Sujet de projet : Functionnalized graphene for gas sensing

Dates prévisionnelles de l'accueil: Mars 2021 (4 à 6 mois)
Localisation: LISIS-IFSTTAR & LPICM-Ecole Polytechnique
Projet : « Capteur » I-site Future
Partenaire international envisagé pour la poursuite en stage (mai-août) : Pedro Alpuim 2D Materials and Devices Research Group-INL Braga Portugal
Encadrant: Fatima Zahra Bouanis &Pedro Alpium
Contact (s): E-mail: fatima.bouanis@ifsttar.fr & Tel: +33 (0)1 81 66 84 28
Filière visée : Systèmes électroniques intelligents, Génie industriel

Présentation générale du sujet :

Environmental monitoring is required to protect the public and the environment from toxic contaminants and pathogens that can be released into a variety of media including air, soil, and water. Moreover, the global environmental monitoring market is poised to grow at a CAGR of 7.5% during 2015-2020, and is expected to reach a value of ~$20.5 Billion in 2020 [1]. As an example: The air segment in the environmental sensing and monitoring market is anticipated to reach USD ~7.7 billion by the end of 2019. This augmentation is driven by different factors such as the massive scale of urbanisation and population growth, development of policies to reduce water, soil and air pollutants and the increase of monitoring environmental stations. In this framework, the development of low-cost, easy-to-use, miniaturized, portable and long-term monitoring of environmental sensors allowing accurate measurements of air pollutants is needed.

Gas sensors based on metal oxides have raised great interest in many areas, such as environmental monitoring, domestic safety, public security, as well as for automotive applications... However, large scale use and effective monitoring of environmental pollution require the development of cheap, small, low power consumption and reliable solid state gas sensors in the coming years [2]. Nanomaterials such as graphene is one of the best promising candidates for the future development of nanosensors applications. This originates from its high surface area (dense number of adsorption sites), high electrical conductivities and low electrical noise (a small change in carrier concentration induced by gas exposure induces significant changes in electrical conductivity) [3]. In addition, graphene can be operated at room temperature, which is impossible in metal oxide semiconductors [3].

Objectif du projet :

In this project, we will develop **a reliable and selective new generation of gas sensors based on graphene that will be used to detect and quantify sensitively and selectively air**

pollutants in various environments. This work is part of a PHC Pessoa Project between IFSTTAR- Marne La Vallée, Ecole Polytechnique- Palaiseau and INL-Braga.

Gas sensors based on graphene have demonstrated excellent sensing characteristics in particular a high sensitivity (a few ppb), a fast response (in a few seconds) and a good stability. However, sensors based on graphene do not prove selective to any specific gas; they rather tend to measure the variation of the global gas content. In most real life applications, especially in urban air, it is not acceptable, as pollutants are numerous with concentrations varying widely in space and time. Various strategies have been studied to enhance the selectivity of carbon nanotubes to specific gases by fingerprinting techniques and functionalization using chosen chemical species. **In order to improve the selectivity, we propose a new approach based on the non-covalent functionalization of the devices, using porphyrins.**

The objective of this project is to develop a gas sensor based on graphene to detect NO_X. First, we will study the functionalization of graphene with porphyrines. Then, the efficiency of the grafting will be characterized by different techniques such as Raman spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and atomic force microscope (AFM). The charge transfer between the molecules and nanomaterials will be confirmed by the study of the electrical characteristics of nanomaterials. Finally, we will study the sensitivity and the selectivity of the devices under NOx.

Bibliographie:

[1] http://www.marketsandmarkets.com.
[2] E. Bakker, Electrochemical Sensors. Analytical Chemistry 2004. 76(12) (2004) 3285–98.
[3] M. Meyyappan, Carbon Nanotubes: Science and Applications, CRC Press, Boca Raton, Fla, USA.