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금속-고분자 계면에서 캐리어의 거동

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Carriers Behavior in Metal-Polymer Interface

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Abstract - In this paper, the behaviour of charge carriers near the metal/polymer interface and its effects on conduction and breakdown phenomena are discussed. The metal/polymer interface strongly affects carrier injection, space charge formation and breakdown phenomena. Based on their experimental results, the physical backgrounds of the interfacial phenomena are explained.

1. Introduction

Organic polymers have been widely used as insulating materials for electrical apparatus, electronic parts, cables, printed-circuit boars and so on. Sometimes their composites are used. Moreover, in practical uses, insulating systems have various interfaces such as polymer/ metal(electrode), polymer/polymer, polymer/ filler, polymer/oil and polymer/air. Such interfaces sometimes strongly affect the performance of insulation systems. Recenly, nano-composites have also attracted much attention as new insulating materials and the role of interface becomes more and more important. However, the properties of such interfaces have not well understood yet. Their understanding are strongly requited to improve practical insulating systems.

In this paper, we will focus mainly on the metal/polymer interface. At first, typical experimental results associated with interfacial phenomena are reviewed. They include carrier injection, high field conduction, space charge and pre-breakdown phenomena. Their physical backgrounds are discussed based on these experimental results.

2. Experiment and Results

To Figure 1 shows the J-F characteristics of EVA (ethylene- vinylacetate copolymer) with Al/Al, Al/Au and Au/Au electrodes). The Au anode shows much higher current than the Al cathode. These results are qualitatively understandable because Au has a higher work function than Al. Polymers which show electron or hole injection are listed up in Table 1 [1, 2]. For further explanation, we have to know the energy diagram for the metal/polymer interface including the barrier height for carrier injection. However, the energy diagram is not clear for the metal/polymer interface.

Table 1. Polymers which show electron or hole injection.

Electron injection	PE	PET	PEN	
Hole injection	EVA	PPX	PTEF	FEP

There are very few papers which treat with the energy diagram of the metal/polymer interface. We estimated the injection barrier heights of PPX (poly p-xylylene) and PET from photoinjection currents [2, 3].

Figure 1 shows plot of photoinjection currents in PPX with various metal electrodes. The intersection with the horizontal axis gives the barrier heigt. Figure 2 shows the barrier height as a function of photon energy for PPX, together with that for PET. The barrier height ϕh of PPX (hole injection) obeys the equation, ϕh = 6.84 - ϕm [eV], where ϕm is the work function of electrode metal and 6.84 eV is the ionization energy of PPX Therefore, we obtain the energy diagram of the metal/PPX interface.

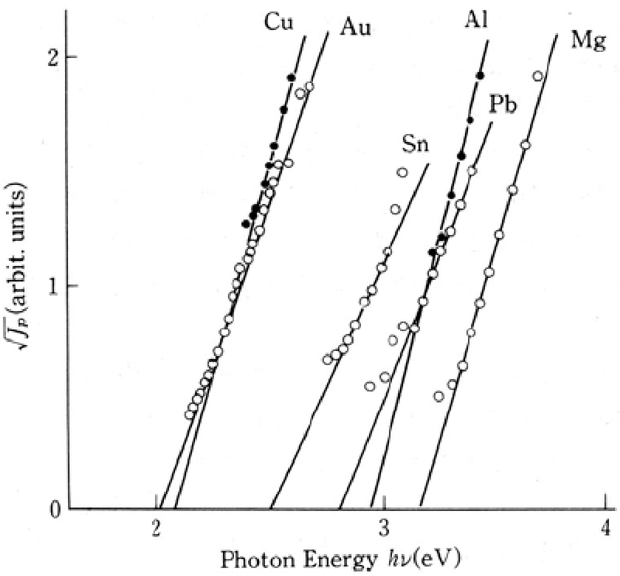

Fig. 1. Fowler plot of photoinjection currents in PPX.

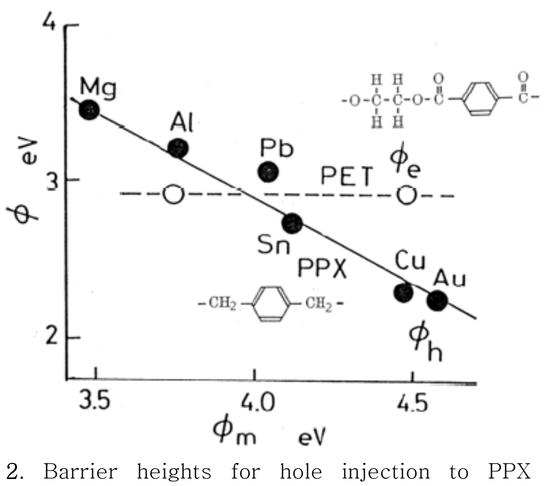

Fig. 2. Barrier heights for hole injection to PPX and electron injection to PET.

The field dependence of the barrier height of hole injection (PPX) obeys the Shottky equation, as shown in Fig. 3, where the solid line is the theoretical curve for εr = 2.65. Of course, Shottky equation is applicable to the flat band case. In case of the band bending at the interface or the existence of localized states (or surface states), you should modify the Shottky equation.

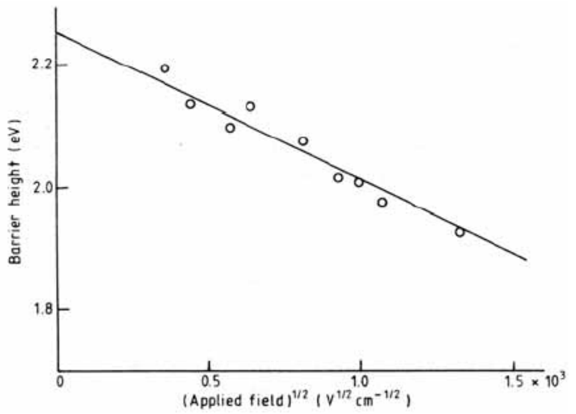

Fig. 3. Field dependence of barrier height for hole injection from Au electrode to PPX.

3. Conclusion

As mentioned above, the metal/polymer interface is closely related to high−field conduction, breakdown and degradation phenomena in practical insulation systems. However, the interfacial phenomena seem complicated because many factors such as surface states, additives, the chemical/physical structures of polymers and so on affect them in complicated ways. Experimental results sometimes seem to be different among researchers partly because of different material or experimental conditions.

[Acknowledgement]

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[References]

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