Topology Optimization of a Gaseous Photoacoustic Spectroscopy Cell Using COMSOL Multiphysics®

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Abstract

It is known that photoacoustic spectroscopy shows the highest signal-to-noise ratio compared to other spectroscopy techniques. This is due to an orthogonal detection scheme: while exciting with light we monitor soundwaves. In gaseous phase, the use of an acoustic chamber called cell enhances the produced sound signal. Therefore, we present here a unique and optimized shape for that cell to use in gaseous photoacoustic spectroscopy. Since the relative positioning of the laser - seen as a linear sound source - and the microphone presents few symmetry, 3D topology optimization was used here to derive non-axisymmetric shapes. The methodology implemented with COMSOL Multiphysics® maximizes the retrieved sound pressure at the microphone location and at one desired frequency. To do so, Pressure Acoustics (handling the physics), Optimization and PDE physics interfaces were set to work in a symbiotic manner. Performance comparison of the optimized chamber with a conventional cylindrical cell was made afterwards and shows promising results and, in a certain way unexpectedly, in a wide frequency range.