Stacking of Van der Waals Hetero-Structures

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Primary CNF Tools Used: SC4500 even hour evaporator, wire bonder, Oxford 81 etcher

Abstract:

We demonstrate the transfer of Van der Waals (vdW) hetero-structure stacks composed of hexagonal boron nitride (hBN) and graphene (Gr). The stacks were fabricated to study their optical absorption.

Summary of Research:

The ability to layer two dimensional vdW solids has proven to have wide reaching applications due to the ability to tune material properties by intercalating different layers [1]. Recent theoretical results have demonstrated that encapsulating Gr layers in hBN would lead to out of plane interactions that may change the bandgap of Gr [2], lead to ballistic electron transport [3] and have interesting optical properties [4]. For this study we are interested in the optical absorption characteristics of monolayer and bilayer Gr encapsulated between hBN.

The monolayers of Gr and hBN used in this study were CVD grown on Cu foils.

A wet transfer scheme, as shown in Figure 1, was used to transfer the monolayers from the Cu foil onto the target substrate, which in in this case was hBN/Cu. The same transfer process was used for both hBN and Gr transfer. A prototypical stack consisted of four hBN layer followed by one or two Gr layers followed by four hBN layers. A gold pad was then evaporated onto the final stack (9-10 layers) using a CVC SC4500 evaporator, this pad was used as a top contact and the bottom contact was the original Cu substrate. Figure 2a shows a depiction of the final stack.

The constructed vdW stacks are currently under testing in order to determine their optical absorption properties and understand the influence of the layering order on the response.

References:

[1] W. Aggoune, C. Cocchi, D. Nabok, K. Rezouali, M. A. Belkhir and C. Draxl, "Enhanced light matter interaction in Graphene-hBN van der Waals heterostructures," The Journal of Physical Chemistry, vol. 8, pp. 1464-1471, 2017.

[2] A. K. Geim and I. V. Grigorieva, "Van der Waals heterostructures," Nature, vol. 499, pp. 419-425, 2013.

[3] G. Giovannetti, et al. "Substrate-induced band gap in graphene on hexagonal boron nitride: Ab initio density functional calculations," Physical Review B, vol. 76, p. 073103, 2007.

[4] A. S. Mayorov, R. V. Gorbachev, et al. "Micrometer-scale ballistic transport in encapsulated graphene at room temperature," Nanoletters, vol. 11, pp. 2396-2399, 2011.

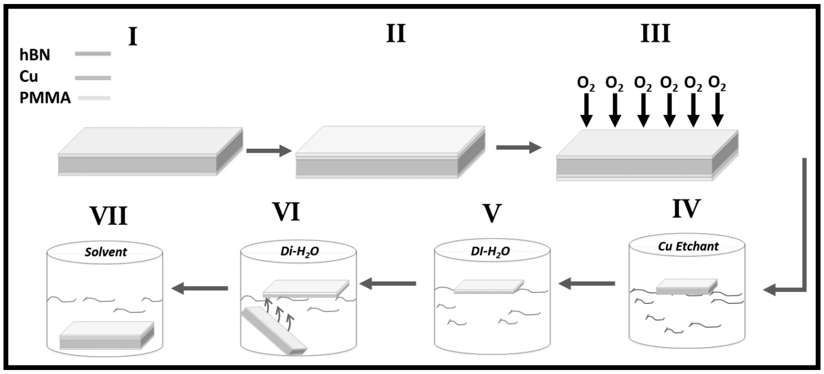

Figure 1: Depiction of wet transfer process used to fabricate the vdW stacks. (I) Original CVD grown hBN on Cu (II) 5.5% PMMA in anisole was spun onto one side of the monolayer in (I). (III) The back side of the hBN/Cu was etched under an O_2 plasma using the Oxford 81 plasma etcher to remove the hBN on this side. (IV) The PMMA/hBN/Cu stack was floated in Cu etchant CE-100 from Transene Inc. (V) Once the Cuw as visibly removed in the prior step the remaining PMMA/hBN stack was then transferred to a DI-water container to remove particulates left over from the Cu etching step. (VI) the floating PMMA/hBN stack was scoped-up onto the target substrate and left to dry. (VII) The scoped-up substrate from step (VI) was left in solvent (1165) over night to remove the remaining PMMA layer.

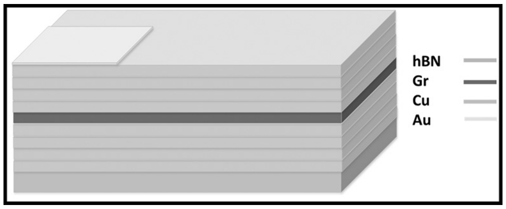

Figure 2: A depiction of the final fabricated vdW stack with a top Au contact and bottom Cu contact.

Materials