



PhD in INGEGNERIA DEI MATERIALI / MATERIALS ENGINEERING - 39th cycle

**PNRR 118 PA Research Field: ENGINEERING PLASMONIC SURFACES FOR THERAPEUTIC
DRUG MONITORING OF ANTIEPILEPTIC DRUGS**

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

Despite their robustness and reliability, the HPLC-MS analytical technique currently used for the Therapeutic Drug Monitoring (TDM) of Antiepileptic Drugs (AEDs), which provide the concentration of a drug in the patient's body over time, is neither time nor cost-effective. This limits the wide application of TDM, with drawbacks on the quality-of-life of epileptic patients that require frequent TDM under medical guidance to determine the suitable pharmacological treatment to prevent the occurrence of seizures. Surface Enhanced Raman Spectroscopy (SERS) is an innovative diagnostic tool [1,2] that can assess the drug concentration in a biological fluid such as saliva [3], and it can therefore be introduced as a complementary method for TDM of AEDs with clinical relevance. If SERS could be adopted as a complementary technique in the TDM of AEDs, more data would be quickly available to the Epileptologist, with positive feedback on the tuning of the pharmacological treatment. Thanks to the production by laser ablation of SERS sensors made of Au nano-islands self-assembled on inert supports, we proved that SERS can be used to quantify the concentration of selected AEDs [1-3]. This project aims at testing and optimizing the plasmonic surfaces developed by laser ablation of selected metals for sensing and quantifying the concentration of specific AEDs in biological fluids of clinical relevance, such as blood plasma and saliva. The project's aims are relevant to the health mission (M6) of the PNRR, with a definite impact



	on the M6C2 framework (Innovazione, ricerca e digitalizzazione del Servizio Sanitario Nazionale). Indeed, introducing SERS in the clinical practice of TDM of AEDs constitutes a significant technological and methodological innovation, which could be possible by the dedicated scientific research implied by this project. A complementary SERS approach to TDM can benefit the patients and SSN because of the significant shortening of reporting compared to the established HPLC-MS technique. [1] https://doi.org/10.3390/nano9050677 [2] https://doi.org/10.1016/j.apsusc.2019.145109 [3] https://doi.org/10.3390/molecules28114309
Methods and techniques that will be developed and used to carry out the research	In collaboration with Dr. Emilio Ciusani and Dr. Ugo De Grazia (Fondazione IRCCS Istituto Neurologico C. Besta) we will select a set of AEDs of clinical interest for which the development of a SERS analytical pathway would constitute a significant and beneficial addition in the context of the current clinical practice. The established collaboration with Prof. Paolo Ossi (Dipartimento di Scienze Chimiche, Biologiche, Farmaceutiche ed Ambientali, Università degli Studi di Messina) and Dr. Sebastiano Trusso (Istituto per i Processi Chimico Fisici, Consiglio Nazionale delle Ricerche, Messina) will support the production by laser ablation of the metallic (mainly, Au) nanostructured plasmonic surfaces to be used as SERS substrates. The close interaction with the team at Besta and the team in Messina will allow us to fine-tune both the experimental conditions in the SERS experiment (biological sample treatment, solvent extraction, control of pH, etc.) and the optimization of the nanostructures produced by laser ablation through the control of the morphology (monitored by SEM) and plasmon resonance (monitored by UV-Vis spectroscopy). The team at Fondazione IRCCS Istituto Neurologico C. Besta will be essential in providing validation of the SERS results through comparison with the reference analytical techniques adopted in their clinical laboratory. During the stay abroad at the laboratory led by Prof. Nisha Agarwal (University of Ontario Institute of Technology, Canada), the Ph.D. candidate will explore the use of the SERS



	substrates developed during the project for the sensing of cannabidiol CBD), presently used for the treatment of patients suffering severe, recurrent seizures associated to the Dravet and the Lennox-Gastaut syndromes. CBD belongs to a class of drugs for which the successful establishment of a SERS-based analytical practice would constitute a significant advancement in the clinical practice and would prove the applicability of the technology developed in the project to another class of relevant psychotropic analytes.
Educational objectives	The Ph.D. candidate will be able to conduct scientific research in close collaboration with the teams described above, working in Milano, Messina [4], and at the University of Ontario Institute of Technology. This will provide the chance to access and learn the use of many different experimental techniques in a multidisciplinary environment featuring clinical biologists, materials engineers, and experimental physicists. [4] http://www.ipcf.cnr.it/laboratories/pld-lab/
Job opportunities	The use of vibrational spectroscopy (Raman/IR) in the field of the characterization of drugs has a growing impact in the pharmaceutical industry. The experience acquired by the Ph.D. candidate in the use of these optical techniques, together with the experience in the production and characterization techniques of the plasmonic nanomaterials is also interesting for the industries in the microelectronics field.
Composition of the research group	2 Full Professors 2 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	Prof. Matteo Tommasini / Dr. Emilio Ciusani

Contacts	
Prof. Matteo Tommasini, matteo.tommasini@polimi.it https://www.cmic.polimi.it/ricerca/elenco-gruppi-di-ricerca/funmat/ Dr. Emilio Ciusani, Emilio.Ciusani@istituto-besta.it https://www.istituto-besta.it/ciusani-emilio	



Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Fondazione IRCSS Istituto Neurologico C. Besta Via Celoria 11, 20133 Milano https://www.istituto-besta.it
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	University of Ontario Institute of Technology 2000 Simcoe St. N., Oshawa, ON L1G 0C5, Canada https://ontariotechu.ca
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Individual budget for research (5.700 euro): 1st year: 1.900 euro; 2nd year: 1.900 euro; 3rd year: 1.900 euro Teaching assistantship (availability of funding in recognition of supporting teaching activities by the PhD student): there are various forms of financial for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities within the limits allowed by the regulation.