

SPECIFICATION

A metallized film, a production method thereof, and a capacitor using it.

Technical Field

The present invention relates to a metallized high polymer film capacitor used in an electric or electronic circuit, particularly a capacitor used as an across-the-line capacitor, etc. Above all, it relates to a safety standard approval capacitor in conformity with various safety standards for ensuring that capacitors are not broken or fired by the rush surge current due to lightning, etc. The present invention also relates to a metallized film suitable for obtaining said capacitor, and a production method thereof.

Background Arts

Noise filter capacitors are used for eliminating the noise coming from the line into various household electric appliances and electronic apparatuses and for preventing the noise generated in apparatuses from going into the power line. It can generally happen that a large rush current goes into capacitors including noise filter capacitors when a lightning stroke occurs. Lest capacitors should be broken or fired by the rush current, standards are established in respective nations to specify severe tests to be performed for capacitors such as noise filter capacitors (safety standards). The standards include, UL 1414, CAS C22.2 N01, VDE 0565-1, IEC

384-14, SEV 1055, JIS C 5151, etc., and furthermore NEMKO, SEMKO, DEMKO, EI, BS, etc.

These standards, assuming a large rush current, specify that when a voltage very high compared to the rated voltage is applied for a certain time, the capacitor shall not become abnormal or broken.

To conform to these standards, a 11 to 12 μm thick polyester film and an aluminum deposited film with a wide margin width have been used, but since they have quality which conforms to the standards at a very narrow tolerance, they have a problem that the fraction defective due to quality dispersion in the production process is large. To say concretely, the rejection rate in a withstand voltage test is large. On the other hand, there is a strong demand for downsizing capacitors, and if the film thickness is reduced for downsizing, the fraction defective increases as a technical bottleneck for downsizing.

Brief Description of the Drawings

Fig. 1 is a schematic drawing showing an example of the sectional form of the metallized film of the present invention.

Fig. 2 is a schematic drawing showing another example of the sectional form of the metallized film of the present invention.

Fig. 3 is a schematic drawing showing a further other

example of the sectional form of the metallized film of the present invention.

Fig. 4 is a schematic drawing showing an example of the sectional form of the metallized films of the present invention overlaid to make a capacitor.

Fig. 5 is a schematic drawing showing another example of the sectional form of the metallized films of the present invention overlaid to make a capacitor.

Fig. 6 is a schematic drawing showing an example of the aluminum-zinc content ratio in the deposited metal layer zone of the metallized film of the present invention.

Fig. 7 is a schematic drawing showing an apparatus for producing the metallized film of the present invention.

Fig. 8 is a schematic drawing showing an example of the sectional form of a capacitor produced by overlaying and winding the metallized films of the present invention into a roll.

Meanings of symbols

- 1 : metallized film of the present invention
- 2 : high polymer film
- 3 : margin
- 4 : deposited metal layer zone
- 5 : boundary zone
- 6 : oil covering the margin
- 7 : vacuum metallizer

- 8 : unwinding roll
- 9 : winding roll
- 10 : cooling drum
- 11 : oil evaporating nozzle
- 12 : Al evaporation source
- 13 : Zn evaporation source
- 14 : low temperature plasma treatment device
- 15 : oil evaporator
- 16 : pressure gauge
- 17 : control system
- 18 : output power supply
- 19 : exhaust vacuum pump
- 20 : schoop layer
- 21 : electrode lead portion

Disclosure of the Invention

The object of the present invention is to provide a capacitor which is small in the fraction defective in inspection and can prevent the dielectric breakdown of the high polymer film particularly at the margin and the boundary with the deposited metal layer zone mainly likely to suffer breakdown due to the high voltages applied in the tests of safety standards, and furthermore, to provide a small capacitor excellent in performance, a metallized film used for producing it, and a production process thereof.

The inventors studied intensively, and as a result, the

object of the present invention could be industrially advantageously achieved by the present invention with the following constitution.

[1] A metallized film, comprising a deposited metal layer zone destined to be an electrode with a surface resistance of $1 \Omega/\text{sq.} - 15 \Omega/\text{sq.}$, a margin with a surface resistance of $1 \times 10^{10} \Omega/\text{sq.}$ or more, and a 0.02 to 1 mm wide boundary zone existing between the deposited metal layer zone and the margin and continuously decreasing in the thickness of the deposited metal layer from the deposited metal layer zone to the margin, at least on one side of a high polymer film.

[2] A method for producing a metallized film, in a process of producing a metallized high polymer film by vapor-depositing an oil on the surface of a high polymer film or coating the surface of a high polymer film with an oil and subsequently vapor-depositing a metal in a vacuum metallizer, comprising the step of controlling the quantity of the oil applied by vapor deposition or coating, to keep the width of the boundary zone between the deposited metal layer zone and the margin in a specified range of 0.02 to 1 mm.

[3] A capacitor produced by winding into a roll or stacking high polymer films respectively having a deposited metal layer zone destined to be an electrode with a surface resistance of $1 \Omega/\text{sq.} - 15 \Omega/\text{sq.}$, a margin with a surface resistance of $1 \times 10^{10} \Omega/\text{sq.}$ or more, and a 0.02 to 1 mm wide

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

boundary zone existing between the deposited metal layer zone and the margin and continuously decreasing in the thickness of the deposited metal layer from the deposited metal layer zone to the margin, at least on one side of a high polymer film.

The largest feature of the present invention is that a metallized film has a specific boundary zone, i.e., a 0.02 to 1 mm wide boundary zone where the thickness of the deposited metal layer decreases continuously from the deposited metal layer zone to the margin, and that if the metallized film is used to make a capacitor, the dielectric breakdown of the high polymer film at the margin and the boundary zone can be prevented.

The Most Preferred Embodiments of the Invention

A schematic sectional view of the metallized film as an embodiment of the present invention is shown in Fig. 1. The present invention is not limited to or by the embodiment.

In Fig. 1, symbol 1 denotes the metallized film of the present invention; 2, a high polymer film; 3, a margin; 4, a deposited metal layer zone; 5, a boundary zone; and L, the width of the boundary zone.

The high polymer film 2 in the present invention is obtained by molding a natural, or semi-synthetic or synthetic high polymer resin. Above all, a high polymer film made of a synthetic high polymer resin is preferable in view of heat resistance, mechanical properties, electric properties and

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

physicochemical properties.

Preferable synthetic high polymer resins which can be used here include polyolefin resins, polyester resins, polyamide resins, polyimide resins, polyamidoimide resins, polycarbonate resins, polysulfone resins, polyphenylene resins, polyarylate resins, fluorine resins, polystyrene resin, polyallylene resin, etc. Especially, polypropylene, polyethylene terephthalate, polyethylene naphthalate, polyphenylene sulfide, polycarbonate and polystyrene are more preferable in mechanical properties and electric properties. Above all, polypropylene, polyethylene terephthalate and polyethylene naphthalate are especially preferable in view of a high withstand voltage.

The metal of the deposited metal layer zone 4 is not especially limited as far as it is electrically conductive, being able to be selected from Al, Zn, Cu, Ag, Au, Sn, Ti, Co, Ni and their alloys, etc. Among them, Al, Zn, Cu, Sn, etc. are preferable in view of corona deterioration resistance. Above all, an Al-Zn alloy is more preferable in view of moisture resistance, corona deterioration resistance and self-healability. Especially preferable is a deposited metal layer formed by an Al-Zn alloy, the Al content ratio $\{(Al \text{ content} \times 100) / (Al \text{ content} + Zn \text{ content})\}$ of which changes continuously as $C2 < C1 \leq C3$ or $C2 < C3 \leq C1$ (where $C1$ is the Al content ratio at the surface of the deposited metal layer; $C2$, that at

the center in the thickness of the deposited metal layer; and-
 C3, that at the interface with the high polymer film) in the
 deposited metal layer and 0.5 to 15 wt%, preferably 8 to 12
 wt% in the entire deposited metal layer. Above all, an Al-Zn
 alloy with an Al content ratio distribution of $C2 < C1 \leq C3$ is
 preferable since the self-healability is less deteriorated.
 The resistance of the deposited metal layer must be 1 to 15 Ω
 /sq. An especially preferable range is 2 to 12 Ω /sq. If the
 resistance of the electrode portion (active portion) is 4 to
 12 Ω /sq. when the deposited metal layer is made thicker in an
 about 2 to 5 mm portion in contact with the sloop layer as a
 so-called heavy edge, as shown in Fig. 2, for improving the
 adhesiveness to the sloop layer, especially the withstand
 voltage and $\tan \delta$ characteristic can be improved.

To raise the moisture resistance of the deposited metal
 layer, it is more preferable to form a very thin layer of an
 oil or deposited silicon or deposited silicon compound on the
 surface of the deposited metal layer.

It is important that the metallized film has a boundary
 zone 5 between the deposited metal layer zone 4 and the margin
 3. The boundary zone refers to a region which continuously
 decreases in the thickness of the deposited metal layer from
 the deposited metal layer zone 4 to the margin 3 as shown in
 Fig. 1. When observed by an optical microscope, the boundary
 zone refers to a region with a width (L) of 0.02 to 1 mm,

preferably about 0.02 to 0.5 mm, more preferably 0.02 to 0.25 mm, especially preferably 0.05 to 0.2 mm where the brightness changes gradually from the dark portion of the deposited metal layer zone 4 to the bright portion of the margin 3 as shown in Fig. 1. The conventional metallized films for capacitors must not have a continuously unclear portion at the end of the deposited metal layer as specified in 4.3 "Margin width" of JIS C 2319-1977 (Metallized polyester films for capacitors). One of preferably used conventional margin forming methods is the tape margin method in which a tape as wide as the margin is placed as a mask on the high polymer film to be metallized, for forming a non-metallized zone (margin) as a margin with a clear boundary between the deposited metal layer zone and the margin. Another conventional method is the oil margin method in which an oil is deposited by evaporation in a width of the margin on the high polymer film, since the deposited metal layer does not adhere to the oil portion. To clarify the boundary with the margin, (not to form the boundary zone 5) as in the tape margin method, it is proposed to use a special fluorine based oil unlikely to allow the deposition of the metal as stated in Japanese Patent Publication (Kokoku) No. 3-59981 or to cool the film before or when the film passes over the metallization source as stated in Japanese Patent Publication (Kokoku) No. 63-57932. These conventional techniques do not contain any technical idea at all that a

boundary zone with a specific width is formed and controlled as in the present invention.

The present invention has been completed based on the finding that if a boundary zone 5 with a specific width is formed, the dielectric breakdown of the high polymer film particularly at the boundary between the margin and the deposited metal layer zone where breakdown mainly occurs can be prevented even if high voltages are applied in the capacitor test in conformity with the safety standards. If dielectric breakdown occurs at the boundary between the margin and the deposited metal layer zone, it often appears as a phenomenon that the sloop layer of the capacitor is broken.

Furthermore, as shown in Fig. 3, it is more preferable that the margin 3 is covered with an oil 6. The amount of the oil is too slight to be specified, but the existence of the oil can be detected by X-ray electron spectroscopy (XPS or ESCA). Moreover, as shown in Fig. 4, when the metallized film is wound to form a roll or stacked with other identical metallized films, it is preferable the margin portions between respectively two adjacent overlying portions of the metallized film or the two adjacent overlying metallized films are filled with an oil 6, more preferably free from any air layer formed there. In this case, the oil 6 can be compatible with the oil used for impregnating the capacitor, so that the oil 6 and the impregnant oil may fill the margin portions, to eliminate any

air layer. It is preferable that an oil exists in the margin portions, so that the margin portions between the overlying portions of the metallized film or the overlying metallized films forming a capacitor are filled with the oil, to be free from any air layer.

Of course, the margin is intended for electric insulation, and the surface resistance should be 10^{10} $\Omega/\text{sq.}$ or more. More preferable is 10^{12} $\Omega/\text{sq.}$ or more.

Fig. 7 is a schematic drawing showing an apparatus for producing the metallized film of the present invention. The method for producing a metallized film of the present invention is briefly described below in reference to the drawing. The present invention is not limited to or by this embodiment.

A vacuum metallizer 7 is internally reduced to a predetermined pressure (vacuum degree) by a vacuum pump 19. When a specified pressure has been reached, a predetermined oil is vapor-deposited onto a high polymer film 2 unwound from an unwinding roll 8, through an opening for the width of the margin width (actually approximately twice the width of the margin) of an oil evaporating nozzle 11 controlled at a specific internal pressure identified by measurement. Then, from an Al evaporation source 12, a predetermined amount of Al is evaporated, for acting as nuclei of Zn and deposited on the high polymer film 2, and in succession, from a Zn evaporation

source 13, Zn is evaporated to be deposited so that the surface resistance of the deposited metal layer may be as specified. Subsequently, as required, the deposited metal layer zone, the boundary zone and the margin are treated on the surface by a gas plasma containing oxygen atoms using a low temperature plasma device 14, and furthermore, as required, through the narrow opening of an oil evaporator 15 controlled at an internal pressure identified by measurement, an oil is evaporated and deposited on the surface of the deposited metal layer zone, the boundary zone and the margin. The metallized film in which the deposited metal layer zone and the margin are formed is wound by a winding roll 9, and finally taken out of the vacuum metallizer 7, being slit into a necessary narrow width and reeled.

In this method, it is very important for controlling the width of the boundary zone, to measure and control the internal pressure of the oil evaporating nozzle 10. To described in more detail, the pressure in the oil evaporating nozzle 11 is measured by a diaphragm type or other pressure gauge (vacuum gauge) 16, and the output signal is applied to a control system 17. If the pressure in the oil evaporating nozzle 11 is different from the set value, it is fed back to a heater output power supply 18, for control to keep the pressure in the oil evaporating nozzle constant, so that a predetermined quantity of oil vapor may be always formed, to

make a predetermined quantity of the oil deposited on the surface of the high polymer film 2. On the margin with the oil deposited, the Al acting as nuclei and Zn are not deposited or are very slightly deposited.

As shown in Fig. 3, the oil covering the margin does not exist with a uniform thickness, but exists with a crest thickness distribution. It is estimated that when the metal is deposited, the oil is partially evaporated at the end by condensation heat, and that the metal is deposited in inverse proportion to the oil concentration, to form a boundary zone continuously decreasing in thickness. Therefore, it is estimated that in the relation between the amount of the oil covering the margin and the degree of evaporation at the end of oil, the kind of the oil used plays an important role in forming the boundary zone.

The low temperature plasma treatment is preferable for controlling the width of the boundary zone and for improving the phenomenon that the capacitor generates a noise when a voltage is applied if the adhesion between film layers is poor. The low temperature plasma treatment refers to exposing the metallized film to a plasma generated by the discharge initiated and maintained by applying a high voltage of direct current or low frequency, medium frequency, high frequency or other alternating current, or microwaves, etc., for modifying the surface.

The metallized film of the present invention is wound to form a roll or stacked with other identical metallized films, and processed as usual, to make a capacitor with a high withstand voltage. Especially it is more preferable to use an oil compatible with the oil covering the margin 3 and high in electric insulation, as the impregnant oil, since a capacitor with a higher withstand voltage can be produced.

An oil can be judged to be compatible with the oil covering the margin 3, if when a sealed 100 cc sample bottle containing 30 cc each of the oil used to cover the margin 3 and the impregnant oil is sufficiently shaken and allowed to stand for 30 minutes, the mixture is not separated into two layers or not suspended, being dissolved transparently. As a more simpler method, a swab impregnated with an impregnant oil is used to apply the impregnant oil to the surface of the metallized film from the deposited metal layer zone to the margin 3 according to JIS K 6768-1971 "Wet test methods for ethylene and polypropylene films", and if the coating width of the impregnant oil on the margin is not narrowed and remains the same or widens, the impregnant oil can be judged to be preferable.

It is more preferable that the oil covering the margin is a silicone oil and that the impregnant is also a silicone oil. An especially excellent silicone oil is dimethyl polysiloxane or methylphenyl silicone oil.

The margin 3 of the metallized film of the present invention refers to the margin (free margin or the margin stated in JIS C 2319-1997) formed for ensuring the insulation between the deposited metal layer and the sloop layer as shown in Fig. 1, and also the margin for safety mechanism proposed in Japanese Patent Publication (Kokoku) No. 1-21613, Japanese Patent Laid-Open (Kokai) Nos. 4-225508 and 7-86088, USP 5057967, etc., or a margin formed to keep electrodes separated.

Even conventional capacitors with such a margin for safety mechanism or a margin for keeping electrodes separated have a problem that dielectric breakdown occurs at the boundary between the deposited metal layer zone and the margin, to lower the capacity, but the capacitor produced by using the metallized film of the present invention is remarkably improved in the problem.

A margin for safety mechanism can be formed as described in Japanese Patent Laid-Open (Kokai) No. 63-114956 (USP 4832983). In the metallized film of the present invention, the oil 6 remains after metallization, to cover the margin 3, and the boundary zone 5 is formed.

In the conventional metallized film for a capacitor, it is important for quality that the margin does not have the boundary zone and that no oil remains on the margin. However, in the present invention, the boundary zone is formed and the

oil remains on the margin on the contrary, to invent a metallized film with a very high withstand voltage.

The capacitor using the metallized film of the present invention is suitable as a capacitor for an application requiring a high withstand voltage. It is especially excellent as a capacitor in conformity with the safety standards requiring high withstand voltages. The metallized film of the present invention is suitable for producing a small capacitor with excellent performance.

The metallized film of the present invention has the margin covered with an oil unlike the conventional metallized films. So, the conventional capacitor manufacturing conditions such as press conditions may be required to be changed, but it is a matter of course for the persons skilled in the art, to set optimum processing conditions suitable for the respective metallized films.

In the present invention, physical properties were measured according to the following methods.

(1) Composition of Al-Zn alloy

Nine square centimeters of a metallized film sample was dissolved by diluted nitric acid, and the solution was diluted to have a volume of 20 ml. The solution was analyzed by ICP emission spectral analysis, to determine Al and Zn. The ICP emission spectral analyzer used was Model SPS1200VR produced by Seiko Denshi Kogyo K.K.

(2) Al-Zn composition distribution

Auger electron spectral analyzer, Model AMP-10S produced by JEOL was used to determine Al and Zn while etching the surface of the deposited metal layer with Ar ions.

Ar ion etching conditions

Accelerating voltage: 3 kV

Sample current: 1×10^{-6} A

Etching rate: 190 Å/min in terms of SiO_2

Measuring conditions

Accelerating voltage: 3 kV

Slit No.: 5

Sample current: 8×10^{-8} A

Sample inclination angle: 72 degrees

Beam diameter: 10 μm

The film interface refers to the position at which the Al content becomes maximum in a range where the Al content increases to reach the maximum and subsequently decreases in a range from the center in the thickness of the deposited metal layer to the film interface. The content ratio at the maximum point is expressed by C3.

(3) Width of boundary zone

The boundary between the deposited metal layer zone and the margin was measured at a magnification of 50 to 100 times using an optical microscope, and the value was read to the third decimal place, being rounded at the third decimal place.

For measurement, a slit roll was used. Measurement was effected at 10 points at 50 cm intervals of the metallized film, and the lowest value, the highest value and the average value were obtained.

(4) Existence of an oil on the margin

The margin was observed by XPS (ESCA), to confirm whether or not the oil existed.

Instrument: SSX-100-206 produced by SSI

Exciting X rays: Monochromatized Al $K\alpha_{1.2}$ rays (1486.6 eV)

Photoelectron escape angle (θ): 35°

Energy correction: Binding energy of C1s main peak was adjusted to 284.6 eV.

Since XPS has a good sensitivity, it can happen that the oil as a contaminant is detected. However, if the margin is covered with an oil, the signal from the detected oil is remarkably high, to allow distinction from the contaminating oil.

(5) Molecular weight distribution of the oil on the margin

The surface of the metallized film was washed by isopropyl alcohol, and the oil contained in the washing was measured using gel permeation chromatograph GPC-244 (Waters) and differential refractometer detector R-401 (Waters), and molecular weights were calibrated using polystyrene.

In the case of a silicone oil with phenyl groups, TSK-gel-

G3000HXL (1) and G2500HXL (1) (Tosoh Corp.) were used as columns.

Examples

Examples 1, 2, 3 and 4, and Comparative Examples 1, 2, 3 and 4

On an 8 μ m thick polypropylene film, a deposited Al-Zn alloy layer with a total width for two zones of 33 mm and a margin (non-deposited zone) with a total width for two zones of 5 mm were formed in Examples 1, 2, 3 and 4 and Comparative Examples 1, 2 and 3. In Comparative example 4, a deposited Al layer with the same width and a margin with the same width were formed.

In Examples 1, 2, 3 and 4 and Comparative Examples 1, 2 and 3, a metallic pipe (margin nozzle) containing an oil for forming the margin or a polypropylene film unwound from the unwinding side of a vacuum metallizer was heated, to evaporate the oil from an almost rectangular hole opened on the surface of the pipe, to have a width shorter than the width (actually approximately double the width) of the margin by the thermal expansion allowance in the width direction, for depositing the oil at the portion destined to be the margin on the surface of the film at a vapor deposition rate of 400 m/min. Then, Al was vapor-deposited and in succession, Zn was continuously vapor-deposited. In succession, except Comparative Example 3, all the surface of the deposited metal layer zone, the boundary zone and the margin was treated by a low temperature

plasma of oxygen gas, and subsequently had the same oil as the margin oil evaporated and deposited. Then, the film was wound by a winding roll. In Comparative Example 3, the film was wound after it had Zn-vapor-deposited.

The temperatures of the Al and Zn evaporation sources were controlled to form a deposited metal layer of 2.4 wt% in entire Al content ratio, 6.0 wt% as C1, 0.1 wt% as C2, 14.0 wt% as C3 and 4 $\Omega/\text{sq.}$ in resistance.

The margin oil used in Examples 1, 2, 3 and 4 and Comparative Examples 1 and 2 was phenylmethyl dimethyl polysiloxane of 520 in MW and 1.0 in MW/MN (SH702 produced by Toray Dow Corning Silicone K.K.). In Example 1, the internal pressure of the margin nozzle was controlled at 60 Pa, and the boundary zone widths measured at 10 points at 50 cm intervals in the slit roll circumferential direction were 0.02 to 0.04 mm. Similarly, in Example 2, the pressure was controlled at 52 Pa and boundary zone widths were kept in a range from 0.05 to 0.07 mm. In Example 3, the pressure was controlled at 45 Pa, and the boundary zone widths were kept in a range from 0.2 to 0.4 mm. In Example 4, the pressure was controlled at 35 Pa, and the boundary zone widths were kept in a range from 0.8 to 1.0 mm. In Comparative Example 1, the pressure was controlled at 70 Pa, and the boundary zone widths were kept in a range of less than 0.01 mm (like an ordinary margin). In Comparative Example 2, the pressure was controlled at 25 Pa,

and the boundary zone widths were kept in a range from 1.3 to 1.5 mm. In these examples, in reference to the pressure in the oil evaporating nozzle, the margin nozzle temperature was controlled to control the pressure in the oil evaporating nozzle.

In Comparative Example 3, perfluoro polyester oil was used as the margin oil, and the oil vapor pressure was kept at 40 Pa, while the margin nozzle temperature was controlled to keep the boundary zone width at less than 0.01 mm (like an ordinary oil margin).

In Comparative Example 4, a heat resistant film was used, and a margin zone corresponding to two margins with a total width of 5 mm was formed at a vapor deposition rate of 300 m/min. According to the tape margin method, Al was vapor-deposited to form a deposited metal layer with a resistance of 4 Ω /sq.

The respective metallized films were slit at the center of the deposited metal layer zone and at the center of the margin zone, by an ordinary method, to have metallized film reels (19 mm wide) respectively with a deposited metal layer zone width of 16.5 mm and a margin width of 2.5 mm.

The slit metallized films were overlaid by an ordinary method as shown in Fig. 2 and wound to form rolls respectively, pressed, had a schoop layer attached, heat-treated and had an electrode attached, to make element.

capacitors as shown in Fig. 8. Then, they were impregnated with dimethyl polysiloxane oil (100 cst in viscosity) and armored with an epoxy resin by an ordinary method, to produce 0.15 μ F capacitors.

These capacitors had an AC voltage of 1250 V AC (60 Hz) applied for 1 minute according to UL 1414, to examine their breakdown conditions. The capacitors were visually observed after completion of test, and furthermore, disassembled, to confirm the breakdown positions by an optical microscope.

Moreover, the margins of the metallized film reels were observed by XPS, to check whether the margins were covered with the oil.

The results are shown in Table 1. It can be seen that the products of the present invention (Examples 1 to 4) were little broken, showing very excellent performance.

Table 1

	Oil vapor pressure (Pa)	Width of the boundary zone (L) (MM)	Result of oil analysis by XPS	Broken samples/Tested samples	Broken position
Example 1	60	0.02 - 0.04	Much oil (large Si signal)	3/100	
Example 2	52	0.05 - 0.07	Much oil (large Si signal)	1/100	
Example 3	45	0.2 - 0.4	Much oil (large Si signal)	0/100	
Example 4	35	0.8 - 1.0	Medium oil (medium Si signal)	1/100	
Comparative Example 1	70	Less than 0.01	Much oil (large Si signal)	29/100	Broken at schoop portion(at boundary of deposited metal layer zone, or slightly inside deposited metal)
Comparative Example 2	25	1.3 - 1.5	Medium oil (medium Si signal)	18/100	Broken near schoop portion(at boundary of deposited metal layer zone, or slightly inside deposited metal)
Comparative Example 3	40	Less than 0.01	Medium oil (medium F signal)	56/100	Broken at schoop portion(at boundary of deposited metal layer zone, or slightly inside deposited metal)
Comparative Example 4	-	Less than 0.01, tape margin	Contaminated (slight Si signal)	100/100	Broken at schoop portion(at boundary of deposited metal layer zone, or slightly inside deposited metal)

Example 5, and Comparative Examples 5, 6, 7 and 8

Metallized films were produced under the conditions shown in Table 2, using a 10 μm polyethylene terephthalate film in Example 5, and a 12 μm polyethylene terephthalate film in Comparative Examples 5, 6, 7 and 8. Then, as described in Example 1, capacitors were produced. The capacitor production conditions were the conditions generally adopted for producing capacitors using metallized polyester films (metallized polyethylene terephthalate films). These capacitors were tested as described in Example 1, except that the voltages applied were 1250 V AC and 1500 V AC. The results are shown

in Table 2.

As shown in Table 2, the capacitor of the present invention (Example 5) showed excellent performance, though the film thickness was thinner by 2 μm than that of the comparative examples.

Table 2

	Metallized film production conditions (metallization conditions)	Broken samples/Tested samples	
		1250VAC	1500VAC
Example 5	Example 2	0/30	0/30
Comparative Example 5	Comparative Example 1	3/30	20/30
Comparative Example 5	Comparative Example 2	2/30	16/30
Comparative Example 6	Comparative Example 3	5/30	26/30
Comparative Example 7	Comparative Example 4	7/30	30/30

Industrial Applicability

The metallized film of the present invention has a boundary zone between the deposited metal layer zone and the margin, and has the margin covered with an oil. So even if high voltages are applied as specified for capacitors in safety standards, breakdown near the margin little occurs, and capacitors with very high safety can be produced.



25
CLAIMS

1. A metallized film, comprising a deposited metal layer zone destined to be an electrode with a surface resistance of $1 \Omega/\text{sq.} - 15 \Omega/\text{sq.}$, a margin with a surface resistance of $1 \times 10^{10} \Omega/\text{sq.}$ or more, and a 0.02 to 1 mm wide boundary zone existing between the deposited metal layer zone and the margin and continuously decreasing in the thickness of the deposited metal layer from the deposited metal layer zone to the margin, at least on one side of a high polymer film.
2. A metallized film, according to claim 1, wherein the width of the boundary zone is 0.02 to 0.5 mm.
3. A metallized film, according to claim 1 or 2, wherein the width of the boundary zone is 0.02 to 0.25 mm.
4. A metallized film, according to any one of claims 1 through 3, wherein the width of the boundary zone is 0.05 to 0.2 mm.
5. A metallized film, according to claim 1, wherein the margin is covered with an oil.
6. A metallized film, according to claim 5, wherein the oil is a mineral oil or a silicone oil.
7. A metallized film, according to claim 6, wherein the oil is a silicone oil.
8. A metallized film, according to claim 7, wherein the weight average molecular weight MW of the silicone oil is $300 \leq MW \leq 800$, and the ratio of the weight average molecular weight MW to the number average molecular weight MN is $1.0 \leq MW/MN \leq 1.1$.
9. A metallized film, according to claim 7 or 8, wherein the silicone oil is dimethyl polysiloxane oil or methylphenyl

This Sheet Has Been Replaced



REPLACED SHEETS SG

- | | | | | | |
|-------------------------------------|-------------|---------|-------|----------|-------|
| ☐ | Description | : paged | | to paged | |
| ☒ | Claim(s) | : paged | 25 | to paged | 28 |
| ☐ | Drawing(s) | : paged | | to paged | |
| ☐ | Abstract | : paged | | to paged | |



silicone oil.

10. A metallized film, according to claim 9, wherein the silicone oil is methylphenyl silicone oil.

11. A metallized film, according to any one of claims 1 through 10, wherein the deposited metal layer is composed of an alloy consisting of Al and Zn, and the Al content ratio (Al content/(Al content + Zn content)) changes continuously as $C2 < C1 \leq C3$ or $C2 < C3 \leq C1$ (where $C1$ is the Al content ratio at the surface of the deposited metal layer; $C2$ is that at the center in the thickness of the deposited metal layer; and $C3$ is that at the interface between the deposited metal layer and the high polymer film), while the Al content ratio (Al content $\times$ 100/(Al content + Zn content)) of the entire deposited metal layer is 0.5 to 15 wt%.

12. A metallized film, according to claim 11, wherein the Al content ratio is 8 to 12 wt%.

13. A metallized film, according to claim 11 or 12, wherein the Al content ratio changes as $C2 < C1 \leq C3$.

14. A metallized film, according to any one of claims 1 through 13, wherein the deposited metal layer, the boundary zone and the margin are treated by a low temperature plasma.

15. A method for producing the metallized film stated in any one of claims 1 through 14, in a process of producing a metallized high polymer film by vapor-depositing an oil on the surface of a high polymer film or coating the surface of a

This Sheet Has Been Replaced





high polymer film with an oil and subsequently vapor-depositing a metal in a vacuum metallizer, comprising the step of controlling the quantity of the oil applied by vapor deposition or coating, to keep the width of the boundary zone between the deposited metal layer zone and the margin in a specified range of 0.02 to 1 mm.

16. A method for producing the metallized film, according to claim 15, wherein when the oil is applied by vapor deposition or coating, the pressure in the oil evaporator is measured and controlled.

17. A method for producing the metallized film, according to claim 14, wherein after a main metal has been vapor-deposited in the vacuum evaporator, a low temperature plasma of a gas containing oxygen atoms is used for treating the surface of the deposited metal layer zone, the boundary zone and the margin.

18. A capacitor produced by winding into a roll, a high polymer film having a deposited metal layer zone destined to be an electrode with a surface resistance of $1 \Omega/\text{sq.} - 15 \Omega/\text{sq.}$, a margin with a surface resistance of $1 \times 10^{10} \Omega/\text{sq.}$ or more, and a 0.02 to 1 mm wide boundary zone existing between the deposited metal layer zone and the margin and continuously decreasing in the thickness of the deposited metal layer from the deposited metal layer zone to the margin, at least on one side of a high polymer film, or stacking said high polymer





film with other identical high polymer films.

19. A capacitor, according to claim 18, wherein the metallized film stated in any one of claims 1 through 14 is used.

20. A capacitor, according to any one of claims 5 through 14, 18 and 19, wherein an oil compatible with the oil covering the margin is used as an impregnant.

21. A capacitor, according to claim 20, wherein the oil covering the margin and the oil used as an impregnant are a silicone oil.

22. A capacitor, according to claim 21, wherein the silicone oil is dimethyl polysiloxane oil or methylphenyl silicone oil.

23. A capacitor, according to any one of claims 18 through 22, which conforms to safety standards.

This Sheet Has Been Replaced

