Simultaneous growth of monolayer graphene on nickel-copper bimetallic layered catalyst

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Graphene, a layer of carbon arranged in sp^2-bonded carbon atoms arranged in a honeycomb structure, has become the main subject of research around the world since 2004 when a free-standing graphene was successfully exfoliated mechanically. The attractiveness of graphene lies in the remarkable electrical, mechanical, thermal and optical properties, enabling it to be potentially used in myriad applications. Chemical vapor deposition (CVD) is the most promising method to produce a wafer-scale graphene because it allows easier separation of graphene from the catalytic substrate. CVD is widely known to involve in the decomposition of a carbon feedstock with the aid of heat and metal catalysts. Ni and Cu are two most widely studied catalysts due to moderate and low carbon solubility, respectively. However, both Ni and Cu require different extreme conditions to grow monolayer graphene. Our research work has shown that monolayer graphene could be grown simultaneously on polycrystalline Ni and Cu foils by Ni-Cu bilayer catalyst under single atmospheric CVD process. High uniformity and quality of the monolayer structure of graphene was evidenced by Raman spectroscopy mapping and High resolution transmission electron microscope (HRTEM). Our straightforward bimetallic catalyst allows the control of carbon diffusion to the area between Ni and Cu surfaces. In particular, carbon access is reduced to the inner Ni surface, while Cu behaving as a carbon barrier. The growth mechanism of monolayer graphene facilitated by carbon diffusion through the bulk and Ni grain boundary, in which the driving force comes from the concentration gradient of carbon-rich surface to carbon-lacked surface. The results show that free-standing high-quality monolayer garphene can be synthesized in a controlled and simple way with an affordable catalyst system.