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Controlled Growth and Field Emission Properties of Plasma-Grown Graphene Sheet via Nitrogen Doping: A Theoretical Study

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Graphene, the two-dimensional monolayer of sp2 hybridized carbon atoms characterized by its nanoscale thickness, high aspect ratio, and exceptional electrical and thermal conductivities is considered to be a potential candidate for field emission devices. The presence of sharp edges renders graphene to be superior for electron emission as compared with other carbon nanostructures. In order to enhance or control the electron emission characteristics of graphene, doping is considered as one of the most feasible technique. Amongst various potential dopants, nitrogen is the most popular dopant of the carbon nanomaterials as it has similar atomic radii as that of carbon. Plasma enhanced chemical vapor deposition (PECVD) is considered as the most viable technique for the synthesis of nitrogen doped graphene as it exhibits better control over the GS structure at relatively low temperatures and also offers the advantage of graphene structure modification by nitrogen plasma treatment.

The effect of nitrogen doping on the plasma-assisted growth and field emission properties have been investigated through a theoretical model that incorporates the charging rate of the graphene sheet; number density of all the plasma species, i.e., electrons, positively charged ions, and neutral atoms including the nitrogen doping species; and the growth of the graphene nuclei and graphene sheet. The numerical calculations have been carried out for typically glow discharge plasma parameters and it is found from our study that nitrogen doping strongly affects the dimensions of the graphene sheet. It is found that the thickness and height of the graphene sheet decreases upon nitrogen doping. This is due to the fact that carbon species available for growth of the graphene sheet decreases upon nitrogen doping [1,2].

Field emission current density is primarily characterized by the field enhancement factor β that specifies the amplification of electric field at the tip of the emitters and is mainly dependent on the geometry of the emitter. In the case of graphene sheet β (≈ h/t, where h is the height and t is the thickness of the graphene sheet) [3].The geometry of the graphene sheet changes during the growth with the effect of doping, and henceforth the field enhancement factor β gets consequently affected. The field emission characteristics of the nitrogen doped as well as of the pristine (undoped) graphene sheet have been estimated and it is found that the field enhancement factor β of the nitrogen doped graphene sheet is higher than the undoped graphene sheet. Some of the results of the present investigation are in accordance with the existing experimental observations [4].The results of the present investigation can thus serve as a major tool for efficient fabrication of graphene-based field emitters.

References

[1] Seo D H, Kumar S, Rider A K, Han Z, and Ostrikov K, Deterministic control of structural and optical properties of plasma-grown vertical graphene nanosheet networks via nitrogen gas variation, Opt. Mat. Express (2012) **2**, 700

[2] Koos A A, Murdock A T, Incze P N, Nicholls R J, Pollard A J, Spencer S J, Shard A G, Roy D, Biro L P, and Grobert N, Effect of temperature and ammonia flow rate on the chemical vapour deposition growth of nitrogen-doped graphene, Phys. Chem. Chem. Phys. (2014) **16**, 19446

[3] Miller R, Lau Y Y, Booske J H, Electric field distribution on knife-edge field emitters, Appl. Phys. Lett. (2007) **91**, 074105

[4] Takeuchi W, Kondo H, Obayashi T, Hiramatsu M, And Hori M, Electron field emission enhancement of carbon nanowalls by plasma surface nitridation, Appl. Phys. Lett. (2011) **98**, 123107

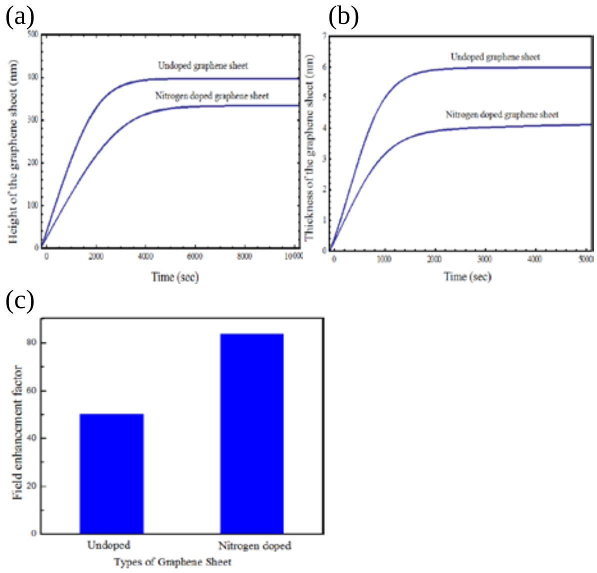

Figure 1 (a) Time evolution of the height of undoped and nitrogen doped graphene sheet, (b) Time evolution of the thickness of undoped and nitrogen doped graphene sheet, and (c) Field enhancement factor of undoped and nitrogen doped graphene sheet