Graphene strain sensing using quantum transport theory

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Abstract

Piezoresistance effect in graphene has been studied using various 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]. In this paper, we investigate the piezoresistance effect of suspended graphene using quantum transport theory.

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

Our simulation predicts, a very small magnitude of longitudinal gauge factor of graphene (~0.3) whereas a 11 times change in the transverse gauge factor (~ -3.3) along with sign inversion.

We rationalize our prediction using deformation of Dirac cone due to an applied uniaxial strain, leading to a change in mode density. Owing to the small thickness, the sensitivity per unit area is very high. Thus, graphene in transverse configuration is extremely useful for pressure sensing. Based on our result, we suggested a highly sensitive nano pressure sensor in transverse configuration. The results obtained herein may serve as a template for high strain piezoresistance effect of graphene in nano electromechanical systems.

References

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Figures

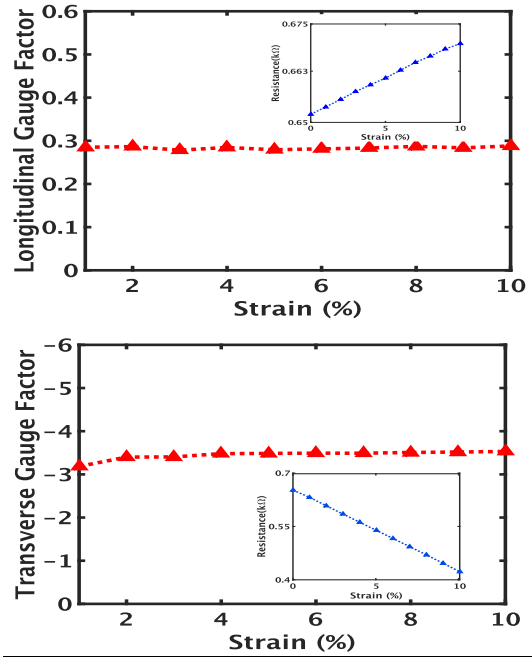

Figure 1: Gauge factor of graphene sheet for strain along armchair and zigzag directions in: (a) Longitudinal configuration and (b) Transverse configuration.