

Abstract Submitted  
for the MAR12 Meeting of  
The American Physical Society

**Image potential states of Graphene/Ru(0001) interface**  
SHENGMIN ZHANG, XUEFENG CUI, LEIMING WANG, HRVOJE PETEK, Department of Physics and Astronomy, University of Pittsburgh, LABORATORY OF ULTRAFAST DYNAMICS TEAM — Graphene, the parent of all graphitic forms, has become one of the most exciting topics in condensed matter physics. It is now well understood that the low-energy electronic properties of graphene are described by two-dimensional Dirac equation for massless particles, but the unoccupied bands are hardly unexplored in experimental research. In this talk we will present new results on the unoccupied electronic structure, namely the image potential states (IPS), measured by two-photon photoemission spectroscopy (2PPS). The single layer graphene is prepared by thermal decomposition of ethylene on a Ru(0001) surface. Through low energy electron diffraction (LEED) and 2PPS, we verify formation of high-quality, single layer thick graphene samples. Based on the graphene/Ru(0001) system, we first measured the surface structure and IPS on Ru(0001) by angle-resolved 2PP. From the angle-resolved spectra, we obtain the effective mass  $m_{eff} = 1.1m_e$ , which is close to the expected value for a free electron state of  $m_{eff} = 1m_e$ . With the same method, we measured the IPS on the graphene/Ru(0001) surface. However, we observe complex structure consisting of two nearly degenerate states that reflect the mutual interactions between graphene and Ru(0001) substrate.

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Date submitted: 11 Nov 2011

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