Simulation of Helmholtz Resonators for Optical Gas Sensing: Comparison Between Pressure Acoustics and Thermoacoustics

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Abstract

Among optical gas sensing methods, photoacoustic (PA) spectroscopy combined with a laser source has proven to be a very robust and sensitive method for trace gas detection [1]. In PA spectroscopy the light source is modulated at acoustic frequency. This modulation creates a periodic variation of temperature in the absorption cell due to non-radiative relaxation of excited molecules, and thus an acoustic wave. PA signal and minimum detectable gas concentration are enhanced using acoustic resonances that depend on the size and shape of the gas cell.

COMSOL Multiphysics® was used to calculate the frequency response of differential Helmholtz resonator cells in order to optimize the detection limit of PA sensors. Two different kind of simulation were performed: Resolution of the heterogeneous Helmholtz equation using eigenfrequencies determination in Pressure acoustics, Frequency Domain mode and computation of frequency response using an expansion on the eigenmodes [2,3].

When the PA cell dimensions are reduced to the millimeter range, the Pressure acoustics is no longer accurate and the cell response can be studied using Thermoacoustics , Frequency Domain either for Eigenfrequency or Frequency Domain studies.

We will present comparisons between experimental determination of the cell frequency response and the two kinds of simulation performed using COMSOL Multiphysics®. The influence of mesh characteristics will be discussed

Reference

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