

# Xsense Explosive Detection

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## Abstract

This project is a four year program supported financially by NABIT under the strategic research council enabling hiring of 5 Ph.D. students and 2 post docs. The goal is to realize a portable reliable sensing device, to detect explosive vapours in air with a ppb sensitivity. The sensing device should comprise four different sensing principles. Having independent sensors will improve both sensitivity and selectivity. The different methods of sensing are cantilever based, calorimetric, colorimetric and surface enhanced Raman spectroscopy sensing. Each sensor has its own unique advantages and because the sensors use different physical properties for explosive recognition the combined detection will be more selective sensitive. In order to achieve this, the results from each sensor are analyzed and combined using signal processing. The four individual sensors will be integrated in a portable device where explosive detection will rely on data from all 4 sensors. The activities are coordinated by an advisory board comprising military and other institution that could benefit from the developed technologies. Industry partners are also a part of the project, to help mature the technologies for real life use. Work is currently in progress on all 4 sensor types and individual results proving the concepts for each sensor has been obtained.

## 1.0 Calorimetric Sensing

The calorimetric sensing principle is utilized as a small MEMS device with integrated heater and measurement resistors. Downscaling results in a low thermal mass that enables rapid heating and high sensitivity. The sensor is designed as a bridge for thermal isolation. Measurements on TNT, PETN and RDX have been done and can be seen in Figure 1. [1, 2]

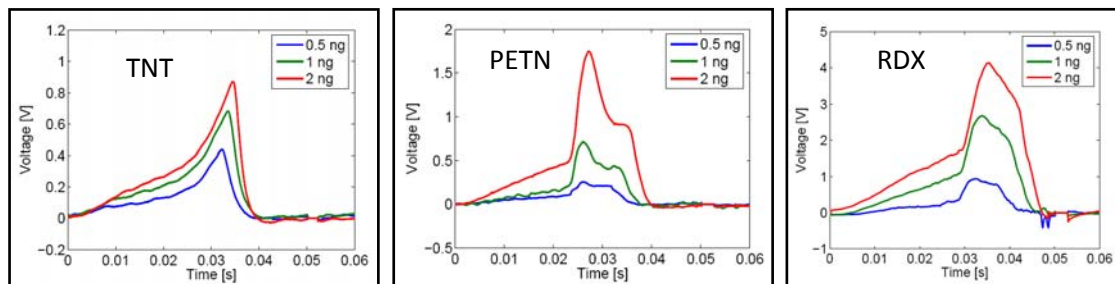


Figure 1: Calorimetric signal for 3 different explosives. The desorption profile is different for each explosive providing selectivity. Measurements are done 0.5, 1 and 2 ng proving scalability with amount and a very high sensitivity.

## 2.0 Cantilever Sensing

The cantilever sensors will use a detector layer specific to different explosives as demonstrated in [3]. When an explosive molecule binds to the cantilever it will bend due to surface stress. The bending can be observed either optically using a laser and a photodiode or using built in piezoresistors. Currently a system is being built where polymer cantilevers are used with an optical readout system on a rotating platform for fast readout of multiple cantilevers.

## 3.0 Colorimetric sensing

Simple colorimetric sensor arrays have shown useful in the detection, identification, and quantification of volatile organic compounds (VOC) in gas phase. Furthermore, they have been used to detect and differentiate mixtures of organic compounds dissolved in aqueous solutions. The sensor arrays are inexpensive, and can be produced as single use disposables. Selecting dyes with specificity to explosives and positioning them in arrays will allow recognition of different explosive by using pattern recognition and signal processing on the exposed array.

## 4.0 SERS sensing

When exposing molecules to specific light, they start to vibrate and emit a spectrum of light. This is known as the Raman effect. The light is measured to reveal the identity of the molecules. The Raman effect is enhanced when the analyte molecules adsorb to rough metal surfaces. Using a nano structured metal surface the interaction between molecules and light can be enhanced up to a factor 1.000.000.000 or more. Using plasma etching or electroless etching of silicon, surfaces with suitable roughness are sought produced and tested for explosive detection.

## 5.0 References

- [1] Dechang Yi, A. Greve, J. H. Hales, L. R. Senesac, Z. J. Davis, D. M. Nicholson, A. Boisen and T. Thundat, "Detection of adsorbed explosive molecules using thermal response of suspended microfabricated bridges," *Appl. Phys. Lett.*, vol. 93, pp. 154102 (3 pp.), 2008.
- [2] L. R. Senesac, Dechang Yi, A. Greve, J. H. Hales, Z. J. Davis, D. M. Nicholson, A. Boisen and T. Thundat, "Micro-differential thermal analysis detection of adsorbed explosive molecules using microfabricated bridges," *Rev. Sci. Instrum.*, vol. 80, pp. 035102 (9 pp.), 2009.
- [3] L. Senesac and T. G. Thundat, "Nanosensors for trace explosive detection," *Materials Today*, vol. 11, pp. 28-36, 2008.