A new knob in graphene CVD growth

Pierre L. Levesque[1], Saman Choubak[2], Carl-Bernard Charpin[1], Dhan Cardinal[2], Philippe Gagnon[2], Minh Nguyen[1], Patrick Desjardins[2], Richard Martel[1]

[1] Regroupement Québécois sur les Matériaux de Pointe (RQMP) and Département de Chimie, Université de Montréal, C.P. 6128, Succursale Centre-Ville, Montréal, Québec H3C 3J7, Canada

[2] Regroupement Québécois sur les Matériaux de Pointe (RQMP) and Département de Génie Physique, Polytechnique Montréal, Montréal, C.P. 6079, Succursale Centre-ville, Montréal, Québec H3C 3A7, Canada

p.levesque@umontreal.ca

Abstract

Several milestones have been achieved for the chemical vapor deposition (CVD) of graphene films on copper foils since it was first reported back in 2009 and the technology is now mature enough so companies are developing tools for mass productions. Still, continuous monolayer coverage of graphene on copper requires surprisingly long growth times and several inconsistencies remains to be elucidated in order to scale the production and reach the constancy and uniformity of the resulting material as required by the industry.

Our recent research revealed oxidizing impurities as a dominant factor governing the growth. For instance, oxygen impurities and not hydrogen, are responsible for graphene etching on copper and hydrogen have the protecting role of counter balancing oxidizing impurities reactions. When the level of oxidizing impurities are minimized, continuous layer of graphene can be grown in the sole presence of methane [1, 2]. The kinetics of the reactions have been addressed and revealed a competitive action between precursor oxidation and carbon growth during graphene formation in the CVD reactor. Based on our experimental evidences and the kinetic model developed, a criterion is found for the O_2/H_2 partial pressure ratio setting a limit between impurities limited growth and methane adsorption-dissociation limited growth. Most of the work to date, even using ultra-high purity (UHP) gases, are in the impurities limited growth regime. In this presentation, the adsorption-dissociation limited growth regime is explored in a series of growth experiments where the level of oxidizing impurities is strictly controlled. With this new control knob, the growth can be speeded up by a factor of x50 compared to recipes under UHP conditions without affecting graphene quality. The purified regime also allowed us to identify an origin of bilayer islands and gave us some insight on the copper surface quality effects on the resulting graphene morphology.

Studies in purified conditions allow the necessary fundamental knowledge to be gained in order to tailor the graphene growth and gives the consistency required in a manufacturing context. In addition, the growth method shown in this report is straightforward and very simple to implement in industrial manufacturing processes making graphene sheets mass production economically feasible.

References

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