**Non-catalytic chemical vapor deposition of nanocrystalline graphene on insulating and semi-conducting substrates**

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There are various ways of producing large-scale graphene, all resulting in different kinds of material suitable for different applications. Catalytic chemical vapor deposition (CVD) of graphene on Cu is the most common way to produce high-quality graphene for electronics [1]. It relies, however, on the successful transfer of graphene from metal catalyst to the desired, typically insulating or semi-conducting, substrate. This transfer is often related to issues with metal residues, adhesion problems, and holes in the graphene film. Hence, a transfer-free method of growing graphene is desirable.

We grow nanocrystalline graphene non-catalytically on practically any high-temperature compatible substrate. Hence, there is no transfer involved in the process. The main difference from CVD of graphene on Cu is the significantly higher partial pressure of carbon precursor gas, typically $C_2H_2$. At the growth temperature of 1000 °C, we grow similar graphene films on $Si_3N_4$, $SiO_2$, $HfO_2$, and GaN [2-5]. This process is not self-limiting, and the thickness of the film can be controlled form nominally monolayer to hundreds of nm by the process parameters.

The films are characterized by Raman spectroscopy, transmission electron microscopy, and electrical measurements. They exhibit very small crystal domains in the order of 10 nm and electrical mobility in the order of 10 $cm^2$/Vs. However, they also exhibit high mechanical strength, uniformity over optical length-scales, and show optical properties similar to pristine graphene.

Such properties make it a promising candidate for applications including transparent heaters, transparent conductives, and membranes [6-8]. Especially, we use it as a current spreading layer in GaN devices.

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