Models for Simulation Based Selection of 3D Multilayered Graphene Biosensors

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Introduction:Through COMSOL Multiphysics modeling and simulation were identified the best fitted solutions for a multilayered biosensing device structure from the presently known graphene (and composite materials including different forms of graphene.

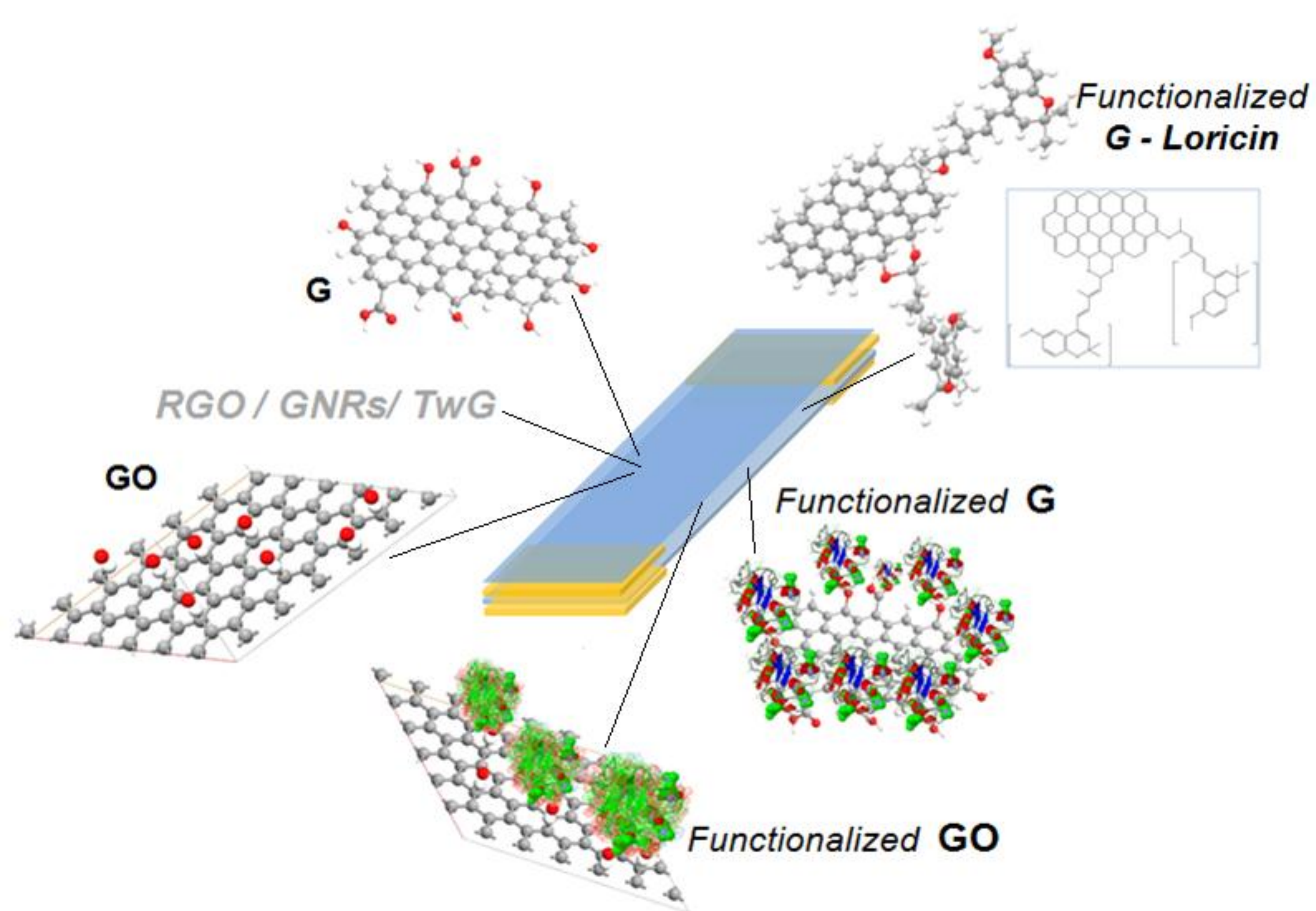

Figure 1. Basic and functionalized graphene structure models *(ChemBio 3D Ultra©)*

Computational Methods: All these models are having the same continuum-like background of a biosensor device structure based on weak van der Waals interaction forces that describe the nonlinear behavior of graphene into a surrounding viscoelastic environment through classical Kirchhoff plate theory

$$D\nabla^4 w + \propto_1 w + \propto_3 w^3 + \rho h \frac{\partial^2 w}{\partial t^2} + N_x \frac{\partial^2 w}{\partial x^2} + N_y \frac{\partial^2 w}{\partial y^2} = 0 \quad (1)$$

where: *Nx*, *Ny* are biaxial in-plane loads; *a, b*- length, width of graphene; *h*- thickness of graphene; *p* – distributed transverse load per unit area (due to surrounding medium effect) ; *D* is the bending stiffness of the plate:

$$D = \frac{Eh^3}{12(1-\nu^2)} \quad (2)$$

for all models were studied the charge density distributions of electric, thermal and acoustic field stimuli responsible for *(ē – ph), (ph – ph)* and *(ion –ph)* interactions.

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Results: A large number of device module types have been tested in order to define the best response of the hydrogel- polymer layer (PVA Hydrogel) on the graphene sheets and of the protein functionalized graphene biosensors.

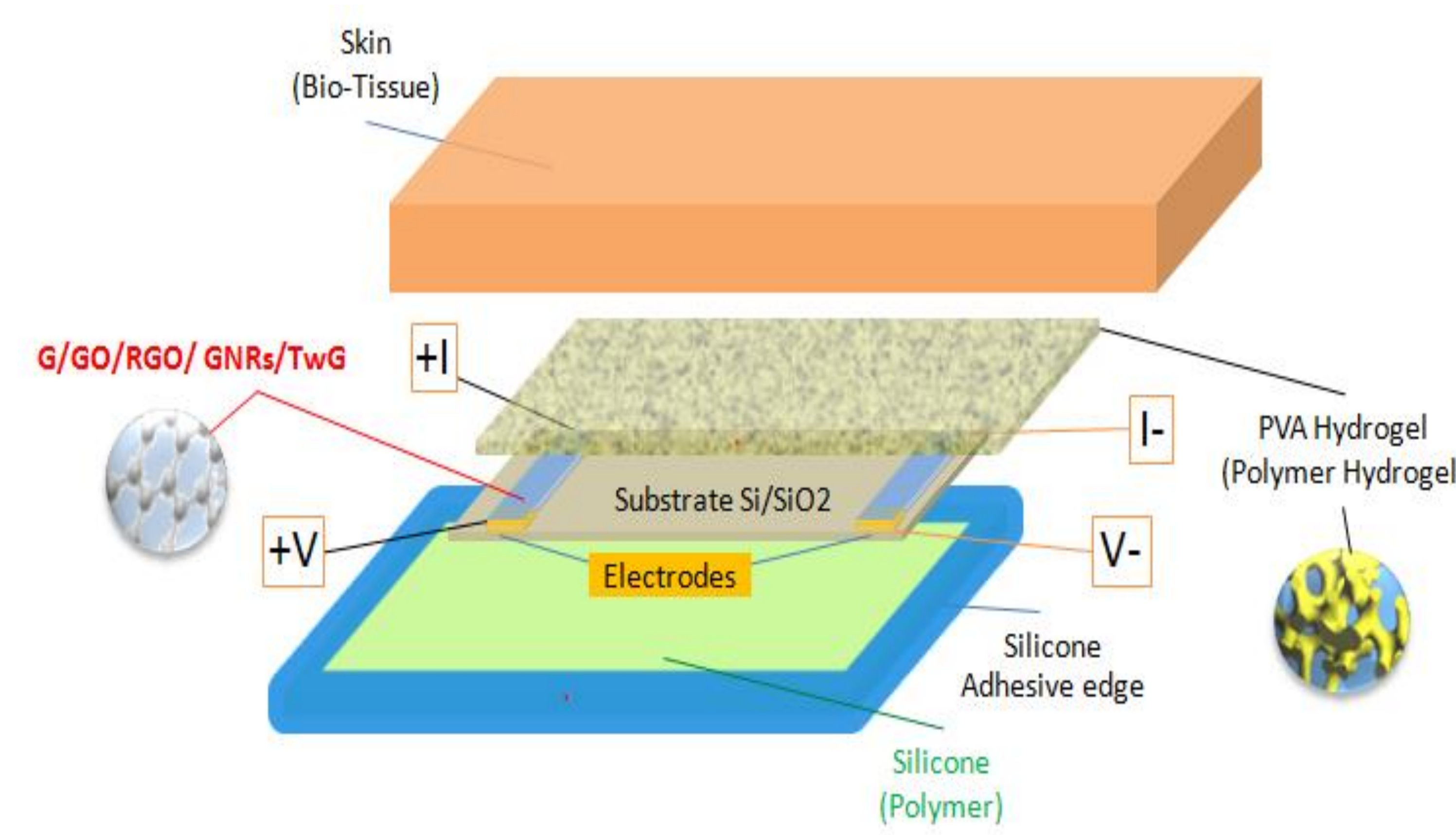

Figure 3. Multilayer graphene sensing device

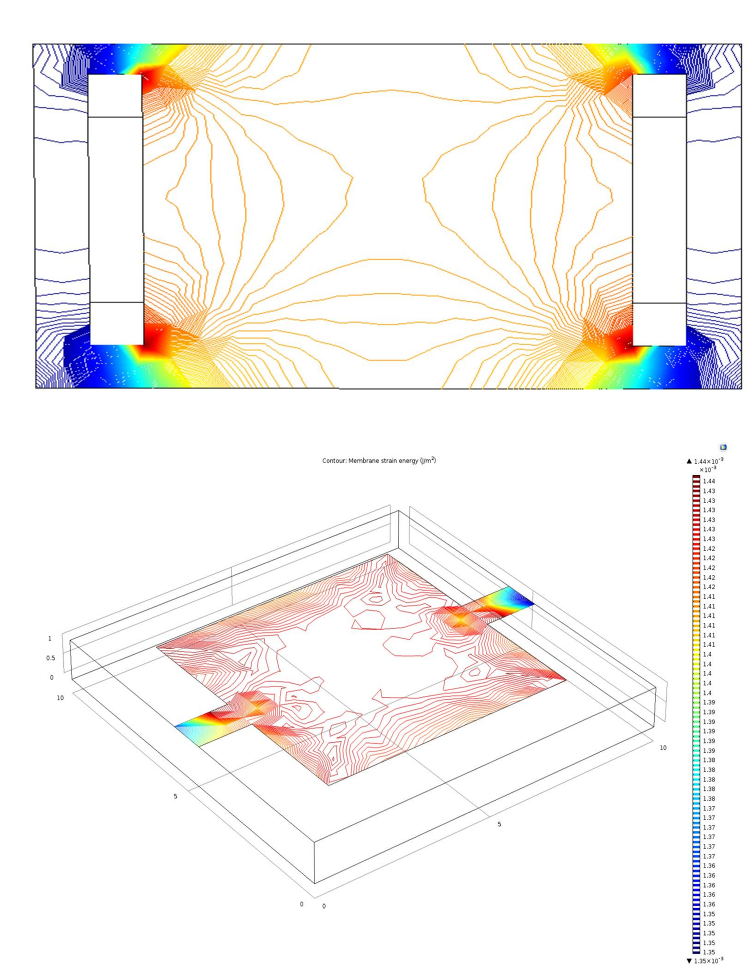

Figure 4. Electric potential
(a) 2 electrodes device; (b) 4 electrodes device

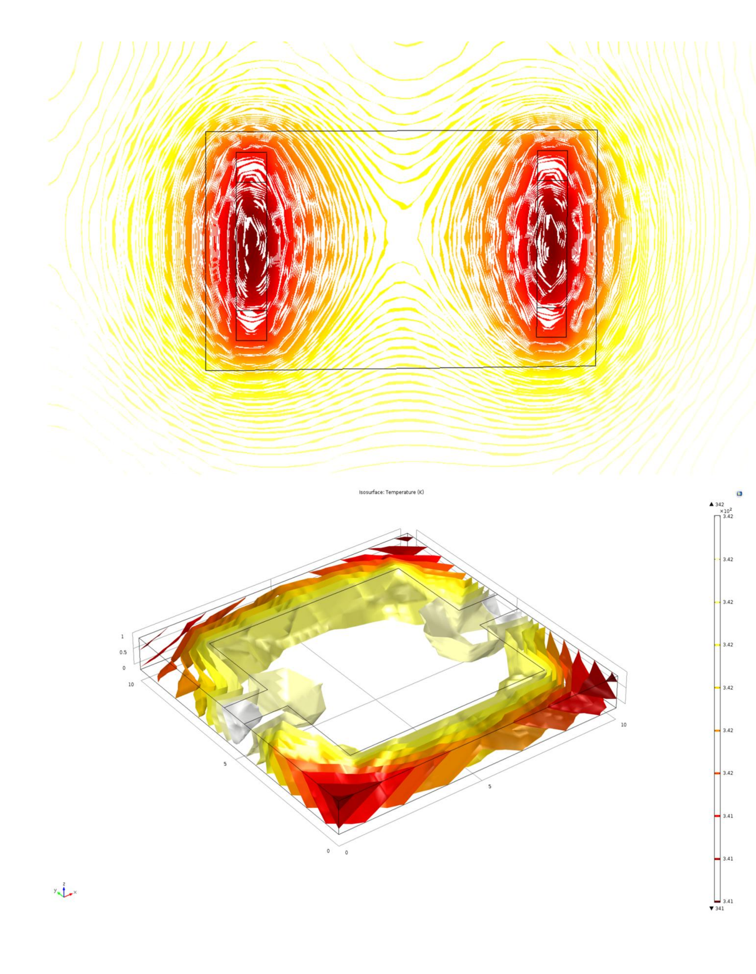

Figure 5. Temperature
(a) 2 electrodes device; (b) 4 electrodes device

Conclusions: For each module type the graphene/ graphene composite materials generate clearly differentiate responses to the environmental stimuli, or process microvariables evolution, thus confirming the biosensing ability of this class of materials.

References:

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