Quanum transport model for graphene strain sensing

Abhinaba Sinha
Abhishek Sharma, Ashwin Tulapurkar, Valipe Ramgopal Rao, Bhaskaran Muralidharan

Department of Electrical Engineering, IIT Bombay, Mumbai, India

asinha@iitb.ac.in

Abstract

Piezoresistance effect in graphene has been studied using different theoretical and experimental techniques. But the value of piezoresistance gauge factor reported in literature vary in a wide range (2-10^6) and are not consistent with each other [1,2]. We investigate the piezoresistance effect of graphene using quantum transport theory to get a deeper insight into the physics.

In this work, we develop a general model for studying the piezoresistance effect in 2D materials. Our model computes mode density from band structure using band counting method [3] and employ Landauer formalism to compute gauge factor of 2D material. Since, graphene behaves as a ballistic conductor upto 0.3-0.4 micron of length [4], we use this model to compute gauge factor of graphene along armchair and zigzag direction in linear elastic strain regime (0%-10%) [5].

Our simulation predicts, very small magnitude of gauge factor of graphene (~1) which is close to the known value of gauge factor of suspended graphene membrane (~2) [1]. Moreover, for the first time, we predict reverse sign on the magnitude of gauge factor along armchair and zigzag direction. We obtain a negative gauge factor for strain along armchair direction and a positive GF for strain along zigzag direction. We explain this converse effect in gauge factor on the basis of reverse change in transmission due to strain along these directions. The reverse change in transmission is due to the compression/expansion of Brillouin zone of graphene due to strain along armchair/zigzag direction. Our results are useful for application in graphene based NEMS strain sensors.

References


Figures

Figure 1: Gauge factor of graphene sheet for strain and current along: (a) armchair direction. The average gauge factor along armchair direction is ~1. (b) zigzag direction. The average gauge factor along zigzag direction is 1. The sign on the magnitude of gauge factor is opposite