Babar Ali

Optical Fiber Sensors for Oncological Applications

Tutor: Prof. Cutolo Antonello
Co-Tutor: Prof. Marco Pisco

Cycle: XXXVI

Year:20-2021

My background

- MSc. degree: Electronics and Communication Engineering
- Research laboratory: Information Photonics and Optical Communication
- PhD start date: November 2020
- Scholarship type: UNINA

Research field of interest

Optical Fiber Sensors for Oncological Applications

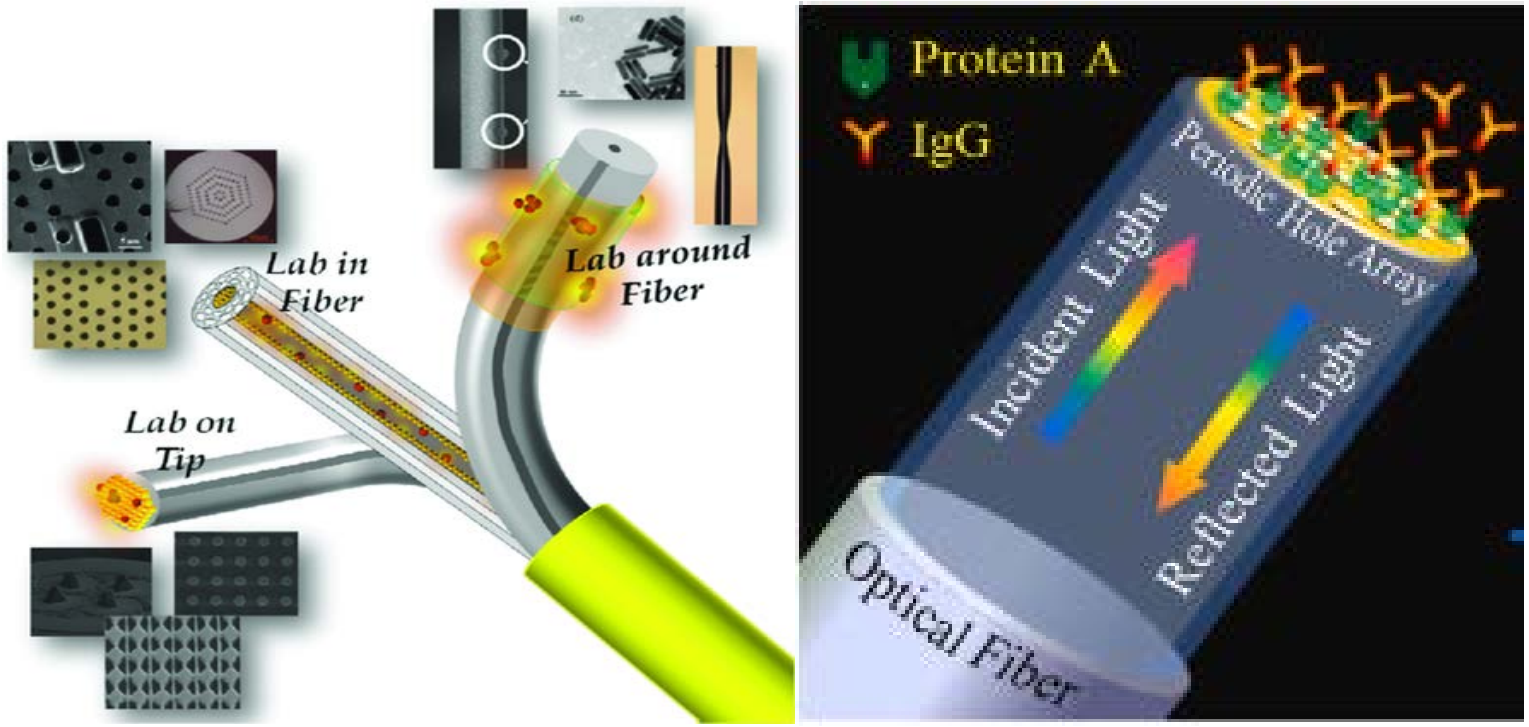

Fig.1. Lab on Fiber Schematic representation of the sensor

Vaiano, P. , et al. "Lab on Fiber Technology for biological sensing applications." Laser & Photonics Reviews 10.6(2016):922-961.

Nabarun Polley. Et al " Fiber optic plasmonic sensors: Providing sensitive biosensor platforms with minimal lab equipment, 11 March 2019

Research field of interest

Surface Enhanced Infrared Absorption Spectroscopy(SEIRAS) on Fiber-Tip for Oncological Applications

SEIRA on fiber technology will pave the way for this technology to be employed as **in-Vivo and real-time monitoring of biomolecular interactions for cancer biomarkers detection**.

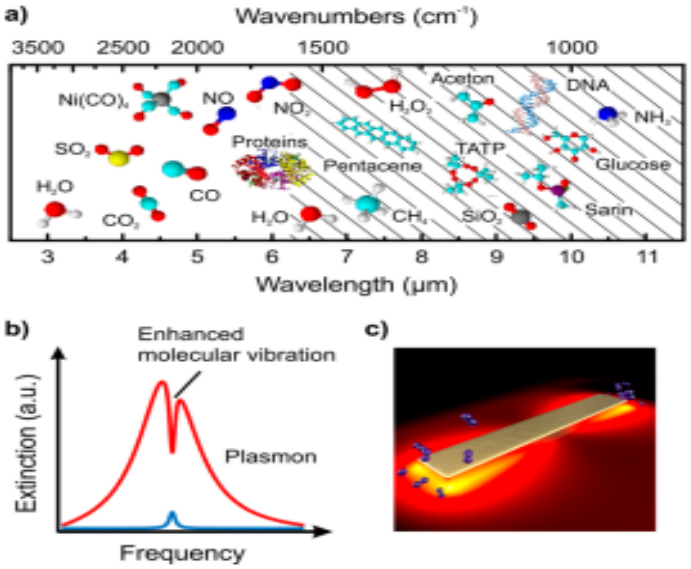

Fig.2. (a) Characteristic infrared vibrations of selected molecular species. The fingerprint region containing skeletal vibrations is hatched. **(b,c)** Principle (SEIRA)

Neubrech et al, Chem. Rev. 2017, 117, 7, 5110−5145

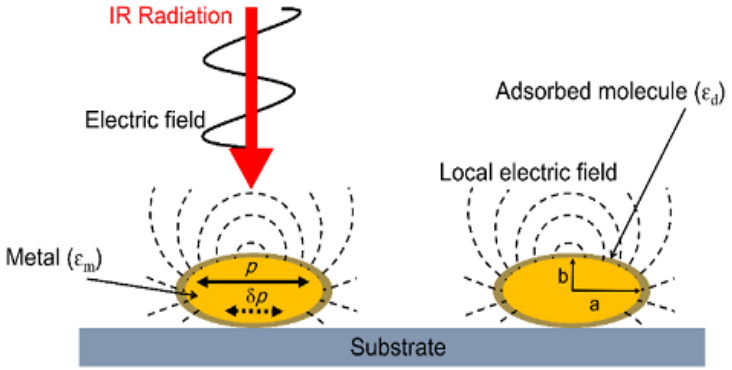

Fig.3. Schematic representation of the electromagnetic mechanism of SEIRA on metal island film

- **Vibrational Signal Enhancement**

- Near field enhancement depends on:
  - Nanostractures shape and sizes
  - Spectral Tuning
  - FWHM

Chem. Sci., 2020,**11**, 4563-4577

Summary of study activities

- ***Briefly summarize the study activities of the academic year***
  - *Attended (Courses, Seminars, PhD Schools)*
  - *Research Tool Learning (MATLAB, COMSOL Multiphysics, and FTIR)*
  - *Briefly Literature Study*
- ***Ad hoc PhD courses / schools***
  - *Data Science for Patient Records Analysis*
  - *Scientific Programming and Visualization with Python*
  - *Matrix Analysis for Signal Processing with MATLAB Examples*
  - *Advanced Topics in Radar Signal Processing*
  - *AIRO PhD School 2021 and 5th AIRO-Young Workshop*
  - *PhD School - 5G Italy 2020*
- ***Courses borrowed from MSc curricula***
  - *Optoelectronics*
- ***Conferences / events attended***
  - *Seeing the Sound: Optical Neural Interfaces for In Vivo Neuromodulation*
  - *Virtual Reality Optics: Present and Future*
  - *Photonics Spectra Conference 2021*

Summary of study activities

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	**0**	**5.35**	**-**	**0**	**5.35**
Bimonth 2	**5**	**4.7**	**-**	**0**	**9.7**
Bimonth 3	**10.1**	**1.8**	**-**	**0**	**11.9**
Bimonth 4	**13**	**6.8**	**25**	**0**	**44.8**
Bimonth 5	**05**	**0**	**10**	**0**	**15**
Bimonth 6	**0**	**0**	**10**	**0**	**10**
Total	**33.1**	**18.65**	**45**	**0**	**96.75**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

Research activity: Overview

- **Problem**
  - *Precision medicine demands for advanced specific and sensitive biomedical tools for early cancer detection*
- **Objective**
  - *Development of optical fiber probe based on SEIRA spectroscopy for oncological application*
- **Methodology**
  - *Theoretical investigations of light interaction with plasmonic nanostructures (NA)*
  - *Design and numerical investigations of NA using MATLAB and COMSOL Multiphysics*
  - *NA fabrication by using available fabrication techniques (Lithography Method)*
  - *Comparison of numerical and experiment results*
  - *Transfer NA on fiber probe for SEIRA spectroscopy characterization*
  - *Collaborate with biologist for bioassay preparations*
  - *Characterization using portable Fourier-transform infrared (FT-IR)*
  - *After integration of all the components in a single system, the objectives are to determine the performance (sensitivity, selectivity, reproducibility) of our biosensor and to validate it for in vitro and in-vivo detection of biomolecules*
  - *Determine the enhancement factor and limit of detection of "SEIRA on Fiber"*

Research activity: Overview

- **Primarily Simulation Based Results**

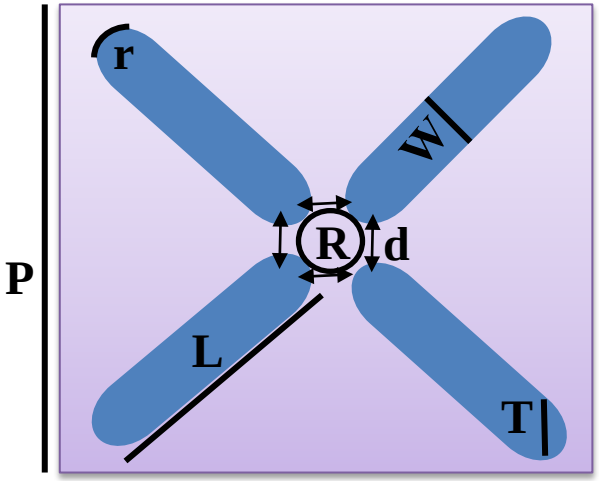

Fig4. Plasmonic NA

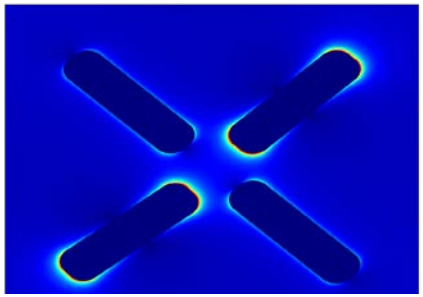

Fig5. Electric-field intensity distribution

Design Parameters

L=Rod Length, **W**=Width of Rod, **T**=Thickness of Rod **r**=Radius,

R= Centre Radius , **d**= Distance , **P**=Periodicity of Unit Structure,

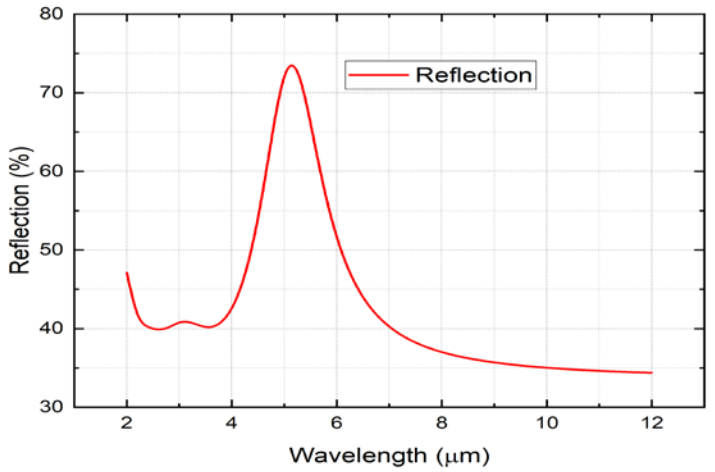

Fig6. Simulated Reflection as a Function of Wavelength

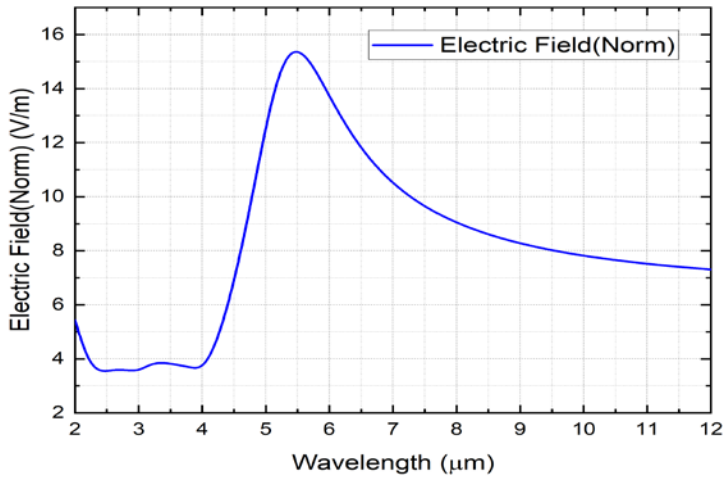

Fig7. Simulated Electrical Field as a function of wavelength


Thank You