

Development of measurement systems for bulk and surface charge distributions of dielectric materials

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Measurement systems for bulk and surface charge distributions of dielectric materials have been developed. Bulk charge accumulation in dielectric materials under electron beam irradiation was observed using acoustic measurement techniques. Recently, some accidents in spacecraft due to the charging up of electric potential have been reported. Some of them are caused by surface discharge normally happens in plasma environment. Some others seem to be caused by discharge due to an accumulation of charge in bulk of materials in relatively higher altitude environment. Surface charge is usually measured using surface potential meter. However, there had been no useful method to measure the bulk charge in the materials. Therefore, we have been developing the bulk charge measurement system. The developed system is applicable to measure the charge distribution in dielectrics in vacuum environment under electron beam irradiation. Using the systems, we carried out the measurements of bulk charge distributions in polymeric films and glass materials under electron beam irradiation. Judging from the obtained result, it is found that the characteristics of the charge accumulation in bulk strongly depend on the type of materials. For example, while a large amount of charge was accumulated in the bulk of PTFE film, the amount charge in polyimide film was not so much even under same condition of electron beam irradiation. In glass material, a polarity of the accumulated charge after irradiation of the electron beam depends on the impurity included in the material. The developed measurement system is useful to estimate the dielectric materials for the spacecrafts. Furthermore, a measurement system for surface charge distribution has been developed using an optical method. The electric potential of insulating materials on the surface of the spacecraft charged up when the cosmic rays are irradiated to the spacecraft. Sometimes, the change of the electric potential causes an unexpected accident of electrostatic discharge (ESD) with serious damage to the electric devices. To understand the mechanism of the ESD, the measurement of charge distribution on surface of the dielectric materials should be carried out. Therefore, we have proposed to use an optical method using Pockels effects for the measurement of surface charge distribution. Using these methods, we have already succeeded in observing the two dimensional surface charge distributions on polyimide film. By applying a positive high voltage to a needle tip on the surface of the polyimide film, the growth of, so called, streamers were observed clearly. On the other hand, the negative discharge was spread with round shape on the surface. These results show the measurement is suitably carried out.