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Research Group for Nanoscale Structure and Function of Advanced Materials

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Macroscopic properties of matter based on its local states could be understood by investigating a nanoscale region of the sample. An experimental technique that can be used to selectively investigate a surface, bulk, impurity/defect, or ultrathin film can extend the field of materials research. Existing technical developments enable us to efficiently produce high-intensity beams, especially beams of synchrotron light, electrons, neutrons, muons, and positrons, which are useful for studying various atomic structures and dynamics of functional materials. In addition, experimental techniques that correspond to each local state such as surface, interface, and impurity have been developed and they can be used to obtain new scientific insights. Our research objectives are to develop these new advanced measurement technologies and study the nanoscale structures of functional devices and materials to clarify the essential properties of matter.

Growth Mechanism of Graphene on Au was Revealed

Graphene, a two-dimensional honeycomb lattice composed of sp^2 C atoms [1], shows fascinating mechanical, thermal, and electronic properties and is promising for many applications including high-temperature coating materials. Since graphene applications require mass-production of graphene, chemical vapor deposition (CVD) has been studied among other growth methods for graphene. In CVD growth of graphene, small C molecules (growth precursor of graphene) gather on a substrate to form graphene lattice, resulting in the large-area monolayer graphene. Particularly, CVD growth of graphene on Cu from CH_4 and H_2 has been the most popular system [2].

Recently, the growth of graphene on Au substrates has attracted attention of researchers since graphene on Au was known to be applicable for electrodes of electrochemistry as well [3]. Nevertheless, the studies focused on graphene on Au have been made, but the basic growth mechanism has been still unknown so far. In addition, although there is an advantage that graphene can be grown on Au without supplying explosive H_2 [3], how H_2 supply affects the growth of graphene has not been well investigated.

In the present study, we discussed the growth mechanism of graphene on Au foil substrates for the first time [4]. We revealed the effect of H_2 supply on the growth of graphene on Au foil substrates. The results of scanning electron microscopy and Raman spectroscopy showed that the coverage of graphene grown without H_2 supply was higher at the same growth time. The Raman spectra of the graphene samples also indicated that the graphene grown without H_2 supply had larger compressive strain. The Au foil substrates showed (001) surfaces after the graphene growth, which was confirmed by electron back scattering diffraction. We attributed the differences in the growth rate and compressive strain of graphene to the interaction between the adsorbates (graphene and its precursors) and Au surface. Therefore, the Au foil surface was reconstructed to form hex-Au (001) surface, enhancing the interaction between the adsorbates and Au when H_2 was not supplied. The supply of H_2 broke the interaction between them, lowering the growth rate and compressive strain of graphene. Our results suggested that despite the inert surface of graphene and Au, the supply of H_2 can control the interaction between graphene and Au, which is useful for controlling the growth of graphene to realize the high-quality graphene on Au substrates.

Asymmetric Structure of Single-Layer Superconductor revealed by Positron Diffraction

We have investigated the atomic configuration of single-layer superconductor of iron selenide (FeSe) using positron diffraction technique [5]. FeSe material is a typical example of Fe-based superconductors, which shows the superconductiong transition temperature (T_c) of 8 K. Recently, single-layer FeSe has been successfully fabricated on an oxide substrate, and showed the highest T_c (> 50 K) among the Fe-based superconductors. Although various mechanisms have been proposed to elucidate the origin of the highest T_c, the atomic configuration remains unresolved. In this study, we performed the structure analysis of single-layer FeSe by positron diffraction, which is a surface sensitive technique owing to the positive charge of the positron. As a result, we found that the height of the top-Se layer from the Fe layer is larger than that of the bottom-Se layer, leading to the asymmetric layer structure (Fig. 1). The averaged height is almost the same as the optimum height, where the bulk-FeSe exibits the highest T_c under pressure. Consequently, the structure of single-layer FeSe is asymmetrically optimized for the highest T_c.

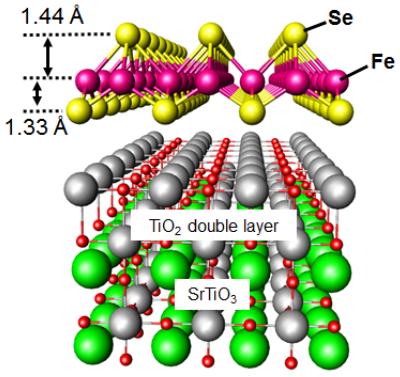

Fig.1 Asymmetrically optimized structure of single-layer FeSe on an oxide substrate, which was determined in this study. Se layer on the top of Fe layer becomes taller as compared to Se layer on the bottom.

References

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