Application of Total-reflection high-energy positron diffraction (TRHEPD) to the analysis of the graphene structures

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Abstract

Total-reflection high-energy positron diffraction (TRHEPD) [1, 2], is the positron (the antiparticle of the electron) counterpart of reflection high-energy electron diffraction (RHEED). Its surface sensitivity お riginates from the inelastic scatterings, as is the case for the electron diffraction such as low energy electron diffraction (LEED) and reflection high-energy electron diffraction (RHEED), i.e., once a particle undergoes an elastic scattering it loses coherence to contribute the diffraction pattern. In addition to this, TRHEPD has a reason which renders the the method exceedingly surface sensitive, i.e., the electrostatic potential inside every solid is positive and thus the surface is repulsive for a positron. A fast positron incident on a surface with a glancing angle smaller than a certain critical angle is totally reflected. In this condition, the diffraction pattern is determined only by the atoms on the topmost surface [3]. It is also possible to get information on the immediate subsurface by increasing the glancing angle across the critical angle. In this condition the positron is refracted toward the surface in contrast to the electron which is refracted off the surface and penetrates deeper. Thus TRHEPD is best suited for the the determination of the atomic arrangement of the atomic layer materials such as graphene.

A TRHEPD station with a brightness-enhanced intense positron beam is now in operation at the Slow Positron Facility, KEK, where positrons are created via pair creation from the Bremsstrahlung of 50 MeV electron accelerated by an electron linac [4]..

We report here recent application of this TRHEPD station to the structure of graphene on a Cu(111) and a Co(0001) surfaces. It was confirmed that the graphene has no buckling and the distance between graphene and the substrate was determined [5]. In a study of silicene on Ag(111), amount of buckling and the distance between the substrate and the bottom silicon atoms were determined [6]. TRHEPD has lso been applied to a more complex surface structure of rutile-TiO_2(110)-(1×2) surface [7]

References

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Figures

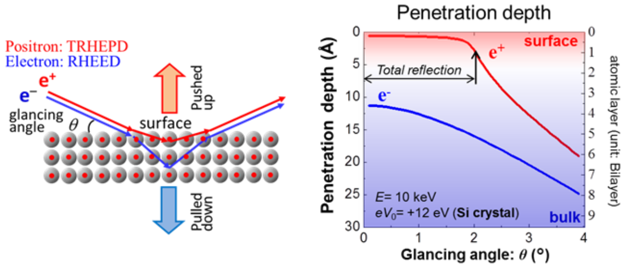

Figure1 Because of the positive electrostatic potential of every material, the positron is refracted toward the surface, while the electron is refracted off the surface. When the incident glancing angle is smaller than the critical angle, the positron is totally reflected and thus the diffraction pattern is determined solely determin by the arrangement of the topmost atoms.

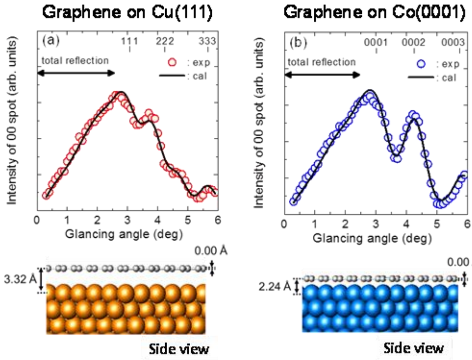

Figure 2 The TRHEPD 00-spot rocking curves for the graphene on Cu(111) and Co(0001) and the obtained structures – amount of bucking and the graphene-substrate distance.