ABSTRACT

The aim of this project is to study and develop graphene-based DNA sensor model for detection of DNA hybridization application. This includes modeling and simulation of carrier concentration, conductance, and current-voltage characteristics of graphene-based sensors on the field effect transistor (FET) platform. The main challenge is to validate the developed model with the experimental data, since graphene is considered as a new emerging material and research is still rapidly taking place with fabrication effort reported so far. In this research, first, numerical model is developed which shows the dependency of current-voltage characteristics on the DNA concentration factor. The iteration method is used for developing the numerical model. The proposed model is simulated utilizing MATLAB software to validate with experimental data of DNA hybridization. The $I_d-V_g$ characteristic of the proposed numerical model is depicted for different concentrations of DNA molecules and compared with experimental data for the verification purpose. After determining the accuracy of the models, particle swarm optimization (PSO) technique is used to minimize the error of the numerical model. Then, optimization results are shown. Overall, the accuracy of more than 98% represents an overall error of less than 2% which is quite acceptable for the optimized numerical model.

Graphene has been the subject of much interest even though it has been a relatively short period since the discovery of it. The reason for that being the idiosyncratic physical and chemical characteristics like exceptional strength (Novoselov et al., 2004), and its great thermal conductivity plus biocompatibility that it possess (Novoselov, Jiang, et al., 2005). Graphene and nanotubes have been utilized as an essential element in several electronic device e.g. biosensors. There has been major evidence indicating biosensing applications shown in graphene and its by-products (Y. Shi, Dong, Chen, Wang, & Li, 2009). Due to the biocompatibility and extreme environmental distress affectability of thin graphene plates, it provides an essential biosensing application for them. Meaning they are greatly sensitive to variables such as electronic doping (Collins, Bradley, Ishigami, & Zettl, 2000; Kong et al., 2000; Y. B. Shi et al., 2006; Snow, Perkins, Houser, Badescu, & Reinecke, 2005) and molecule adsorption (X. Dong et al., 2009; Mohanty & Berry, 2008; Y. Shi et al., 2009; Wehling et al., 2008). In addition it is considerable that, because of easier contact, the surface structure of graphene (Displayed in Figure 1) in comparison to other carbon derivatives ensures a higher adsorption of DNA(Zheng et al., 2003). This resulted in the selection of graphene as the DNA detection sensory framework in this study. With the help of the study and molecular analysis of nucleic acids, almost 400 and increasing genetic conditions are diagnosable now (Mastrangelo, 1999).

Graphene-Based Fet Structure

Plus the rewarding experiments on electronic peripherals such as field effect transistor (FETs) (Nilsson, Neto, Guinea, & Peres, 2007) made possible with the application of thin graphene plates (Novoselov, Geim, et al., 2005)nano microlithographic fabrication (L. X. Dong & Chen, 2010). This suggests and justifies the call for action and the necessity of further DNA detection studies (Drummond, Hill, & Barton, 2003) as well as understanding the high sensitivity of the transport carriers in graphene plates and the conductance to environmental distress (Huang, Dong, Liu, Li, & Chen, 2011). In the process of observing the conductance variations of fabricated device base carbon materials electrical and label free DNA detection hybridization was possible to attain (Star et al., 2006). Graphene conductive characteristic as a channel in the FETs was considered as a seminal electronic features in the material (Dankerl et al., 2010). Presently the attention has moved towards been a focus on the exploratory capabilities in single-layer graphene (Abergel, Apalkov, Berashevich, Ziegler, & Chakrabory, 2010); Besides, single-

Figure 1. Monolayer graphene structure with one atom thickness
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