Doppler broadening spectra from multilayer graphene on copper

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We present the Doppler broadening spectra measured from six to eight layers of graphene on Cu using an advanced positron beam system developed at the University of Texas at Arlington. Sample surface may be considered as a large defect and hence the gamma spectrum originating from the annihilation of surface trapped positrons may be different from the gamma spectrum originating from the annihilation of positrons from a defect-free bulk of the same sample. This may make it difficult to analyze and deduce the chemical architecture of the sample surface from the surface annihilation line shape as most of the calculated and experimental spectra in literature [1] are from bulk samples. Therefore, a systematic investigation of the Doppler spectrum from surface state annihilations is warranted. In order to obtain positron annihilation almost exclusively from the surface, experiments were performed using low energy positrons (~2.0 eV). It has been shown previously [2] that, at these low energies, positrons trap and annihilate in the surface state of the sample which in this case is graphene. The ratio of the Doppler broadened gamma spectrum collected at a positron beam energy of 2 eV (surface) to that collected at 20 keV (mainly bulk Cu) (Fig.1 (a)) was compared to a theoretically calculated ratio curve obtained by taking a ratio of the calculated Doppler spectrum for the bulk graphitic Carbon to the calculated Doppler spectrum for bulk Cu (Fig. 1(b)). The experimental ratio curve is different from the theoretical ratio especially at low momentums. However, there is an agreement in the high momentum region (> 0.015 m_0c), which shows that surface annihilations can be used to deduce chemical information from the top most atomic layer. We will discuss the above results by comparing the shape of the experimental ratio curve to the theoretical ratio curve obtained for individual electron orbitals of bulk graphitic carbon.

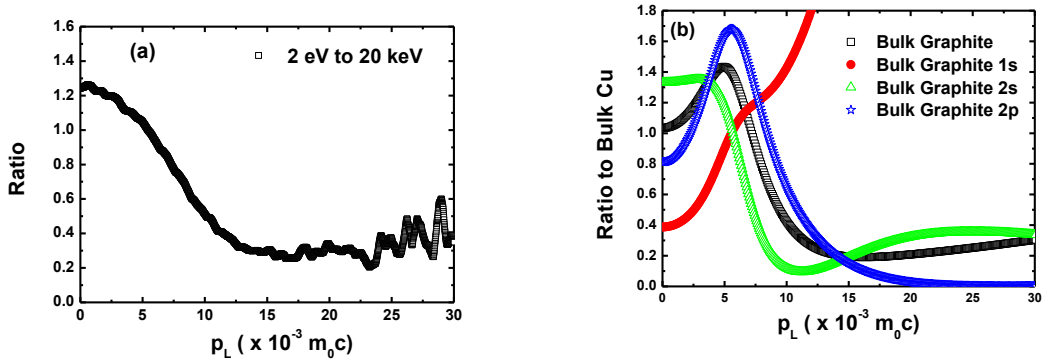

Figure 1 (a) *Doppler broadened gamma spectra from the surface of 6-8 layers of Graphene (2 eV) divided by the Doppler broadened spectrum from bulk Cu (20 keV) (black squares). (b) Ratio curve obtained by dividing the theoretically generated Doppler broadened spectrum from bulk graphitic carbon and various electron orbitals in carbon to that obtained from bulk Cu.*

References

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