Funded by
the European Union

FunctiGlass

Project title DC1: Er^{3+}-doped nanoparticles containing silica and silicate-based fibers with enhanced 1.5µm emission

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

Since the advent of optical fibers in the 1980s, silica glass has proven to be the most widely used thanks to its many qualities. The development of manufacturing processes has made it possible to make this glass extremely transparent, with light being able to propagate over 100 km before losing 99% of its initial intensity. This ultra-transparency has led to the era of optical communications. Its rise has also been accompanied by the development of an amplifying fiber doped with rare earth ions (erbium ions, Er^{3+}) to amplify light for wavelengths around 1.5 µm [1]. Again, this fiber was made from silica. Despite all these successes, silica fibers also have limitations imposed by glass. For example, the luminescence properties are linked to the chemical and structural environment of the rare earth ions. A crystalline environment could thus be interesting for producing fiber lasers because the absorption and emission cross sections are higher than in glass.

To meet this expectation, a new family of optical fibers is being developed. Its originality lies in the presence of nanoparticles within the core of the optical fiber [2]. This approach makes it possible to keep a silica glass while providing new properties thanks to the presence of nanoparticles. By embedding rare earth ions in these nanoparticles, the new chemical and structural environment thus opens up new luminescence properties.

Nanoparticles in optical fibers can be obtained mainly by two routes. The first is based on thermodynamic mechanisms to form nanoparticles by phase separation [3]. The second approach consists in pre-synthesizing nanoparticles and including them in the glass. It is this second route that will be more particularly studied during this thesis. Although it appears simpler than the first approach, the difficulty of doping with pre-synthesized nanoparticles lies in their survival throughout the manufacturing process because of the high temperatures involved. The Institute of Physics of Nice (France) and the Photonic Glasses Group at Tampere University (Finland) reported for the first time that doping with $YbPO_4$ crystals led to the presence of these same crystals in the optical fiber [4]. This result constitutes the starting point of this research topic. During the PhD thesis, nanocrystals (doped with Er^{3+} ions) of different compositions will be prepared by chemical route. They will then be inserted into glasses prepared by the melting process or by the Modified Chemical Vapor Deposition process. The glass rods thus obtained will then be drawn into optical fibers. The nanoparticles will be characterized at each stage to follow their evolution, as well as the luminescence properties of the Er^{3+} ions.

The main objectives of the PhD are to:

- Advance the fundamental understanding of the synthesis of Er^{3+} nanoparticles with tailored size, size distribution and spectroscopic properties
- Ensure the survival and dispersion of the nanoparticles in the silica and silicate preforms prepared using MCVD and melting process
- Determine the key parameters during the drawing process to fabricate nanoparticles containing fibers with low loss and strong spectroscopic properties

[1] E. Desurvire, Erbium-Doped Fiber Amplifiers: Principles and Applications, 2002, Wiley
[2] A. Veber, Z. Lu, M. Vermillac, F. Pigeonneau, W. Blanc, and L. Petit, Nano-structured optical fibers made of glass-ceramics, and phase separated and metallic particle-containing glasses. Fibers, 7(12), p.105, 2019
[3] W. Blanc, V. Mauroy, L. Nguyen, B.N. Shivakiran Bhaktha, P. Sebbah, B.P. Pal, and B. Dussardier, Fabrication of rare earth-doped transparent glass ceramic optical fibers by modified chemical vapor deposition. Journal of the American Ceramic Society, 94(8), pp.2315-2318, 2011
[4] Z. Lu, N. Vakula, M. Ude, M. Cabié, T. Neisius, F. Orange, F. Pigeonneau, L. Petit, and W. Blanc, $YbPO_4$ *crystals in as-drawn silica-based optical fibers. Optical Materials, 138, p.113644, 2023*

Practical information

- Contract will start in October 2025, for 4 years.
- Recruiting institution: CNRS (France)
- Doctoral school: Doctoral School for Fundamental and Applied Sciences (ED SFA), Université Côte d'Azur (France)
- Industrial mentor: NYFORS
- Host laboratory: Institut de Physique de Nice (France)
- Supervisor: Dr. Wilfried Blanc
  Co-host laboratory: Photonics Laboratory, Tampere University (Finland)
  Co-supervisor: Prof. Laeticia Petit
- Secondments: NYFORS (Sweden, one month) to draw silicate fibers and AOI (France, two months) to test the lasing properties of the silica and silicate 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 English language. French skills would be appreciated.
- Knowledge of the language of the host country may be considered a merit
- Team-mindedness

Criteria specific for PhD1

- Good knowledge in materials science, luminescence, fiber technology
- Basic knowledge in crystallography, optics in waveguide
- 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