Funded by the European Union

FunctiGlass

Project title DC3: Direct-laser-writing of mid-IR active photonic integrated circuits in Tm^{3+} doped tellurite glass

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

Photonic integrated circuits (PICs) are microchips containing photonic components that work together to detect, generate, transport, and process light. One notable fabrication technique, direct-laser writing (DLW) of PICs in glass, consists in tightly focusing an ultrashort-laser inside the chip to modify its structural and chemical properties at the microscale. DLW offers a unique advantage by enabling the rapid prototyping of complex, high-precision 3D photonic waveguide-based structures. DLW has been widely used to produce PICs with low-loss and high-fidelity optical components for classical and quantum information processing. Most of the DLW photonic systems are currently designed for the visible and telecom range and mostly built with passive components. Nowadays, there is a crucial need to develop integrated active photonic components operating in the mid-IR (2–5 µm) especially for medical and environmental applications, astronomical instrumentation and quantum sensing where compact, stable and flexible PICs offered by DLW [1] are of major importance.

Among the rare-earth ions, Tm^{3+} has gained significant attention, mainly for the development of novel mid-IR lasers [2]. Indeed, when excited at 800 nm, Tm^{3+} can emit at 1470 nm, which overlaps with the S band of optical communication, and more importantly, from 1800 to 2200 nm. Glasses appear to be promising host materials for Tm3+ due to their relatively easy synthesis method and low production cost when compared to those used for preparing crystals. Moreover, the efficiency of the emission processes is strongly dependent on the glass systems and is very high in low phonon energy glasses such as tellurite glasses. In this context, the main aim of the thesis is to develop and fabricate by DLW an integrated efficient light source emitting in the mid-IR from novel tellurite glasses doped with Tm3+. As higher absorption/emission cross-section and longer

lifetime of luminescent levels can be achieved if the Tm^{3+} are located in crystals, glasses will be prepared with Tm3+ doped crystals using the glass-ceramics method which is based on the nucleation and growth of nanoparticles. The DLW technology will be used to fabricate integrated waveguiding microstructures directly embedded in such active glasses.

The main objectives of the PhD are to:

- Synthesize the Tm^{3+} doped tellurite glass-based materials and demonstrate enhanced MIR emission from the crystals embedded in the glass.
- Advance the fundamental understanding of the photo-response of tellurite glass-based materials to IR femtosecond laser radiation [3]
- Design, fabricate and characterize the active optical waveguides written in glass prepared crystals with metallic nanoparticle precursor.
- Realize a proof-of-concept demonstrator of femtosecond laser-written active waveguides in crystals/metallic particles containing tellurite glasses.

[1] A. Le Camus et al., Opt. Exp. 29, 8531 (2021).
[2] J. Wu et al., IEEE Photon. Technol. Lett. 18, 334 (2006)
[3] G. Torun et al., Adv. Mater. 35, 2210446 (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: Fastlite by Amplitude
- Host laboratory: Institut de Physique de Nice (France)
- Supervisor: Dr Matthieu Bellec
- Co-host laboratory: Tampere University
- Co-supervisor: Prof. Laeticia Petit
- Secondments: Włodzimierz Trzebiatowski Institute of Low Temperature and Structure (Poland, 2 months) to analyze the spectroscopic properties of the MIR glasses and particles containing glasses, Fastlite by Amplitude (France, 1 month) to write waveguides with advanced laser pulse shaping and Nazarbayev University (Kazakhstan, 1 month) to characterize the active waveguides.
- 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 PhD3

- 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