Grain Boundaries in Graphene: Control and Observations

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Abstract

The ability of synthesis graphene as large scale gives rise to use graphene as many applications e.g transparent flexible conducting electrode, transistors, optoelectronic… However, the quality of graphene is governed by many impacts from their intrinsic defects (grain boundaries, point defects, wrinkles, ripples…) to substrate interaction (charge puddles, lattice mismatch, interface interaction…). In this presentation, we will focus on the mechanism to form graphene grain boundaries (GGBs) that were observed both in SEM and Confocal Raman mapping. We observed that the graphene film is formed by stitching different graphene flakes. By oxidation of graphene flakes, GGBs inside individual flake are also observed by confocal raman mapping. The new method using optical microscopy is also introduced to probing GGBs. This imaging technique was realized by selectively oxidizing the underlying copper foil through the graphene grain boundaries using OH radicals generated by ultraviolet light irradiation under moisture-rich ambient conditions. This approach permitted the graphene grain boundaries that are distinguishable from the copper grain boundaries to be visualized using optical microscopy. We found that the sheet resistance of large-area graphene decreased as the extracted graphene grain sizes increased, but no strong correlation with the grain size of the copper was revealed, in contrast to previous reports. To control GGBs or graphene grain size, polishing and annealing copper foil at high temperature are performed to reduce number of nucleation seeds. Different polishing methods will be compared and the effects of annealing time and temperature will also be presented. Combination of polishing and high temperature annealing gives the best properties of graphene,

In the last part of this presentation, we will introduce a method to control number layers of graphene and their interaction in growth process using atmosphere chemical vapor deposition. The key control is the ratio of CH_4 and H_2 in the chamber. Two different growth modes were observed: i) Stranski–Krastanov in which a full monolayer of graphene is firstly formed following by multilayer islands on the top of monolayer, ii) Volmer–Weber (island) in which multilayer graphene islands are growth simultaneously. The later growth mode shows strong interactions while the former shows random stacking order with weak and strong interactions between layers. These are confirmed by Raman spectroscopy and TEM measurements. The uniform and large scale synthesis of strong interaction graphene layers promises a potential application for bilayer graphene where the gap can be opened up to 0.35 eV by electric field.

References

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Figures

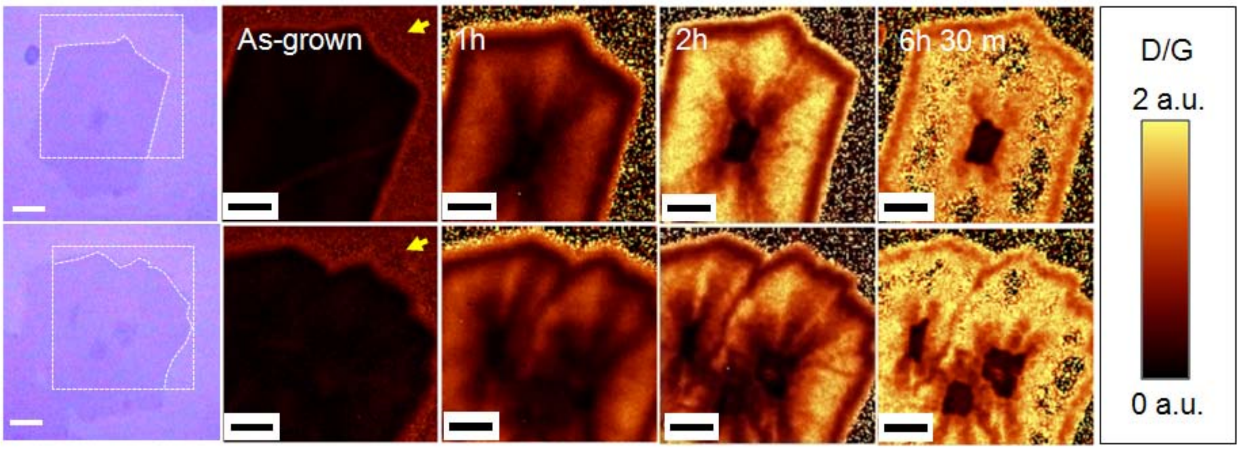

Figure 1: Evolution of different patterns on graphene flakes under different oxidation time [1].

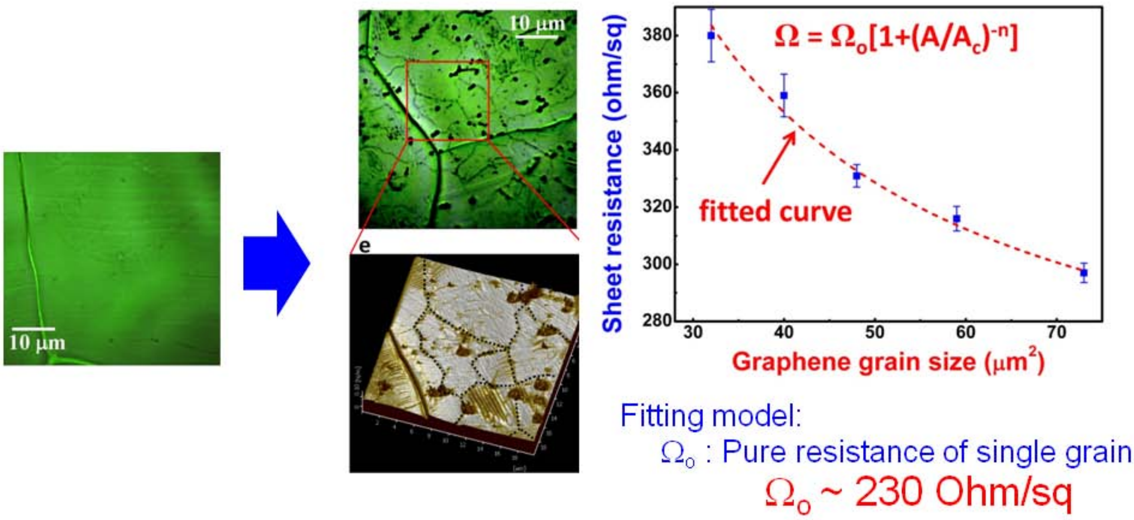

Figure 2: Observation of graphene grain boundaries by optical microscopy and their effect to sheet resistance [2].