Novel Synthesis and Nanocharacterization of Graphene and Related 2D Nanomaterials Formed by Surface Segregation

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Nanosheets of graphene and related 2D materials have attracted much attention due to excellent physical, chemical and mechanical properties. Single-layer graphene (SLG) was first synthesized by Blakely et al in 1974 [1]. Following his achievements, we initiated the growth and characterization of graphene and h-BN on metal substrates using surface segregation and precipitation in 1980s [2,3]. There are three important steps for nanosheet growth; surface segregation of dopants, surface reaction for monolayer phase, and subsequent 3-D growth (surface precipitation). Surface phase transition was clearly demonstrated on C-doped Ni(111) by in situ XPS at elevated temperatures [4]. The growth mode was clarified by inelastic background analysis [5]. The surface segregation approach has been applied to C-doped Pt(111) and Pd(111), and controllable growth of SLG has been demonstrated successfully [6]. Recently we proposed a promising method for producing SLG fully covering an entire substrate using Ni films deposited on graphite substrates [7]. A universal method for layer counting has been proposed [8]. In this paper, we will focus on the effect of competitive surface-site occupation between carbon and other surface-active impurities on the graphene growth. It is known that S is a typical impurity of metals and the most surface-active element. The surface sites shall be occupied by S through surface segregation. In the case of Ni(110), it is confirmed by AES and STM that the available surface sites is nearly occupied by S with a centered 2×2 arrangement. When Ni(110) is doped with C, surface segregation of C may be interfered by surface active elements like S. In this case, nanoscopic characterization has discovered a preferred directional growth of SLG, exhibiting a square-like shape (Fig. 1). Also the detailed characterization methodologies for graphene and h-BN nanosheets, including AFM, STM, KPFM, AES, HIM and XPS shall be discussed.

References
7) M.S. Xu et al, ACS Nano 5, 1522 (2011)
8) M.S. Xu et al, Nanoscale 3, 2854 (2011)

Fig. 1 Helium ion microscopy image of rectangular-shaped singlelayer graphene formed on C-doped Ni(110).

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