Graphene Transparent Conductive Films Toward Large Area Flexible Devices

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We review the development of synthesis technique of highly-electrically conductive graphene by plasma assisted chemical vapor deposition (CVD). The biggest problem of the plasma CVD of graphene is the crystal size of 10 nm or smaller, which inhibits the electrical conductivity and limits its Hall mobility to 10–100 cm^2/Vs.[1] Smaller domain sizes of graphene degrade its electrical properties, and ensuring a larger domain size is essential for improving the electrical conductivity of graphene films.

Plasma exposure enhances the decomposition of the carbon source gas such as methane and the activation by the catalyst, resulting in a high growth rate of the graphene. If the carbon concentration is high the nucleation density on the metal catalyst is increased, resulting in a smaller domain size. For plasma CVD, the carbon concentration should be much lower than that for thermal CVD. Decreasing the carbon concentration during the graphene synthesis, which is expected to suppress the nucleation density, is one way to expand the size of the graphene crystal and to improve the controllability of a few layers. We developed the synthesis method of graphene by plasma CVD with very low carbon-source concentrations to improve the crystalline quality and the electrical properties of graphene transparent conductive films.[2, 3]

Graphene with high electrical conductivity has been synthesized by using hydrogen plasma treatment of copper foils for 30 seconds at the temperature of 850°C together with joule-heating treatment of the foils without using a carbon-containing gas such as methane in order to suppress the nucleation density of graphene. The electrical conductivity has been significantly improved by this method. The sheet resistance of bilayer graphene exhibits 951 Ω in average. The carrier mobility shows 1000 cm^2/Vs in maximum at room temperature. The sheet resistance of 130±26 Ω has been attained after the doping by gold chloride solution as shown in fig.1.[2, 3] We have demonstrated flexible heater by using graphene transparent conductive films (fig.2).

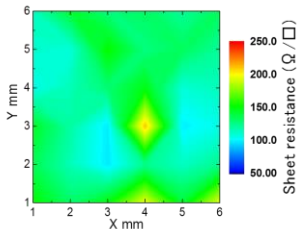

Fig. 1. Sheet resistance map of graphene film after wet doping by gold chloride.[1]

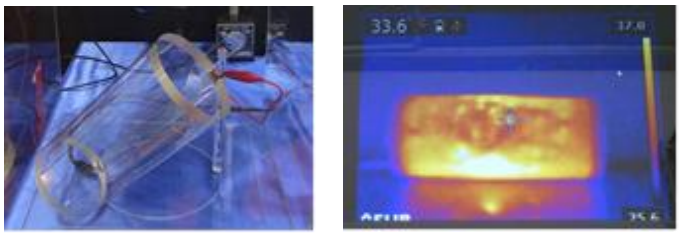

Fig. 2. Picture of fabricated curved graphene transparent heater (left), and thermography image of this heater (right).

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References

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