Interreg France-Wallonie-Vlaanderen

SMARTBIOCONTROL
BioSens

Highly sensitive smart biosensor, based on the surface plasmon resonance (SPR)

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Our Aim is to use SPR technique in phytosanitary field

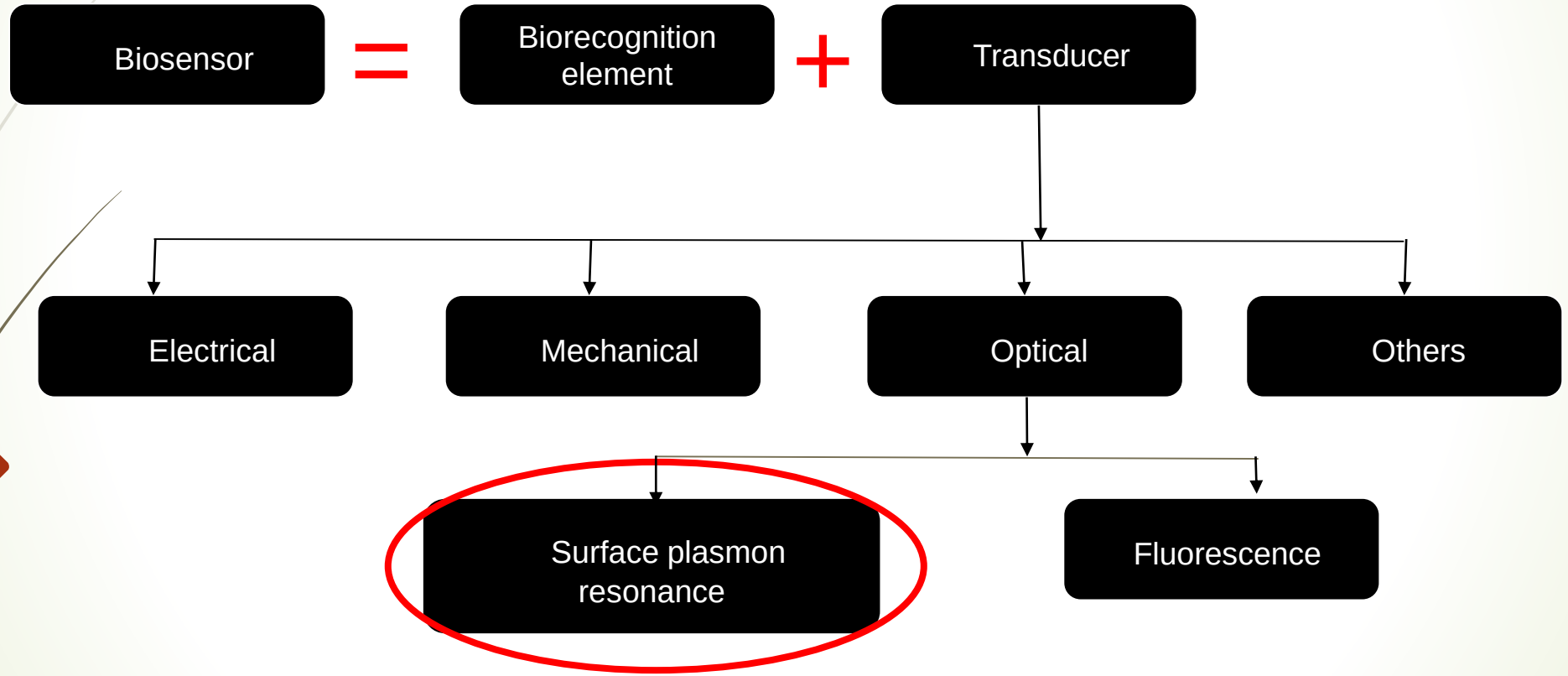
Zymoseptoria tritici

- It is a wheat plant pathogen causing septoria leaf blotch that is difficult to control due to resistance to multiple fungicides.

- Reduce yields of wheat by 30 to 50% with a huge economic impact.

- This fungus is difficult to control because populations contain extremely high levels of genetic variability and it has very unusual biology for a pathogen.

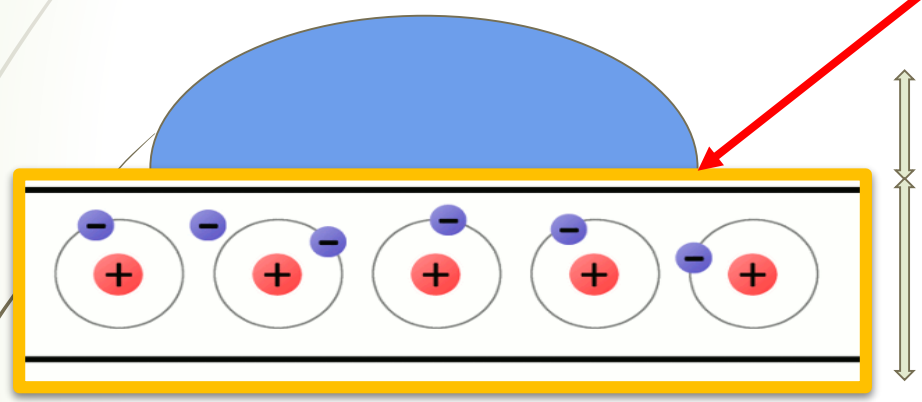
What is a biosensor?



What are surface plasmons ?

Surface plasmons are free electron oscillations that exist at the interface between two materials.

Within a metal



Material 2: Dielectric material
(Plasmonic waves prob few hundreds of nanometers deep ≡ penetration depth)

Material 1: Metallic surface
(Some tenths of nanometers thick layer)
(Ag and Au are "best" plasmonic materials)

➔ This oscillations can be imaged as evanescent waves. Plasmonic waves extend into both materials → penetration depths.

➔ The plasmonic wave property depends on both the materials physical properties eg: dielectric permittivity.

Basic principles of surface plasmon resonance ?

- ➔ The plasmonic wave does not exist spontaneously, it required additional energy to be excited e.g.: photons.
- ➔ For the photons to excite the plasmons, they must have same frequency momentum as that of the plasmons (they must be in resonance).

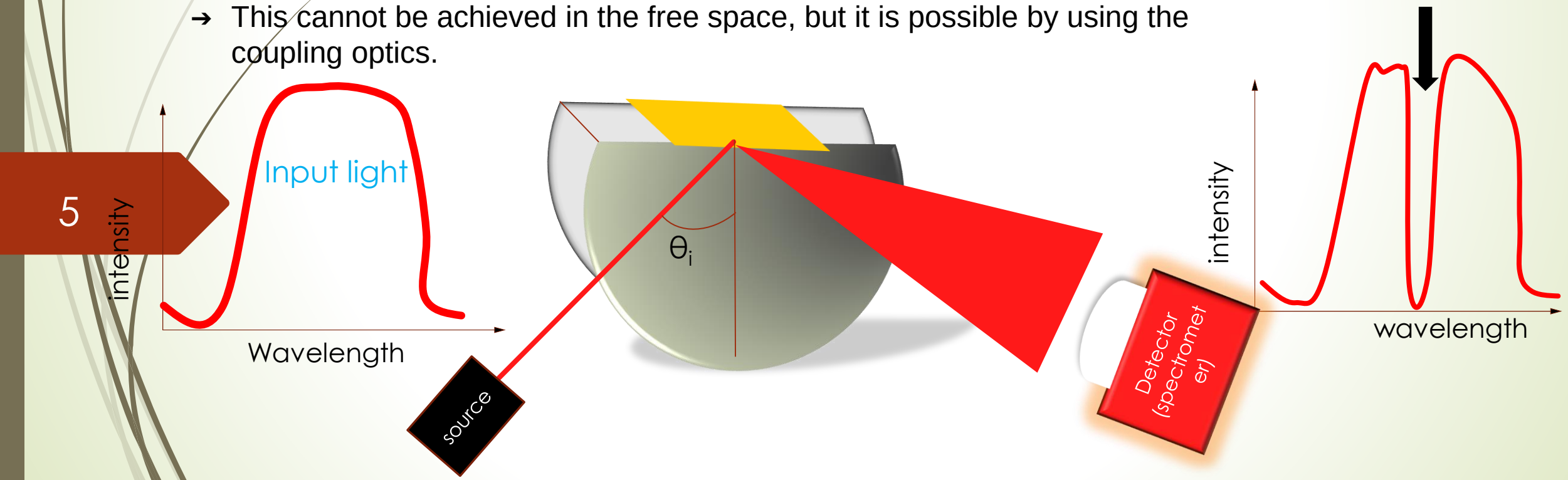
Angular Interrogation

Spectral Interrogation

Phase Interrogation

Loss in wavelength corresponds to plasmonic wave

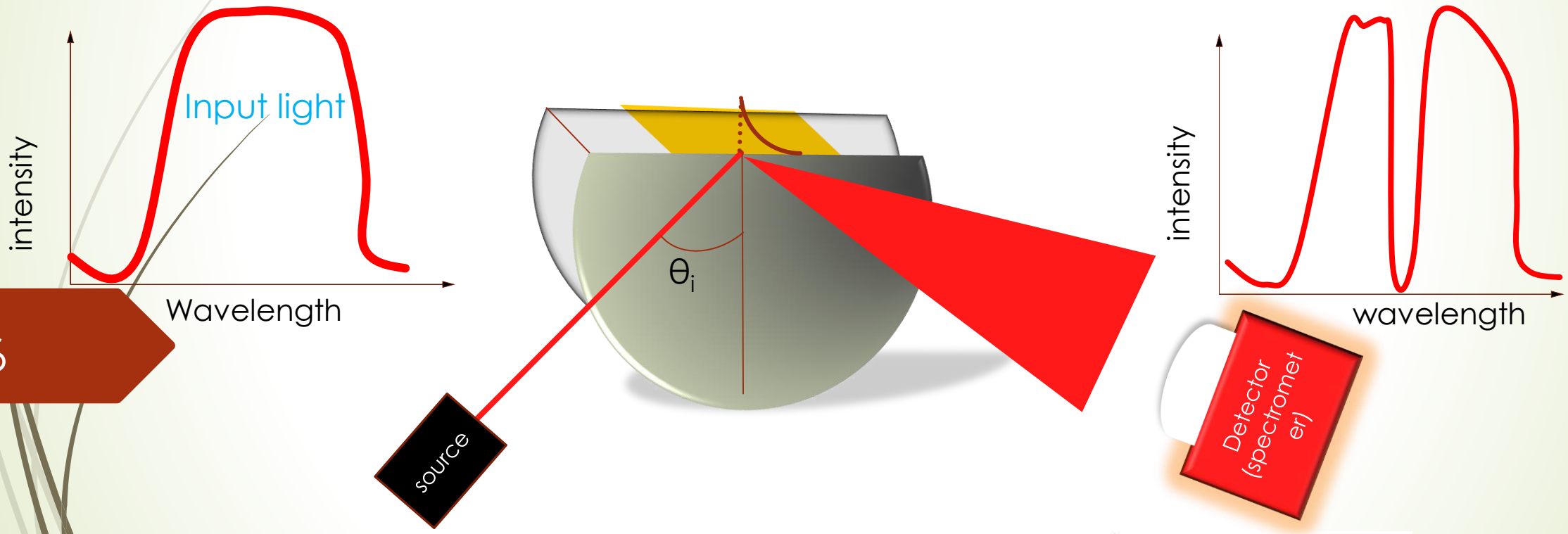
- ➔ This cannot be achieved in the free space, but it is possible by using the coupling optics.



Basic principle of SPR detection

➔ Sensing could be possible within the penetration depth of the plasmonic wave.

Refractive index of water



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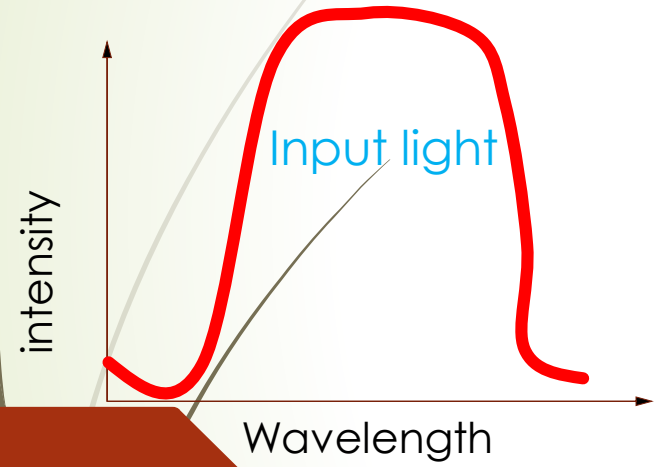
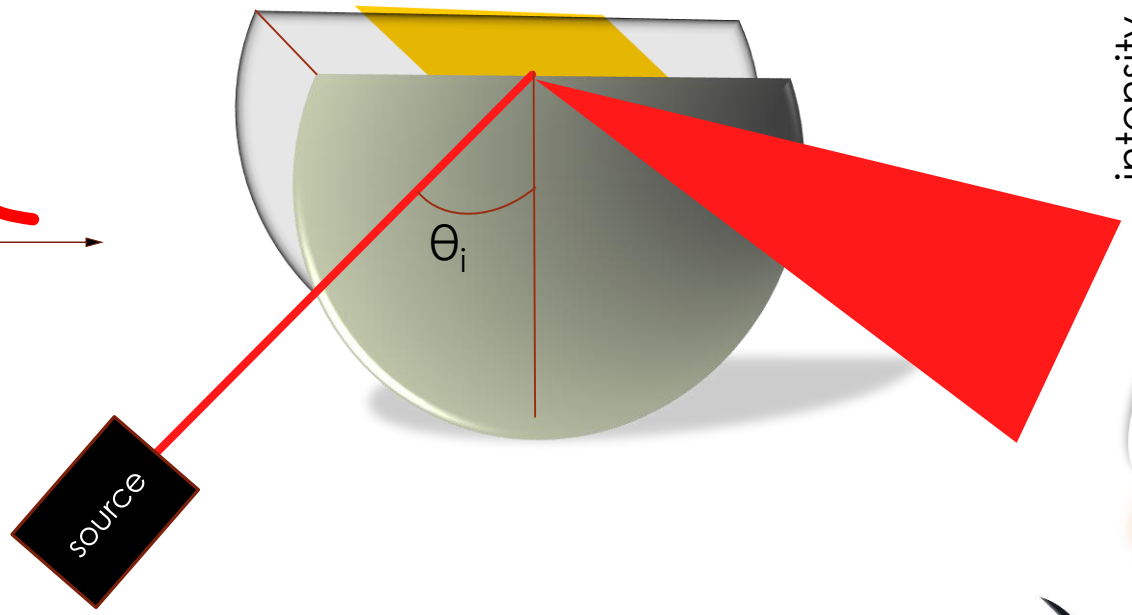
SPR-Biosensor

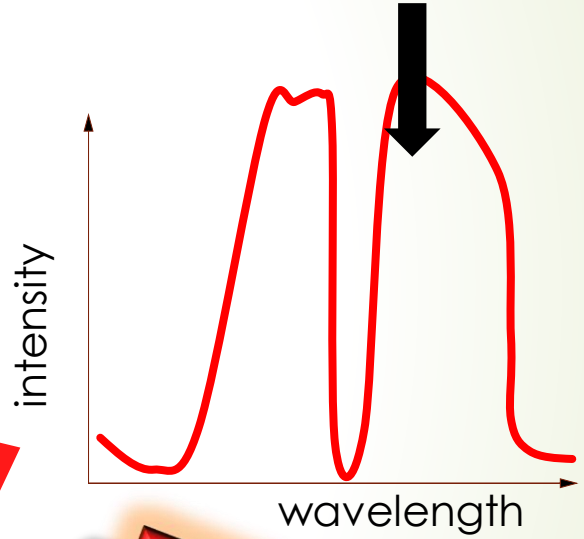
As the penetration depth is few hundreds of nm, So the biorecognition element shall be very close to the surface of the metal.

➔ Thiol chemistry is used to bind biomolecules(example: DNA or Antibodies) to the metal surface (Gold(Au)).

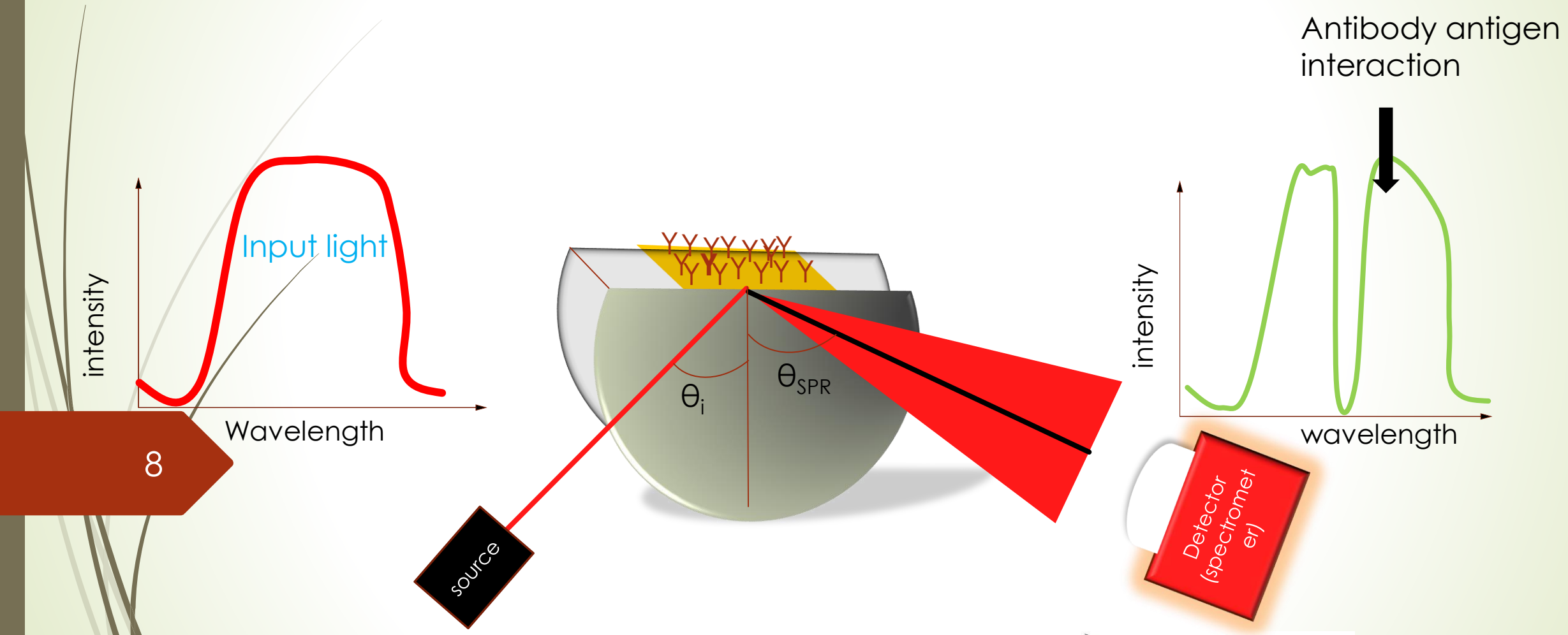




Refractive index corresponding to antibodies



SPR-Biosensor



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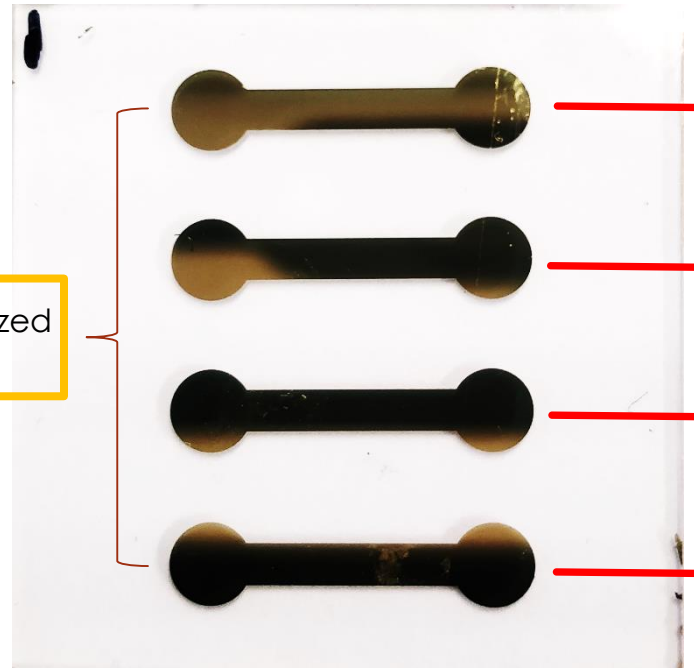
SENSOR Design



Functionalized surface

Reference (Buffer solution)

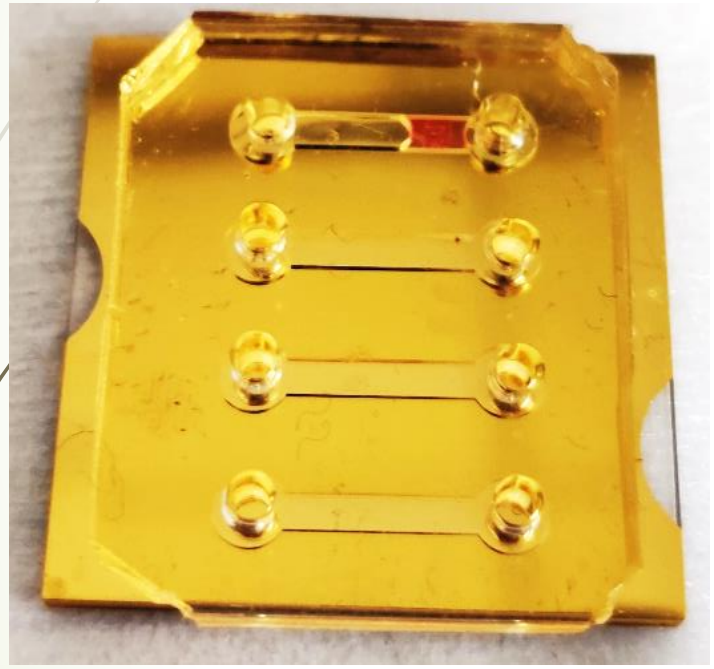
Positive Test

Negative Test

Fixed reference

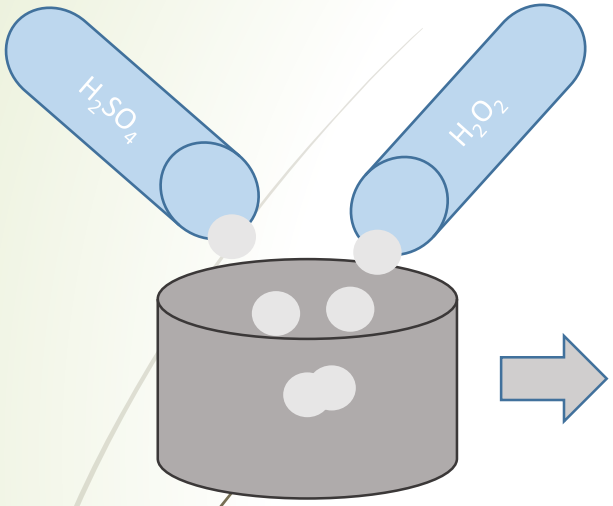
SENSOR Design

Fully metallized

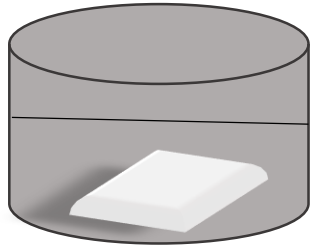


SPR sensor separated by channels

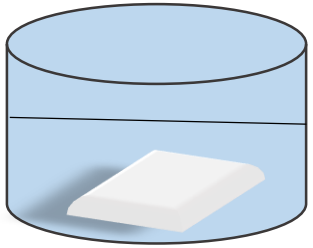
Fabrication of fully metalized SPR sensor



Piranha solution



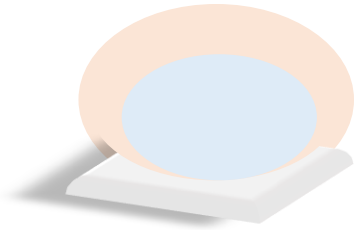
Immerse the substrate into Piranha solution



Cleaning in water

Substrate o the hot plate of 100^0C to remove remaining solvents

Piranha cleaned substrate



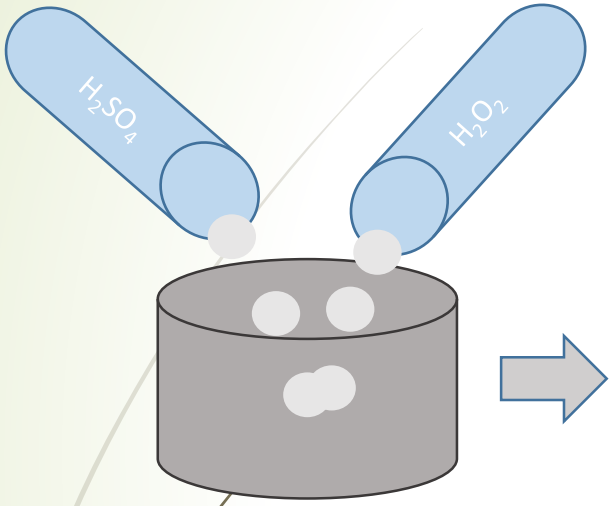
O_2 Plasma etching

Thin film Titanium(Ti) (2nm)

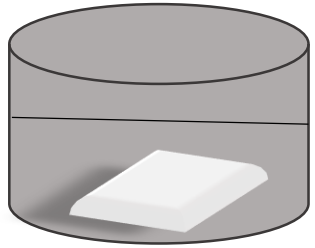
Thin film Gold(Au) (35nm)

Deposition of metal using e-beam evaporation under high vacuum

Fabrication of fully metalized SPR sensor



Piranha solution



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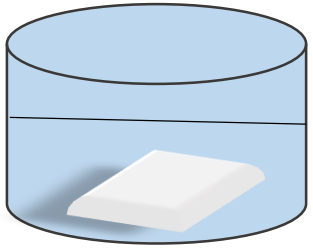
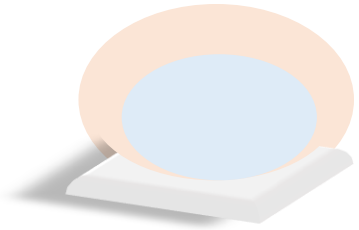


Cleaning in water

Substrate o the hot plate of 100^0C to remove remaining solvents

Piranha cleaned substrate



O_2 Plasma etching

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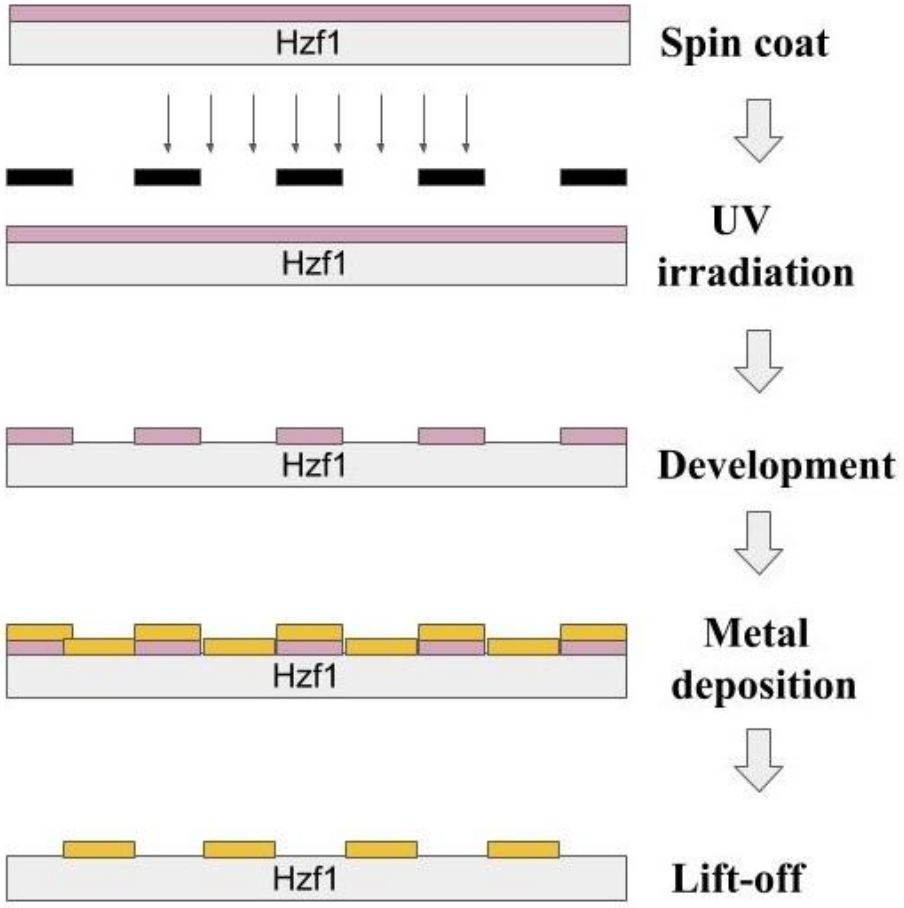
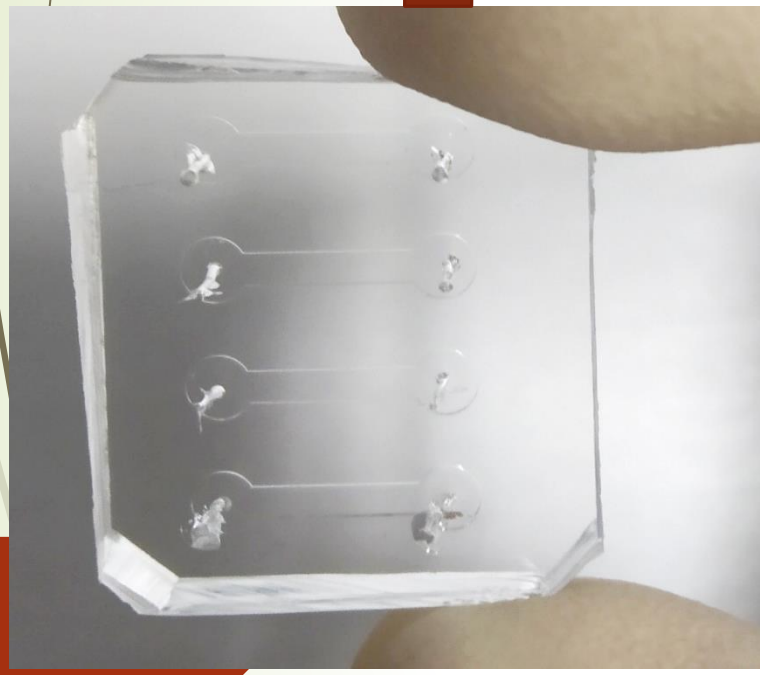
Deposition of metal using e-beam evaporation under high vacuum

Fabrication of 4-channels SPR sensor



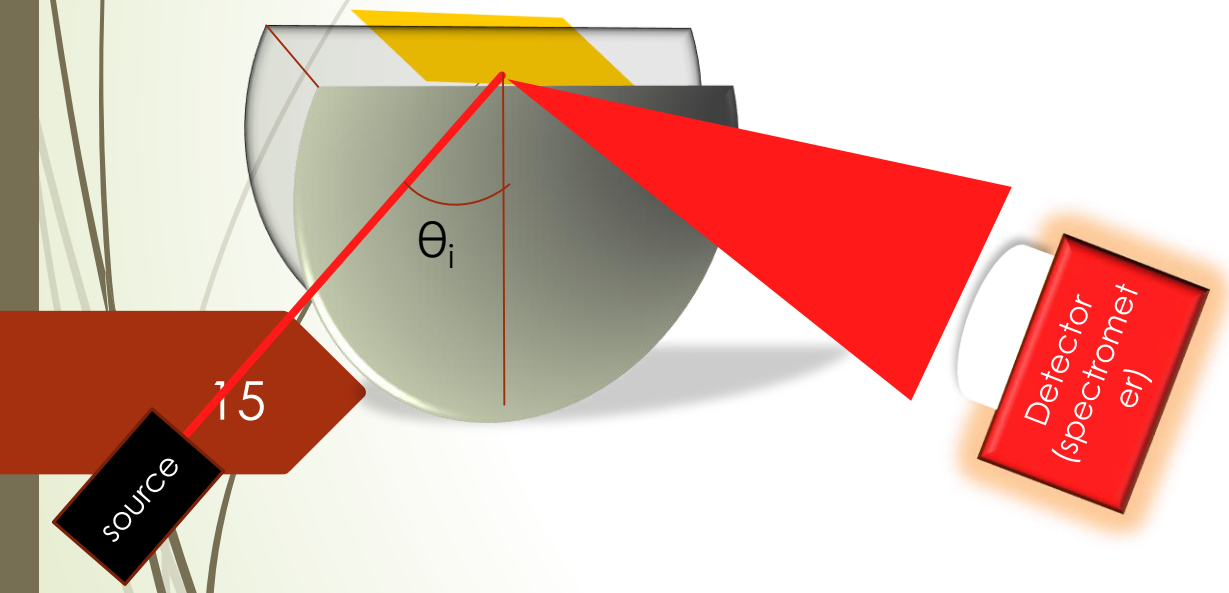
Integration of microfluidics on 4-channels SPR sensor



Plasma corona treatment
of PDMS surface and
4 channel SPR sensor

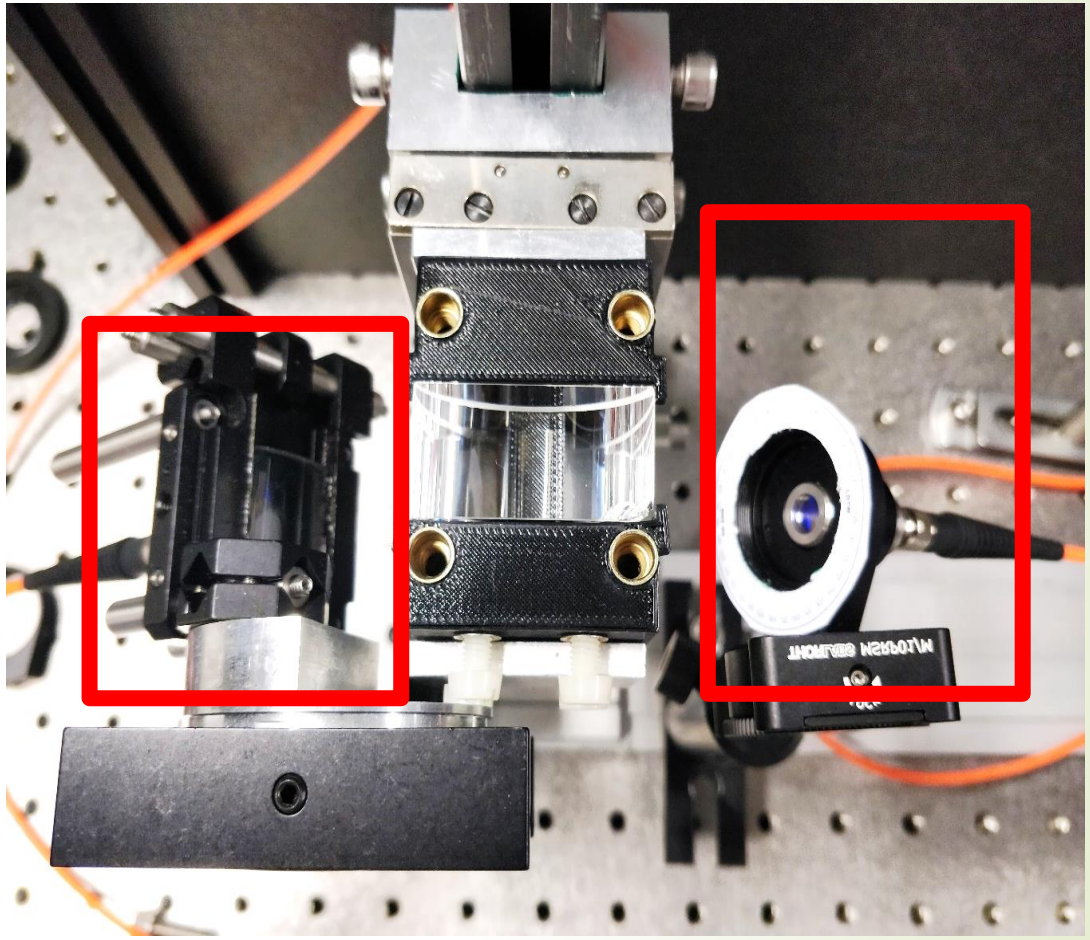
Sensor with microfluidic facilities.

Spectral interrogation SPR set-up



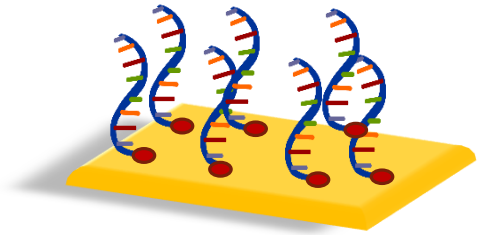
Input light source

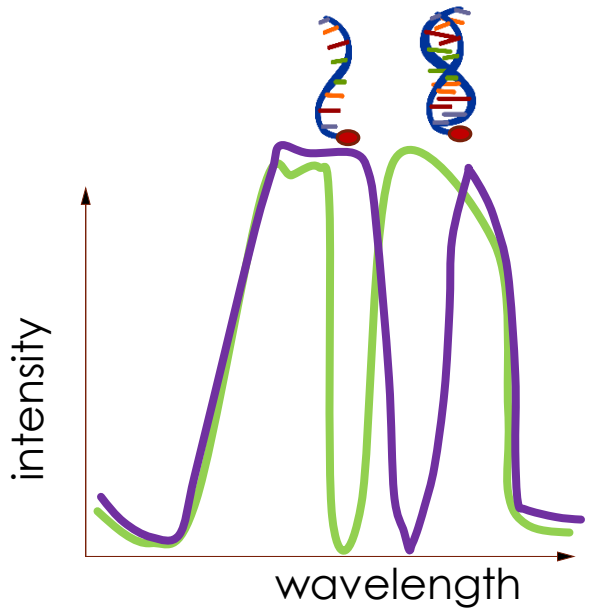
Detector, spectrometer



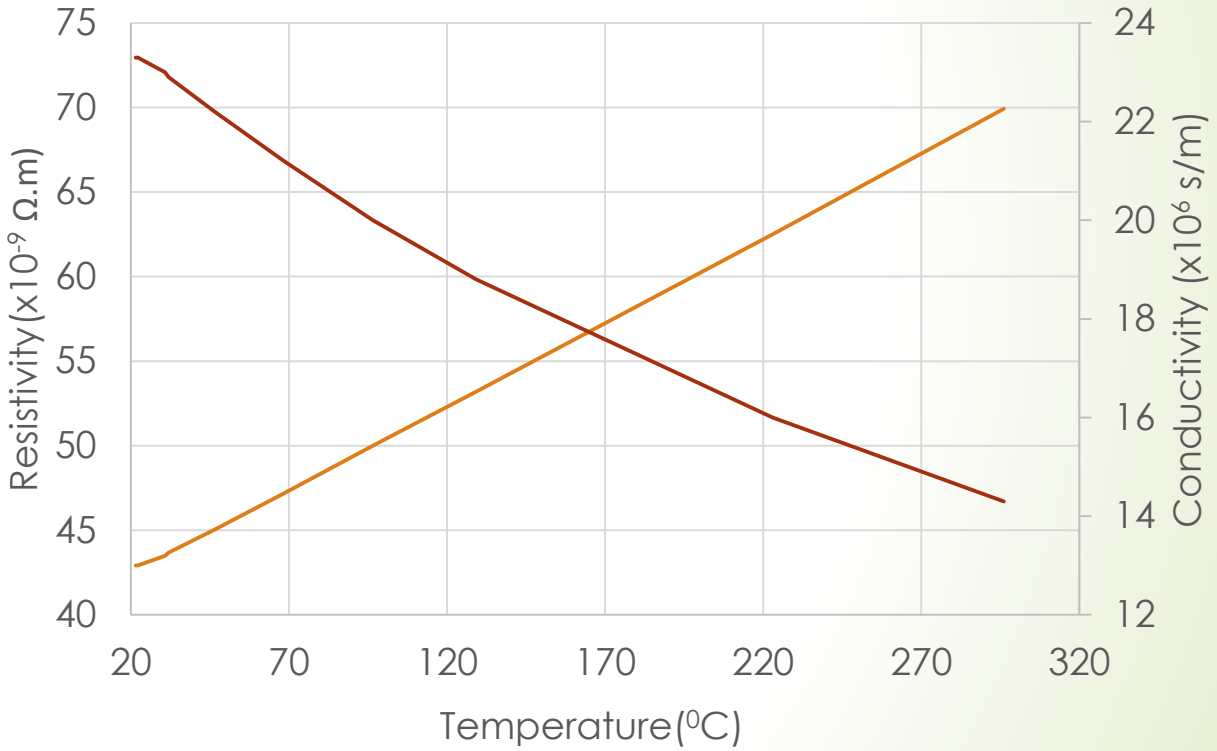
Detection of Zymoseptoria

Importance of temperature during the measurement of molecular interaction(eg: DNA DNA interaction)

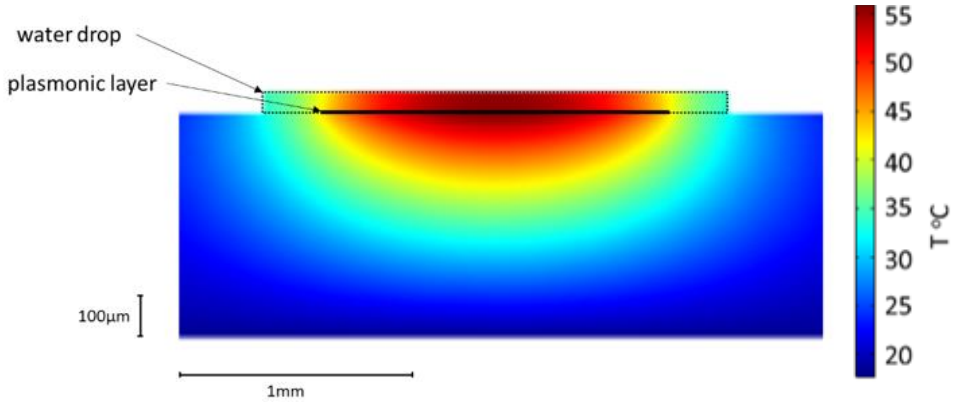


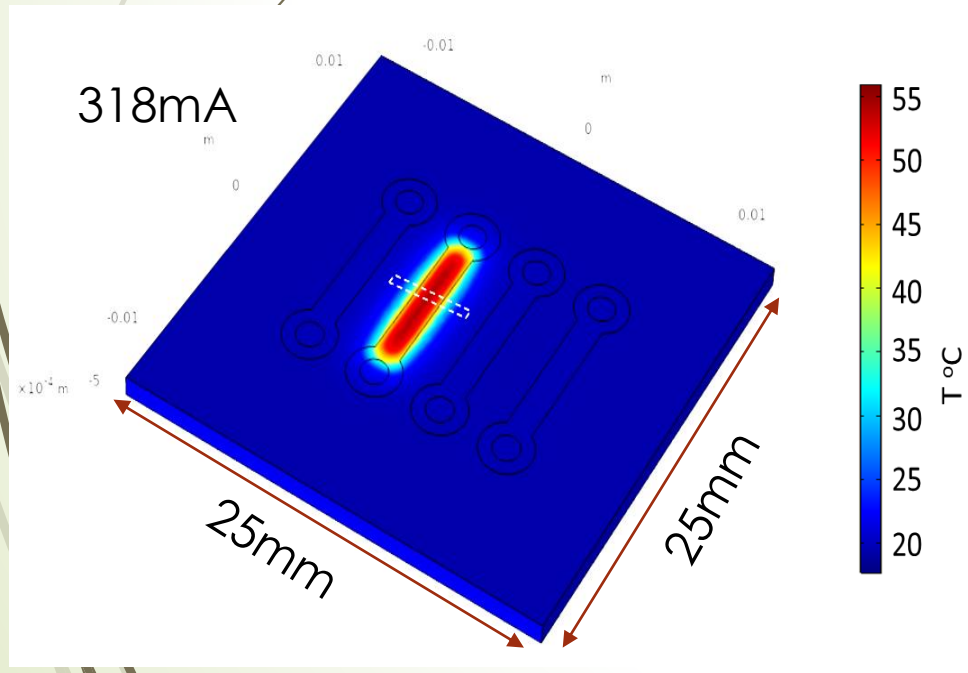


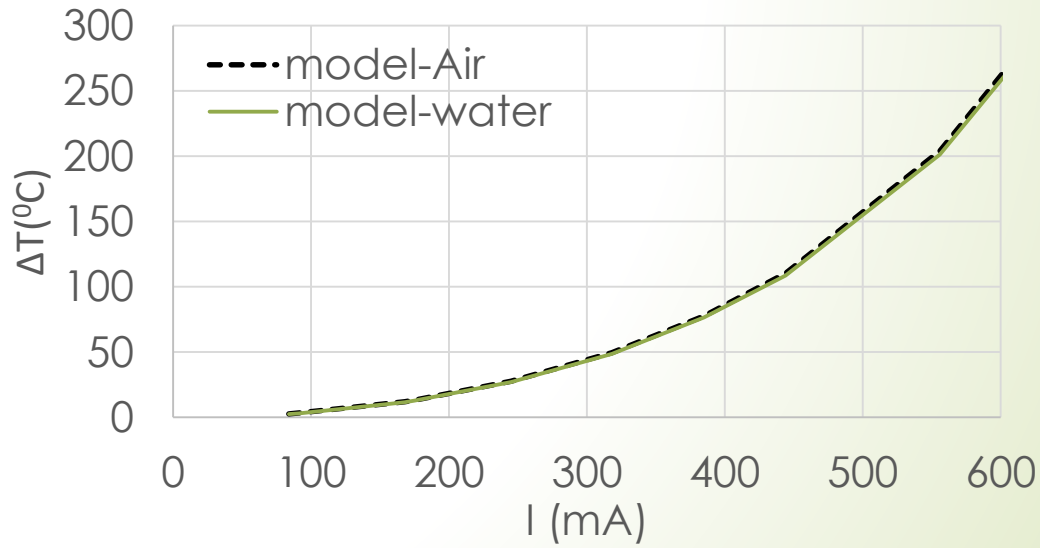
SPR sensor channel as a Joules heater and Experimental characterization



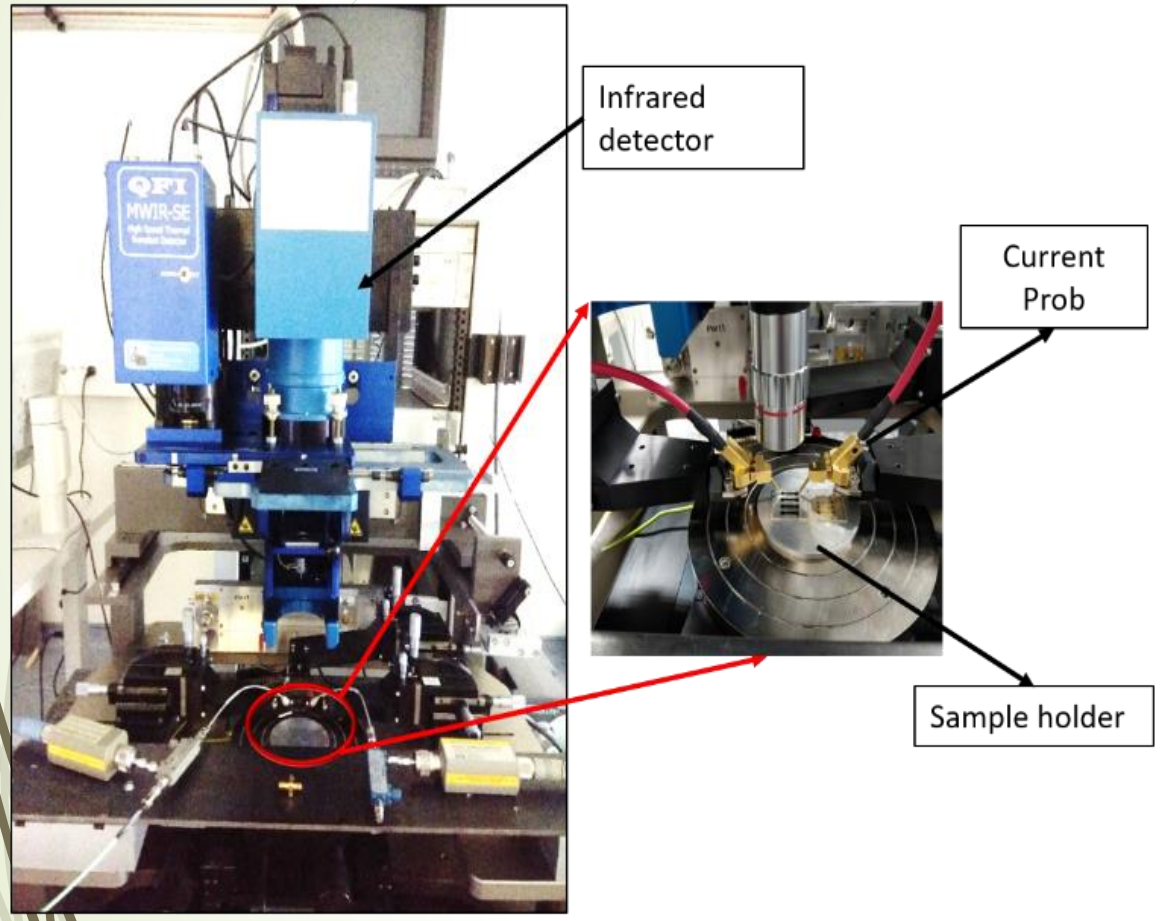
Modelling of the thermal behavior of the plasmonic layer

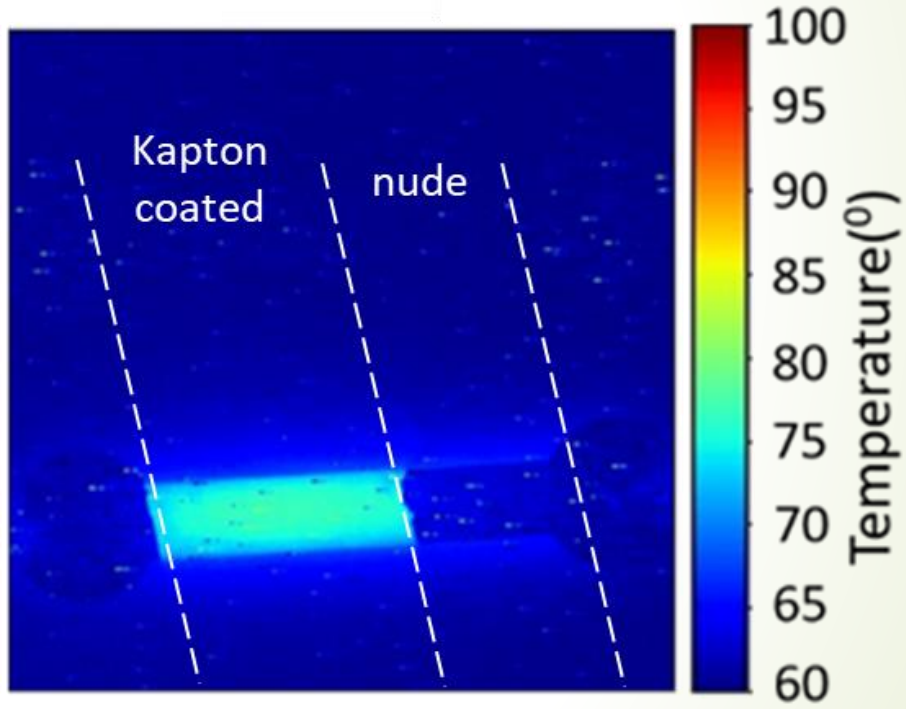






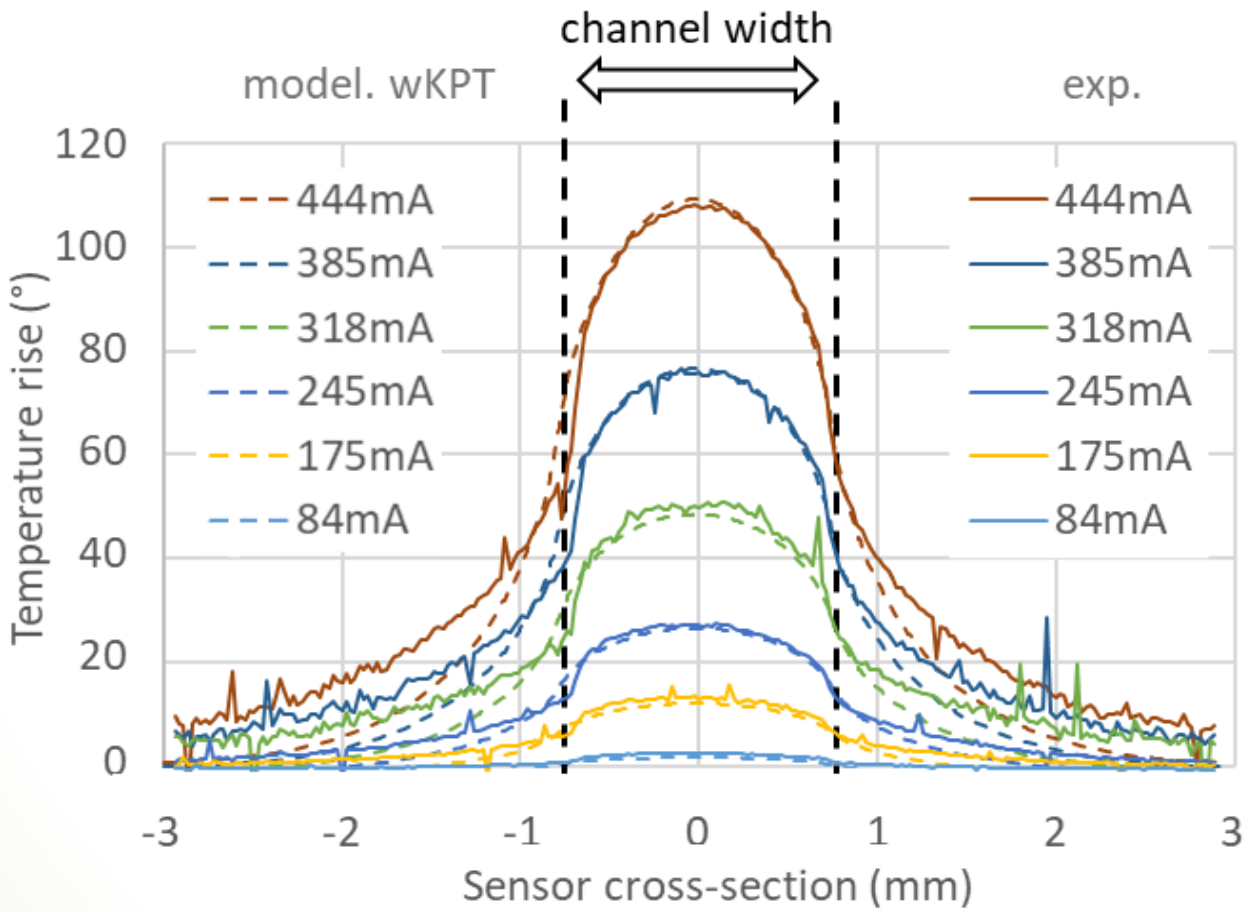
Thermal characterization of the plasmonic layer.



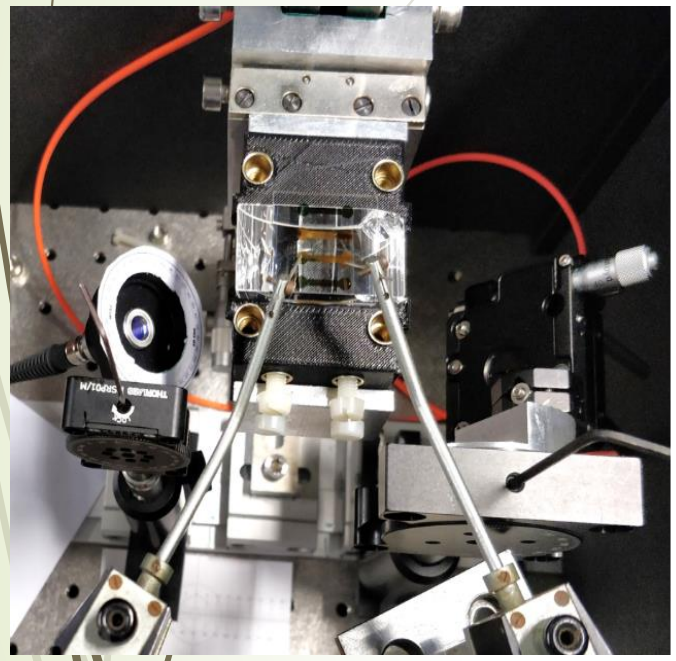


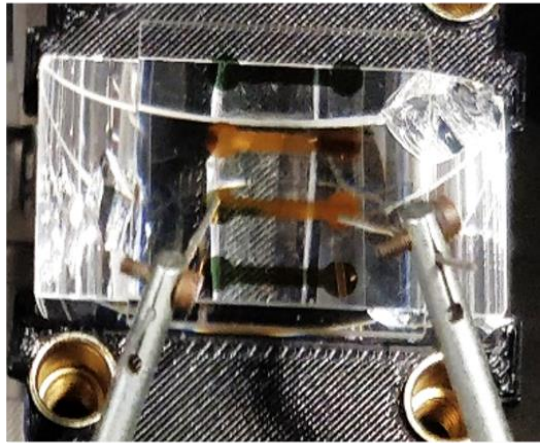
QFI- Quantum focus instrument
InfraScopeTM Temperature Measurement Microscope Systems:

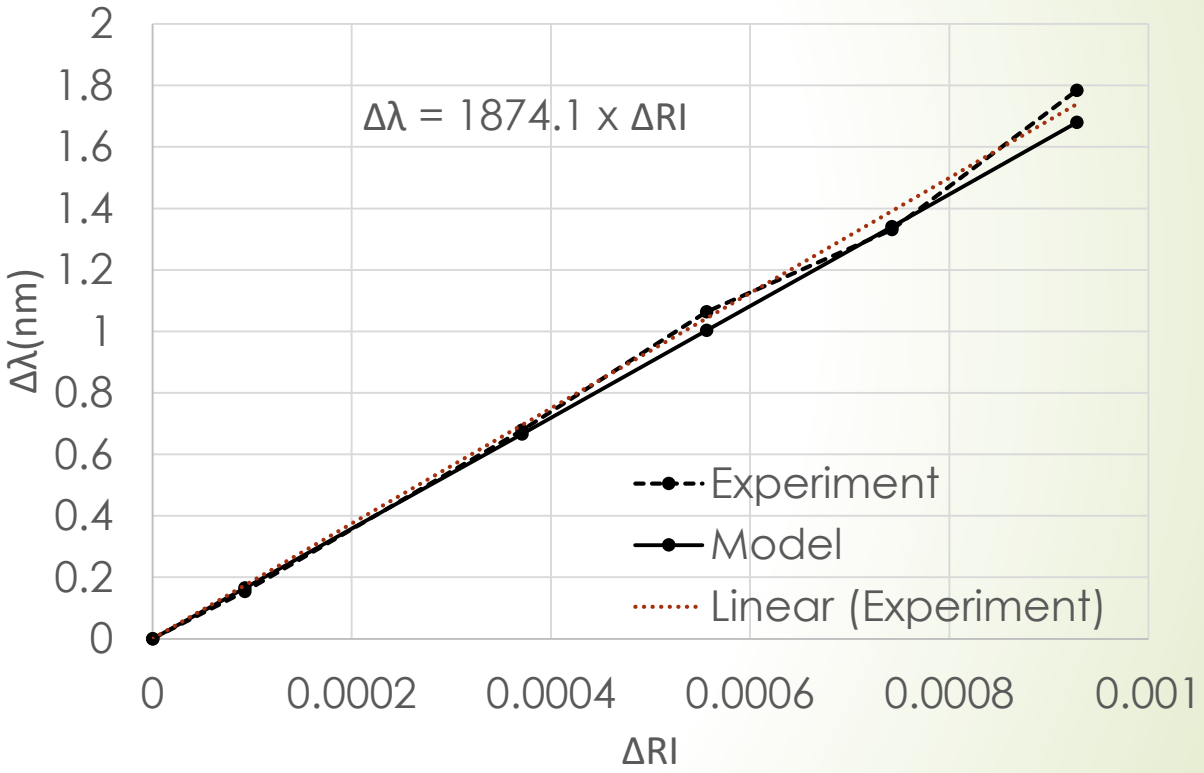
Comparison of Experiment and modelling results



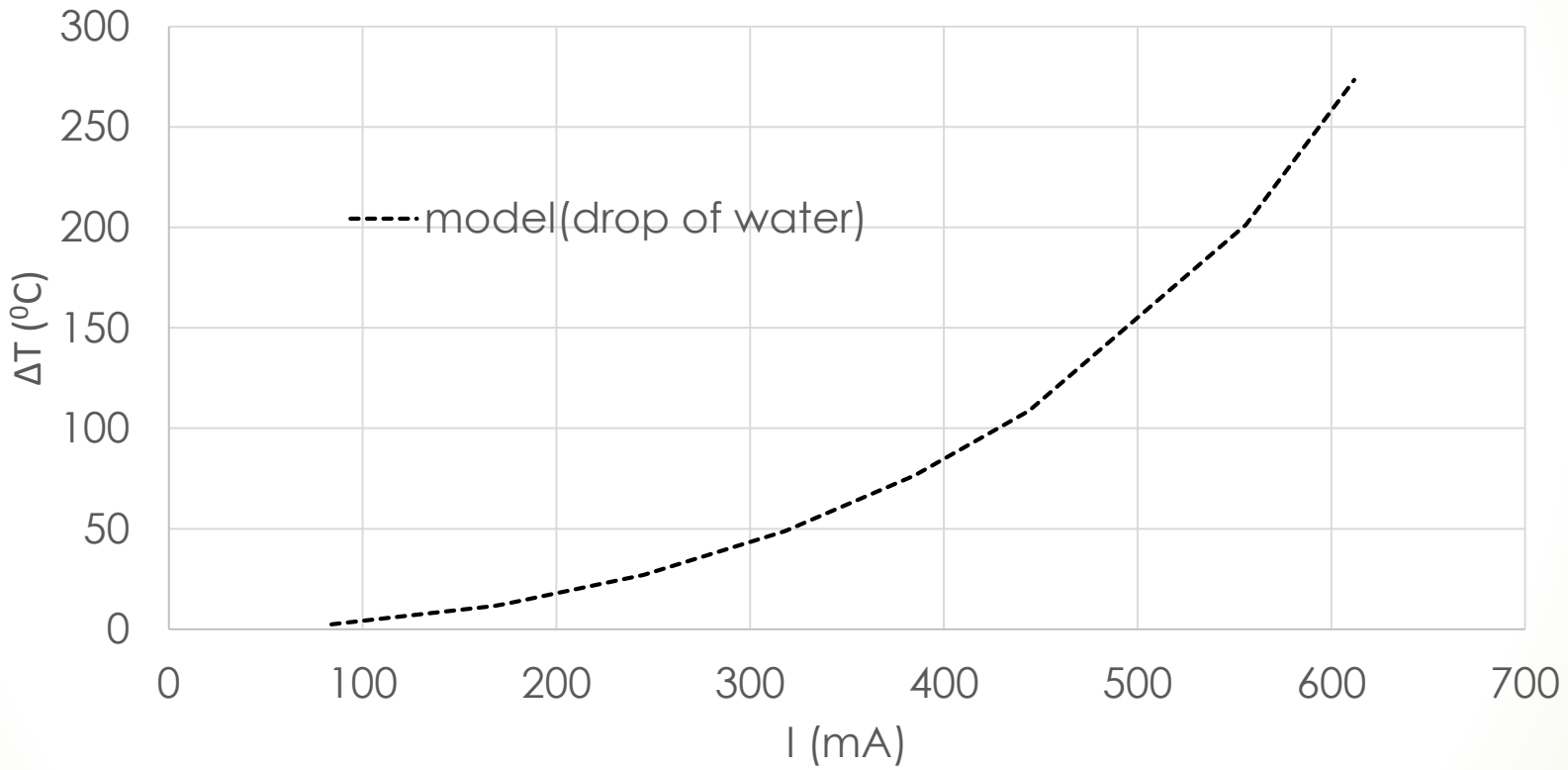
Measuring the refractive index of water in function of temperature Using SPR sensing instrument







Calculate Temperature on injected current through a plasmonic channel



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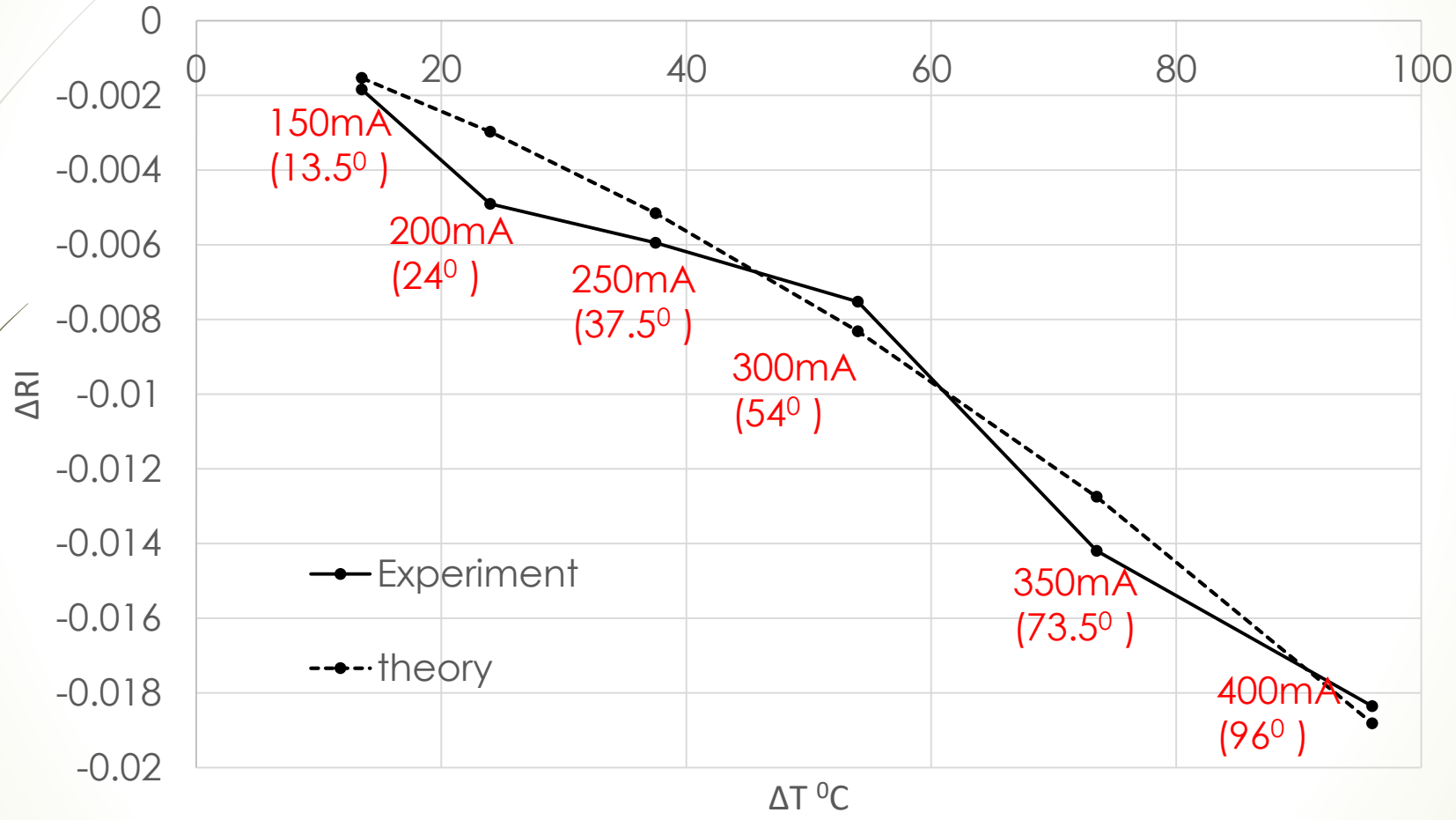
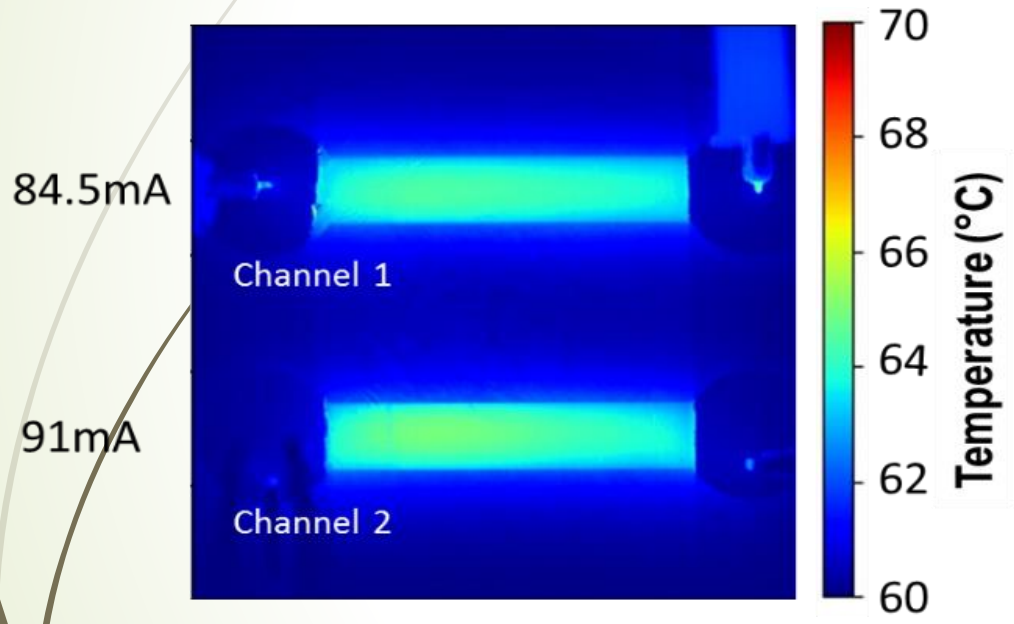
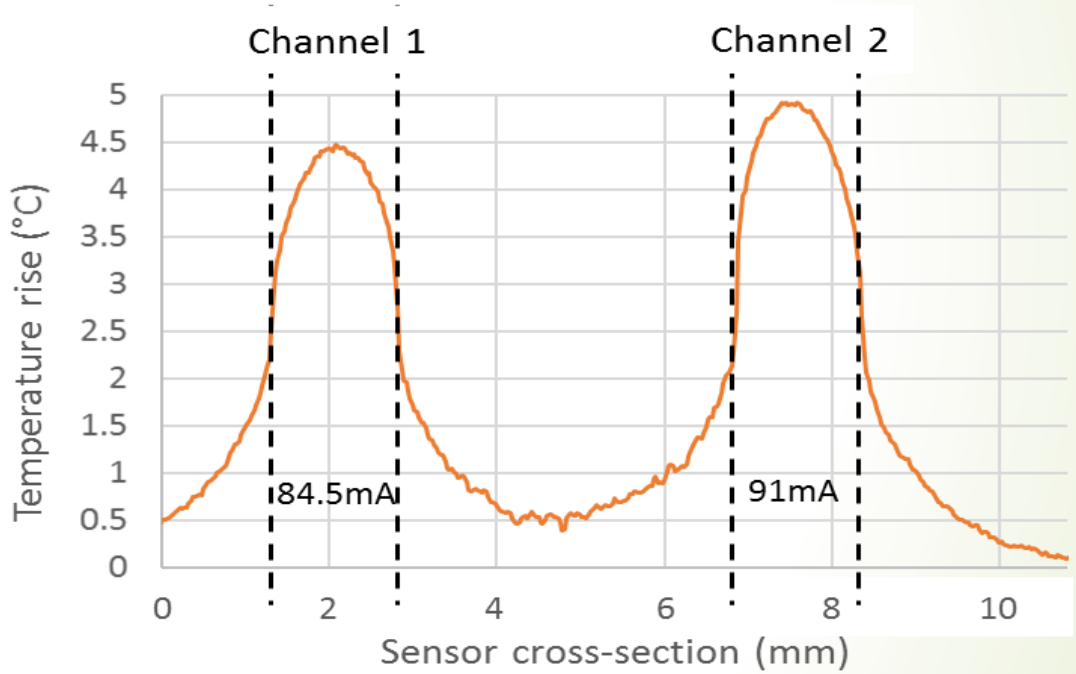


Simultaneous temperature control of two plasmonic channels





Conclusion

- Using plasmonic layer as a heater to be used for portable SPR systems.
- Sensitivity improvement of the portable SPR system.
- Implementation of temperature sensor(Pt) on the Plasmonic layer to directly measure the temperature at the sensor surface.

Thank you

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