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Towards the Rapid Synthesis of High-Quality Monolayer Continuous Film of Graphene on High Surface Free Energy Existing Plasma Modified Cu Foil

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Abstract : Graphene is an extraordinary 2D material that shows superior electrical, optical, and mechanical properties for the applications such as transparent contacts. Further, chemical vapor deposition (CVD) technique facilitates to synthesizing of large-area graphene, including transferability. The abstract is describing the use of high surface free energy (SFE) and nano-scale high-density surface kinks (rough) existing Cu foil for CVD graphene growth, which is an opposite approach to modern use of catalytic surfaces for high-quality graphene growth, but the controllable rough morphological nature opens new era to fast synthesis (less than the 50s with a short annealing process) of graphene as a continuous film over conventional longer process (30 min growth). The experiments were shown that high SFE condition and surface kinks on Cu(100) crystal plane existing Cu catalytic surface facilitated to synthesize graphene with high monolayer and continuous nature because it can influence the adsorption of C species with high concentration and which can be facilitated by faster nucleation and growth of graphene. The fast nucleation and growth are lowering the diffusion of C atoms to Cu-graphene interface, which is resulting in no or negligible formation of bilayer patches. High energy (500W) Ar plasma treatment (inductively Coupled plasma) was facilitated to form rough and high SFE existing (54.92 mJm-2) Cu foil. This surface was used to grow the graphene by using CVD technique at 1000C for 50s. The introduced kink-like high SFE existing point on Cu(100) crystal plane facilitated to faster nucleation of graphene with a high monolayer ratio (I2D/IG is 2.42) compared to another different kind of smooth morphological and low SFE existing Cu surfaces such as Smoother surface, which is prepared by the redeposit of Cu evaporating atoms during the annealing (RRMS is 13.3nm). Even high SFE condition was favorable to synthesize graphene with monolayer and continuous nature; It fails to maintain clean (surface contains amorphous C clusters) and defect-free condition (ID/IG is 0.46) because of high SFE of Cu foil at the graphene growth stage. A post annealing process was used to heal and overcome previously mentioned problems. Different CVD atmospheres such as CH4 and H2 were used, and it was observed that there is a negligible change in graphene nature (number of layers and continuous condition) but it was observed that there is a significant difference in graphene quality because the ID/IG ratio of the graphene was reduced to 0.21 after the post-annealing with H2 gas. Addition to the change of graphene defectiveness the FE-SEM images show there was a reduction of C cluster contamination of the surface. High SFE conditions are favorable to form graphene as a monolayer and continuous film, but it fails to provide defect-free graphene. Further, plasma modified high SFE existing surface can be used to synthesize graphene within 50s, and a post annealing process can be used to reduce the defectiveness.

Keywords : chemical vapor deposition, graphene, morphology, plasma, surface free energy
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