

Surface potential mapping in terraced bilayer perylene derivative and phthalocyanine:

A study about charge redistribution in *p-n* domain interfaces

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Abstract. In this work, phthalocyanine (H₂Pc) and 3,4,9,10-perylenetetracarboxylic-bis-benzimidazole (PTCBI) based terraced bilayer systems were prepared as a large-scale (*ca.* 1 cm x 1 cm) thin film heterojunction model to study surface potential of boundary as p-type and n-type material formed interfacing structure (*p-n* domain interfaces). As the scanning made between bilayer region and single layer region, the boundary region in the terraced bilayer ITO/PTCBI(40 nm)/H₂Pc(40 nm) was observed to have lateral surface potential rise, while for terraced bilayer ITO/H₂Pc(40 nm)/PTCBI(40 nm) showed a transition between low potential and high potential within the lateral region. At the boundary region of terraced bilayer ITO/PTCBI/H₂Pc, observation showed that surface potential was distributed (440 -540 mV) into lateral region to be more than 30 μm width. Moreover, lateral surface potential rise was observed to be *ca.* 80 – 110 mV which is higher than that of the bilayer region. The observations of those two distinct characteristics of build-up and non build-up lateral surface potential are discussed based on a charge redistribution mechanism in the boundary region.

Lateral surface potential analysis (*i.e.* parallel to the surface of substrate) extensively provide information about correlation between surface potential variation and surface morphology. (M. Chiesa et. al., Nano Letters, 2005). In this work, we focus on the lateral surface potential analysis of the *p-n* domain interface (*i.e.* at the p-type/*n*-type OSM boundary region). The comparison of surface potential characteristic for both the case of ITO/*p*-type/*n*-type and ITO/*p*-type/*n*-type is reported in here.

Single layered thin film ITO/PTCBI and ITO/H₂Pc were prepared and analyzed for their definite surface potential polarity when in contact with the electrically grounded ITO substrate. The surface potential polarity of them suggesting that PTCBI and H₂Pc donate electron to the ITO. Their surface potential shifted after illumination and the shifts were in good agreement with that of our photoelectrochemical study of both thin films. (Abe, T., Nagai, K., et. al., Phys. Chem. Chem. Phys., 2008)

Photoemission spectroscopy in the bilayer ITO/PTCBI/H₂Pc study suggest that H₂Pc donate electron to PTCBI. In the terraced bilayer, regional scanning area for single layer, boundary and bilayer are made. Two distinctive surface potential characteristics were found at the boundary region for the both of terraced bilayers, (i) a peak (more positive value) in lateral of surface potential for terraced bilayer ITO/PTCBI/H₂Pc (see Figure), (ii) gradual transition between a negative to a positive lateral surface potential for terraced bilayer ITO/H₂Pc/PTCBI. Additionally,

a large area of the surface potential rise was observed by using the low resolution masking setup.

Because the boundary region has a ramp kind of structure, it is suggested that, the observation of those surface potential characteristics was due to the existence of an incomplete space charge region in the boundary region, where the charge redistribution can be occurred. The charge redistribution mechanism in each of the terraced bilayer sample leads to their distinctive surface potential characteristics. Provided with having those similar properties of electron transfer by the Fermi level alignment, we expect that the build-up surface potential and non build-up surface potential characteristics will also be shown in other kinds of terraced bilayer *p*-type on *n*-type and terraced bilayer *n*-type on *p*-type respectively.

