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X-ray Photoelectron Spectroscopy Analysis of Fullerene - Transition Metal Hybrid Systems for Organic-Spintronics

Seiji SAKAI*[1], Yoshihiro MATSUMOTO[1], Isamu SUGAI[1,2], Hiroshi NARAMOTO[1], Norie HIRAO[3], Tsuyoshi YAITA[3], Yuji BABA[3], Yoshihito MAEDA[4]

[1]Advanced Science Research Center, Japan Atomic Energy Agency, Tokai, Naka, Ibaraki 319-1195, Japan
[2]Institute for Materials Research, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai, 980-8577, Japan
[3]Synchrotron Radiation Center, Japan Atomic Energy Agency, 2-4 Shirakata-Shirane, Tokai, Naka, Ibaraki 319-1195, Japan
[4]Department of Energy Science and Technology, Kyoto University, Sakyo-ku, Kyoto 606-8501, Japan

The hybrid systems between organic-molecules (OMs) and transition metals (TMs) have recently attracted much attention as a new kind of spintronics systems following the pioneering study of the spin-dependent electron transport through carbon nanotubes (CNTs) [1] and theoretical predictions for anomalously high spin polarization [2]. The magnetoresistance (MR) ratio reported for the OM-TM systems, however, is as small as less than a few 10% [1, 3], different from the theoretical predictions. Recently, we found that the alternatively deposited C_{60}-Co film exhibits anomalously large tunnel MR (TMR) effect of 80 % at maximum in the temperature (T) range of T < ~10 K [4, 5]. The structure of the C_{60}-Co film was indicated to be a granular-typed one composed of the C_{60}-Co compound ($C_{60}Co_{\sim 4}$) and Co nanoparticles embedded therein [6]. The extent of MR observed for the C_{60}-Co film is significantly larger than TMR of 50% theoretically expected for insulating-granular systems under the ideal condition of complete spin-polarization of tunnelling electrons and negligible spin-flips. This suggests that some enhancement effect associated with the electronic structure of the C_{60}-Co compound is taking part in the MR effect, in addition to the high spin-polarization at the Co nanoparticle/C_{60}-Co compound interface.

In the present study, a deposition apparatus of OMs (e.g. fullerene C_{60}) and TMs (e.g. Co), which is connected with the apparatus for synchrotron radiation X-ray photoelectron spectroscopy (SR-XPS) at BL-27A, is designed for the purpose of investigating the electronic structure of OM-TM hybrid systems (e.g. C_{60}-Co films) under in-situ conditions.

Figure shows an image and schematics of the OM/TM deposition apparatus (left side in the image) with the SR-XPS apparatus (right side in the image) at BL-27A. The deposition apparatus is composed of a load-lock chamber and a deposition chamber. The deposition chamber is evacuated to the base pressure of 10^{-6} Pa by using a turbo-molecular pump (TMP) and a cooling jacket of sacrificial liquid nitrogen. The chamber is equipped with an electron beam (EB-) evaporator (Oxford Scientific, EGN-4, 4 pockets) and a Knudsen-cell to deposit inorganic and organic materials under alternative or simultaneous conditions. The EB-evaporator is capable of evaporating up to 4 different materials with controlling the evaporation rates individually. The deposition rates from both evaporators can be controlled precisely in the range of less than 0.1 nm/min and a few nm/min by using a film thickness monitor. It is possible to investigate the electronic structure of the deposited films by SR-XPS without surface contaminations by immediately transferring to the SR-XPS chamber kept at 10^{-8} Pa. Furthermore, investigations by X-ray/UV-light photoemission electron microscopy (PEEM) can be performed by using the PEEM apparatus directly connected with the SR-XPS chamber (on the backside of the deposition and SR-XPS apparatuses in the image).

Our analytical studies for the C_{60}-TM (including Co) systems are progressing by the use of these apparatuses.

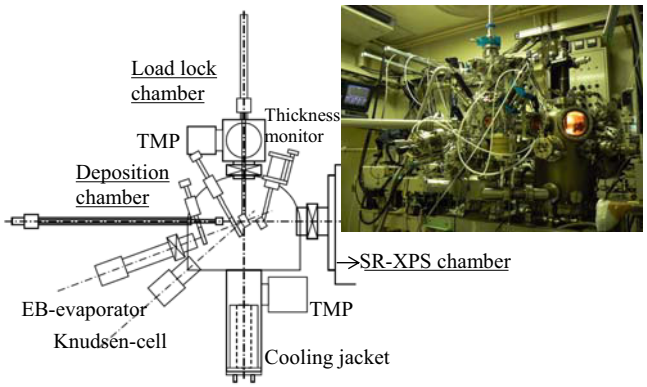

Figure Image (right) and schematics (left) of the OM/TMs deposition apparatus (left side in the image) connected with the SR-XPS chamber (right side in the image) prepared at BL-27A.

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* sakai.seiji@jaea.go.jp