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Analysis and Modeling of Graphene-Based Percolative Strain Sensor

Authors : Heming Yao

Abstract : Graphene-based percolative strain gauges could find applications in many places such as touch panels, artificial skins or human motion detection because of its advantages over conventional strain gauges such as flexibility and transparency. These strain gauges rely on a novel sensing mechanism that depends on strain-induced morphology changes. Once a compression or tension strain is applied to Graphene-based percolative strain gauges, the overlap area between neighboring flakes becomes smaller or larger, which is reflected by the considerable change of resistance. Tiny strain change on graphene-based percolative strain sensor can act as an important leverage to tremendously increase resistance of strain sensor, which equipped graphene-based percolative strain gauges with higher gauge factor. Despite ongoing research in the underlying sensing mechanism and the limits of sensitivity, neither suitable understanding has been obtained of what intrinsic factors play the key role in adjust gauge factor, nor explanation on how the strain gauge sensitivity can be enhanced, which is undoubtedly considerably meaningful and provides guideline to design novel and easy-produced strain sensor with high gauge factor. We here simulated the strain process by modeling graphene flakes and its percolative networks. We constructed the 3D resistance network by simulating overlapping process of graphene flakes and interconnecting tremendous number of resistance elements which were obtained by fractionizing each piece of graphene. With strain increasing, the overlapping graphenes was dislocated on new stretched simulation graphene flake simulation film and a new simulation resistance network was formed with smaller flake number density. By solving the resistance network, we can get the resistance of simulation film under different strain. Furthermore, by simulation on possible variable parameters, such as out-of-plane resistance, in-plane resistance, flake size, we obtained the changing tendency of gauge factor with all these variable parameters. Compared with the experimental data, we verified the feasibility of our model and analysis. The increase of out-of-plane resistance of graphene flake and the initial resistance of sensor, based on flake network, both improved gauge factor of sensor, while the smaller graphene flake size gave greater gauge factor. This work can not only serve as a guideline to improve the sensitivity and applicability of graphene-based strain sensors in the future, but also provides method to find the limitation of gauge factor for strain sensor based on graphene flake. Besides, our method can be easily transferred to predict gauge factor of strain sensor based on other nano-structured transparent optical conductors, such as nanowire and carbon nanotube, or of their hybrid with graphene flakes.

Keywords : graphene, gauge factor, percolative transport, strain sensor
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