In-situ Characterization of Graphene Growth

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Chemical vapor deposition (CVD) is the most promising technique for scalable and economical mono- and few-layer graphene (M-/FLG) growth, a key requirement for future device applications. The current understanding of the M-/FLG growth processes, however, is very limited. Key questions remain open, such as what M-/FLG quality can be achieved with CVD, in particular, if for cost effectiveness sacrificial poly-crystalline metal films/foils and less stringent vacuum/CVD process conditions are used. We study M-/FLG CVD by complementary in situ probing under realistic process conditions with the aim of revealing the dominant growth mechanisms. Here we focus on time-resolved in-situ X-ray photoelectron spectroscopy and in-situ X-ray diffractometry of model polycrystalline Ni catalyst films [1,2]. We show that M-/FLG growth occurs during isothermal hydrocarbon exposure and is not limited to precipitation upon cooling. We show that growth is however also not limited to a pure surface process as we find significant dissolution of carbon into the bulk and sub-surface of the metallic Ni catalyst. A coherent growth model is established based on our insights from surface chemistry and structural evolution. Alloying Ni with Au is found to allow low temperature (<450ºC) CVD of predominantly monolayer (>74%) graphene films with an average D/G peak ratio of ~0.24 and domain sizes in excess of 220 μm^2 [1]. Au alloying drastically lowers the graphene nucleation density, allowing more uniform and controlled growth at CMOS compatible temperatures.

References

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