Funded by
the European Union

FunctiGlass

Project title DC11: Inverse design of femtosecond laser written nanostructures in optical fibers to harness light scattering

Recruiting institution: CNRS (France)

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 for telecommunications and fibered lasers.

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 distributed optical sensors or narrow linewidth fiber laser lasers. To induce this light scattering, the chosen route consists of inserting nanostructures into the core of the optical fiber [1]. Such nanostructures can be directly embedded (nanoparticles containing optical fibers [1]) or induced a posteriori via a femtosecond laser irradiation. The latter consists in tightly focusing an ultrashort laser directly in the optical fiber core. At sufficient high energy, such a direct-laser-writing technique allows to fabricate nanogratings whose structural properties are controlled via the laser parameters (mainly the polarization) [2, 3]. The performances of the final devices therefore depends directly on our ability to understand the link between light scattering and the nanostructures characteristics.

In this context, this thesis work will consist of studying the light scattering induced by femtosecond laser inscribed nanogratings in both single mode and multimode silica optical fibers. In particular, it will involve optimizing the structural properties of the nanogratings to engineer the scattered light

(backward, forward) and control the mode coupling. The first part of the work will leverage computational electrodynamics solvers, numerical simulations, and inverse design methods for nanophotonics, to achieve controlled scattering and modal coupling both in the linear and nonlinear propagation regimes. The second stage of the thesis work will consist in the fabrication by DLW of point-like and continuous nanograting scatterers and performing the experimental characterization.

The objectives of the PhD are to:

- Optimize nanograting formation via inverse design techniques for scattering and mode coupling engineering.
- Simulate the light propagation in such nanostructured single mode and multimode optical fiber.
- Fabricate nanograting-based scatterers in single mode and multimode optical fiber cores.
- Characterize the optical properties of such optical fibers (attenuation, backscattered signal, scattering diagram, mode coupling).

[1] W Blanc et al. Opt. Commun., 131300 (2024)
[2] M. Wang, et al. Opt. Exp., 28, 20225 (2020)
[3] Q. Xie et al. Nanoscale Adv. 6, 489 (2024)

Practical information

- Contract will start in October 2025, for 3 years.
- Recruiting institution: CNRS (France)
- Doctoral school: Doctoral School for Fundamental and Applied Sciences (ED SFA), Université Côte d'Azur (France)
- Industrial mentor: Fastlite by Amplitude
- Host laboratory: Institut de Physique de Nice (France)
- Supervisor: Dr Matthieu Bellec
- Co-host laboratory: Leibniz University Hannover (Germany)
- Co-supervisor: Prof. Antonio Calà Lesina
- Secondments: Nazarbayev University (Kazakhstan, 1 month) to perform light backscattering characterization.
- 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 English language. Knowledge of the language of the host country may be considered a merit
- Team-mindedness

Criteria specific for PhD11

- Very good knowledge in glass science and/or light-matter interaction
- Good knowledge in material characterization and/or optical and photonic instrumentation
- Master degree in Material Science or Physics or equivalent with experience in experimental work

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