2nd International
Nanotechnology Conference & Expo

April 3-5, 2017   Dubai, UAE

Atomic-scale structural control of Graphene nano-ribbon for smart sensor applications

Hideo Miura, Meng Yang and **Ken Suzuki**
Fracture and Reliability Research Institute, Graduate School of Engineering, Tohoku University, Japan

Graphene have great potential for ultra-sensitive strain sensors applications due to its high mechanical strength and good compatibility with the traditional semiconductor processes. In the current study, we investigated the effect of tensile and bending deformations on the electronic states of graphene nano-ribbons (GNRs) using density functional theory (DFT) to clarify the underlying mechanism of the piezoresistive properties of graphene. It was found that the electronic properties of GNRs change from metallic to semiconductive when the width of the GNRs is thinner than 70 nm at room temperature, and the electronic structure of armchair graphene nano-ribbons (AGNRs) is very sensitive to the tensile deformation. When uniaxial tensile strain is applied to AGNRs with different width, their electronic band structureschange drastically depending on the width of the AGNRs and the amplitude of the applied strain, leading to the change in band gap approximately from 0 eV to 1.0 eV. The band gap values of bended AGNRs decrease significantly when the maximum local dihedral angle between the nearby π-orbits exceeds a critical value due to the orbital hybridization between σ-orbit and π-orbit. In order to assure the unique strain-dependent characteristics of GNRs, it is very important to control the number of carbon atoms along the width direction of AGNRs.

Based on these analyses, we fabricated a strain sensor using the graphene film grown by thermal chemical vapor deposition (CVD) method on Cu foil using acetylene gas. The strain sensor is fabricated directly on the graphene-coated Cu foils by using the standard photolithography process and reactive ion etching (RIE) and then, transferred onto a stretchable and flexible polydimethysiloxane (PDMS) substrate. The measured mobility of holes was 1130 $cm^2/(V \cdot s)$. This result clearly indicates that the high-quality graphene was successfully deposited on the SiO2/Si substrate suing acetylene-based CVD process and the proposed process was easily adaptable with the conventional fabrication processes for thin-film devices. The one-dimensional tensile test and three-dimensional bending test are performed to investigate the piezoresistive properties. The fabricated strain sensor also exhibits good performance to detect bending deformation. The obtained maximum gauge factor of the GNR-base strain sensor was much larger than that of conventional semiconductor strain gauges. Finally, it was concluded that stable and low-cost fabrication process of the graphene-base transistor and strain gauge has been successfully developed by using the CVD process using acetylene gas.

Biography:

Hideo Miura received the B.S. degree in Electrical Engineering, the M.S. degree in Electronic Engineering, and PhD. in Mechanical Engineering from Tohoku University, Japan in 1981, 1983 and 1992, respectively. He joined Mechanical Engineering Research Laboratory, Hitachi ltd., Ibaraki, Japan in 1983. Since then, he had been engaged in research and development of technologies for mechanical reliability design of semiconductor devices such as 256 kb-256 Mb DRAM and 1 Mb-16 Mb SRAM, their packages, and testing methods for them. In February 2003, he moved to Tohoku University as a Professor of Graduate School of Engineering. He is now a Director and Professor of Fracture and Reliability Research Institute, Graduate School of Engineering, Tohoku University. His main research topic now is prediction and prevention of fracture of advanced functional materials and devices.

Madridge J Nanotechnol Nanosci. 2017
MJNN an open access journal

Nanotech-2017
April 3-5, 2017

Conference Proceedings

Page 14