The key to speed-up Graphene Chemical Vapor Deposition

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Abstract

Chemical vapor deposition (CVD) of graphene films on copper foils is the most studied growth method and it is widely employed to produce large high quality graphene sheets. Still, continuous monolayer coverage of graphene on copper requires surprisingly long growth times and several inconsistencies remains to be resolved to clearly establish the role of hydrogen within the growth.

In a series of growth experiments with a controlled level of oxidizing impurities, we first showed that oxygen impurities and not hydrogen, are responsible for graphene etching on copper. [1] We evidenced the protecting role of hydrogen against etching by oxidizing impurities and we demonstrated the growth of a full layer of graphene in the sole presence of methane when oxidizing impurities are minimized. [2] The kinetic of the reaction is further address and reveals the competitive action between precursors oxidation and carbon growth during graphene formation in LP-CVD reactor. From our results and with the aid of a simple kinetic model including oxidizing impurities, a criterion on the O_2 / H_2 partial pressures is found. This criterion sets a boundary between impurities limited growth and methane adsorption-dissociation limited growth.

With standard ultra-high purity gas, growth are in the impurities limited growth regime and 30 min. is required to complete a full layer. In the absence of oxidizing impurities, we demonstrate graphene formation on copper within 1 min with methane as a carbon source while maintaining graphene quality.

Oxidizing impurities and the growth regime in which graphene growths are realized have been overlooked to date. Our findings are certainly highlighted by their impact in speeding-up graphene growth and should also be considered in future attempts to tailor graphene growth and properties. Our method is totally fitted to large scale manufacturing of graphene films on copper, and will become unavoidable for a viable synthesis of graphene materials in an energy and cost saving manner.

References

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