VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Sergei Mikhailov**

The public defense will take place on **Friday 10th February 2023 at 5:00pm** in room **D.2.01** (Building **D**, Brussels Humanities, Sciences & Engineering Campus)

To join the digital defense, please click here
Meeting ID: 364 657 435 507
Passcode: jGZ3t2

HIGHLY BIREFRINGENT MICROSTRUCTURED OPTICAL FIBRES FOR FULLY-DISTRIBUTED PRESSURE SENSING

BOARD OF EXAMINERS

Prof. dr. ir. Aurélie Bellemans

Prof. dr. ir. Iris De Graeve

Prof. dr. ir. Christof Devriendt

Prof. dr. ir. Svend Bram

Prof. dr. ir. Tigran Baghdasaryan

Prof. dr. Miguel González-Herráez

Prof. dr. ir. Marc Wuilpart

PROMOTORS

Prof. dr. ir. Francis Berghmans

VRIJE UNIVERSITEIT BRUSSEL

Abstract of the PhD research

Distributed optical fiber sensing (DOFS) conventionally relies on standard telecommunication-grade optical fibers. These fibers are well suited for the measurement of temperature or axial strain, as demonstrated in many field-proven applications. On the other hand, only a few demonstrations of fully distributed fiber-based pressure sensors have been reported. The previously reported distributed hydrostatic pressure measurements were based on commercially available standard optical fibers and on a pressure-sensitive highly birefringent microstructured optical fiber (MOF). The pressure sensitivity of conventional fibers is insufficient for distributed pressure sensing with sub-bar resolution, and they also feature high cross-sensitivity of pressure measurements to axial strain and temperature.

In this thesis we aim to contribute to the field of distributed pressure sensing by developing a new MOF with enhanced sensitivity to hydrostatic pressure and negligible sensitivity to temperature, compatible with distributed fiber-optic sensing (DOFS) methods. To achieve this overarching goal, the specific objectives of this thesis are: 1) to study to what extent the pressure-sensitive MOFs are compatible with existing DOFS techniques, 2) to investigate how distributed interrogating techniques can benefit from an optimized MOF design, 3) to design, model and fabricate the MOF, and finally 4) to characterize and demonstrate the pressure sensing capabilities of the novel MOF.

First, we evaluate the feasibility of distributed sensing with pressure-sensitive “Butterfly”-type MOF, and we report on distributed pressure measurement with sub-bar resolution using a frequencyscanned optical phase-sensitive time domain reflectometry. We then develop design of a novel highly birefringent MOF optimized for distributed pressure sensing, capable of pressure measurements with sub-bar resolution. We carry out extensive finite element method simulations to study the properties of the MOF and we manufacture the MOFs according to the developed design. Finally, we demonstrate the sensing properties of the distributed sensing system based on the developed fiber. We report on hydrostatic pressure sensitivity of our MOF 8 times higher than in commercial MOF previously used for distributed pressure measurements and about 3 orders of magnitude above the sensitivity of conventional step-index fibers. The temperature sensitivity of the novel MOF is an order of magnitude lower than in the conventional optical fibers. Given the low propagation loss comparable to that of commercially available MOFs, our fibers appear to be excellent candidates for distributed pressure sensing over distances up to several kilometres.