Chapter 10

Conclusion and outlook

The experimental proof-of-principle of a PhC-based spectroscopic gas sensor by measuring the enhanced absorption and the enhanced interaction of light and gas, respectively, has not yet been demonstrated. However, after the design and the progress in fabrication techniques developed in this thesis a demonstrator seems to be within reach. The challenge consists in the achievement of transmission through PhC structures of several mm length. Currently, the roughness of the pore wall surfaces is suspected to be the major reason for high scattering losses. Investigation of this topic and reduction of the surface roughness by either changes in the PECE parameters or, e.g., wet chemical postprocessing, is currently being performed.

The chances of such a new type of spectroscopic gas sensor to make its way to a commercial product are promising. However, to bring the fabrication from laboratory to industrial production scale will take some more time, money and manpower. Recent developments indicate that photonic crystal structures might find their application first in sensing schemes and not so much in optics, as was envisioned when this field emerged.

Further developments of the design suggested so far might concern alternative or improved coupling schemes, different from the ARL concept. Vertical confinement of light in the PhC structure could be achieved and optimized by using index guiding along the z-direction as depicted in fig.10.1a. Macropores with increased diameter in their top and bottom part and a central part used for gas detection are a possible realization. In case it turns out that transmission of light through several hundred or thousand unit cells of a PhC structure is not realizable, a reflection-based PhC gas sensor shown in fig.10.1b might be an alternative. Here the total interaction would be limited by the penetration depth of light into the PhC structure. This would then have to be

![Figure 10.1: Alternative PhC-based gas sensor schemes: a) Transmission-based with vertical light confinement by index guiding due to lower $n_{eff}$ above and below the detection region. b) Reflection-based.](image-url)
(over)compensated by the enhancement factor. Another option to avoid problems arising from transmission through very large bulk PhC volumes is to use PhC waveguide structures. Light transmission through PhC waveguides of several hundred lattice constants has been demonstrated. In addition it is possible to tailor its dispersion properties to realize low group velocities. The interaction with the gas in the surrounding pores could be achieved by the parts of the guided mode that penetrate into the surrounding pores. Closely packed waveguides could therefore be almost as effective as a bulk PhC. Such structures could in principle also be realized in the macroporous Si material system and are compatible with the ARL concept, promising efficient coupling as well as precise and easy device fabrication. In principle, other material systems such as, e.g., opals, could also be explored since they can also be produced on a macroscopic scale. Due to their inherently 3-dimensional nature their photonic band structure might offer promising bands for gas sensing with additional interesting properties.