Systematically Varying the Active Material Volume in a Photonic Crystal Nanolaser

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**INTRODUCTION**

Using light for data transmission promises higher speeds than traditional transmission through copper wires [1]. The bottleneck for introducing optical components in various transmission is energy consumption and ultimately price. Today data transmission through metallic interconnects on chip use more than 50% of the total power consumption [2] and optics could be faster and cheaper. Photonic crystal lasers have already shown great promise [3]. Here we present an investigation of laser characteristics where the extent of the gain material is varied while the photonic crystal cavity is kept constant. This systematic variation gives control of the total gain material in the cavity as well as confinement factor and allows for systematic investigations, e.g. of the role of slow-light effects on the threshold gain.

**REFERENCES**

[3] K. Takeda et al. Few-fJ/bit data transmissions using directly modulated lambda-WDM. This allows for collection of input-output curves from different lasers to be obtained. The curves can be fitted to a laser rate equation model and parameters can be extracted [8], while the threshold powers can be readily obtained.

**EXPERIMENTAL SETUP**

The sample is pumped from the top with a 300 mW CW laser @1480 nm. Scattered light is then collected via the same objective and split from the pump by a WDM. This allows for collection of input-output curves from different lasers to be obtained. The curves can be fitted to a laser rate equation model and parameters can be extracted [8], while the threshold powers can be readily obtained.

**SYSTEMATICALLY VARYING THE ACTIVE MATERIAL VOLUME IN A PHOTONIC CRYSTAL NANOLASER**

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**EXPERIMENTAL RESULTS**

The resonance wavelengths obtained from experiments redshifts as the BH is increased and agree well with simulations. From the input-output curves it can be seen that the sample with BH smaller than two periods doesn’t lase.

**OUTLOOK**

- Further investigate the threshold powers.
- Fit data to a rate equation model, to extract laser parameters.
- Fabricate new sample with smaller increments in the BH around 0a-2a where the transition from LED to laser behaviour changes.

**DESIGN AND FABRICATION**

A photonic crystal line defect cavity fabricated around a selectively etched gain material allow for a very compact structure. The slow-light phenomena occurring in line defect photonic crystal waveguides also add enhanced gain [4] and having BH embedded in an InP membrane provides good thermal operation [5]. The length of the active material region within the photonic crystal cavity is varied in steps a one photonic crystal period, a. This variation is done in a normal L7 cavity as well as an optimized cavity where holes are shifted to increase Q-factor [6, 7].

**EQUIVALENT PASSIVE CAVITIES**

The photonic crystals design is investigated in the FDTD simulation software Lumerical to optimize resonance wavelengths, Q-factors and mode volumes before fabrication. Simulations of the equivalent passive cavities highlight how the resonance shifts as the size of the gain region is increased, corresponding to a higher effective refractive index in the cavity region.

**VILLUM FONDEN**