Funded by
the European Union

FunctiGlass

Project title DC10: Inverse design for optical meta-fibers sensors

Recruiting institution: Gottfried Wilhelm Leibniz University Hannover (Germany)

Background
Over the past four decades, **glass, glass-ceramics and composites** have contributed to the most advanced socio-economic breakthroughs as high-tech materials. To compete with emerging economies such as China and India, the European glass sector must strive for product leadership by investing more in research and innovation to develop new materials and train specialists for a competitive but promising market.

Contributing to this challenge is the main objective of the 'Structured functional glasses for lasing, sensing and health applications' (FunctiGlass) project, dedicated to **advanced high-tech materials for three sectors: light sources, sensors and biological applications.**

FunctiGlass, coordinated by CNRS, is a unique interdisciplinary research and training programme with a **double degree** as part of Horizon Europe's Doctoral Networks (Marie-Skłodowska Curie Actions, project 101169415). It will train 11 doctoral candidates who will take part in a joint research training programme based on **very close cooperation between academia and industry.** It will ensure that the trainees are exposed to 11 academic environments (universities and research institutes) and 9 non-academic environments (industry and SMEs) representing 9 different countries. **Each PhD candidate will be supervised by two academic tutors from different countries (spending her/his time between both units) and one mentor (industrial partner)** to ensure cross-sector knowledge sharing and the acquisition of transferable skills with a focus on entrepreneurship and innovation. Through the multi-dimensional training of the

FunctiGlass programme, the 11 PhD candidates will excel in the future economy by acquiring a multi-dimensional perspective and mindset to become **future leaders in glass science and in particular glass-based nano/micro-structured materials.** Through this programme, they will find their own path of innovation in academia or industry.

The project will create the conditions necessary for the establishment of long-term relationships between the academic and private sectors for the transfer of technologies and skills.

5 institutions will award the double degrees: Université Côte d'Azur (Nice, France), Tampere Universities (Finland), Gottfried Wilhelm Leibniz University Hannover (Germany), University Milano-Bicocca (Italy) and the Institute of Low Temperature and Structure Research, Polish Academy of Sciences (Wroclaw, Poland).

Industrial partners: AOI Tech (France), Corning (France), Fastlite (France), Klearia (France), Else Nuclear (Italy), Nobula3D (Sweden), Nyfors Teknologi (Sweden), Rosendahl Nextrom (Finland), Scout Scientific Outsourcing (Poland).

Other universities involved in the project as partners (not awarding doctoral degrees): University of Cergy-Pontoise (France), University of Gent (Belgium), University of Pardubice (Czech Republic), University of Nazarbayev (Kazakhstan), Umeå University (Sweden).

Description of the PhD project

Optical fibers have enabled many revolutions in recent decades. The paradigmatic example is optical telecommunications, but the fields of application also extend to fiber lasers and fiber amplifiers as well as sensors. One of the main properties exploited concerns the ultra-transparency of silica glass. Thanks to this, it is possible to transport light over 100 km (interest for telecommunications). This transparency is also sought for lasers since it allows to lower the threshold power for the appearance of this effect.

Conversely to this quest for transparency, another approach has been developed, based on the use of light scattering [1]. This effect induces optical losses but it has been shown that it can be exploited to develop new sensors or benefit the development of lasers [2]. To induce this light scattering, the chosen route consists of inserting nanoparticles into the core of the optical fiber [1]. The performance of applications therefore depends directly on our ability to understand the link between light scattering and nanoparticle characteristics and to prepare optical fibers containing nanoparticles to the specifications required for the intended applications. For example, in the case of sensors, the measurement is performed by analyzing the spectral characteristics of the backscattered light. The length of the sensor therefore depends on the compromise on light scattering so that there is enough backscattered light while being able to probe the longest possible length of fiber.

In this context, this thesis work will consist of studying the light scattering induced by nanoparticles embedded in optical fibers. In particular, it will involve optimizing the shape/size/material of the nanoparticles to engineer the backscattered light or, on the contrary, promote the transmission of light while minimizing light scattering outside the axis of the fiber. This first part of the work will leverage computational electrodynamics solvers, numerical

simulations, and inverse design methods for nanophotonics, to achieve scattering and dispersion engineering both in the linear and nonlinear regimes. The second stage of the thesis work will consist of manufacturing an optical fiber with the optimized nanoparticles and performing the experimental characterization.

The objectives of the PhD are to:

- Optimize nanostructures via inverse design techniques for (1) transparency and (2) scattering engineering.
- Simulate the embedding of such nanostructures within optical fibers: (1) the nanostructure does not scatter (it is transparent) for straight propagation, and the scattering resulting from a fiber bending can be used as a sensing mechanism; (2) the scattering can be engineered to have the nanoparticles diffuse/scatter light in a desired direction.
- Fabricate optical fibers with embedded nanostructures, with a special focus on their alignment and position within the fiber.
- Perform measurements to prove the design principles.

[1] W Blanc, D Tosi, A Leal-Junior, M Ferrari, J Ballato, Are low-and high-loss glass-ceramic optical fibers possible game changers?, Optics Communication, 131300, 2024
[2] J Luo, X Zhang, S Yang, W Blanc, Z Yan, X Yu, Sub-kilohertz narrow linewidth fiber laser based on nanoparticles doped self-injection module, IEEE Photonics Technology Letters 35 (11), 613-616, 2023

Practical information

- Contract will start in October 2025, for 3 years.
- Recruiting institution: Leibniz University Hannover (Germany)
- Doctoral school: Mechanical Engineering, or Leibniz School of Optics and Photonics
- Industrial mentor: Corning
- Host laboratory: Hannover Centre for Optical Technologies (Germany)
- Supervisor: Prof. Antonio Calà Lesina
- Co-host laboratory: Institut de Physique de Nice (France)
- Co-supervisor: Dr Wilfried Blanc
- Secondments: Corning (France, 1 month) to characterize (SEM) the preforms and the fibers.
- The gross monthly salary based on the MSCA rules varies between 1920€ and 4063€, depending on the country of recruitment.
- The student will also receive a mobility allowance and a family allowance (depending on family situation) of up to 600 € and 495€ per month, respectively.

Recruitment criteria

- MSCA Mobility Rule: researchers must not have resided or carried out their main activity
- (work, studies, etc.) in the country of the recruiting beneficiary for more than 12 months in the
- 36 months immediately before their date of recruitment
- All researchers recruited in a DN must be doctoral candidates (i.e. not already in possession
- of a doctoral degree at the date of the recruitment)
- Possession of a Master’s degree before the start date of the contract
- Scientific excellence to fit the PhD project
- Fluent (oral and written) English skills as the project operates in the English language

- Knowledge of the language of the host countries (German, French) may be considered a merit
- Team-mindedness

Criteria specific for PhD10

- Very good knowledge of electrodynamics and programming languages
- Good knowledge of computational electromagnetics and numerical methods
- Master's degree in Physics, electrical engineering

Application

Documentation to be sent in by the applicants

- Application form completed
- CV + Letter of motivation
- Contact of two reference persons to be contacted by the selection committee (name, relation to the candidate, e-mail address and phone number)
- Complete list of publications and academic works
- Proof of language proficiencies
- Proof of master diploma or 2024 registration to master degree

How to apply?

- Download application form and fill it indicating all the offers you wish to apply for
- Send your application by email to **recruit@functiglass.eu**. The title of your email MUST be:
  FunctiGlass PhD x, x, x application (x, x, x being the number(s) of the PhD position(s) you want to apply for)
- Be careful to join all documentation required (see list above)

Deadline for application
15th April 2025

Contact
contact@functiglass.eu