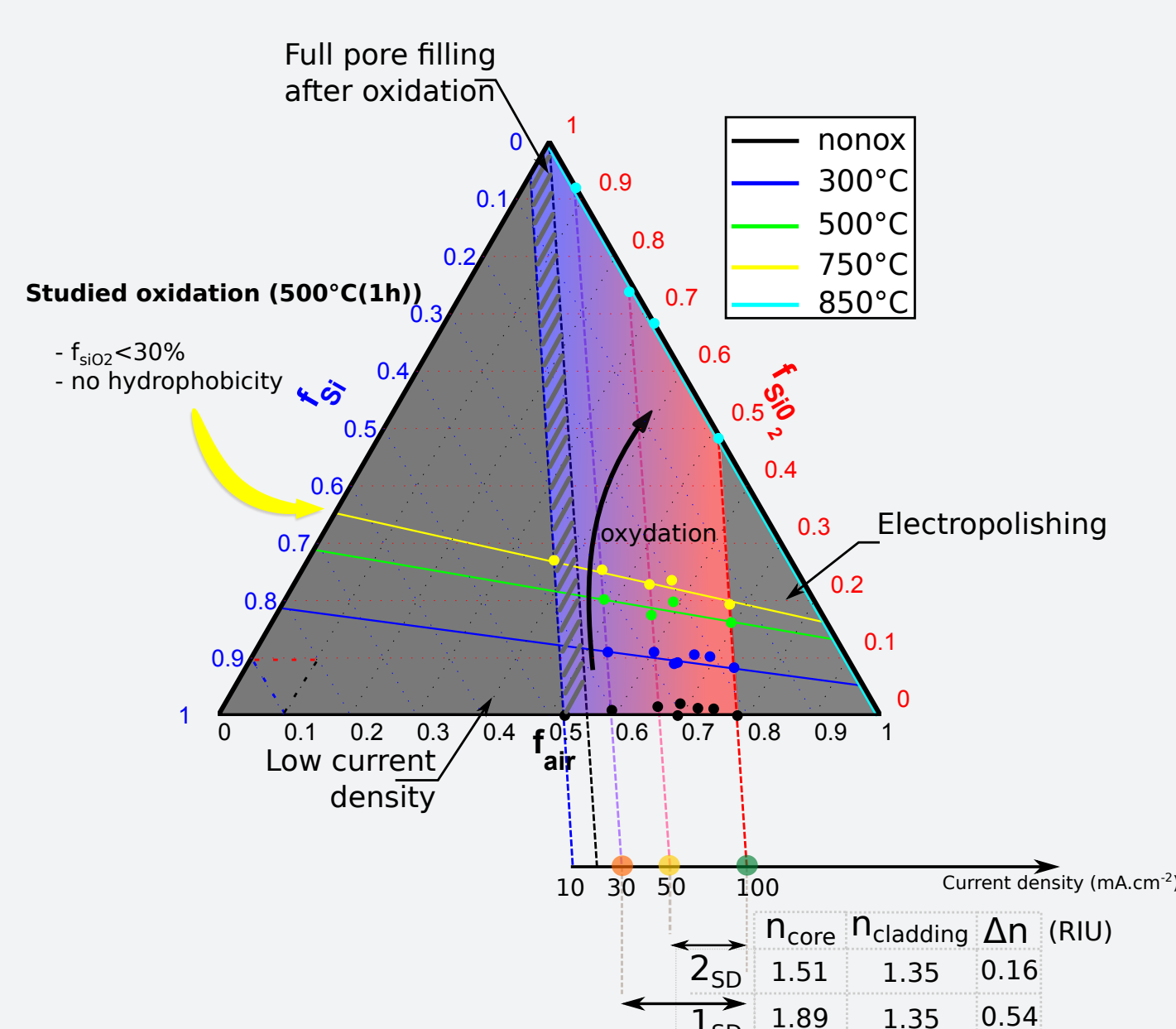
### • Perspectives

- Hybrid PSi-polymer fabrication process optimization
- Microfluidics
- Experimental functionalization

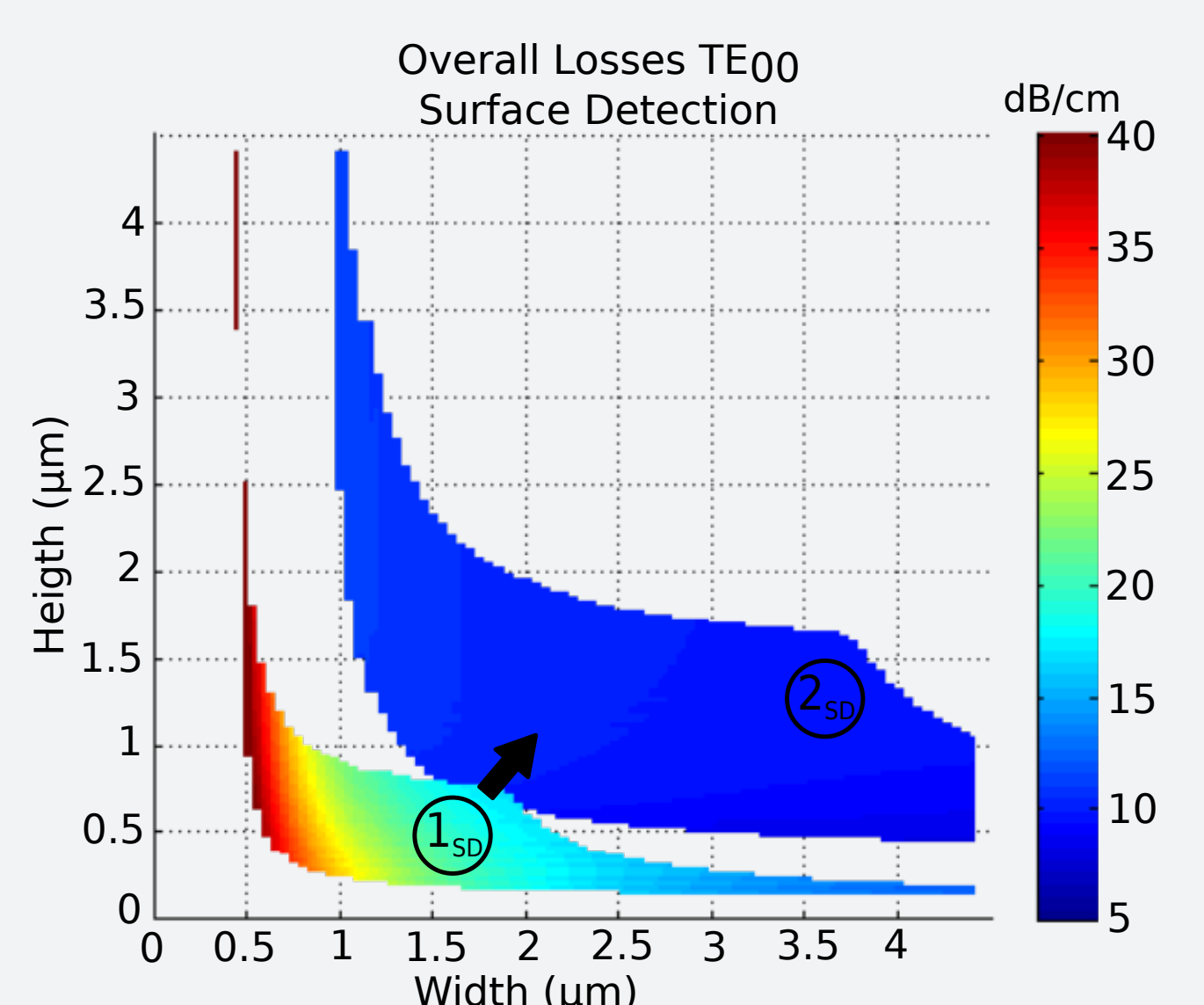
## Optimization of ridge PSi waveguides dimensions

### Losses evaluation in PSi waveguides

#### • Choice of PSi porosity and oxidation rate

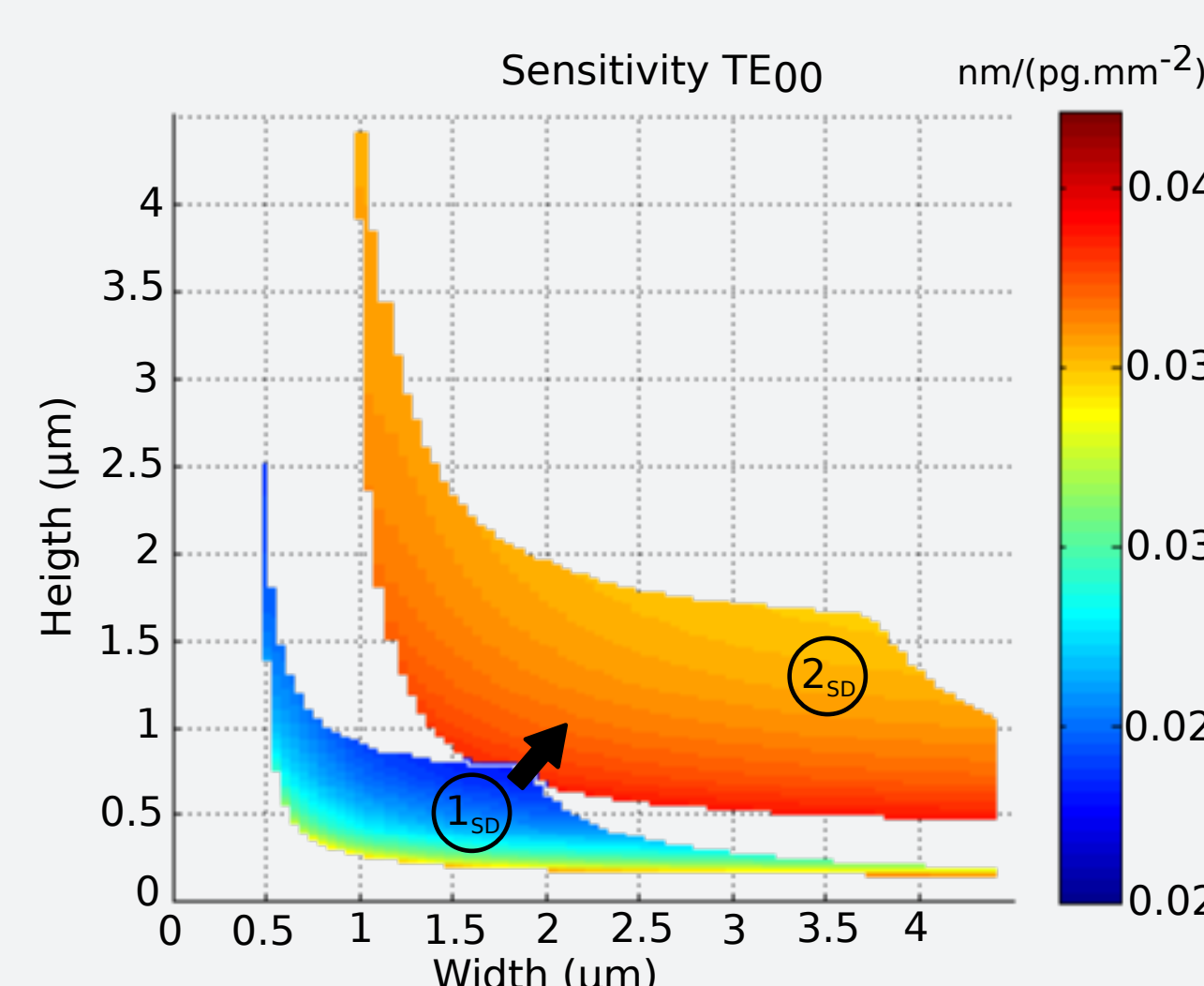


#### • Determination of losses with waveguide dimensions

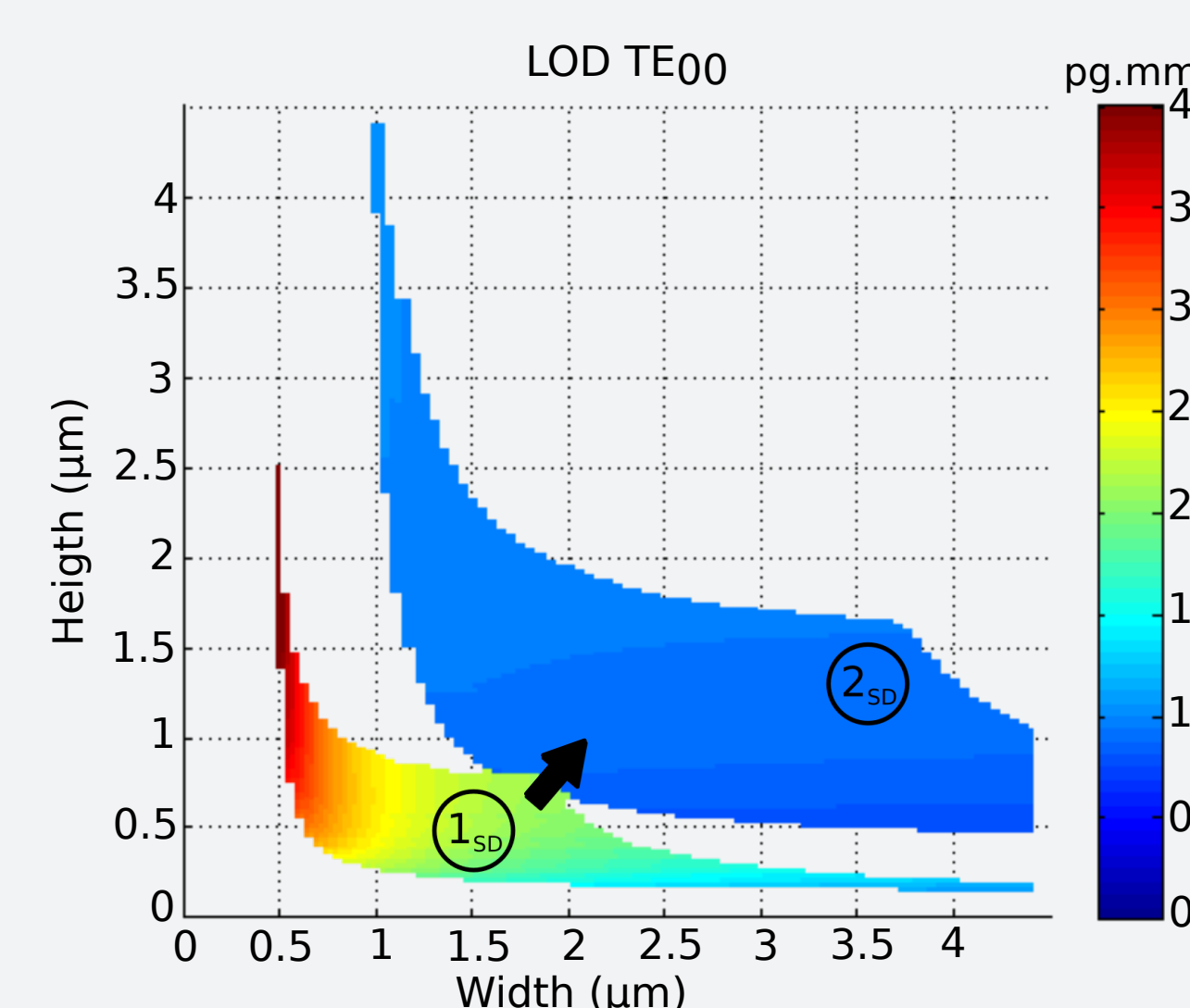


### Sensitivity and Limit of detection

#### • Sensitivity of PSi MR



#### • Limit of detection



Optimized performances :  
 $S=0.04 \text{ nm}/(\text{pg}.mm^{-2})$   
 $LOD=0.5 \text{ pg}.mm^{-2}$