Chapter 12

DETECTION OF DYNAMIC SMELL INTENSITY
Characterisation Of Explosives By The Response Of Gas Sensor Array To Modulated Intensity Of The Smell

Arūnas Šetkus
Semiconductor Physics Institute, A.Gostauto 11, Vilnius, LITHUANIA

Abstract: A method increasing the rate of the detection of complex volatile compounds by solid-state gas sensors is proposed. An original approach includes special modulation of the smell intensity and analysis of the kinetics of the sensor response. Essential aspects of the method are theoretically described considering dynamics of the processes in the model of the response of solid-state sensors to gas. The experimental transients of the response of metal oxide thin film sensors to a step change in gas composition of the atmosphere are analysed considering controlled injection of volatile compounds of pure TNT and explosive mixtures containing TNT.

Key words: Tin oxide, gas sensors, kinetics, volatile compounds, TNT.

1. INTRODUCTION

Detection of explosives is an important problem in various applications, such as finding hidden explosives in airports, tracing and elimination of landmines, etc. [1-3]. The effectiveness of well-known detection methods based on electromagnetic induction and geophysical techniques, such as ground penetrating radar, is significantly limited in finding novel types of mines and explosives. Analysis of chemical composition is currently proposed as an advanced approach in development of novel methods for detection of mines and explosives [4,5]. Activities in the chemical approach is mostly initiated by the knowledge that traces of characteristic volatile compounds evaporated from the explosives or from the remaining of the explosives on the explosive’s container surface can be measured and
recognized by suitable method (e.g. [6,7]). An artificial odour recognition system is one of the tools acceptable for the implementation of a chemical detection method to locate explosives.

A great variety of sensors and sensor systems have been developed for detection of chemical compounds in air and in liquids (e.g. [8-10]). Resistive sensors are amongst the simplest types of the sensors considering handling, capabilities to modify and production terms. In spite of the basic limitations of the selectivity to gases in single sensors, systems based upon these sensors (usually called an Electronic Nose (EN)) were effective in identification of target gas in a given mixture (see e.g. [11-13]). Standard ENs are based on the measurement of the response signals at equilibrium and processing of these signals by sophisticated methods. In these systems, each individual sensor is associated with one signal in the database. Based on numerous studies, technological methods were developed for the production of different sensors aiming to build up the systems capable to generate large databases of the response signals that are used for the featuring of a smell. Some of these systems were probed for recognition of explosives in various laboratories.

In different studies, it was recognised that mine detection by EN in the field conditions is limited by the parameters of the sensors. An increase of the sensitivity of the devices seems to be the primary task of most current developments, because very small amounts of the characteristic volatile compounds (mostly in ppb or even sub-ppb intervals) have to be traced and recognised in gas mixture. Another limitation for the EN applications is related to comparatively long response time of the sensors when small amounts of the chemicals are to be detected. Low rate of adsorption and desorption process for complex volatile compounds seems the main problem in reduction of the detection time in EN especially when it includes solid-state gas sensors.

This report deals with the dynamic response of the solid-state gas sensors when the gaseous composition of the atmosphere is intentionally varied. The study is focused on the featuring of the chemical composition of the atmosphere using the information extracted from the transients of the response. Theoretical analysis of the surface processes in the sensors is aimed at a description of the response kinetics by a set of the parameters acceptable for the featuring of an odour. The method was tested by experimental investigations of the response kinetics under exposure to various volatile compounds including that from TNT based explosives.