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Cavity Ring-Down Spectroscopy measurements of Acetone concentration

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Abstract. The Cavity Ring-Down Spectroscopy system for medical applications is created and first results for detection of acetone are shown. The acetone concentration was measured in the air. In the system a pulsed 1 kHz 266 nm DPSS laser with pulse length of 10 ns is coupled in a gas cell with high reflectivity mirror.

1. Introduction

Acetone in human breath gas has been established as a biomarker for type-1 diabetes (T1D) [1] and different other diseases. Normal human breath contains many volatile organic compounds (VOC) in low concentration. The Cavity Ring-Down spectroscopy (CRDS) is sensitive technique to detect VOC in the air or human breath in real time however there are no commercial systems to detect broad range of VOCs. We report in this publication the first measurements of acetone concentration by the CRDS system build in Latvia.

2. Results and discussion

The acetone concentration in the air was measured using the Cavity Ring-Down Spectroscopy (CRDS) technique. System is assembled on the optical breadboard. The picture of the CRDS system is shown in Fig.1. In the vacuum part we use Teflon pipes, metal valves, Teflon thread *Locktight 55*, three stage oil-free membrane pump *Ilmvac*, 5.5 purity grade nitrogen. Resonator can be evacuated to 0.2 mbar. In the system a pulsed 1 kHz 266 nm DPSS laser with pulse length of 10 ns is coupled in a gas cell with high reflectivity mirrors attached to both ends. The cell operates as a resonator in which the laser pulse decays with a specific decay rates.

The decay rate is determined by the distance between the mirrors, mirror reflectivity coefficient and absorptivity of the gas at 266 nm.

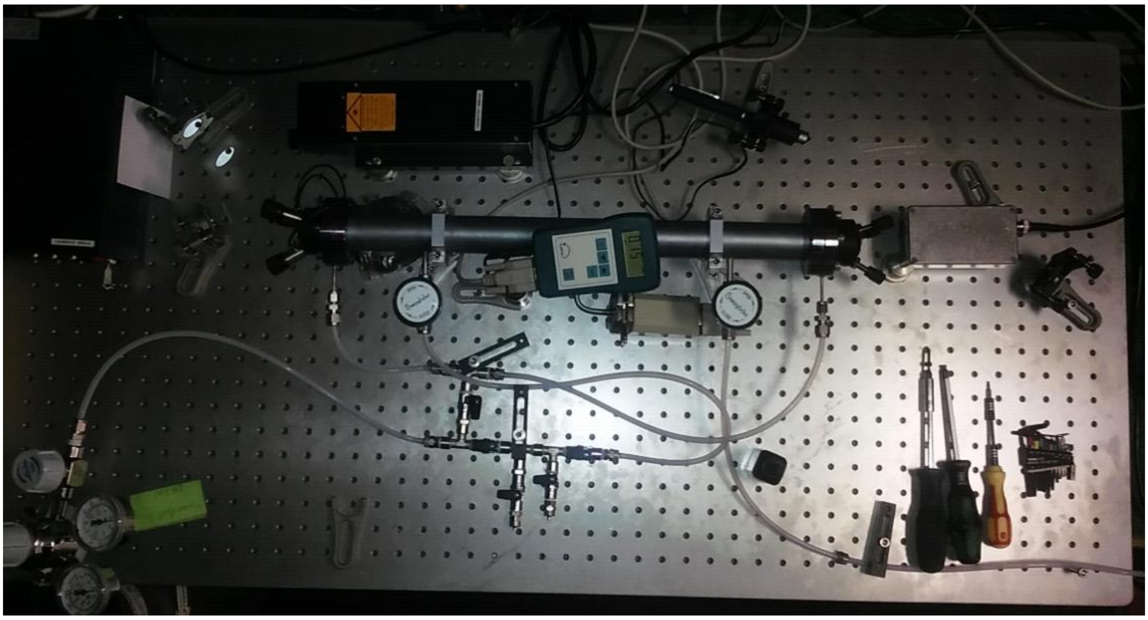

Figure 1. The set-up of the cavity ring-down system (CRDS) for acetone concentration measurements in air.

An example of pulse decay for empty cell (vacuum of 0.3 mbar) is shown in Fig. 2. The light intensity is captured using a high-speed avalanche photodiode. Afterwards an exponential fit in the form f(t)=A*exp(-t/τ)+B is done, where the A is the amplitude of the signal, B is the intercept and τ is the decay rate. In the experimental data curve small oscillations are visible. These are caused by different modes which travel at different speeds in the resonator.

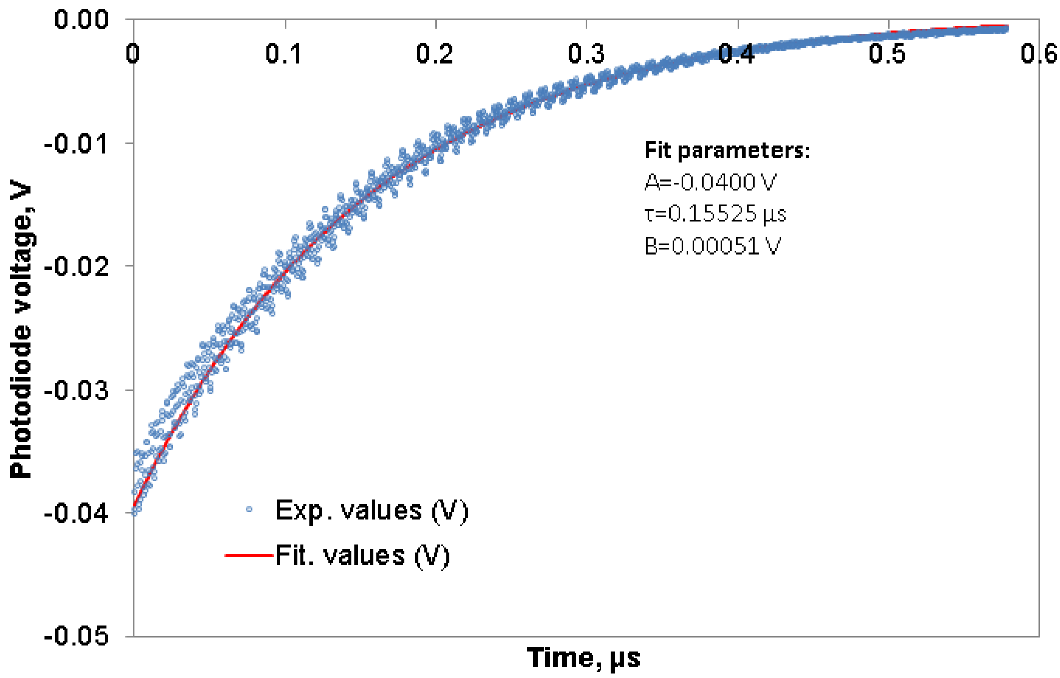

Figure 2. The decay of laser pulse in the resonator cell measured at low pressure of 0.3 mbar.

The decay rate was captured as the cell was consecutively filled to 1000 mbar with air with low amount of acetone (30 ppm and 5 ppm respectively), high purity nitrogen gas as well as vacuumed (air pressure of around 0.3 mbar) cell. The obtained experimental data are evident in Fig. 3.

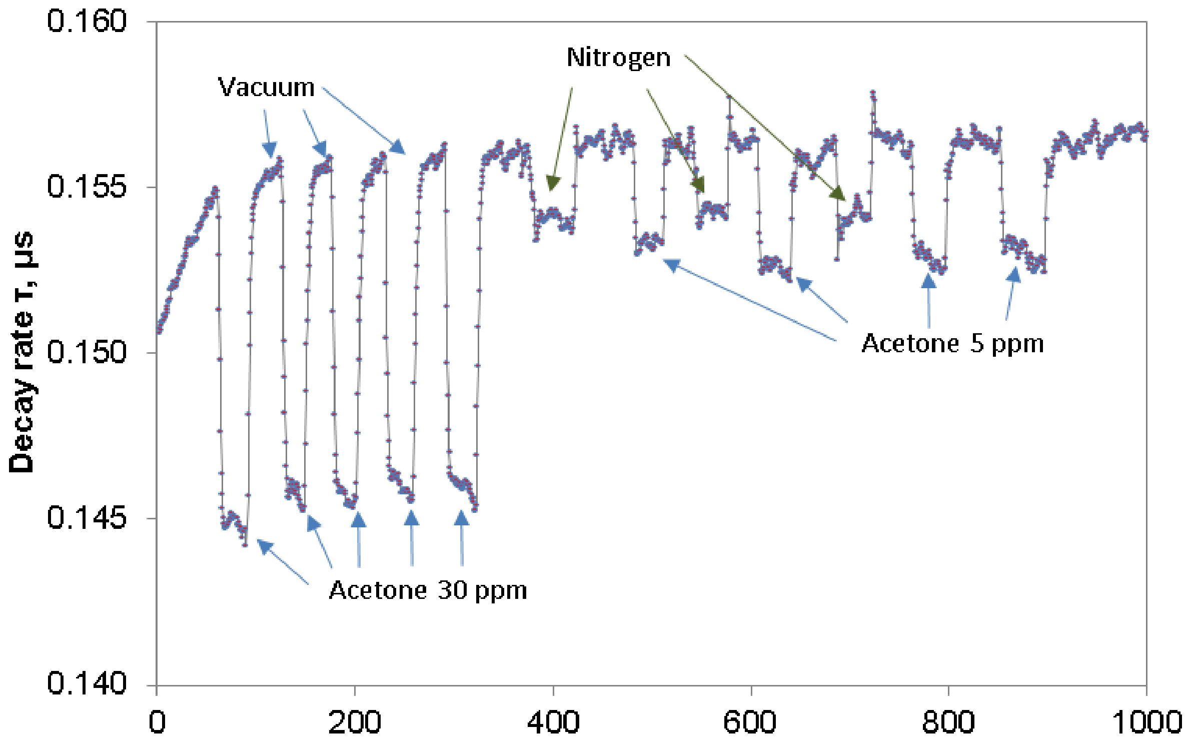

Figure 3. The ringdown decay rate signal for Acetone of 30 ppm and 5 ppm concentration, captured in time.

3. Conclusion

The Cavity Ring-Down Spectroscopy (CRDS) system for medical applications was created and first results for detection of acetone were received. The possibility to measure acetone concentration in the air at the level of 5 ppm was shown.

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