Monolayer Graphene Formation on Transition Metal Catalysts

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Abstract (Arial 10)

A key requirement to exploit graphene's unique properties in applications is the development of scalable and economic production techniques that are compatible with device production processes. Chemical vapor deposition (CVD) is the most promising and versatile method to achieve this large area production without compromising material quality. CVD of graphene has been demonstrated on a range of transition metal catalysts; [1,2] however further progress requires an improved understanding of the growth mechanisms and detailed role of the catalyst in determining the growth outcome.

We perform in-situ time- and depth- resolved X-ray photoelectron spectroscopy and X-ray diffraction on polycrystalline catalysts films (Co, Cu, Ni) during hydrocarbon exposures at temperatures between 500-1000°C, and subsequent cooling. [3,4,5] We thus show that graphene grows at temperature during hydrocarbon exposure on all of the studied metal catalysts, rather than by precipitation on cooling, and that C dissolution into the catalyst subsurface plays an important role. [3,4] Based on these results, we develop a generalized framework for graphene CVD growth on transition metal catalysts, which enables rational optimization of the growth process. On the basis of this, we perform a systematic study to show the growth of single layer graphene (SLG) on polycrystalline Co at relatively low temperatures (~700°C). Our findings provide insights for the correlation between thermodynamic and kinetic properties where the saturation of the catalyst plays a key role in growth results. [3,4] We thereby identify conditions under which monolayer graphene can be formed and experimentally demonstrate that for Co, Cu, and Ni catalyst foils monolayer graphene can be uniformly stabilized. [1] We emphasize that the finite carbon solubility of the catalyst is a key advantage, as it allows the catalyst bulk to act as a mediating carbon sink while optimized graphene growth occurs by only locally saturating the catalyst surface.[1]

The understanding developed in this study suggests that monolayer graphene can be grown on a wide range of transition metal catalyst, and even on alloys. [3] Our results provide important insights for engineering catalytic growth of graphene to control the material properties and tailor them according to application requirements.

References

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