Funded by the European Union
NextGenerationEU

Ministero dell'Università e della Ricerca

Postdoc positions for the development of a

Multi-resonant Raman Sensors in liquids

at

Dr. Gianluca Gagliardi
Head of Naples Unit
CNR, Istituto Nazionale di Ottica (INO)
Comprensorio "A. Olivetti", Via Campi
Flegrei 34
I-80078 Pozzuoli (Naples), Italy
gianluca.gagliardi@ino.it
https://opticalsensorslab.ino.it/

Prof. Giulia Rusciano
Dept of Physics "Ettore Pancini"
University of Naples "Federico II"
Complesso Universitario Monte Sant'Angelo
Via Cinthia - 80126 - Napoli (Italy)
giulia.rusciano@unina.it
https://www.docenti.unina.it/giulia.rusciano

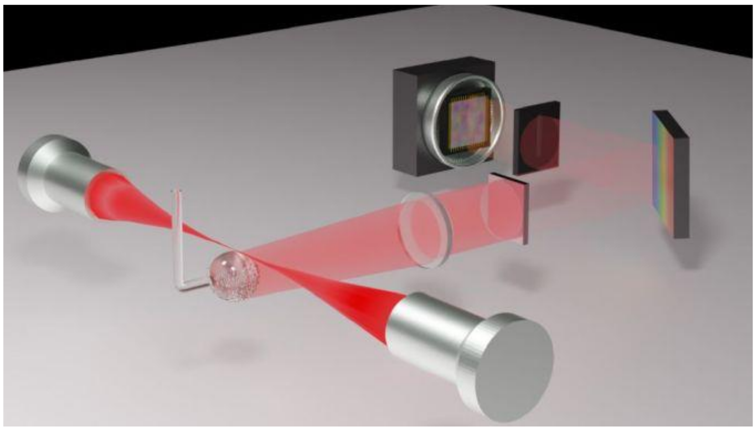
Napoli, February 20th, 2023

Topic: Combined photonic & plasmonic platform for ultra-sensitive detection of contaminants in liquids

We are seeking candidates for two post-grad positions funded by the Italian Ministry of University and Scientific Research (MuRS), in the framework of a PRIN project, involving the National Institute of Optics of the Italian CNR (CNR-INO) and the University of Naples "Federico II". Both positions will start approximately between November 2023 and January 2024 and last 1 year. The research will focus on the development of a new concept of localized surface-plasmon WGM micro-sensors, harnessing the photonic amplification and light confinement to ultra-small volumes of resonant silica microcavities, combined with the huge light-matter interaction enhancement given by the metallic nanostructures that decorate the silica surface. The envisaged photonic-plasmonic resonant platform is ideally suited to exploit the potentialities of micro-resonators and metallic nanostructures. At the same time, it opens new pathways towards label free sensing applications, ranging from quality control of freshwater reservoirs and monitoring of marine pollution to quantification of food contaminants and direct detection of biomarkers in biological fluids.

Funded by the European Union
NextGenerationEU

Ministero dell'Università e della Ricerca



Context and objectives

Anthropic activities are leading to alarming pollutant levels with dramatic effects on human health and the whole eco-system. Of particular concern is the degradation of synthetic polymers, leading to release in the environment of very small particles, grouped as micro- (<5 mm), sub-micro- (1 µm–100 nm) and nano-plastics (<100 nm) [1-4]. In this frame, identification and quantification of such particles requires the development of adequate standardized analytical methods [5]. Dielectric optical microresonators have attracted a lot of interest in recent years and found a wide range of applications, such as bio-chemical sensing [6,7] and microfluidics [8]. The peculiarity of WGMs is that light travels for long times along equatorial paths and remains confined in ultra-small mode volume close to the outer dielectric surface. Most of the light circulates inside the resonator but a significant evanescent-wave tail may interact with the external medium, where it experiences absorption, dispersion and scattering effects. Ultra-sensitive detection of chemical analytes with WGMs has already been demonstrated by measuring tiny shifts and lineshape changes of the WGM spectrum induced by molecules or nanoscale objects adhered at the interface [6] or dissolved in liquids [9,10]. Moreover, the combination with the "chemical fingerprint" character of Raman-based techniques, such as SERS (Surface-Enhanced Raman Spectroscopy), would constitute an added value, leading to the identification of such particles [11]. Our project will investigate new radiation-matter interaction mechanisms deriving from plasmonic properties. An overall enhancement of Raman spectrum is expected when the excitation energy matches an internal field resonance. Since the Raman spectrum of our analytes likely spans over several free-spectral ranges of our micro-sized cavity, we expect a stronger enhancement of the emitted Stokes light at specific wavenumbers, due to Purcell effect. Raman spectra would add quantitative information and details on the chemical composition of the sample. To our knowledge, only few experimental works where SERS on micro-resonators is augmented by the WGM enhancement have been reported so far. Globally, our approach would represent a fundamental breakthrough in pollutant sensing in liquid environments.

Candidate's profile:

The candidate must possess a background in optics and/or spectroscopy consolidated through a MSc or a PhD. Experimental skills in building optical apparatus is desirable too. The candidate should be able to provide valuable insights and actively contribute to the development of new experiments for the ongoing research project.

Funded by
the European Union
NextGenerationEU

Ministero dell'Università
e della Ricerca

Important dates:

Application deadline: tbd

Interview: in person or online upon request

For information, please contact gianluca.gagliardi@ino.it and giulia.rusciano@unina.it

References

[1] Gigault J, et al. Current opinion: What is a nanoplastic?, Environ. Pollution,235, 1030 (2018)
[2] Ramasamy BSS, et al. A review on occurrence, characteristics, toxicology and treatment of nanoplastic waste in the environment. Environ Sci Pollut Res Int. 32, 43258 (2021)
[3] Mitrano, D.M., et al. Synthesis of metal-doped nanoplastics and their utility to investigate fate and behaviour in complex environmental systems. Nat. Nanotechnol. 14, 362 (2019)
[4] Gigault, J., et al. Marine plastic litter: the unanalyzed nano-fraction. Environ. Sci. Nano 3, 346-350 (2016)
[5] Mariano S, et al. Micro and Nanoplastics Identification: Classic Methods and Innovative Detection Techniques, Frontiers in Toxicology, 3 636640 (2021)
[6] Vollmer, F., et al. Whispering-gallery-mode biosensing: label-free detection down to single molecules. Nat Methods 5, 591 (2008)
[7] Zhu, J., et al. On-chip single nanoparticle detection and sizing by mode splitting in an ultrahigh-Q microresonator. Nat. Photon 4, 46 (2010)
[8] White IM, et al. Liquid-core optical ring-resonator sensors. Opt. Lett. 31, 1319 (2006) [
[9] Avino S., Krause A., Zullo R., Giorgini A., Malara P., De Natale P., Loock H.-P., and Gagliardi G., Direct sensing in liquids using whispering-gallery mode droplet resonators, Adv. Opt. Mat. 2, 1155 (2014)
[10] Foreman M. R., Avino S., Zullo R., Loock H.-P., Vollmer F., and Gagliardi G., Enhanced nanoparticle detection with liquid droplet resonators, Eur. Phys. J. ST 223, 1971 (2014)
[11] Caldwell J, et al. Detection of Sub-Micro- and Nanoplastic Particles on Gold Nanoparticle-Based Substrates through Surface-Enhanced Raman Scattering (SERS) Spectroscopy. Nanomaterials 11, 1149 (2021)