Abstract of the dissertation of M.Sc. Arkadiusz Hudzikowski entitled. "Multi-pass cells for laser spectroscopy and spectral broadening of ultrashort light pulses".

Multi-pass cells have a major function in laser absorption spectroscopy. Each molecule interacts with electromagnetic radiation by absorbing the energy of selected frequencies. According to Labert-Beer's law, the longer the interaction path of light with molecules, the higher the absorption. Multi-pass cells, through multiple reflections of the light beam, allow increasing this path without increasing the dimensions of the entire device. Over the past decades, many types of multipass cells have been developed, characterized by increasingly smaller dimensions and longer optical path lengths. A new multi-pass cell solution for compact gas sensor applications has been proposed as part of this PhD thesis.

The dissertation presents an overview of various methods of absorption spectroscopy, basic types of multi-pass cells with examples of calculations of their parameters and simulation methods. A computer application was developed to simulate such cells and optimize them using a genetic algorithm. This software significantly improved the work on a new compact multi-pass cell consisting of spherical mirrors, but allowing to obtain a dense reflection pattern as in cells with specialized astigmatic mirrors. The developed cell with an optical path of 24 m and an internal volume of 80 cm^3 was physically fabricated and experiments were carried out to confirm its correct operation. Compact gas sensors were built using it. The first one allowed the detection of CO_2 with a detection limit of 0.4 ppm. The second enabled the measurement of different isotopes of methane, making it possible to distinguish the sources of this gas. The measurement accuracy of the $^{13}C/^{12}C$ isotope ratio was 0.3‰ for a methane concentration of 200 ppm and 14‰ for a concentration of 2 ppm, the best result of those presented in the literature so far. For the implementation of these sensors, a complete electronic system was developed to control the measurement laser and to realize data acquisition and processing. The author's software was also used to simulate multi-pass cells in photothermal spectroscopy and cavities in quartz enhanced photoacoustic spectroscopy.

Multipass cells are also used in a spectral broadening of ultrashort pulses of light. The interaction path of light with the medium causing spectral broadening is important in this case, as well. The dissertation describes the process of broadening laser pulses in gases and their subsequent compression. Based on simulations using previously developed software, a multi-pass cell design was created for this purpose. The physical fabrication of the cell was followed by tests with argon, krypton and xenon, which resulted in the compression of the laser pulse down to 31 fs.

The results of the PhD-related work were published in three peer-reviewed JCR, six conference presentations were given, and a patent application for the author's multi-pass cell was submitted.

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