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Plasma Surface Modification for High Voltage Insulation Improvement

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In recent years, with the development of higher voltage and larger capacity of electrical equipment, the improvements of electrical insulation performance for various materials are urgent. The present investigations indicate that the characteristics of material surface, such as adhesion, hydrophilicity, charge accumulation, hardness, can be enhanced by surface modification including direct fluorination, nano-doping and low temperature plasma treatment. Among them, low temperature plasma surface modification takes many advantages, such as environment-friendly, controllability and flexible structure. In our group, pulsed plasma was used for polymer and metal surface modification to inhibit micro-discharge in high voltage insulation system. Different plasma discharge devices, such as dielectric barrier discharge (DBD), atmospheric-pressure plasma jet (APPJ) or diffuse discharge were developed for surface modification. Both SiOx, TiO2 and SiOx-TiO2 composite thin film with nanostructures were deposited on polymer and metal surface. The film thickness, composition and morphology can be easily controlled by changing pulsed plasma parameters. The experiments can be divided into two parts: 1) By introducing SiOx on polymer surface, the surface charge dissipation rate was accelerated and the surface flashover voltage was increased. Further studies showed that SiOx film with Si-OH group intruded shallow traps on the material surface. 2) The SiOx and TiO2 thin film covered on copper surface can decrease the electric filed distortion and inhibit micro-discharge. Furthermore, the deposited film was used for metal particle activity suppression in DC GIL. The results showed that, after film deposition (any of them), the lifting voltage of metal particle and the lifting time delay were enhanced. The lift voltage and time delay enhancement degree were TiO2-SiOx composite≈TiO2>SiOx. In summary, the pulsed plasma surface modification technology developed by our group has been proven a feasible method for high voltage insulation performance improvement.

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