Investigation of graphene piezoresistor for use as strain gauge sensors

X. Chen, X. H. Zheng, J. K. Kim and D. W. Lee*
MEMS & Nanotechnology Laboratory, School of Mechanical Systems Engineering, Chonnam National University, Gwangju, Republic of KOREA
mems@jnu.ac.kr

X. X. Li
State Key Laboratory of Tranducer Technology, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, 865 Changning Road, Shanghai, 200050, China

There are few reports on piezoresistance effect-widely used in electromechanical sensors made out of silicon-of graphene sheet. Associated research [1,2] is limited to the piezoresistance effect of graphene films obtained by either ultrasound cleavage of graphite or chemical vapour deposition, showing the gauge factor in the range of 6 to 30. Although mechanically exfoliated graphene shows relatively small sizes and are only suitable for pure science researchers so far, based on its superior crystal quality, high-dense grain and few structural defects, its natural properties are advantageous over other methods made graphene. Therefore, we predict and experimentally confirm the graphene fabricated by mechanical exfoliation has higher gauge factor than those by fabrication methods, similar to the electron transport and thermal conductivity properties that has already been proved.

The graphene was transferred on the surface of SiO_2 with Cr markers. A highly transparent photoresist was spin-coated on its surface to define the electrode structures. The contact material (15nm Ti/35nm Au) was deposited and followed by a liftoff process, in Fig. 1. Free from expensive and low batch fabrication e-beam lithography, the graphene piezoresistors are simply fabricated by normal lithography. It promises a low-cost, low graphene contamination and easy process for graphene-based device fabrication, allowing for wide popularization of microelectromechanical system (MEMS) technology in the field of graphene. The measurement systems we use is an equivalent stress beam that works as a bending apparatus, therefore, commercial strain gauge as strain calibration and a graphene piezoresistor are fixed together on the beam's surface and suffer from the same stress. According to the relation between the strain and the change ratio of the electrical resistance, the gauge factor of the single or multi-layer graphene sheet could be measured and calculated, a typical current-voltage (I/V) characteristic for various graphene sheets at room temperature shows the electrical resistance of the multi-layer graphene is about 102 kΩ. The corresponding gauge factor was about 300, as demonstrated in Fig. 2. The relationship between the gauge factor and layer-number of the graphene sheet is also investigated. The relationship between electrical resistance and strain for single-layer graphene under different temperature was experimentally confirmed.

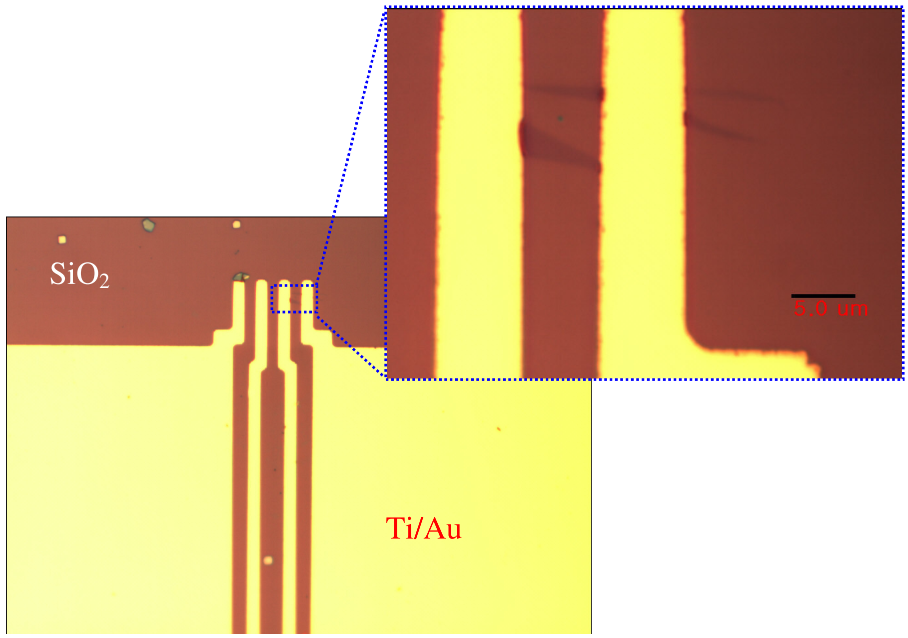

Figure 1: Optical images of graphene piezoresistor consisting of graphene sheet and Ti/Au electrodes. Before fabrication, the number and topography of graphene layer is confirmed by both Raman spetrum and atomic force microscopy.

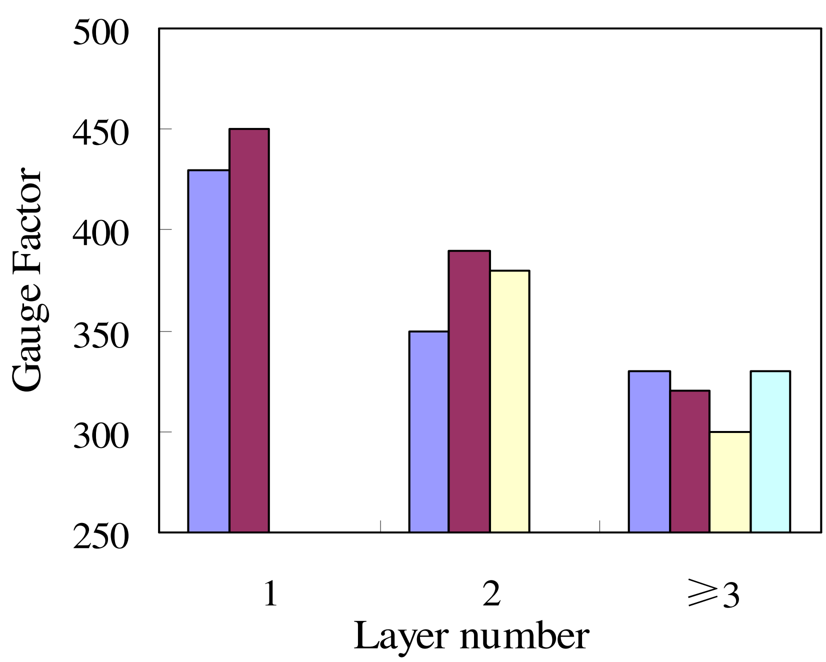

Figure 2: Relationship between the gauge factor and the number of layers for graphene sheet. It is clear that the gauge factor was increased from about 300 to 450 with the decrease of the number of the graphene sheet layer.