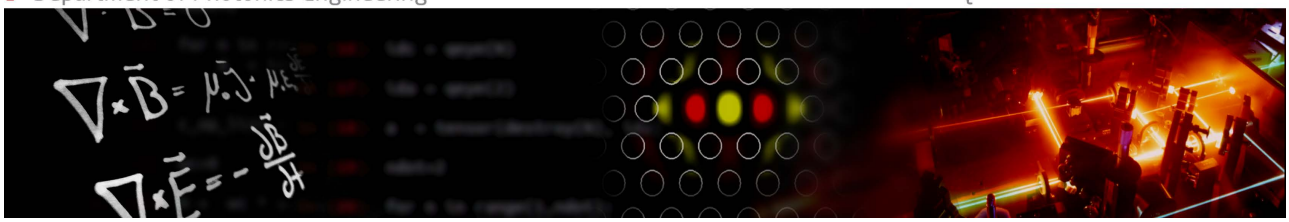

M.Sc. project

Hybrid photonic crystal laser for silicon photonics

The aim of this theoretical project is to investigate wave-guiding properties of a newly proposed hybrid photonic crystal lasers integrated onto a silicon-on-insulator (SOI) wafer.

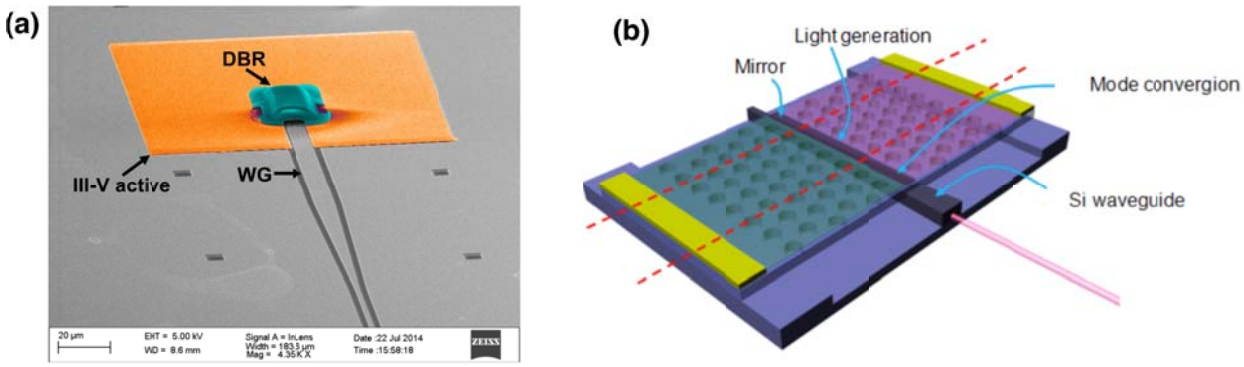

Figure 1. (a) Scanning electron microscope image of the world-first hybrid vertical cavity laser with an in-plane output by DTU. (b) Schematic of the hybrid photonic crystal laser.

Integrating photonics functionalities with electronics on the same silicon platform has been a dream for long time, and is coming true. However, the integration of an energy-efficient laser onto a silicon wafer is still challenging, which is essential for on-chip integration, e.g., for CPUs in a high-performance computer.

Since silicon-related materials are inefficient in light generation, integrating a III-V semiconductor onto a silicon-on-insulator (SOI) wafer appears to be a promising approach, which is called hybrid approach. Recently, DTU has proposed a novel hybrid micro laser with a vertical cavity [1] and demonstrated it for the first time in the world [2], as shown in Fig. 1(a). It is a new class of micro lasers on a SOI wafer.

Now, based on our knowledge on the hybrid laser design and photonic crystals, we propose a hybrid nano laser structure with photonic crystal for achieving ultra-small energy consumption and would investigate its characteristics in this project. Photonic crystal is a periodic array of materials with different refractive indices and can mold the follow of light. Using this property, a photonic crystal laser structure based on a III-V semiconductor membrane has proven its potential to achieve very small energy consumption [3]. The hybrid photonic crystal laser of this project combines a III-V photonic crystal membrane onto a Si waveguide. As illustrated in Fig. 1(b), the combination of a photonic crystal waveguide and a Si waveguide

is expected to work as a light generator section, a mode converter section, a reflector section, and an output section.

Goals of the project (which may be modified according to the interests of the student):

- Understand the waveguide dispersion of the composite photonic crystal and Si waveguide.
- Identify design criteria for sections with different functionalities.
- Propose an optimized laser design.

For these goals, you will do numerical simulations and theoretical analysis of them. This requires solid understanding on electromagnetism and solid-state physics. A basic understanding on programming is a plus. If successful, the outcome of this project could be developed as a Ph.D. project that may include the fabrication of the designed laser. Thus, this project is open not only for a student interest in theory, but also for one in experiment.

If you want to hear more about the project, you are encouraged to come by our offices or send us an email.

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References:
[1] I.-S. Chung et al., Applied Physics Letters **97**, 151113 (2010).
[2] G. C. Park et al., to be submitted.
[2] K. Takeda et al., Nature Photonics **7**, 569 (2013).