PCB 절연체에서 전하 형성과 수분 흡수의 영향

구정현, 최용성, 이경섭
동신대학교 전기공학과

Influence of Water Absorption and Charge Formation in PCB

Jung-Hyun Goo, Yong-Sung Choi, and Kyung-Sup Lee
Dept. of Electrical Eng., Dongshin University

Abstract - We observed internal space charge behavior for two types of epoxy composites under dc electric fields to investigate the influence of water at high temperature. In the case of glass/epoxy specimen, homocharge is observed at water-treated specimen, and spatial oscillations become clearer in the water-treated specimens. Electric field in the vicinity of the electrodes shows the injection of homocharge. In aramid/epoxy specimens, heterocharge is observed at water-treated specimens, i.e. negative charge accumulates near the anode, while positive charge accumulates near the cathode. Electric field is enhanced just before each electrode. In order to further examine the mechanism of space charge formation, we have developed a new system that allows in situ space charge observation during ion migration tests at high temperature and high humidity. Using this in situ system,

1. Introduction

Recently consumer electronics such as mobile phones are to be designed even smaller and more concentrated. The operating frequency is also being increased to support more access to the internet, and thus the wiring in printed circuit boards (PCBs) must be shorter to minimize transmission loss and delay. In this trend, embedded PCBs have been developed. Compared to conventional surface mount-type PCBs, which have ICs and other components on the boards, the developed embedded PCBs contain their components inside the base boards except for ICs to be mounted on boards. Therefore, all the aspects of dielectric properties including the effects of ageing should be evaluated not only at the surfaces of the boards but also on the inside. However, most of research on ageing or breakdown of PCBs has been investigated only for the surface degradation phenomena.

On the other hand, more and more electronics are to be used under various environments such as at high temperature and in high humidity. Such high temperature and high humidity must facilitate generation and transport of ionic mobile carriers, which would in turn build space charge in PCBs inside the electronics. Therefore, in this research, we measure space charge formation behavior under dc electric field for two types of PCBs used in telecommunication industry.

2. Experiment

Table 1 shows the specimens measured in this research. Specimen A is a glass/epoxy composite with the flame-retardant grade FR4. It consists of three prepreg layers made of lattice-woven E-glass fibers soaked into epoxy vanish, and is commonly used in various industries. Specimen B is an aramid/epoxy composite consisting of five layers of prepreg made of aramid nonwoven fabric papers coated with epoxy resin, which is typically used for mobile phones. The specimens were soaked into water at 358 K (85 ℃) for 1 to 10 hours and the specimen weight was measured by a digital balance. After the specimens were immersed in water at 358 K (85 ℃) for 48 hours, the water was analyzed by ion chromatography in order to examine ion species and their quantities extracted from the specimens into water. A dc electric field of 3 kV/mm was applied to the non-treated or water-treated specimens for 60 minutes and the space charge profiles inside the specimens were measured by the pulsed electroacoustic (PEA) method[1, 2]. Here, a new *in situ* PEA unit was placed in an environmental chamber that can control the temperature and humidity according to standard test conditions established by the Institute for Interconnecting and Packaging Electronic Circuits (IPC) such as 313 K (40 ℃) + 90 %RH and 358 K (85 ℃) + 85 %RH, in order to observe space charge profiles simultaneously during the migration test of materials for PCBs. The in suit PEA observation should expose the specimen to open air in the same manner as the condition of the surface migration test, although the ordinary PEA unit sandwiches a specimen by two electrodes.

Table 1. Specimens.

Materials	Permittivity ε′ (at 1 MHz)	Thickness, Number of layers
Glass/Epoxy (Specimen A)	5.2	0.73 mm, 3 layers
Aramid/Epoxy (Specimen B)	4.0	0.57 mm, 5 layers

3. Result and Discussion

Fig. 2 shows the increment in weight as a function of the duration of water treatment. The weight increases with an increase in the duration of water treatment. The aramid/epoxy specimen B tends to absorb more water than the glass/epoxy specimen A.

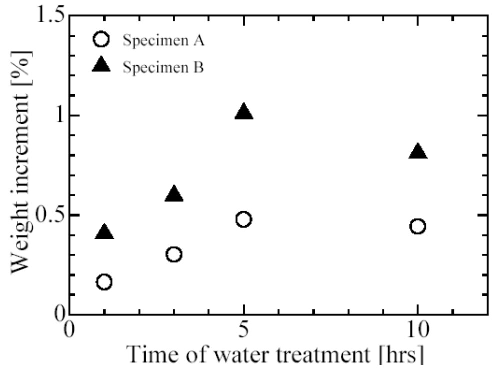

Fig. 2. Increment in weight as a function of the duration of water treatment.

Fig. 3 shows the space charge and electric field profiles observed in the glass/epoxy specimen A. Here, the measurements were done with an ordinary PEA measurement system. Partly because the sound impedance of the glass fiber is almost 5 times higher than that of the epoxy resin, the sound wave traveling in the specimen is scattered and absorbed.

Therefore, the charge profiles are not as clear as those observed in a homogeneous specimen such as a regular polystyrene sheet. In Fig. 3, the cathode was the electrode set near the piezo-electric element. First, spatial oscillation with three repetitions, which is in agreement with the number of composite layers of specimen A, is seen in all the specimens shown in Fig. 3, and it becomes clearer in the water-treated specimens.

Secondly, among the charge distributions right after the voltage application shown in Fig. 3 (a1), a positive heterocharge layer in front of the cathode is seen only for the specimen treated for 3 hours. In the same signal, the charge appearing on the cathode is quite large since the image charge induced by the nearby heterochage is superposed on the charge induced by the applied dc voltage. The heterocharge disappeared by the 60-min application of dc voltage as shown in Fig. 3 (b1). Instead of the heterocharge, oscillatory repeating negative and positive charge becomes clearer in water-treated specimens. Since a comparatively large amount of negative charge is present near the cathode, the electric field in the vicinity of the cathode is weakened as shown in Fig. 3 (b2). The electric field in the vicinity of the anode also seems to become smaller. That the electric field is weakened at both electrodes indicates homocharge injection from the electrodes, although the final decision cannot be done until more distinct results are obtained.

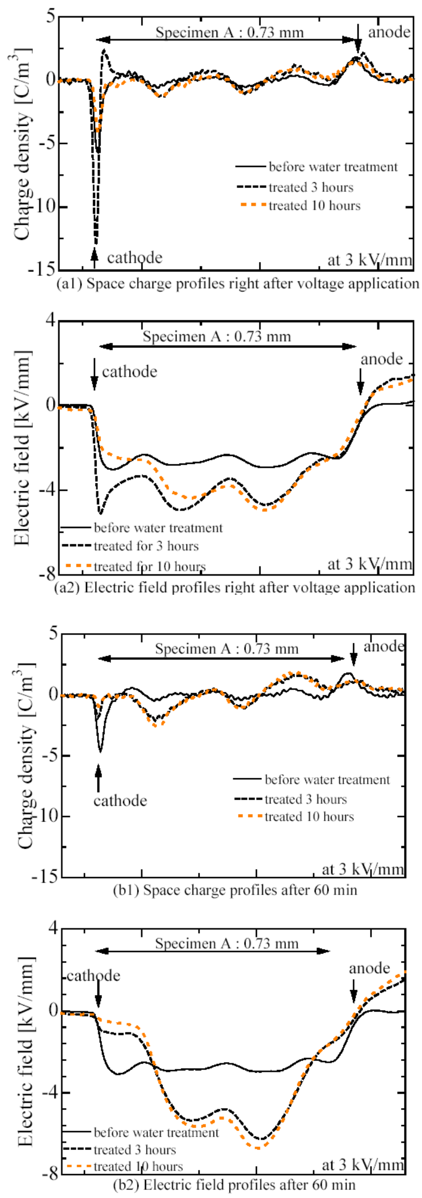

Fig. 3. Charge and electric field profiles in glass/epoxy specimen A under dc electric field at 3kV/mm.

4. Conclusion

We have observed internal space charge in epoxy composites. It has become clear that water treatment gives a fairly large influence on the charge profiles, especially in the vicinity of electrodes. In the glass/epoxy composite specimens, the electric field in the vicinity of electrodes is weakened and homo charge appears. In the aramid/epoxy composite specimens, the electric field in the vicinity of electrodes is enhanced and hetero charge appears.

[Acknowledgement]

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[References]

[1] T. Maeno, T Futami, H. Kushibe, T. Takada and C. M. Cooke, "Measurement of Spatial Charge Distribution in Thick Dielectrics Using the Pulsed Electroacoustic Method", IEEE Trans. EI, Vol.23, No. 3, pp. 433-439, 1988.

[2] V. Griseri, K. Fukunaga, T. Maeno, C. Laurent, L. Lévy and D. Payan, "Pulsed Electro-acoustic Technique Applied to In-situ Measurement of Charge Distribution in Electro-irradiated Polymers", IEEE Trans. DEI, Vol. 11, No. 5, pp. 891-898, 2004.