Novel Positron Annihilation Based Surface Spectroscopies

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Recent results will be reviewed which demonstrate how positron based surface spectroscopies can obtain information regarding surface phenomena that are unobtainable by other techniques. Positron annihilation induced Auger electron emission, first reported in 1988, forms the basis of a top-layer specific surface spectroscopy, Positron Annihilation Induced Auger Electron Spectroscopy (PAES) [1]. The high degree of surface specificity of PAES results from the trapping of the positron in an image potential well just outside the surface prior to the annihilation of the positron with a core or deeply bound valence electron. Chemical information regarding the surface is obtained from an analysis of the energy of electrons emitted as a result of the filling of the annihilation induced hole through an Auger transition. Furthermore, the use of low energy positrons (< 1.5 eV) allows PAES to measure Auger electrons down to 0 eV without any secondary electron background. We have recently used the high surface selectivity and background free nature of PAES to measure the Auger spectra (0 eV to 600 eV) from graphene over layers that are only a few layers (1-8) thick [2]. Recently it has been proposed [3] to take advantage of the localization of the positron at surfaces to obtain top-layer specific surface information from an analysis of the Doppler broadened gamma spectra. Here we report preliminary results obtained using both gamma-gamma and gamma-Auger electron coincidence that provide evidence that Doppler broadened annihilation gamma spectroscopy could be applied to surface analysis and that such a spectroscopy could be used to characterize both external and internal surfaces under in-situ (operando) conditions.

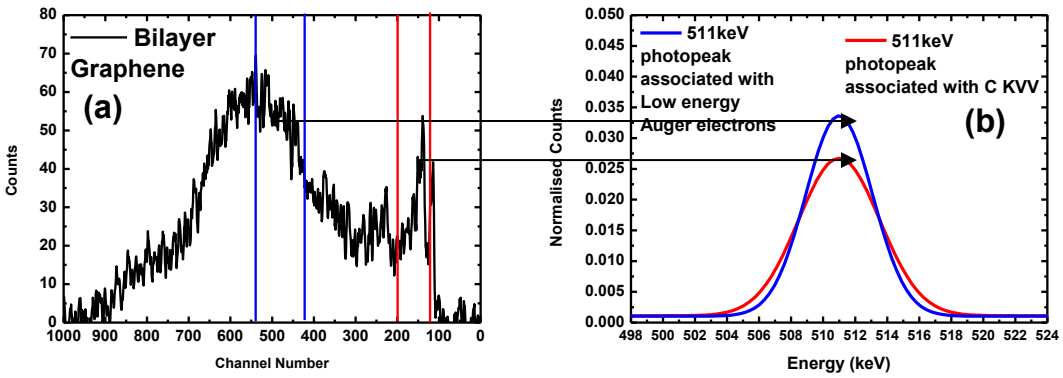

Figure 1 *Panel (a) shows time of flight PAES data from Graphene. We interpret the intensity in the regions between the coloured lines as due to Auger electron emission resulting from annihilation-induced holes in the C 1s level (red lines) and in the graphene valence band and O 2s level (blue lines). Panel (b) shows a comparison of the Doppler broadened gamma spectra obtained in coincidence with Auger electrons in the corresponding regions.*

References

[1] Weiss et al., *Phys. Rev. Lett*, **61**, 2245 (1988)
[2] V. A. Chirayath et al., *Nature Comm.*, **8**, 16116 (2017).
[3] Weiss et. al., *Radiation Physics and Chemistry*, **76,** 285 (2006).

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