Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 120 (2015) 586 – 589

Procedia Engineering

www.elsevier.com/locate/procedia

EUROSENSORS 2015

Graphene based sensor for environmental monitoring of NO_2

S. Novikov[a]* , N. Lebedeva[a], A. Satrapinski[b] and J. Walden[c]

[a]*Aalto University, Espoo, Finland*
[b]*VTT, Technical Research Centre of Finland, Espoo, Finland*
[c]*Finnish Meteorological Institute, Helsinki, Finland*

Abstract

Ultrasensitive gas sensor based on epitaxial graphene on SiC has been fabricated. The sensor exhibits strong and reproducible response to nitrogen dioxide (NO_2) in the concentration in air down to 1 part-per billion (ppb). Prototype of the transportable device for environmental monitoring allows fast and reproducible measurements of NO_2 concentration in the range typical for environmental pollution (5 ppb – 50 ppb).

Peer-review under responsibility of the organizing committee of EUROSENSORS 2015

Keywords: nitrogen dioxide; graphene

1. Experimental details and results

Graphene is a promising material that has unique properties like high surface-to-volume ratio, low electrical noise, and exceptional transport properties associated with its two-dimensional structure [1]. High adsorption ability and high surface-to-volume ratio of graphene make it attractive as a gas sensing material. In the late years interest for the air pollutants and their monitoring has been growing in our life. Nitrogen dioxide (NO_2) is typical air pollutants that causes environmental and health problems. From this point of view, it is necessary to develop highly sensitive and inexpensive gas sensor, able to detect low concentrations of NO_2 gas. Currently, gas sensing experiments have demonstrated that epitaxial graphene can be an excellent material for future NO_2 sensors. Graphene layers grown on

* Corresponding author. Tel.:+358405910534; fax:
E-mail address: sergey.novikov@aalto.fi

Peer-review under responsibility of the organizing committee of EUROSENSORS 2015
doi:10.1016/j.proeng.2015.08.731

SiC have demonstrated sensitivities down to ppb level, and shown high selectivity for NO_2 detection with respect to typical interfering gases [2, 3].

Graphene films were grown on 6H SiC wafer, (obtained from Nitride Crystals Inc.) by annealing in Ar ambient at temperature 1700°C. Before growth the substrate was etched at 1600° C in 1-atm of 5% H_2/95% Ar gas mixture in order to remove scratches from the surface. Raman and Auger spectroscopies confirm existence of single-layer graphene on the sample surface. Ti/Au contacts to graphene were made by E-beam evaporation and lift-off photolithography. Patterns for the sensor devices were made on graphene surface using RF-plasma etching. Sensor chip (size 1.5 mm x 1.0 mm) was assembled on a holder together with Pt100 resistor, which was used as a heater. Suspended construction of the sensor (Fig.1a) has low thermal inertia and allows fast thermal circling. Sensor together with sampling system and computer interface were assembled into the unit suitable for mobile monitoring of NO_2 concentration (Fig.1b).

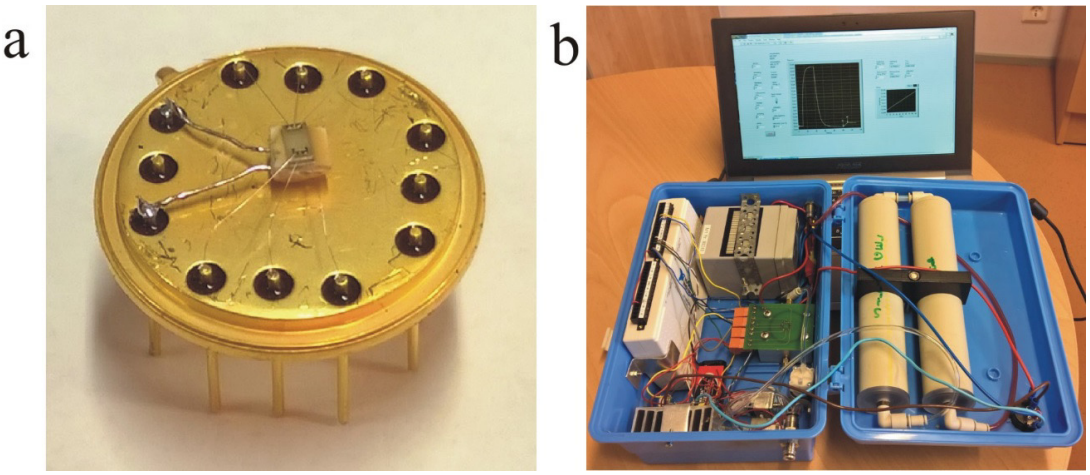

Fig.1 (a) Graphene sensor chip on the holder and (b) prototype of device for mobile NO_2 monitoring.

In Fig.2 the block diagram of the measurement setup is presented. Procedure of the measurement of the gas concentration consist of 3 main stages: regeneration, stabilization and exposure to the sampling gas. Pump (1) provides the gas flow through the sensor (2). During regeneration and stabilization the three way valve (3) directs the ambient air flow through the charcoal filter (4) which eliminates nitrogen dioxide from the incoming gas. Pure air is necessary for successful regeneration of the graphene sensor surface. Desorption rate of nitrogen dioxide from graphene surface is very slow at room temperature. In order to recover the sensor to its initial condition an annealing at 110°C was applied after each exposition period. This method significantly increases sensitivity to low

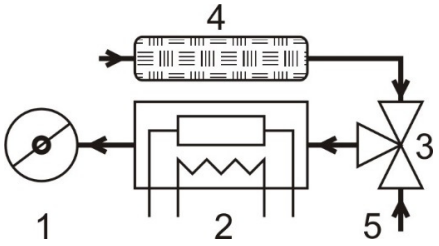

Fig.2 Block diagram of the measurement setup.