The faculty of Engineering of the Vrije Universiteit Brussel and the Faculty of Science of the Universidad de Cantabria invite you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES (VUB)
DOCTOR IN SCIENCE AND TECHNOLOGY (UC)

of **Daniel Plaza Vas**

The public defense will take place on **Monday 15th December 2025 at 4 pm** in room **D.2.01** (Building D, VUB Main Campus)

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ENHANCEMENT STRATEGIES FOR GAIN-SWITCHING- AND MODELOCKING–ENABLED OPTICAL FREQUENCY COMBS IN COMPACT SEMICONDUCTOR LASERS

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Abstract of the PhD research

The topic of this joint PhD between VUB and University of Cantabria (UC) is focused on compact semiconductor lasers with pulsed operation. Such lasers find applications in many different domains ranging from optical datacommunication and biophotonics to high-resolution metrology and remote sensing.

There exist different approaches to obtain pulsed operation in semiconductor lasers. When using modelocking as the pulsing mechanism, very short pulses in the femtosecond and picosecond range can be generated. In recent years modelocking has been successfully demonstrated in extremely compact semiconductor lasers integrated on an Indium Phosphide (InP) chip. The modelocking element typically used in these lasers is a semiconductor-based saturable absorber that is monolithically integrated together with the semiconductor amplifier in the laser cavity. Various cavity outlines were shown to yield modelocked operation with different levels of output power. However, no systematic study has been carried out so far on how to maximize the peak output power while keeping stable laser operation.

Another often used pulsing mechanism is gain switching. Gain switching is a very flexible pulsing technique where the pulse repetition rate can be varied in real time and as such an optical frequency comb with a variable comb spacing can be generated. Compact free-space-emitting semiconductor lasers, such as vertical cavity surface emitting lasers (VCSELs) and discrete mode lasers, have been used to generate gain-switched combs. Combined with optical injection locking techniques, the characteristics of the gain-switched combs can be enhanced while keeping the same flexibility as the initial comb. However, further study is needed to evaluate the impact of the properties of the injected signal on the final output frequency comb.

The topic of this PhD work is two-fold: on the one hand, at VUB with supervision by Prof. Vermeulen, I have investigated on-chip InP modelocked lasers combined with on-chip optical amplifiers for high power generation and I have conceptualized a custom amplifier layout that allows efficient amplification while keeping stable laser operation. On the other hand, at UC with supervision by Prof. Quirce, I have demonstrated gain-switching-enabled flexible frequency combs generated through optical injection in VCSELs and discrete mode lasers while varying the properties of the injected signal. Through these investigations, this PhD research has made important contributions to the development of compact pulsed semiconductor lasers and their applications.