



PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Babar Ali

Cycle: XXXVI

Training and Research Activities Report

Year: Second

Babar Ali

student signature

A. Cutolo

Tutor: Prof. Cutolo Antonello tutor signature

Co-Tutor: Prof. Marco Pisco

Date: October 28, 2022

Training and Research Activities Report

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Cycle: XXXVI

Author: Babar Ali

1. Information:

- **PhD student:** Babar Ali
- **DR number:** DR995148
- **Date of birth:**08-March-1993
- **Master Science degree:** Electronics and Communication Engineering
- **University:** Beijing University of Posts and Telecommunication
- **Doctoral Cycle:**36
- **Scholarship type:** UNINA
- **Tutor:** CUTOLO Antonello
- **Co-tutor:** Prof. Marco Pisco

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
Software Defined Radio Applications for Radar and Localization Systems	Course	-	3	22-23-24-25-26-29-30/11 2021	Proff. Antonio De Maio, Augusto Aubry, Dr. Vincenzo Carotenuto - DIETI	Y
Single cell omics leverage Machine Learning to dissect tumor microenvironment and cancer immuno editing	Seminar	2	0,4	02/12/2021	Prof. Anna Corazza - DIETI, Unina	Y
Threat Hunting Use-Cases	Seminar	2	0.4	13/12/2021	Prof. D. Cotroneo, Prof. S.P. Romano, Dr. R. Natella, DIETI - Unina	Y
GDPR basics for computer scientists	Seminar	2	0.4	14/12/2021	Prof. Piero Bonatti, DIETI - Unina	Y
All roads lead to WebRTC: an introduction to Janus	Seminar	2	0.4	16/12/2021	Prof. S.P. Romano, DIETI - Unina	Y
Ultra-High Field Magnetic Resonance Imaging	Course	-	3	17-18-20-25-26-31/01 2022	Prof. G. Ruello - DIETI - ICTH	Y
Virtualization technologies and their applications	Course	-	5	17/01-18/02 2022	Dr. Luigi De Simone, DIETI	Y
Using Delays For Control	Seminar	1	0.2	21/04/2022	Prof. Stefania Santini - DIETI - Unina	Y

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Explainable Natural Language Inference	Seminar	1.5	0.3	13/04/2022	Prof. Francesco Cutugno, DIETI, Unina	Y
An Introduction to Deep Learning for Natural Language Processing	Seminar	1	0.2	13/04/2022	Prof. Francesco Cutugno, DIETI, Unina	Y
Imprenditorialità Accademia	Course	-	4	26/05 - 14/06 2022	Università degli Studi di Napoli Federico II	Y
Vine robots: design challenges and unique opportunities	Seminar	-	0.2	31/05/2022	Dr. Mario Selvaggio, DIETI - Unina	Y
Probing and infusing biomedical knowledge for pre-trained language models	Seminar	2	0.4	07/06/2022	Prof. Francesco Cutugno, DIETI, Unina	Y
5G Networks in Action - The Private Mobile Era	Seminar	2	0.4	11/05/2022	Alessandra Baldi	Y
Machine Learning for Science and Engineering Research	Course	-	-	20/06-01/07-2022	DIETI, Dott. Giovanni Pezzulo	N
Clinical experiences and error detectability tests with RadCalc's 3D EPID module	Seminar	-	-	26/08/2022	Claude Bernard University Lyon 1 , Physics World	N
User experience of MRIIdian and Halyon linacs commissioning and QA with the THALES 3D MR SCANNER	Seminar	1	0.2	13/10/2022	LAP GmbH Laser Applicational	N
Visualizing Quantum Matter at Atomic-Scale	Seminar	1	0.2	18/10/2022	JC Seamus Davis, Ryan Dahn Physics Today, RHK Technology, Imaging the Future of Nanoscience	N
Integrated DSP Solution for Seamless Campaign Management	Seminar	1	0.2	20/10/2022	Event Brite, On Spot Data Webinar: Integrated DSP Solution	N
Dynamic Beam Lasers: Introducing New Parameters for Laser Welding	Seminar	1	0.2	20/10/2022	Photonics Media	N
MATLAB Campus-Wide License per la formazione nelle discipline STEM	Seminar	1	0.2	26/10/2022	DIETI, School-politec-sc-base	N

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Bio Photonics Conference 2022	Conference	-	-	25-27/10/2022	Photonics Media	N
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- 1) Courses, Seminar, Doctoral School, Research, Tutorship
- 2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	3	1.6	10	0	14.6
Bimonth 2	3	0	8	0	11
Bimonth 3	5	0.7	6	0	11.7
Bimonth 4	4	1	5	0	10
Bimonth 5	0	0	5	0	5
Bimonth 6	0	0.8	10	0	10.8
Total	15	4.1	44	0	63.1
Expected	10 - 20	05 - 10	30 - 45	0 - 4.8	

3. Research activity:

My research focuses on research and development of a surface enhanced infrared spectroscopy (SEIRA) platform for biomedical and oncological applications. Specifically, my activities aim to identify and develop novel plasmonic nanostructures exhibiting good SEIRA properties (namely, the gain factor) in order to improve the detection characteristic of a ATR-FTIR instrument for cell analysis. Attenuated total reflectance (ATR) is the most widely used sampling methodology for Fourier transform infrared (FTIR) spectroscopy. In a ATR-FTIR the interaction between the sample and the cell occurs through the evanescent wave in a prism based configuration. Therefore, I am engineering a nanostructures substrate able to improve the recognition of the spectral characteristic of a cell in ATR-FTIR configuration.

During the second year, I identified a reliable numerical model to analyse the nanostructures (under test) in the configuration of the ATR-FTIR. I am carrying out numerical simulations of the SEIRA substrates composed of period pattern of nanostructures. The nanostructures are fabricated by nanosphere lithography at the institute SCITEC-CNR in Milan. To support the fabrication process, I am performing the morphological and spectral characterization of received SEIRA substrates by Atomic force microscopy (AFM) and ATR-FTIR. The two research activities are ongoing concurrently. Both numerical analysis and experimental activities provide feedback to each other.

▪ Numerical simulations:

In literatures [1] it is well documented that well-designed plasmonic nanostructures can amplify the enhancement factors of vibrational spectroscopic biosensors. Therefore, with this in mind, I have investigated thoroughly by numerical simulation a suitable plasmonic SEIRA substrate with the focus on optimizing the SEIRA substrate near-field (also called Hot-Spot), far field spectra, and resonance tunability. The SEIRA substrates are designed and simulated using a numerical method based on the finite element method (COMSOL Multiphysics). The design principle is based on Otto configuration and the COMSOL Multiphysics provides versatile flexibility in order to design and simulation these configurations. Also, the design principle is in line with the optical characterization instrument ATR-FTIR most suitable for these types of SEIRA substrates. In addition, the experimental data of the sample received by CNR-Milan are used to validate the numerical model. Numerically simulation activities are still ongoing.

▪ Experimental Characterization:

Concurrently with the numerical simulation, some plasmonic SEIRA substrates (i.e., Gold nano star on glass substrate) have been realized by a group (CNR-Milan) we are collaborating with. The SEIRA substrates were realized using self-assembly techniques. We have characterized these sample using two advanced optical techniques.

1. Attenuated total reflection integrated with Fourier transform infrared spectroscopy (ATR-FTIR):

The ATR-FTIR is an advance spectroscopic technique widely used to reveal valuable optical and chemical information about a sampling in liquids, solids, powders, semisolids, and pastes form. Using the ATR-FTIR (at CeRICT SCRL-Benevento), I performed reflection and absorption measurements in the mid-infrared electromagnetic wave region, on the samples received from CNR-Milan. The reflection and absorption were normalized using the reference background collected at the initial of the measurements.

2. Atomic force microscopy

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To have more insight on the fabricated samples, a morphological analysis is performed using Atomic force microscopy (AFM). The AFM scan was able to reveal details on self-assembly nanostructures roughness, heights and shapes. The morphological characterizations have been taken into account for the numerical model definition and provide a useful feedback for the fabrication stage.

References:

1. Kato, Yuichi, Kikugawa, Masashi, Sudo, & Eiichi. (2017). Attenuated total reflection surface-enhanced infrared absorption (ATR-SEIRA) spectroscopy for the analysis of fatty acids on silver nanoparticles. *Applied Spectroscopy: Society for Applied Spectroscopy*, 71 (9), 2083-2091.
2. Yuichi Kato, Masashi Kikugawa, and Eiichi Sudo, "Attenuated Total Reflection Surface-Enhanced Infrared Absorption (ATR-SEIRA) Spectroscopy for the Analysis of Fatty Acids on Silver Nanoparticles," *Appl. Spectrosc.* 71, 2083-2091 (2017)
3. Cheng Shi, al. Metamaterial-enhanced infrared attenuated total reflection spectroscopy†Infrared Plasmonic Biosensor with Tetrahedral DNA Nanostructure as Carriers for Label-Free and Ultrasensitive Detection of miR-155." *Advanced Science* (2021).
4. Kas R, Ayemoba O, Firt NJ, Middelkoop J, Smith WA, Cuesta A. In-Situ Infrared Spectroscopy Applied to the Study of the Electrocatalytic Reduction of CO₂ : Theory, Practice and Challenges. *Chemphyschem.* 2019 Nov 19; 20(22):2904-2925. Doi: 10.1002/cphc.201900533. Epub 2019 Sep 11. PMID: 31441195.
5. Yulastuti, D. D., et al. "observation of surface plasmon resonance in gold and silver thin films using a handy home-made computerized optical device set-up in the kretschmann configuration."

4. Research products:

N/A

5. Conferences and seminars attended

N/A

6. Activity abroad:

N/A

7. Tutorship

N/A