커패시터용 MPPF의 셀프힐링시 증착금속 비산특성

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Demetalization Characteristics at Self Healing of MPPF for Capacitor Applications

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Abstract - This paper describes the metalization burn out characteristics and spreading-out mechanisms of metalized polypropylene films(MPPF) with defects.

As a result, the variation in diameter of the demetalized spots was verified and the spreading-out processes of the demetalized spots were characterized and illustrated by several patterns. Subsequent self healing events was also depicted in this paper.

1. Introduction

When breakdowns due to defects occur on MPPFs for capacitor applications, they are automatically recovered in electrical insulation, so called "self-healing". Self healing can be accomplished by metalization, and the metalization makes the capacitors lighter in weight and higher in energy density. Self healing can suppress the failure expansion of the capacitors[1]. However, when voltages are continuously applied after the first failure, current path is formed along the surface of the polymer film and partial discharges are likely to occur at the edge of the demetalized spots. These phenomena lead to the deterioration of dielectric materials and reduction in capacitance with time[2].

This paper experimentally deals with the expansion in diameter of the demetalized spots just after pre-self healing events and the expanding processes with time. All processes observed in this experiment are illustrated, which characterizes the pre-self healing mechanism of the MPPF for capacitor applications.

2. Experiment

2.1 Experimental setup

Fig. 2 shows the experimental setup to study the metalization burn out characteristics and spreading-out mechanisms of MPPFs with defects when MPPFs with defects were self healed under ac voltage.

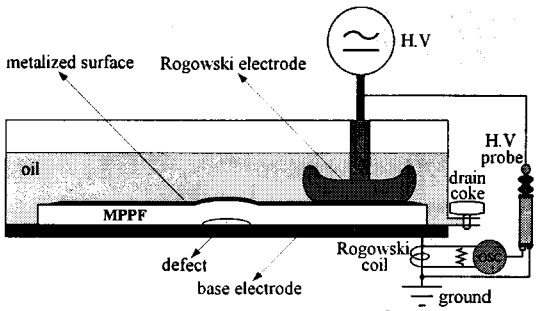

Fig. 2 Experimental setup

As shown in Fig. 2, ac and dc voltages were applied to the metalized surface of the MPPF with defects through a Rogowski electrode. The Rogowski electrode was connected to the high voltage generator which was corona free and the base electrode was grounded. To measure the applied voltage at self healing, a high voltage probe was installed at the output terminal of the high voltage generator. And it was connected to the input terminal of an oscilloscope.

The metalization resistance is generally determined by 3~9[Ω], and it plays an important role in oxidizing and burning out the metalization at self healing. Higher resistance of metalization can be more effective from the viewpoint of the insulation ability of the burn out area, because the higher the metalization resistance is, the broader the burn out area becomes. However, the capacitance is getting reduced by self healing, and thus, the performance of a capacitor will be worse[3]. Table 1 shows the specification of the MPPF used in this experiment.

Table 1 Specification of MPPF

PPF thickness	deposited metal/thickness	metalization resistance
12[㎛]	Al / 300[Å]	7[Ω]

The insulating oil can be contaminated by the metallic oxide and the hydrocarbon gas generated at self healing, which can affect the experimental results including the expanding progress of the demetalization. Therefore, the

insulation oil was refilled with new one every time the MPPF was changed. Table 2 shows the electrical and physical properties of the oil.

Table 2 Electrical and physical properties of oil

specific weight	viscosity[cSt]	ε'	tan δ	dielectric strength[kV/2.5㎜]
0.916	12.3	2.8	0.03	72

2.2 Experimental procedure

First of all, 12[㎛] PPFs metal-deposited by 300[Å] were sheared by 6×15[㎝]. Each of the PPFs was put on the base electrode and impregnated in the insulating oil. When ac and dc voltages generated by high voltage generators were applied to the MPPF and the voltages were increased at the rate of 0.3[kV/s], pre-self healing events took place at lower voltage than breakdown voltage of the 12[㎛] PPF. Among the pre-self healing events, 5 samples whose pre-self healing voltages were about 2.9[kV_{ac}] and 4.6[kV_{dc}](80[%] of the breakdown voltage of 12[㎛] PPF) were selected[4][5]. Once pre-self healing took place on the selected MPPF, the applied voltage was no more increased but kept constant. The diameter of the demetalized spots with time, expanding processes and subsequent self healing events were observed and the data were averaged.

3. Results and discussion

3.1 Diameter of demetalization with time

Pre self-healing events occurred when ac and dc voltages were applied to the 12[㎛] MPPF. In both ac and dc cases, they took place at about 80[%] of main self healing voltages of the PPF. Fig. 3 shows the diameter of the demetalized spots with time after pre-self healing.

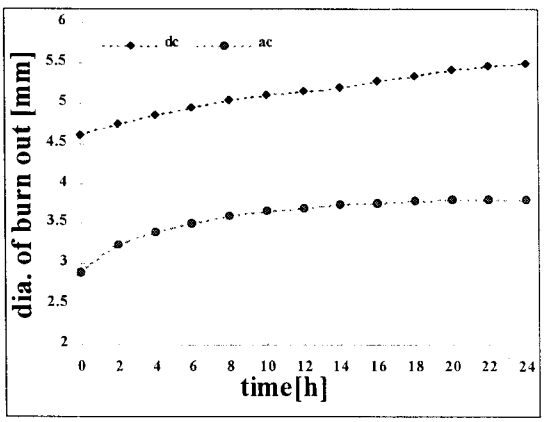

Fig. 3 Diameter of demetalized spots with time after pre-self healing

As shown in Fig. 3, the diameter of the demetalized spots after pre-self healing events was increased with time, and the diameter of the demetalized spots under dc condition was about 1.4 times that under ac condition. The diameter of the demetalized spots tended to be gradually saturated with time, and it is considered because the leakage current path along the demetalized surface is gradually lengthened with time.

3.2 Expanding processes of demetalized spots

After pre-self healing, it was observed that many subsequent self healing events took place at the burn out edge of the metalization, and it could be considered a kind of self healing mechanism. The creation of all self healing events acquired in this experiment is synthesized and the expanding processes of the self healing events are illustrated in Fig. 5.

As shown in fig. 5, the circumference of the demetalized spots was relatively smooth just after pre-self healing, but it was getting coarse with time. It is considered because the erosion of the metalization is progressed from the edge of the demetalized spots. Therefore, current leakage path is formed from the puncture due to self healing to the edge of the demetalized spots, and fine tracking is also progressed at the edge of the demetalized spots. After all, the expansion of the demetalization is progressed with voltage-applied time. For this reason, the shape of the demetalized spots on MPPFs looks like frost as sown in Fig. 5(a), (b). Since weak points due to the concentration of the electrical field are formed at the edge of the frost shape, subsequent self healing event occurs centering the weak points and it is expanded as shown in Fig. 5(a), (a)′, or the ends of the frost shape are inter-bridged and expanded to reduce the metalized area as shown in Fig. 5(b). By the way, it was observed that the demetalized shape looks like some pieces of cloud at pre-self healing and it globally spreads out ultimately as shown in Fig. 5(c). This is considered because the leakage current path is uni-directionally formed at demetalized spots. Fig. 5(d) also shapes like cloud. In this case, however, it occurred at relatively low ac voltage and did not occur frequently. It is considered because the electric field was concentrated at the edge of the demetalized spots, like Fig. 5(a), (b). However, the expanding shape was not same as the mentioned earlier, but it was expanded all over the circumference of the demetalized spots. In case of Fig. 5(e), it could be described as bridge shape and its frequency was relatively low compared with Fig. 5(a), (b). It was observed with noise in case that the applied voltage was increased near the breakdown

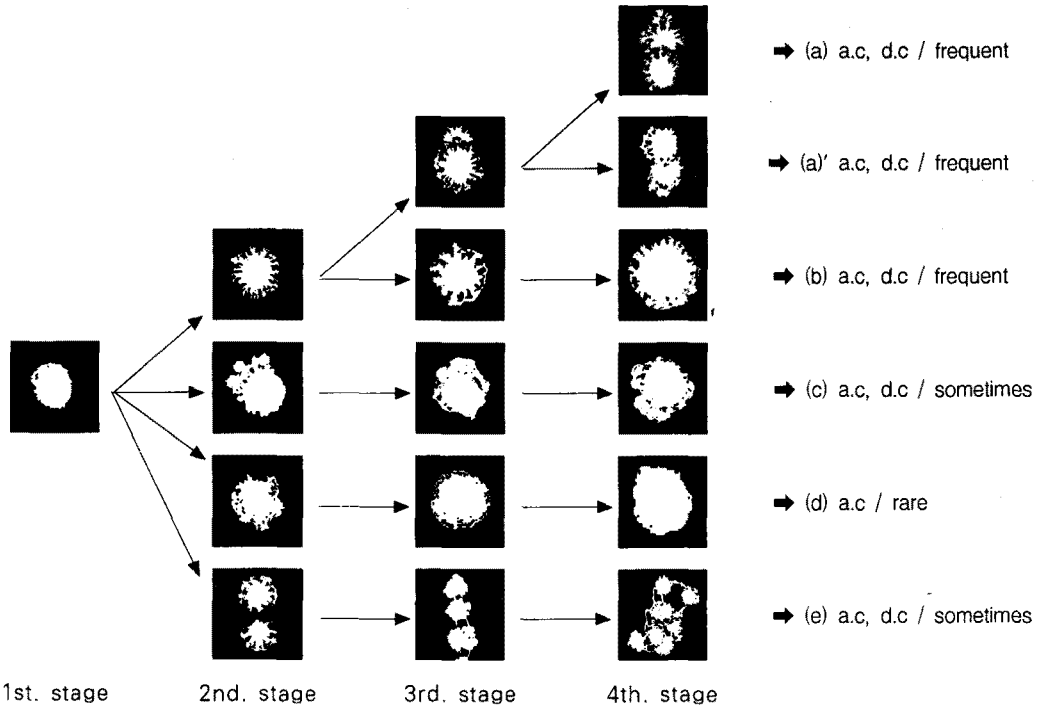

Fig. 5 Self healing creation and expanding processes

voltage of PPF after several pre-self healing events. The demetalized area is largest in this case because each demetalized spot due to self healing was bridged. In this case, even though the area surrounded by the bridge between two or more demetalized spots was not burnt out, the area was electrically isolated by the demetalized bridge line, which made the capacitance loss highest.

By the way, there were some second stage self healing events without first stage, according to the applied voltage and the increasing rate of the applied voltage.

5. Conclusions

After applying ac and dc voltages to the MPPF with defects, the pre-self healing creation on MPPF for capacitor applications and its expanding processes were observed.

As a results, this paper concludes as follows:

(1) The diameter of the demetalized spots after pre-self healing events was increased with continuous voltage-applied time, and the diameter of the demetalized spots under dc condition was 1.4 times that under ac condition.

(2) The expanding processes after pre-self healing events were characterized by several patterns. And, subsequent self healing events occurred at the edge of the demetalized spots, and they were connected one onother, which made the demetalized area expanded as a whole.

Acknowledgement

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