



Micro Plasma-based Electronic Nose

Introduction and background

One of the main design and development projects being undertaken by ST&D is MPEN – the Micro Plasma based Electronic Nose.

This is an innovative approach within the area of gas sensing devices and provides a very flexible device which can detect almost any chemical without prior knowledge or calibration.

The device is fully patented.

The system has many potential uses in a large market as this section from external market research illustrates :

"The US demand alone for chemical sensors, which include gas sensors and biosensors, is expected to reach \$2.7 billion in 2006, driven by advances in the large diagnostic test market and growing use of chemical sensors in larger scale environmental and industrial applications. New product development and expanding applications will provide considerable growth opportunities despite relatively slow gains in mature markets such as industrial safety, flue gas emissions monitoring and pH testing.

This document provides a brief over view of MPEN and an introduction to the research behind it.



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Benefits of MPEN

- One for ALL, no application-specific design
- MPEN can
 - Discriminate between unknown samples
 - Recognise/label known samples
 - Provide chemical information on gas content
 - Suggest changes to improve sample quality
- No a priori chemical composition knowledge required
- Sensitive response, including small composition changes
- Fast response
- Capable of miniaturisation
- Stable over time ie does not require re-calibration or re-training
- When in situ does not require maintenance
- Key sensing elements of MPEN are low cost and disposable.
- Associated hardware and analysis tools can be easily reprogrammed for different requirements

Areas where this technology and approach can be applied

- Flavour/smell discrimination/recognition
- Breath analysis
- Quality control
- Process control
- Semi-qualitative/quantitative gas analysis
- Product development
- Environmental monitoring

Comparison with other electronic noses

Other conventional gas sensing devices have employed methods based on polymer, metal oxide, infrared technologies etc. These types of sensor tend to be very application specific, wear out within short periods, require frequent calibration procedures and are often relatively expensive to produce. Most of these sensors have to be designed, manufactured and calibrated to detect one particular known gas or particular odour. MPEN will be produced at low cost and will last months or years if required. MPEN is virtually calibrated, trained and adapted to all possible applications by software procedures so that it can detect one expected gas, a range of gases, or analyse a sample of an unknown gas or gases depending on the end user needs.

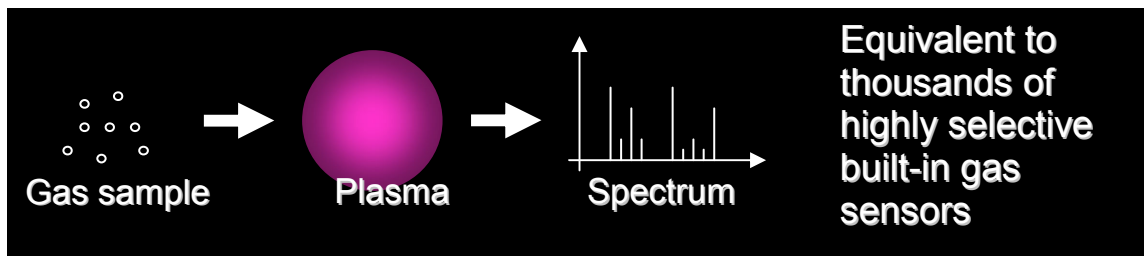


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The science behind MPEN

ST&D approach to gas analysis and artificial olfaction presents unique technological features. The MPEN working principle is schematically and simply depicted in the figure below.



The MPEN device provides energy to the gas sample and generates a small, micro-size plasma. One of the main features of plasmas is represented by light emission; the light is therefore collected and recorded in the form of a spectrum. Each spectrum contains a large number of spectral components which are strictly related to the gas content/composition. For instance, oxygen can be univocally identified by the presence of distinctive spectral lines at 777 nm. In this sense, a spectrum can be thought as the signal response of thousands of highly selective built-in gas sensors.

Spectra for each gas sample can then be analysed and they provide relevant information on gas composition. By mean of pattern recognition techniques human-like task can be performed (e.g. recognition of wine odour) or super-human-like task such as diabetes monitoring through breathe analysis.

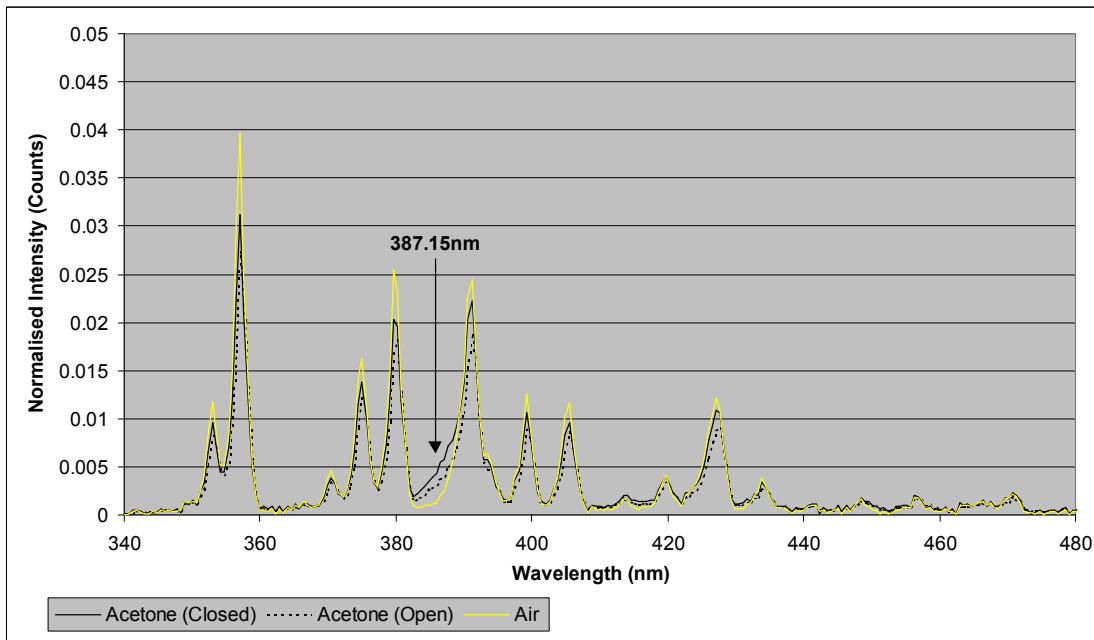
The reference section also has a list of publications where the technology is dealt in more details.

The MPEN development project

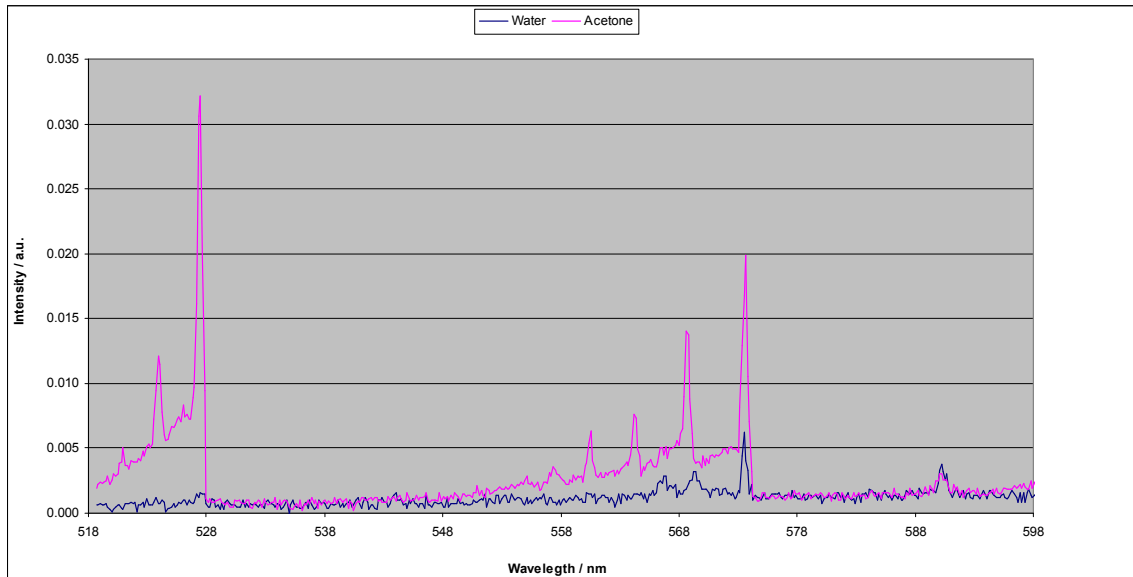
In the research phase, the project demonstrated technological feasibility. This phase was carried out within NIBEC and the University of Ulster. ST&D now owns the resultant patents.

The main thrust in recent work has been the development of a power supply and MPEN system which now allow the device to work in atmospheric pressure regime. With this advance, device size can be dramatically reduced and the signal output and spectral information have greatly improved.

The following graph shows spectral emission related to acetone odour, performed with a previous experimental set-up.



Differences between air samples (yellow) and acetone odour sample (black and broken line; the labelling "closed" and "open" refer to different acquisition method) have to be sought in a very small spectral range. The next graph has been obtained with the most recent development of the MPEN. It shows an improvement in the ability to differentiate between spectra.



The purple spectrum (acetone odour) shows very evident differences which can be exploited for the gas analysis process.

This is only one example, which shows some of the development achieved in the MPEN project. Other tests that have been performed include analysis of different gas mixtures (argon, nitrogen, oxygen etc.), analysis of hydrocarbons, breath samples (for fasting monitoring, diabetes, asthma etc.) and food related gas samples (wine odour, toasted bread etc.).

Calibration and Accuracy

Calibration is against standard gas types at known concentration. It is not however necessary to calibrate for a specific gas. The system is capable of interpolating for unknown gases, based only on a couple of initial known types.

An option is available to dedicate some cells in the array in such a way as to produce self calibration signals.

The library files take care of recognising a wider range of gases ie if calibrated on a few samples, then it can recognise the rest from this reference point.

The more gases the system knows to start with, the more accurate its results. However when interpolating for unknown gases, the system provides a result along with a statement of the accuracy of its own results. Thus gases which are closer (spectrally) to the known samples will be measured more accurately, but this accuracy figures is always stated by the system.

The system is highly stable and does not require periodic re-calibration.

The accuracy of the system clearly depends on a number of factors, but can be better than 5 parts per billion.



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Future development plans

Work is now being concentrated on device design, improving reproducibility together with signal repeatability. It is also intended to produce results from device testing in different applications. This will include clinical trials and the required processes to meet international regulatory standards.

It is intended to produce two versions of the nose :

- Low cost for breath ketones. This will be a single wavelength device ie with no spectrometer. In volume the target system price will be \$20 and the cell will cost only a few dollars
- Where more than one wavelength is required, a handheld version is anticipated ie including in effect a spectrometer. This is likely to have a volume price in the region of \$400-600. It will work by using a CCD array and diffraction grating.

The device is expected to be completed in 2007.

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