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Electronic states of picene thin film on Au substrate

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Introduction

Picene with a zigzag chain structure of five benzene rings is an organic-semiconductor which has an optical band-gap of 3.3 eV. This material has been interested for an application such as a solar battery and an organic-thin-film transistor, *et al.*, because of band-gap near sun light and high electron mobility. On the other hand, physical property as superconductor by intercalating of potassium into picene has been discovered[1]. Therefore it is necessary that mechanism of superconductivity appearance is clear. Thus it is considered that electronic states of potassium intercalated picene play an important role in superconductivity.

In this report the electronic states for specimens of potassium intercalated picene is studied by X-ray emission spectroscopy (XES). The XES spectra have characteristics to give information of partial density of states in the valence band density of states (VB-DOS) because different wave functions for each element in a material under study can be separated due to the dipole selection rule of electron transitions. Therefore, we can obtain a specific signal for an element which can be used as a finger print, otherwise it is difficult.

Experimental

A substrate of gold evaporated on a stainless steel was prepared. Picene thin film with thickness of 100 nm was deposited on this substrate by Joule heating of alumina coated tungsten-basket within picene powder in vacuum. After potassium was intercalated into this picene thin film by evaporation, XES measurement was performed in situ. The XES spectra were obtained in an XES apparatus, which is installed to a beamline BL-19B at synchrotron radiation facility of Photon Factory (PF) in High Energy Accelerator Research Organization (KEK).

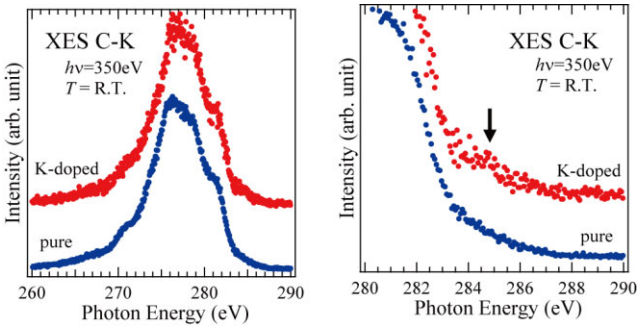

Fig.1. XES spectra; blue dots are pure picene thin film. Red dots are potassium intercalated picene thin film.

Results and Discussion

Figure 1 show XES spectra of C Kα, where the energy of incident photon is 350 eV. Blue dots are an XES spectrum obtained from pure picene thin film. Red dots are an XES spectrum obtained from potassium intercalated picene thin film. Right part of figure is partially expanded from the left part of figure. The shape of both XES spectra (blue and red dots) is similar ones as C Kα of graphite without shown in figure. One can be seen that the spectrum shape of the allowed part is different by the potassium intercalation. Since the XES spectrum of C Kα has the information of partial density of states in VB-DOS, the increase in the intensity near 285 eV reflects on the increase of density of states near Fermi level. Because, after an electron at C 1*s* is excited by a photon of 350 eV and then a hole is formed, an electron at 2*p* within 2*s*2*p* electrons constituted the valence band transfers into the hole for relaxation process to obey the dipole selection rule. The energy difference between the hole and Fermi level is 285 eV. That is, the intensity at allowed part means the increase in electron density of *p* states near Fermi level. Considering that the superconductivity appearance is closely related to electrons near Fermi level, 2*p* states in C atoms may be played the important role.

Summary

The samples of potassium intercalated picene thin film were made by the method of evaporation in situ. The XES measurements were performed at PF. The increase in intensity at the shoulder of high photon energy side in C Kα spectrum is observed with the potassium intercalated samples. This is related to 2*p* states in C atoms near Fermi level.

References

[1] R. Mitsuhashi, et al., Nature **464**, 76-79 (2010).

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