UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Activities and Publications Report

PhD Student: Barbara Rossi

Student DR number: DR996628

PhD Cycle: XXXVIII
PhD Chairman: Prof. Stefano Russo

PhD program student's start date:1/11/2022
PhD program student's end date:31/10/2025

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PhD scholarship funding entity: Università Federico II

General information

Barbara Rossi received in 2022 the Master's degree in Biomedical Engineering from the University of Napoli Federico II. She attended a curriculum in Optical Fiber Probes for Medical Applications within the PhD program in Information Technology and Electrical Engineering. She received a grant from Università Federico II.

Study activities

Attended Courses

PhD Year	Course Title	Type	Credits	Lecturer	Organization
1st	Scientific programming and visualization in Pyhton	Ad hoc course	2	Prof. A. Botta	ITEE
1st	How to boost your PhD	Ad hoc course	4	Prof.ssa Antigone Marino	ITEE
1st	Componenti e Circuiti Ottici	MSc course	9	Prof. A. Capozzoli	UNINA
1st	Ottica e Iperfrequenze	MSc course	9	Prof. A. Capozzoli	UNINA
2nd	Numerical Methods for Thermal Analysis, Modeling and simulation: Application to Electronic Devices and system.	Ad hoc course	4	Dott. A.P. Catalano	ITEE
2nd	Innovation and Entrepreneurship	Ad hoc Course	4	prof. P. Rippa	ITEE
3rd	Fiber optic sensing and optoelectronic circuits: design and application	Ad hoc course	4	Dott. Vincenzo Romano Marrazzo	ITEE

Attended PhD Schools

PhD Year	School title	Dates	Location	Credits	Organization
1st	China-Italy Joint Laboratory on Advanced Manufacturing (CI-LAM) 2023	17-21/07/23	Naples, Italy	5.2	University of Napoli Federico II, Italy
1st	SIE 2023	4-6/09/23	Messina, Italy	4	University of Messina, Italy
3rd	FIT4MEDROB INTERNATIONAL SEASONAL SCHOOL - Robotics and allied technologies for rehabilitation.	18-21/11/ 2024	Rome, Italy	4.8 CFU	University of Rome, Campus Biomedico and CNR

Attended Seminars

PhD Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1st	Entangled relativity	0.2	Prof. Olivier Minazzoli	Permanent researcher at Observatory of Côte d'Azur in Nice	SSM
1st	Cascading risk assessment in the energy and chemical industry: a longlasting issue in the new framework of climate change	0.2	Valerio Cozzani	Professor of Chemical Engineering, University of Bologna – Italy.	SSM
1st	Open Digital framework-crash	0.6	Valeria Crimaldi	Capgemini	5G Academy
1st	Industry 4.0 Fundamentals in Bosch Applications	2	Eng. Martino Bruni	Bosch	National Doctoral program in Autonomous Systems
1st	Principi Architetturali-TOGAF I	0.6	Alberto Curcio, Pietro Boscolo	Capgemini	5G Academy
1st	Principi Architetturali-TOGAF II	0.6	Prof A.Curcio, Ing. P.Boscolo	Capgemini	5G Academy
1st	Effective behavior of random media	0.2	Prof. Felix Otto	Director at the Max Planck Institute for Mathematics in the Sciences, Leipzig – Germany	SSM
1st	Blockchain and 5G in business	0.6	Dr.Conforto Luca, Dr. Mutarelli Gabriele	Capgemini	5G Academy
1st	Multi-robot control of heterogeneous herds	0.2	Dr Eduardo Montijano	Professor at Departamento de Informatica e Ingenieria de Sistemas, University of Zaragoza – Spain	SSM
2nd	Ensuring Electronic Reliability Against CERN's Radiation Environment	0.2	Dr. Salvatore Danzeca	CERN	ITEE
2nd	Emerging Internet, Data & Web Technologies	0.3	Prof. Makoto Ikeda	Fukuoka Institute of Technology, Japan	EIDWT-2024
2nd	Regolazione in Tema di intelligenza artificiale alla luce dell'AI ACT	1	Elvira Raviale	Capgemini	5G Academy
2nd	IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published	0.3	Dr. Derek Abbott	University of Adelaide, Australia	IEEE Advancing Technology for Humanity
2nd	Data Science Strategies to Analyze the Impact of Transportation and	0.2	Jane Macfarlane	University of California	IEEE Advancing Technology for Humanity

	Infrastructure on the Environment				
3rd	Miniaturization of Optical Spectrometers	0.4	Tawfique Hasan	University of Cambridge	ITEE

Research activities

Barbara Rossi participated in research on advanced fiber-optic technologies for precision medicine, focusing on localized and patient-specific diagnosis and therapy. She contributed to the development of the "Hospital in the Needle" vision, which integrates multiple functionalized optical fibers for medical sensing applications, enabling compact theranostic platforms that combine diagnostic and therapeutic functionalities within a single, minimally invasive tool.

Her research primarily focused on all-optical ultrasound systems, employing functionalized optical fibers for high-precision medical applications that benefit from their biocompatibility, electrical passivity, and compactness. Within this framework, several experimental configurations were designed and numerically analyzed to identify optimal solutions for device performance. A central challenge addressed in her work was the limited exploitation of emerging materials and fabrication technologies in the development of Lab-on-Fiber (LoF) devices. In this context, her research critically explored both the generation and detection of ultrasound signals in all-optical systems. Regarding the acoustic detectors, she performed a systematic investigation of three distinct fiber-optic ultrasound detector geometries, each representing a different technological approach: a curved Fabry–Pérot cavity, fabricated via dip-coating for beam refocusing; a multilayer π-shifted Bragg structure, which can be realized through spin-coating to enhance optical interference; and a membrane-based design, which can be produced by two-photon lithography, enabling high-sensitivity and frequency-selective detection. Building upon recent advances in photosensitive resin technology, the research also explored new functional materials for ultrasound generation, focusing on the innovative polymer IP-PDMS, whose mechanical properties make it particularly suitable for photoacoustic transduction. During her period abroad at the Technical University of Denmark, she investigated the thermoelastic and optical behavior of IP-PDMS under optical excitation, assessing its efficiency in ultrasound generation and its suitability for integration within fiber-based photoacoustic systems. Based on the simulation outcomes, an optimal configuration for experimental characterization was defined, and a preliminary setup was proposed to enable systematic evaluation of its acoustic and optical performance. Furthermore, optical characterization in the near-infrared (NIR) range was carried out to investigate the optical properties of IP-PDMS, an innovative polymeric material whose refractive index and absorption behavior in this spectral region had not previously been reported in the literature. This activity was conducted in collaboration with the Italian Institute of Technology (IIT) in Lecce and the University of Sannio, leveraging complementary expertise and facilities. The experimental results provided the first insights into the material's optical response in the NIR range, supporting its potential use as an active medium for a new class of high-sensitivity fiber-optic ultrasound detectors. Overall, this research critically addresses both the generation and detection of ultrasound signals in all-optical systems, providing a comprehensive analysis of Lab-on-Fiber configurations for ultrasound applications. The outcomes support the design of next-generation multifunctional all-optical probes for precision medicine and highlight both the strengths and current technological limitations of emerging materials and fabrication strategies in the field.

Tutoring and supplementary teaching activities

- She served as a *tutor* for the undergraduate courses Physics I and Physics II, assisting students in understanding the fundamentals of classical mechanics, thermodynamics and electromagnetism.

During her PhD, Barbara Rossi served as a *co-tutor* for two Master's students and two Bachelor's students at the University of Naples Federico II.

- She co-supervised Paolo Massimo Aiello, whose Master's thesis was entitled *"Design and Comparison of New Structures for Photo-Acoustic Imaging"*, and Valentina Capuano, who developed a thesis on *"Integrated Methods for the Generation of Ultrasonic Signals in Precision Medicine."*
- At the Bachelor's level, she supervised Lorenzo Fiore, who worked on the project *"Optical Fiber–Based Ultrasound Detection,"* and Alessandra Rozza, whose thesis was titled *"Innovative Optical Fiber Microstructures for Ultrasonic Reception."*

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring/Supplementary Teaching
1st	28	10.4	35	/
2nd	8	2.3	45	2.4*
3rd	4	5.2	60	1**

Research periods in institutions abroad and/or in companies

PhD Year	Institution /Company	Hosting Tutor	Period	Activities
3rd	Technical University of Denmark (DTU),	Professor Massimo De Vittorio, Head of the Optomechanical Biointerfaces Team	02/03/2025-19/07/2025	Research on the development of an optical fiber–based ultrasound generator for brain applications..

PhD Thesis

Precision medicine increasingly demands technologies for localized, patient-specific diagnosis and therapy. The maturity of Lab-on-Fiber technology enables fiber-optic devices for minimally invasive, high-precision medical applications, integrating multiple sensing and imaging modalities toward the "Hospital-in-the-Needle" theranostic tool, a compact theranostic tool combining

diagnostic and therapeutic functions. Among the various possible applications, this thesis focuses on ultrasound, which represents a promising approach for both localized high-resolution imaging and therapy. All-optical ultrasound systems, using functionalized optical fiber, emerge as an innovative solution due to their biocompatibility, electrical passivity, and compactness. A central challenge is that emerging materials and fabrication technologies are not yet fully exploited. In this context, the advantages and limitations of different Lab-on-Fiber configurations, each associated with a distinct technology, were systematically analyzed by employing multiphysics models to investigate polymer-based acoustic detectors and acoustic generation. Three fiber-optic ultrasound detector geometries were investigated: a curved Fabry–Pérot cavity for improved optical confinement, a multilayer structure for higher optical response, and a membrane-based design enabling high-sensitivity, frequency-selective detection. A photoacoustic generation model integrating optical, thermal, and acoustic phenomena was used to investigate the polymer IP-PDMS coated with a thin gold layer, achieving broadband pressure generation up to 100 MHz. Preliminary optical characterization of IP-PDMS in the NIR region was performed to assess its potential as a fiber-optic ultrasound detector. Overall, this work provides a framework for designing and optimizing all-optical ultrasound probes, supporting the development of multifunctional Lab-on-Fiber devices.

Research products

Research results appear in 1 paper published in an international journal, 1 paper submitted, 1 contribution to an international conference, 1 contribution to a national conference, and 1 invited abstract (international).

List of scientific publications

International journal papers

- B. Rossi, M.A. Cutolo, M. Giaquinto, A. Cusano, and G. Breglio (2025). Curved Fabry-Pérot Ultrasound Detectors: Optical and Mechanical Analysis. Sensors, 25(4), 1014.
- B. Rossi, M.A. Cutolo, P.M. Aiello,G. Breglio A. Cusano, M. Giaquinto, "*All-polymer multilayer Lab-on-Fiber structures for photoacoustic applications in biomedical field".* Sensors. (submitted).

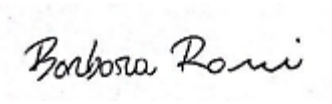
International conference papers

- B. Rossi, P. M. Aiello, M. A. Cutolo, M. Giaquinto, A. Cusano, G.Breglio, A. Cutolo, "*Polymer-Based Lab-on-Tip Microstructures For Ultrasound Medical Diagnostics*," *2024 IEEE Sensors Applications Symposium (SAS)*, Naples, Italy, 2024, pp. 1-6, doi:10.1109/SAS60918.2024.10636662.

National conference papers

- B. Rossi, M. Giaquinto, M. A. Cutolo, A. Cusano, A. Cutolo, "*Advanced integrated optical devices for ultrasound diagnostics*", Springer Nature, Proceedings of SIE 2023 - 54th Annual Meeting of the Italian Electronics Society, A Springer book series Lecture Notes in Electrical Engineering

Date 23/10/2025

PhD student signature 

Supervisor signature