Contribution (Oral/Poster/Keynote)

Graphene/piezoelectric hybrid for Coulomb drag of graphene bilayer system

Dinh-Loc Duong, Young Hee Lee

Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS), Sungkyunkwan University,Suwon 446-746, Korea
ddloc@skku.edu

Excitonic superfluid and Bose-Einstein condensation are expected to occur at higher temperature compared to atomic system due to their low effective mass [1,2,3]. However, excitonic system is unequilibrium and has a short lifetime. The indirect excitonic system which consists of 2 layers insulated by an ultrathin insulator between them to prevent the recombination of electron-hole pair is, therefore, proposed to overcome this issue. The challenges of this approach is how to fabricate the device with an ultrathin insulator thin enough to maintain the interaction between two layers but thick enough to avoid tunneling phenomena.

The explosion of 2D materials opens new opportunities for making devices with well-controlled thickness. Although room temperature excitonic superfluid of graphene bilayer system is still debated from theoretical prediction [4,5], a system of combination between graphene/BN/graphene is ideal structure for indirect excitonic study. However, no evidence of experiments are observed [6,7]. Using both top and bottom gate reduces interaction of carrier between two layer. Therefore, new device designs are required.

In this presentation, we proposed a combination between Graphene/Piezo-electric-layer/Graphene for excitonic study. Hole and electron on two graphene layers are generated by the strong dipole of piezoelectric layer was simulated by density functional theoretical calculation [8,9]. This hybrid structure was also realized by experiments with PVDF thin layer made by Langmuir-Blodgett method. The simulation by is consistent with experimental results from Raman spectroscopy with doping concentration up to 10^{13} cm^{-2}. Our study opens a new design for studying bilayer system not only for graphene but also for another two dimensional materials.

References

[1] Eisenstein, J. P. & MacDonald, A. H. Bose–Einstein condensation of excitons in bilayer electron systems. *Nature* **432**, (2004), 691–694.
[2] Lecture from Prof. Leonid Butov.
[3] David W. Snoke. Dipole excitons in coupled quantum wells: toward anequilibrium exciton condensate. arXiv:1208.1213v1.
[4] Min, H., Bistritzer, R., Su, J. J. & MacDonald, A. H. Room-temperature superfluidity in graphene bilayers. *Phys. Rev. B* **78**, (2008) 121401.
[5] Kharitonov, M. Y. & Efetov, K. B. Excitonic condensation in a double-layer graphene system. Semicond. Sci. Technol. 25, (2010) 034004.
[6] R. V. Gorbachev *et. al.* Strong Coulomb drag and broken symmetry in double-layer graphene. *Nature Physics* **8**, (2012) 896–901.
[7] Kim, S. *et al.* Coulomb drag of massless fermions in graphene. *Phys. Rev. B* **83**, (2011) 161401.
[8] Dinh Loc Duong *et. al.* Band-gap engineering in chemically conjugated bilayer graphene: Ab initio calculations. Phys. Rev. B 85, (2012) 205413.
[9] Dinh Loc Duong *et. al.* Graphene/piezoelectric hybrid. In preparation.