Postdoctoral Fellowship Highlight

Keun Su Kim, Ph.D., Physics

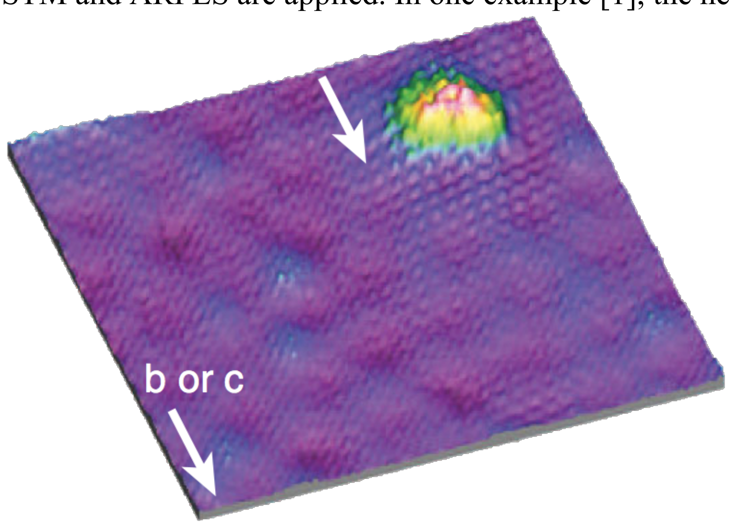
Years of Fellowship: 2011-present
Collaborating Institutions: Fritz Haber Institute, Berlin, Yonsei University, Korea
Currently: ALS

Project: **Exploring the complementary aspects of STM and ARPES**

Angle resolved photoemission spectroscopy (ARPES) is the foremost technique for determining the electronic properties at the length scales of interest in correlated materials. However, much can be learned from complementary tools such as scanning tunneling microscopy (STM), which probe the electronic properties on extremely short length scales. The powerful combination of spectroscopy and microscopy will be an essential ingredient for future studies in mesoscale physics, and therefore the ALS has been exploring the possibility of adding an STM to the MAESTRO beamline.

Keun Su Kim has visited the ALS in a collaboration between Yonsei University (Prof. H. W. Yeom) and Fritz Haber Institute (Prof. K. Horn) with the goal of exploring the complementary aspects of STM and ARPES, in pursuit of a future proposal to add STM capability to the ALS.

Bilayer graphene is an ideal example of how defects can operate at multiple length scales to affect the electronic structure of materials, a complete picture of which emerges when a combination of STM and ARPES are applied. In one example [1], the negative differential resistance (NDR) effect is shown to operate on the atomic scale in bilayer graphene for the first time. Images selected to emphasize this effect prove to be an incredibly sensitive tool to study symmetry-breaking modulations of the electronic structure induced by atomic scale defects. These effects propagate extremely far from the defect site.



STM image of bilayer graphene on SiC, showing modulation of the electronic structure due to defects and substrate lattice mismatch appearing at multiple length scales. From [1].

In ongoing studies, Keun Su has discovered that an even longer-ranging effect on the electronic structure can be observed, related to a subtle misalignment of the two sheets in bilayer graphene, leading to the novel Fermi surface topology indicated by the predicted spectral functions of bilayer graphene [2]. The appearance of these bands, which occur because of modulations in the electronic structure at the ~100 nm length scale, also induce tunneling features at the atomic scale, which can be seen in the STM.

While the STM measurements were conducted in Korea, these experiments provide ample justification of the kinds of experiments that could be made far more accessible if an STM were located at the ALS. A proposal to build an STM at the ALS will be an outcome of the research.

[1] Kim, K. S. et al. Visualizing Atomic-Scale Negative Differential Resistance in Bilayer Graphene. Physical Review Letters 110, 036804 (2013).

[2] Kim, K. S. et al, submitted to Nature Physics (2013).