Doped graphene for optoelectronic devices

Soo Young Kim[1], Ki Chang Kwon[2], Minjoon Park[1], Ho Won Jang[2]

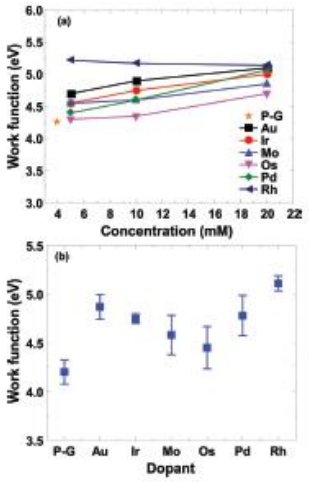
[1]School of Chemical Engineering and Materials Science, Chung-Ang University,
Seoul 156-756, Republic of Korea
[2]Department of Materials Science and Engineering, Research Institute of Advanced Materials,
Seoul National University, Seoul 151-744, Republic of Korea
sooyoungkim@cau.ac.kr

Abstract

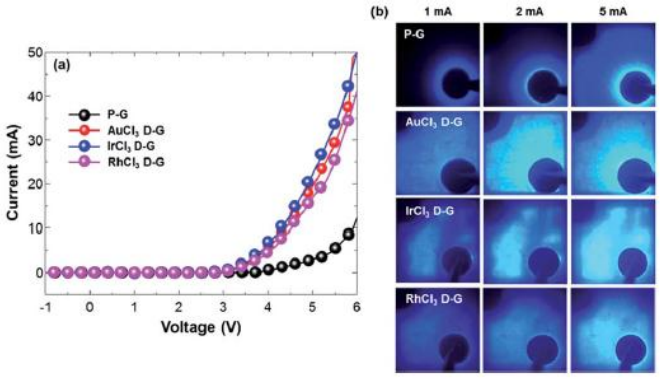
Graphene, a single layer of sp^2-bonded carbon atoms, has many unique physical properties such as excellent charge carriers, quantum hall effect, and good thermal and electrical conductivity. Because of its superior properties, graphene has been applied various electronic devices. The work-function determines the band alignment in the electronic applications for efficient hole and electron transport. Therefore, the work-function is one of important factors in the application of graphene electrode.

In this work, we demonstrated that graphene films synthesized by chemical vapor deposition method can be used as thin transparent electrodes with tunable work function. $AuCl_3$, $IrCl_3$, $MoCl_3$, $OsCl_3$, $PdCl_2$, and $RhCl_3$ were used as p-type dopant. Li_2CO_3, K_2CO_3, Rb_2CO_3, and Cs_2CO_3 were used as n-type dopant. The roles of cation and anion in these inorganic dopants were investigated. It is found that various organic materials with fluorine bonds could tune the work-function of graphene. The thermal degradation of doped graphene is pointed out as severe problems. In order to elongate the doped state, the role of graphene films as a barrier layer for protecting against the evaporation of chlorine on metal-chloride doped graphene with thermal annealing was also investigated. Atomic force microscope, scanning electron microscope, Raman spectroscopy, and x-ray photoelectron spectroscopy were also used to identify doped graphene surface structure. It seems that the dopant ions in doping solution were formed on the surface of graphene films by spontaneous reduction of metal ions. The possible doping mechanism of graphene with metal solution and its application to the devices such as light emitting diodes, organic light emitting diodes, liquid crystal displays, and organic photovoltaic cells will be discussed. Furthermore, method of reusing Cu substrate for the synthesis of graphene will be introduced.

Figures



(a) Work function variation as a function of each p-dopant with different concentrations. The work function increased with increasing dopant concentration. (b) Work function of graphene doped with 20 mM solution. UPS data were taken from different sample positions and the results were averaged.



(a) Device current–voltage characteristics of LEDs with four different electrodes. The pristine graphene (P-G), $AuCl_3$, $IrCl_3$, and $RhCl_3$ doped graphene (D-G) were used as electrodes. (b) The light emission images of LEDs. The image of IrCl3 D-G at an injection current of 5 mA is the brightest among all of the samples.