Synthesis of *h*-BN nanodots embedded-graphene hybrid films by atmospheric pressure CVD.

Boitumelo Matsoso,[a] Bridget Mutuma[a, b], Kamala Ranganathan[a,b], Tsenolo Lerotholi[a], Glenn Jones[c], and Neil J. Coville[a, b]

[a] School of Chemistry, University of the Witwatersrand, Johannesburg, 2050, South Africa.
[b]DST-NRF Centre of Strong Materials and the Molecular Sciences Institute, University of the Witwatersrand, Johannesburg, South Africa, 2193.
[c]Johnson Matthey Research Pty (Ltd), Building 22, CSIR Campus, Pretoria, South Africa.
Email: Boitumelo.matsoso@students.wits.ac.za.

Keywords: *h*-BN nanodots, graphene, APCVD, B-source distance.

The thermal catalytic atmospheric pressure chemical vapour deposition (APCVD) technique was used for the synthesis of *h*-BN nanodots embedded-graphene hybrid films on a Cu foil from methane, ammonia, and boric acid. The APCVD technique was employed due to its successful application in making large-area graphene, *h*-BN films, and BN-doped graphene films [1, 2, 3]. To grow *h*-BN nanodots embedded- graphene films, the first step involves treatment of the Cu foil at 1000 ^{o}C in hydrogen and argon atmospheres by placing the B-source at 2 cm (300 ^{o}C) and 12 cm (1000 ^{o}C) distances from Cu foil placed at the centre of the quartz-furnace (the hot zone). In the second step, specific amounts of methane and ammonia were introduced for 10 min. The as-synthesized films were characterized by X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, atomic force microscopy (AFM), high resolution transmission electron microscopy (HRTEM), and UV-vis spectroscopy. AFM and TEM images (figs 1 and 2) revealed an increased *h*-BN nanodots size distribution (~224.7 nm and ~11.8 nm for 2 cm and 12 cm, respectively) with an increased distance between the B-source and the Cu foil. The presence of B, C, and N atoms in their respective chemical environments were detected by XPS. It was found that most of the B atoms were bonded to N atoms than bonded to both C and N atoms to give sp^2-B-C-N chemical bonding configurations. The C atomic composition was found to increase (42 at%- 65 at %) while both B and N contents were found to decrease (18 at% B and 14 at % N to 8 at % B and 7 at % N) with increased distance of the B-source from the Cu foil. These results indicated that the position of the B-source plays a significant role in controlling the nucleation of nanodots in the form of B_2O_3, which then led to the formation *h*-BN nanodots upon reaction with ammonia. UV-vis absorption spectra (fig 3) showed higher band gap energy for the smaller nanodots (5.77 eV) in comparison with the big nanodots (5.71 eV) due to a quantum confinement effect. In conclusion, the study provides insight into for the controlled growth of *h*-BN nanodots embedded-graphene systems by the APCVD method.

References

[1] Reina, A., Jia, X., Ho, J., Nezich, D., Son, H., Bulovic, V., Dresselhaus, M.S., and Kong, J. *Nano Lett.* **9**, (2009) 30-35.

[2] Ajayan, P.M., Lijie, C., Li, S., Chuanhon, J., Deep, J., Dangxin, W., *et.al. Nature Mater.* **9,** (2010) 430-435.

[3] Bepete, G., Voiry, D., Chhowalla, M., Chiguvare, Z., and Coville, N.J. *Nanoscale*, (2013) **5**, 6552–6557.

Figures

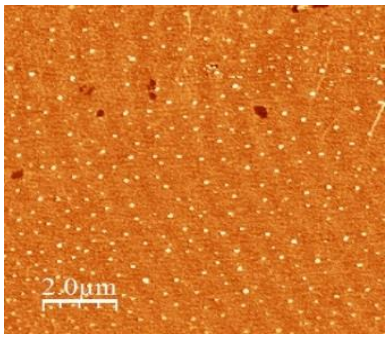

Fig1: AFM image of *h*-BN-graphene film

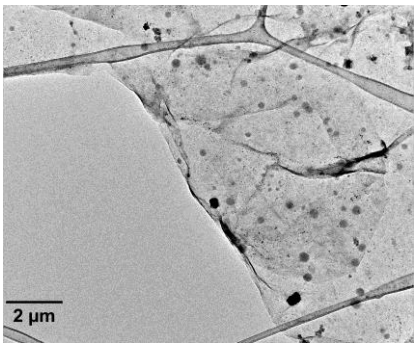

Fig 2: TEM image of *h*-BN-graphene film

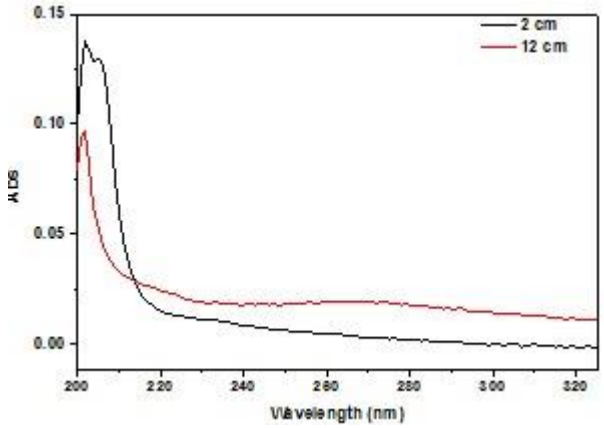

Fig1: UV-vis absorption spectra of *h*-BN nanodots-embedded-graphene film