
---

***Fiber optic in neuroscience research to record and manipulate specific neural activity with light***

Jean-Luc Neron, Doric Lens Company

---

***Recent advances in Mid-IR barium germano-gallate glasses: fiber drawing and direct laser writing***

Théo Guérineau, COPL

---

***Direct-laser-writing of arbitrary long waveguides in optical fibers***

Mathieu Bellec, CNRS, INPHYNI, Université de Bordeaux

---

***Fibers for Future Optical Telecommunications***

Lixian Wang, Huawei

---

# FUNGLASS DAYS – "Special design of optical fibers and their applications"

## Jean-Luc Neron, "Fiber optic in neuroscience research to record and manipulate specific neural activity light", Doric Lens Company


**ABSTRACT**

In the last two decades, neuroscience research did important advances in the development of new sensor that use light to control or monitor neurons activity with techniques like optogenetics, fluorescence imaging of neuronal activity, ...  The main advantage of using optical sensor is the ability to modify only a specific population of cells to make them sensitive to a light stimulation. This allows tailored interrogation and manipulation of neural circuits.

Neuroscientists try to understand how a specific behavior is related to brain activity, or how the inter-connections between different neurons populations work to better understand the mechanisms underlying different pathologies as Alzheimer, Parkinson, chronic pain, drug addictions or other and have strategy to cure or reduce the evolution of those diseases.

To have an optical access to deep region into a living brain, neuroscientists can use optical fibers or gradient-index imaging relay lens of small diameter, from less than 0.1 to 1.0 mm in diameter.  It can be used for acute experiment with head restricted animals, or chronic implant for experiment with freely behaving animals.  There are some challenges related to working with optical fibre and freely behaving animals, i.e. maintaining good optical transmission, minimize impact on animal behavior, reduce brain damage while covering large brain areas, ...

Doric Lenses has developed an expertise and a complete range of optical fiber-based solutions for neuroscience research including optical fiber rotary-joints, fiber-coupled light sources for optogenetics, optical fiber cables and implants, as well as different system for fiber-coupled fluorescence recording (fiber-photometry) and miniaturized fluorescence microscopy.


**BIO**

**Jean-Luc Neron** *studied physics engineering at Université Laval in 1999-2003, and did a master degree with prof. Michel Piché in 2003-2004 on a new manufacturing technique for micro-lenses array based on thin film deposition process.  He started to work in industry in 2004 with Doric Lenses as optical engineer.  Since then, he has overseen various development projects, and is now the director of research and development and engineering for Doric Lenses.*

# FUNGLASS DAYS – “Special design of optical fibers and their applications”

## Théo Guérineau, “Recent advances in Mid-IR barium germano-gallate glasses: fiber drawing and direct laser writing”, COPL

**T. Guérineau[1], J. Lapointe[1], J. Lafreniere-Greig[1], F. Calzavara[3], S. Morency[1], L. Loi[2], L. Canioni[2], Y. Petit[2,3], R. Vallée[1], T. Cardinal[3], Y. Messaddeq[1].**

**[1] Center for Optics, Photonics and Lasers (COPL), Université Laval, Québec, Canada, G1K 7P4**
**[2] CELIA, Université Bordeaux, 351 cours de la Libération, 33405 Talence Cedex, France**
**[3] ICMCB, CNRS UPR9048, Université Bordeaux, 87 av. Dr. Schweitzer, 33608 Pessac cedex, France**

**ABSTRACT**

The quest for groundbreaking technologies in integrated optics faces many challenges to achieve efficient and compact photonic systems. To this issue, femtosecond direct laser writing (DLW) in Mid-IR transparent amorphous materials, such as barium-germanium-gallium glasses (BGG), reveals a high-potential approach. By tailoring BGG glass composition and doping, DLW has allowed for controlling the type of photo-structurations embedded inside the glass. In pristine BGG glass, a DLW investigation has been performed in both gallium- and germanium-rich glasses. While no difference in the DLW-induced glass structure modification was reported in both glass families, an extended range of the smooth refractive index modification has been found in the gallate-rich BGG. In silver-doped BGG glasses, two laser-induced modification regimes have been highlighted depending on the glass structure, both based on the photochemistry of Ag+ ions. At low content of non-bridging oxygens (NBO), DLW leads to the formation of micrometric single-track refractive index change with a double-track fluorescence. Meanwhile, at high content of NBOs, DLW leads to a double-track fluorescence, followed by nanometric double-track refractive index change. Finally, fiber drawings of built-in-casting core-clade BGG preforms have been demonstrated, emphasizing the high potential of BGG materials for various photonic applications including lab-in-fiber gas detection devices.

**BIO**

**Théo Guérineau** *received his Ph.D. degree in Physical chemistry of condensed matter from the University of Bordeaux (Bordeaux, France) in 2020. During his Ph.D. thesis performed at the Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB – CNRS) under the supervision of Prof. Thierry Cardinal and Yannick Petit, he worked on the light-matter interaction and more specifically on the photosensitivity of silver-doped phosphate and heavy-oxide glasses. Then he joined as a postdoctoral researcher the research group of Prof. Younès Messaddeq at Centre d’Optique, Photonique et Laser at the Université Laval (Québec, Canada) in 2020. There he aims at designing, developing and functionalizing heavy-oxide glasses, such as barium germano-gallate glasses, which are great competitors to fluoride glasses, an essential glass family for the mid-infrared applications. Since 2022, he is a postdoctoral excellence fellow of the Sentinel North program, intending to improve our understanding of the northern environment and its impact on humans and their health.*

## FUNGLASS DAYS – “Special design of optical fibers and their applications”


## Mathieu Bellec, “Direct-laser-writing of arbitrary long waveguides in optical fibers”, CNRS, INPHYNI, Université de Bordeaux



**ABSTRACT**

Direct-laser-writing is a unique tool to change, in a controllable way, the structure and optical properties of transparent materials such as glasses. This versatile technique consists in strongly focusing a femtosecond IR laser within the glass sample in order to, via a nonlinear absorption process, locally modify its refractive index at the microscale. By translating the sample, three-dimensional waveguide-based integrated photonic circuits are now routinely fabricated. Femtosecond lasers are also employed to inscribe small scale photonic components in optical fibers, such as waveguides or fiber Bragg gratings. Motivated by the possibility to write arbitrary long complex arrangement of cores in optical fibers, for advanced light transport and sensing applications, we propose an innovative reel-to-reel direct-laser-writing technique.

In a coreless silica fiber, exploiting the phase-mask approach generally used to write FGBs, we fabricated, directly through the coating, ultra-long waveguides (up to 4m). Both the transversal and longitudinal refractive index modifications have been characterized, revealing a very circular cross section with an homogeneous longitudinal distribution. The typical value of the refractive index modifications is about 5x10-3 which makes the waveguide single-mode operating optimally at 1 µm. Using a cutback method, the propagation losses of m-long laser-inscribed waveguides have been properly measured to 0.15 dB/cm. Beyond this first demonstration, different optical fibers are now used to improve the waveguiding performances. Preliminary results with Ge-doped and H2-loaded silica fibers combined with a specific scanning scheme during the laser irradiation have shown an optimal operating wavelength in the telecom range.


**BIO**

**Matthieu Bellec** *received his PhD from the University of Bordeaux in 2009 for his work on femtosecond laser nanostructuring of bulk silver-doped glasses. From 2010 to 2011, he obtained a postdoctoral position to work on laser filamentation at the Institute of Electronic Structure and Laser (IESL, University of Crete, Greece). Since 2013 he is a CNRS researcher at the Institut de Physique de Nice (INPHYNI, Université Côte d’Azur, France) where he is conducted a research activity on photonics in laser-structured complex media. From 2019 to 2021, he has been affiliated to the Centre Lasers Intenses et Applications (CELIA, Université de Bordeaux, France) and visiting researcher at the Centre d’Optique Photonique et Laser (COPL, Université Laval, Québec).*

## FUNGLASS DAYS – “Special design of optical fibers and their applications”

### **Lixian Wang, “Fibers for Future Optical Telecommunications”, Huawei**

**ABSTRACT**

The ever-increasing data traffic of the Internet requires future optical telecommunication system be scaled in a rate of ~ 1.4 times/year. The current fiber transmission capacity has been very close to the Shannon limit. People have run out of the bandwidth of the EDFAs as well as the resources of the digital signal processors. New types of fiber amplifiers that could support larger bandwidth, provide higher space density, have lower power consumption, are very much demanded. This presentation reviews the innovative fiber technologies for the generation of fiber amplifiers.

**BIO**

**Lixian Wang** *got his Ph.D degree of physical electronics in Institute of Semiconductors, Chinese Academy of Sciences (CAS), in 2011. From 2011 to 2013, he was an assistant researcher and then an associate research in CAS, working on microwave photonics. Since 2013, he joint Centre d’optique, photonique et lasers (COPL), Université Laval, as a postdoctoral fellow. He was working on space division multiplexing techniques for optical telecommunications. In 2016, he joint CorActive HighTech as a fiber laser scientist and later in 2018 the lead of the high power fiber laser team. Since 2019, he joint Huawei Technologies Canada as the lead of the fiber amplifier team. His current research interest is advanced fiber amplifier technologies for the next generation of optical telecommunication systems. He has published over 50 journal papers and conference papers. He also holds a couple of US patents. His h-index is 28 and the total citations is about 2100.*