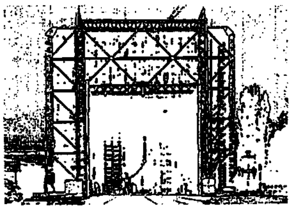

NINTH INTERNATIONAL SYMPOSIUM
ON HIGH VOLTAGE ENGINEERING

August 28 - September 1, 1995

GRAZ CONVENTION CENTER
AUSTRIA, EUROPE

9th ISH

INSULATORS GLAZE MODIFIED BY PLASMA PROCESSES

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Abstract

Surface properties of electrical insulators are responsible for their behaviour, especially during heavy rains in contaminated areas. Different means are used in service to overcome this problem. A new approach can be applied here which involves the technology of plasma processes to modify surface properties of materials. Glaze is the last layer of electrical insulators and it is highly hydrophylic. To modify this some changes in constitution of glaze has to be done and new hydrophobic layer must be created. Such kind of treatments of surface is possible in plasma processes. During these processes the heterogenous plasma polymerization takes place on the surface of glaze and thin deposition film is built. From the electrical applications point of view such films have very interesting properties (high hardness, low friction, good adhesion to substrates, chemical stability).Some electrical properties of plasma modified real insulator glaze have been presented.

1. Introduction

The good electrical properties of outdoor insulators are lost when they are subjected to the influence of atmospheric conditions like wind, humidity, fog, rain and especially natural and industrial pollution particles in air. Apart from high dielectric properties (resistivity, arc tracking and UV resistance the surface of insulators should have low coefficient of friction, antielectrostatic properties and low surface energies (high hydrophobicity).

Different means are used in energy power practice to overcome this problem. Some of permanent solutions are: increase of leakage distance, using hydrophobic materials like silicon rubber composite or hydrophobic coatings (silicon rubber or fluorourethane coatings).

The hydrophilic properties of glaze is the result of its chemical structure. It contains mainly silicon - oxygen bonds which are changed during manufacturing technology by alkali ions (sodium, potasium and other). As the consequnce of that new bonds in a material are created. A hydrolisis of silicondiooxide takes place that making surface highly hydrophylic. The surface properties can be described by surface energy or surface tension forces. The hydrophobic, low energy surface, prohibits a water film to establish and thereby a leakage current is strongly limited. In the case of solid dielectrics. The surface energy is determined by London's dispersion forces or hydrogen bonding forces /1/. Silicon rubber RTV energy is defined by electron movement and therefore is very small 10^{-3} J/m^2, but the glass energy is determined by the second phenomenon and just for that it is very high 0.1 J/m^2. The high energy surface is wetted readily and allows water to spread over it in a continous film and makes it easier to develop surface flashover especially in higly contaminated area and during wet atmospheric condition.

To decrease the value of the material surface energy in a few laboratories a new, alternative to mentioned above, the plasma technology has been studied /2,3/.

2. Plasma technology

Plasma processes are a promising approach to the development of polymer coatings and surface treatments for variety of applications in many industries: electronics, electrical, optical, biomedical and chemical /4,5,6/.

The region of greatest interest to plasma processing are the glow discharges. The low temperature plasma generated by the glow discharges is characterized by following parameters:

- energy of electrons 2 - 8 eV $\Rightarrow T = 10^3 - 10^4$ K,
- energy of ions 0.06 eV $\Rightarrow T = 500$ K,
- energy of atoms 0.03 eV $\Rightarrow T = 300$ K,
- density of ions $10^9/cm^3$.

The ions of the working gas bombarding the glaze surface cause an emission (sputtering) of surface atoms (sodium, potasium, and others). Then after injection of suitable monomer (low molecular compound with silicon - oxygen bonds) into a plasma reactor various components of the plasma interact with the surface of the substrate promoting their electrochemical interaction. In the case of compound with Si - O bonds in final stage a stable and highly hydrophobic layer is created on the substrate surface.

3. Experimental procedure

Two types of glazes used in Poland were selected for experiments. One white ond second one brown. They differ in concentration of alkali ions: white has less K_2O but more N_2O. They also differ in other constituents. The ceramic samples with diameter 110 mm and 5 mm thickness were covered with these two kinds of the glaze. The samples were cleaned with carbon tetrachloride in ultrasonic chamber, washed with alcohol and dried at 110° C for 1.5 hours. Then each sample was placed inside a bell - jar type reactor with internal parallel plate metal electrodes. As a working gas Argon was used. In first step at the gas pressure 133 Pa the sample surface was cleand by a plasmas of the working gas for a few minutes then a vapour of hexametylodisiloxan (HMDSO) was injected into the reactor and the pressure of 112 Pa was set. At this pressure the plasma polymerization processes took place. The reactor was supplied with 150 W, R.F. (27 MHz) generator. As the authors /1,2/ showed, during these processes the concentration of hydrophilic elements are reduced and hydrophobic groups are chemically firmly bonded on the surface, to form a new hydrophobic layer.

The plasma treated samples were then placed in a small fog chamber into which very fine 2.3 μm deionized water mist was injected. The mist is generated by an ultrasonic fog generator. A few measurements were conducted in the fog chamber: AC flashover voltage at a non - uniform electrical field, DC leakage current and surface resistivity. To compare obtained results with another technology a few samples were painted with an insulator fluorourethane coating applied worldwide at high contaminated areas. /8/.

4. Results and discussion

The plasma treated glaze water repellency (hydrophobicity) was primaly studied by using a deionized water drop of 2 μl and measurements of a contact angle with a goniometer. For both type of the glaze the contact angle was in the range 95° - 98°. These values prove that low energy layer was created on the glaze during plasma polymerization processes. The low energy surface repels water, the droplets are very fine and stand seperately as is shown on Fig.1a.

The AC flashover voltage was measured in a fog chamber for a period of about 15 minutes from when the fog generator was switched on. The tests were caried out for a finger like electrodes at the distance of 50 mm. The results are shown on Fig. 2.

During the tests it was observed that non - treated (hydrophilic) surface was wetted readily by big droplets and after flashovers water spread over it on a wide area in continuos film Fig.1c. The plasma modified samples showed higher level of flashover voltage and water films were created only along the path of flashovers, Fig. 1b. Thera are only small differences in the flashover voltages between White and Brown modified glazes. The important is that the first flashover on modified wetted surface tooke place at more than 50 % higher voltage level compared to the non - modified surface.

Also essential differencies were noticed between glazes at leakage and surface resistivity measurements Fig. 3 and 4.

The leakage current tests were done immediately following 15 minutes wetting in the fog chamber. The lowest value of currents was obtained for Brown treated in plasma glaze. It was one order lower, for all testing DC voltages, compared with the non - modified samples.

The surface resistivity measurements were made at DC voltage equal 10 V between two alumina foil electrodes of 100 mm length placed on samples at the distance of 10 mm.

The Fig. 4. shows that after the first minute of wetting a drop of surface resistivity is observed for all type of samples plasma treated and non - treated. Although, it was only about 1 -2 order for the plasma modified glaze and fluorourethane coated glaze in comparision with six order drop for non - modified samples. Moreover for such samples there is slow but continuos drop of resistivity not observed for modified samples.

The last two tests indicated that Brown glaze, which has much less Na_2O than White one, created better condition for plasma

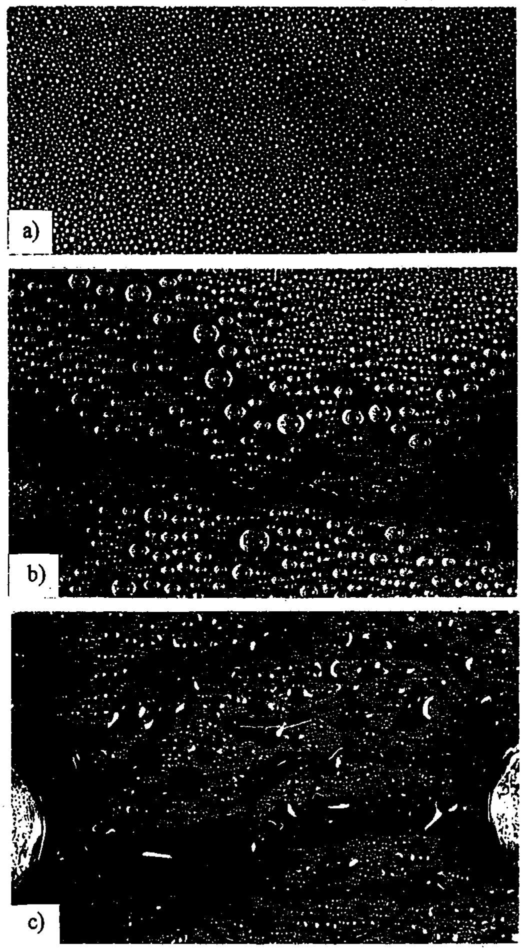

Fig.1. Plasma treated glaze surface after 15 min. wetting in fog chamber a) before high voltage test, b) after few flashovers on modified glaze, c) after few flashovers on non - modified glaze.

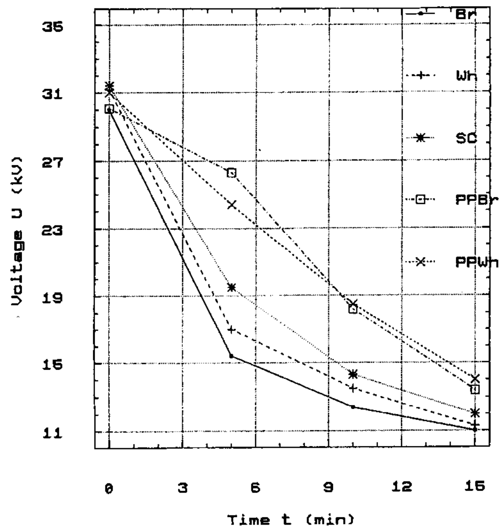

Fig. 2. AC flashover voltage as a function of wetting time in fog chamber: Br - brown glaze; Wh - white glaze; SC - fluorourethan coating; PPBr, PPWh - plasma treated brown and white glaze respectively.

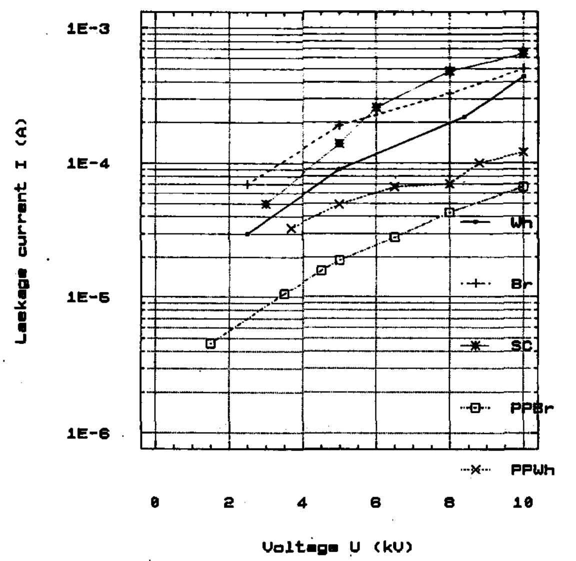

Fig. 3. Leakage current versus DC voltage after 15 min. wetting.

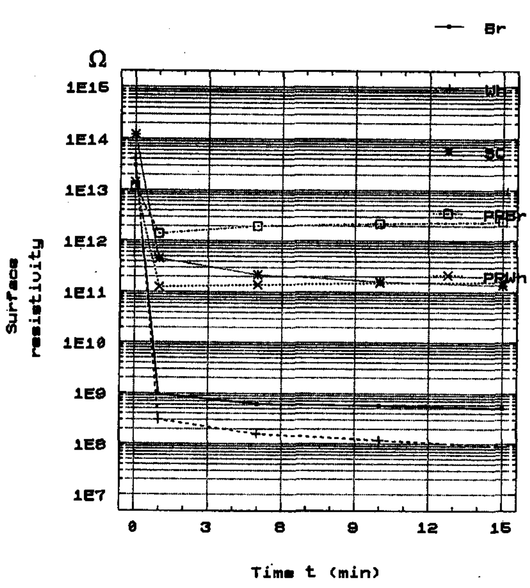

Fig. 4 Surface resistivity versus time of wetting in fog chamber.

polymerization processes and indicated favorable chemicals bonding to build hydrophobic layer. This new layer prohibits the water film to establish on the insulator surface and the leakage current is decreased.

In the next step of our experiments other organosilanes (hexamethyldisilazane, hexamethyldisiloxane) will be tested. Also 500 W R.F. generator will be applied in plasma polymerization experiments.

5. Conclusions

All done experiments have proved that the plasma technology may demonstrate its ability to improve surface properties of the glaze used in insulators industry. The suitable plasma of glow discharges in final stage of the plasma processes is able to build a stable and higly hydrophobic layer.

Acknowledgements

Thanks are due to the Polish Committee of Science Research for fundation the research - KBN No 3 P401 031 06.

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