Novel Method of Graphene Flake Coating on Flexible Substrate to Reduce Sheet Resistance

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Abstract

Indium Tin Oxide (ITO) is one of the most widely used transparent conducting oxides because of its electrical conductivity and optical transparency. However, ITO is a ceramic material making production very expensive, brittle, prone to cracking and therefore of limited use on flexible substrates. In addition, indium is a well kwon metal diffusion material, which leads to a degradation of performance over time at Organic Light-Emitting Diode (OLED). Since graphene has superior high intrinsic mobility, high Young's modulus, thermal conductivity and high optical transmittance, it has attracted tremendous attention as a replacement material of ITO. Unfortunately, synthesis of graphene is limited to the surface of the catalyst. Thus using these graphene for flexible substrate require transfer step and give rise to low-yield and low-throughput.

In recent days, in order to obtain high-yield and high-throughput graphene, many researchers have studied about reduced Graphene Oxide (rGO), which has been reported as a promising synthesis method to address these issues. rGOs are usually obtained in large quantities by an oxidation and reduction process of graphite flakes. Firstly, graphite flakes are oxidized to graphite oxide (GO) by various oxidants. GOs are heavily decorated oxygen-containing group like −OH and >O functionality, which not only expand the interlayer spacing between graphite flakes but also weaken the van der Waals forces between layers. To restore nature of graphene properties, thermal and chemical reduction process have been followed. However, as a matter of fact, while rGOs could be easily realized on plastic substrate, due to the chemical and thermal annealing reduction process which imparts formation of unsaturated and conjugated carbon atoms, electrical conductivity is dramatically changed.

In this study, the graphene flakes solution was prepared in isopropyl alcohol by using sonicator and homogenizer without any surfactant to avoid mobility reduction and V_{dirac} shift. This novel effort meets all functional criteria for a manufacturing graphene films, as it is chemically and thermally inert due to the elimination of oxidation and reduction process, possible to apply TCFs. In order to form the uniform graphene films on PET substrate, we used spray-coating and roll-milling systems. By using spray coating, we could obtain uniformly distributed graphene flakes on the PET substrate but droplets activate and guide graphene flakes into folded structure. While graphene flakes with strong interlayer can form large structures, indivisual flakes could fold into a variety of 3-dimensional structures. Thus, we tried mechanical force along 2-dimensional direction and found that the individual graphene flakes turned into flat and inter-connected each other. Graphene flake film could get 20 % higher transparency and 98.1 % lower sheet resistance using by this novel method. Furthermore, surface uniformity and morphology of graphene flake film are improved during press-milling process, which are very important to electrical conductivity and device performance. As a result, we could discover the potential of graphene flake film as a replacement of ITO electrode.

References

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Figures

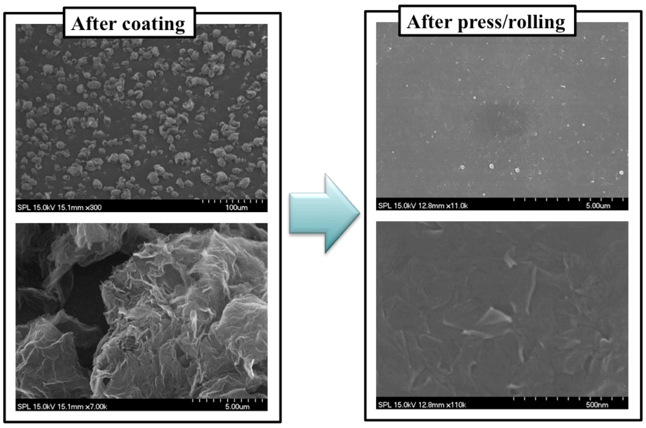
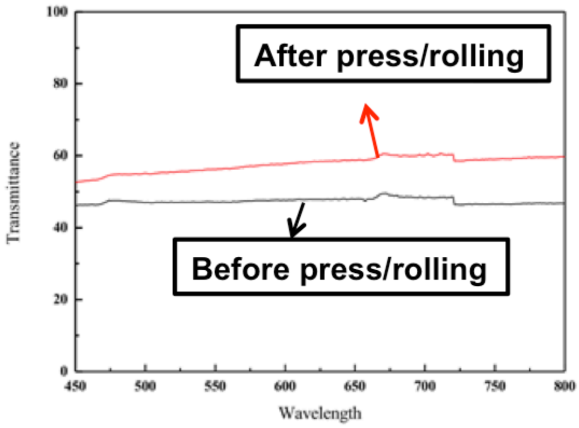


Figure 1. Uniformity and morphology improvement of graphene film after press/rolling process



Fugure 2. Press/rolling effect on transparency of graphene film