Citation of the 2014 (the 2nd) Nishina Asia Award

"The elucidation of electronic properties of monolayer and bilayer graphene"

by Professor ZHANG, Yuanbo

Graphite consists of a stack of honeycomb lattice sheets of carbon and constitutes a quasi-two-dimensional semimetal containing low density electrons and holes. A single atomic layer of graphite, called graphene, is a unique two-dimensional (2D) system in which massless Dirac electrons obeying the relativistic Dirac equation are realized. Andre Geim and Konstantin Novoselov succeeded in making micrometer-size graphene samples, by rubbing graphite flakes onto oxidized silicon substrates, and measuring their unique electronic properties. Geim and Novoselov were awarded Nobel Prize in Physics for their accomplishment.

Yuanbo Zhang, who was a graduate student in Professor Philip Kim's group at Colombia University at that time, vigorously worked on graphene. The paper [1] reporting the quantum Hall effect (QHE) in graphene was published in the same issue of Nature as another paper by Novoselov and Geim reporting essentially the same result. This paper beautifully elucidated a peculiar QHE characteristic of Dirac electrons in monolayer graphene that fundamentally differed from the ordinary QHE observed in standard 2D electron systems such as those in GaAs/AlGaAs heterostructures. This monumental paper, cited more than 5000 times, is established as one of the "classics" in graphene research.

After getting PhD, Dr. Zhang joined Professor Zettl's group at University of California, Berkeley as a postdoc and extended his research on graphene. Electrons in bilayer graphene, unlike monolayer graphene, have non-zero mass. It was theoretically predicted that the energy gap of bilayer graphene vanishes for the case of symmetric bilayer, while a layer asymmetry opens up a gap. Dr. Zhang verified that the band gap of bilayer graphene can be changed over a wide range by an electric field applied normal to the layer and demonstrated the potential application of the bilayer system as a tunable detector in the infrared range [2]. He also studied local electronic state of monolayer graphene using STM, and has shown that the spatial charge fluctuation, which influences the scattering of Dirac electrons, originates from charged impurities [3].

Besides these representative accomplishments, Dr. Zhang has coauthored a number of papers which have been cited hundreds of times. His immense contribution to the graphene research deserves the Nishina Asia Award.

In 2010, Dr. Zhang was appointed to professorship at the Physics Department, Fudan University, and started to set up his own research group in active pursuit of novel atomic layer systems. Prof. Zhang is now producing steady research outputs, including recent results of atomic layer black phosphor system, and has a highly promising future.

References

1. Y.Zhang, Y.-W.Tan. H.L.Stormer, P.Kim, "Experimental Observation of Quantum Hall Effect and Berry's Phase in Graphene", Nature 438, 201 (2005).

2. Y.Zhang, T.-T. Tang, C. Girit, Z. Hao, M.C. Martin, A. Zettl, M.F. Crommie, Y.R. Shen and F. Wang, "Direct Observation of a Widely tunable Bandgap in Bilayer Graphene". Nature 459, 820 (2009).

3. Y.Zhang, V.W. Brar, C.Girit, A. Zettl and M.F. Crommie, "Origin of Spatial Charge Inhomogeneity in Graphene" Nature Physics 5, 722-726 (2009).