Photoemission Studies of the Interfacial Electronic Structure of 2-amino-4,5-imidazoledicarbonitrile Films on Silver and Aluminum

Yen-Hao Huang (黃彥豪)[1], Nakayama Yasuo (中山泰生)[2], Che-Chia Hsu (許哲嘉)[1], Yu-Hsuan Lu (盧宇軒)[1], Pei-Wen Chen (陳珮文)[1], Chi-Bin Wang (王棋斌)[1], Machida Shinichi (町田真一)[2], Guan-Ru Lee (李冠儒)[3], Ching-Hsua Wei (魏竟軒)[4], Tun-Wen Pi (皮敦文)[4], Hisao Ishii (石井久夫)[2], and Shu-Jung Tang (唐述中)[1]

[1]Department of Physics and Astronomy, National Tsing Hua University, Hsinchu, Taiwan
[2]Center for Frontier Science, Chiba University, Chiba, Japan
[3]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan
[4]National Synchrotron Radiation Research Center, Hsinchu, Taiwan

The electronic structures of interface between an organic bistable material 2-amino-4,5 imidazoledicarbonitrile (AIDCN) and electrode metal surfaces (Ag and Al) were investigated by synchrotron radiation photoemission. The photoemission experiments carried out for this research were performed at the NSRRC. All the photoemission spectra were obtained on a 6 m low-energy spherical grating monochromatic beamline (6 m-LSGM, BL-08A). From previous reports, the bistable behavior of organic bistable device using Ag as a top electrode was much more stable then that of the device using Al as a top electrode, and it was pointed out that the key issue for the electrical bistability is the use of metals that easily migrates into organic materials. The electrical bistability strongly depends on metal electrodes and the working mechanism is still controversial. Figure 1.1 shows the photoemission spectrum of the valence bands of the AIDCN thick film deposited on Si(111) and simulated result using Gaussian function with full width at half maximum (FWHM) 0.8 eV around each calculated binding energy, since this value fits the isolated HOMO. The raw energy data shifted by 6.2 eV towards lower binding energies. The zero on the energy axis is referred to the Fermi level. The HOMO in region A, at 3.3 eV, originates from hybridized orbital of C 2p and N 2p wave functions dominated by bonds.

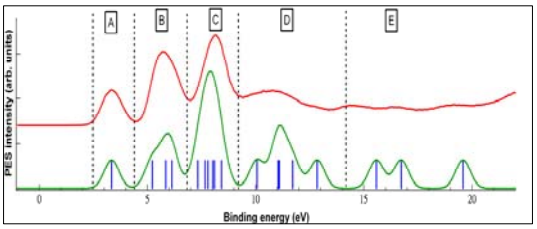

Fig. 1: Photoemission spectrum of the valence region of the AIDCN thick film deposited on Si(111) and simulation result.

For AIDCN/Ag, the film thickness dependence of the vacuum level (VL) and HOMO peak position are not parallel, which is different from that in conventional organic and/or metal systems in low coverage region. In the previous report, the dip shape of VL energy shift was observed in PbPc on highly oriented pyrolytic graphite (HOPG), in which the monolayer and bilayer states of HOMO can be observed. The variation of monolayer state and multilayer state are also observed in our case as shown in left side of Fig. 2(a). The gray curve represents the difference in intensity between the EDC's of last thickness.

For AIDCN/Al, the PES spectra shows diffuse tailing structures at the HOMO region probably reflecting inhomogeneous surroundings of the AIDCN molecules in the randomly oriented overlayers before the bulk-like phase is formed. The edge position of HOMO of AIDCN on Al was initially at 1 eV and it showed further reduction slightly as increasing the thickness as shown in Fig. 2(b). The gray curves indicate the normalized Fermi edge from clean Al thick film for comparison. The dip shape of VL energy shift was also observed in AIDCN on Al. The HOMO peak for AIDCN on Al appears at higher coverage than that for AIDCN on Ag. This, again indicates that nonuniform film affect the HOMO peak line shape at low coverage so that no clear HOMO peak feature can be observed. The hole injection barriers from Ag and Al to AIDCN were estimated to be 1.6 and 0.7 eV, respectively.

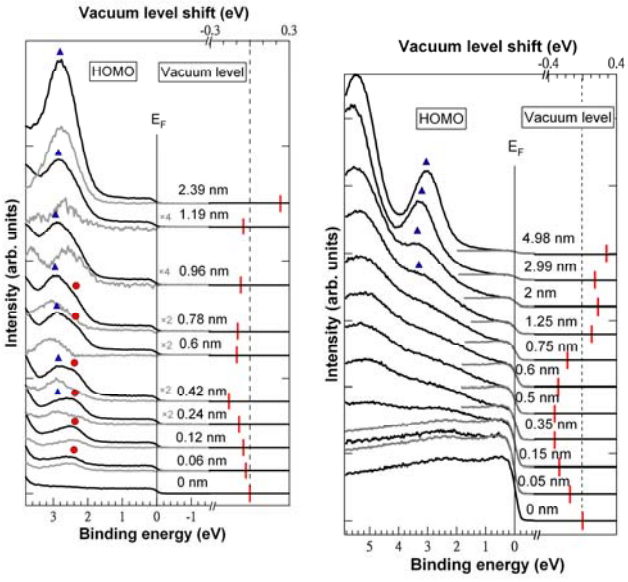

Fig. 2: Photoemission spectrum of (a)AIDCN/Ag and (b) AIDCN/Al in HOMO region