Formation and Control of Bandgap in Graphene by Doping Slow Alkali-Metal Ions

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Abstract

Despite its superb electronic properties over other materials, graphene still remains as a tantalizing candidate to be actively utilized in electronic applications mainly because of its linear gapless band spectrum. Since the massless Dirac fermions in graphene showing ballistic charge transport even at room temperature are ideal charge carriers for fast circuit devices, extensive research efforts have been made to open a tunable bandgap in graphene with several different schemes. In this talk, some previous schemes to open a bandgap in graphene will be quickly reviewed. We then introduce a new scheme of forming and fine-tuning a bandgap for a range suitable for most applications by using slow alkali metal ions. We also demonstrate the on-off switching capability by controlling the size and mid-gap energy (or Dirac point) of the bandgap independently by adding other neutral atoms. Our density-functional theory calculations for the π-band suggest that the sublattice asymmetry enhanced by the doped ions drives the behavior of the ion-induced bandgap in graphene.

References

[1] C. Berger, Z. Song, X. Li, X. Wu, N. Brown, C. Naud, D. Mayou, T. Li, J. Hass, A. N. Marchenkov, E. H. Conrad, P. N. First, W. A. de Heer, *Science*, *312*, (2006) 1191.
[2] M. Y. Han, B. Özyilmaz, Y. Zhang, P. Kim, *Phys. Rev. Lett.*, *98*, (2007) 206805.
[3] T. Ohta, A. Bostwick, T. Seyller, K. Horn, E. Rotenberg, *Science*, *313*, (2006) 951.
[4] Y. Zhang, T. Tang, C. Girit, Z. Hao, M. Martin, A. Zettle, M. F. Crommie, Y. Shen, F. Wang, *Nature*, *459*, (2009) 820.
[5] S. Niyogi, E. Bekyarova, M. E. Itkis, H. Zhang, K. Shepperd, J. Hicks, M. Sprinkle, C. Berger, C. N. Lau, W. A. de Heer, E. H. Conrad, R. C. Haddon, *Nano Lett.*, *10*, (2010) 4061.
[6] A. *J.* Grüneis, *Phys.*: *Condens. Matter*, *25*, (2013) 043001.
[7] S. J. Sung, P. R. Lee, J. G. Kim, M. T. Ryu, H. M. Park, J. W. Chung, *Appl. Phys. Lett.*, *105*, (2014) 081605.

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