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Dielectrophoretic Decoration of Graphene Grain Boundaries

Abstract
Graphene has shown potential to revolutionize the area of transparent and flexible electronic devices. [1] One challenge that arises from its synthesis by chemical vapor deposition is the existence of polycrystallinity. [2-3] Previous studies showed that boundaries between grains deteriorate graphene's mechanical strength and chemical inertness. [4] More importantly, grain boundaries represent a region of high resistance which was found to impede electrical transport. [5-7] Therefore, a way is needed to improve the carrier transport through grain boundaries. Previous approaches selectively deposited metal particles on the grain boundaries using atomic layer deposition schemes [8] or selective chemical reactions. [9] These approaches can not be easily generalized to other deposition materials and require careful tuning of the reaction conditions.
In this work, we use silver nanoparticles to decorate graphene grain boundaries by in-plane dielectrophoresis (Figure 1(a)). Dielectrophoresis is an electrochemical technique where forces are exerted on nanoparticles due to their polarizability in an electrical field gradient. [10-11] Different from traditional dielectrophoresis, we apply a voltage across the graphene. Due to their higher resistance, grain boundaries will experience significant voltage drops. Therefore, conductive particles from solution are more attracted to these regions (Figure 1(b)). Real-time optical microscopy was employed to observe the selective deposition behavior of silver nanoparticles on large-area graphene. (Figure 1(c)) Atomic force microscopy, transmission electron microscope and scanning electron microscope, demonstrated that silver nanowires which are composed of highly crystalline nanoparticles grew only from a few distinct sites and deposited on the graphene grain boundaries. This simple and accurate approach provides selective decoration of defects rapidly, which can be the most effective method for improving the properties of graphene.

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Figures

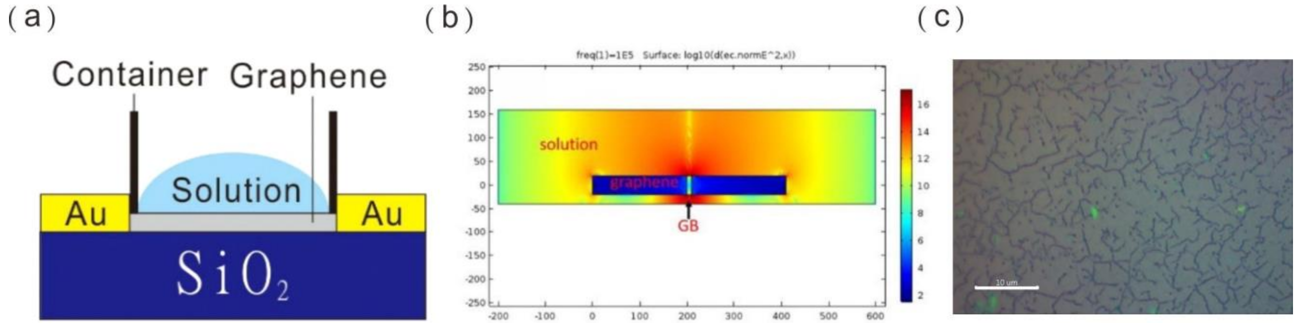

Figure 1: (a) illustration of Dielectrophoresis experimental method (b) field distribution map on graphene (FEM) (c) Optical images of the DEP selective depositon Ag nanoparticles