Physics Department
The University of Texas at Arlington

COLLOQUIUM

Positron annihilation spectroscopy: A novel method to investigate 2D materials and internal surfaces

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Abstract

The electronic structure and the chemical architecture of external/internal surfaces and buried interfaces determine the efficiency of various catalytic processes as well as the performance of hetero-structured devices. Researchers employ novel techniques to probe the top atomic layers of the external and internal surfaces or buried interfaces with minimal contribution from the underlying bulk. Surface spectroscopy using positrons stand out among these techniques because of its ability to sample only the top few mono-layers resulting in signals that is sensitive to the surface electronic density of states and the surface chemical composition. The surface selectivity of positrons stem from the trapping of positrons in an image-potential induced surface state before its annihilation with the surface electrons. The interaction of the positron with the surface electrons results in two signals which can be used to extract the surface electronic and chemical composition, (a) the annihilation gamma photon and (b) the Auger electron emission initiated by the hole created by the annihilation process. We have employed the mono-layer selectivity of positrons to measure the positron annihilation induced Auger electron spectrum (PAES) from single layer graphene (SLG) deposited on a copper (Cu) substrate. The electron spectrum revealed the presence of an Auger emission process starting from the valence band of graphene that has not been observed previously in spite of the theoretical prediction of its existence. I will discuss the importance of this process, termed as “VVV” in the first section of the presentation. The Doppler broadening of the annihilation gamma has been used extensively to derive chemical and defect information from the bulk and the sub-surface regions. However, there are few studies using Doppler broadening spectroscopy to derive chemical information from top one or two atomic layers. Our investigation on graphene on Cu has shown us that the Doppler broadening spectroscopy carries distinct signature of the chemical composition of the top surface. This prompted us to propose a novel technique using positrons to probe the inner-hidden surfaces of porous materials. Few techniques can directly probe the inner surfaces of porous materials as the electron or low energy photon signal generated from the inner surfaces cannot escape from the sample. The ability of the positrons to trap at surface state combined with the ability of a 511 keV annihilation gamma to traverse through the sample and the ultra high vacuum chamber is utilised in this method to characterize the inner surface chemical composition. In the second section of the presentation, I will discuss the developments of this novel technique at our newly developed advanced positron beam at UTA.

Refreshments will be served at 3:30 p.m. in the Physics Lounge