

## Aiming at a More Rigorous Understanding in Electrical Insulating Materials Research

Yoshimichi Ohki

Department of Electrical Engineering and Bioscience,  
Waseda University, Tokyo 169-8555, Japan

In order to fully understand a certain property of a material or to clarify the mechanism of a phenomenon, research must be done with scientific rigor and a scholarly approach. The first three pioneers who introduced the rigorous scholarly approach into the field of electrical insulation research in Japan are Profs. Inuishi, Ieda, and Yahagi. The followers and disciples are inspired by their work and encouraged by the rich heritage following in their footsteps. On this occasion of being awarded the Whitehead Memorial Lecture Award, I feel honored to introduce several examples of research done in my laboratory at Waseda University.

The first example is related to inorganic dielectrics. More specifically, research on characterization of silica glasses and its relation to formation mechanisms of point defects induced by irradiation of intense photons or radioactive rays. For optical communication, pure silica or impurity-doped silica is used. In the 1980s, much research was carried out on radiation-induced loss increase in silica-core optical fibers in the US, Europe, and Japan. Although a substantial amount of data were reported, they were often in contradiction with each other. Through systematic investigations carried out using more than ten kinds of samples synthesized with different manufacturing methods, we found that a slight discrepancy in stoichiometry of the O/Si ratio in the silica samples played a key role in determining the defect formation mechanism upon exposure of intense photons or radioactive rays. In the memorial lecture, I will talk about more topics including the nature of electronic states of a defect center in Ge-doped silica glass examined by a photon-assisted pump-probe method.

The second example is on polymeric insulating materials such as polyethylene. Although quite a lot of advanced measuring techniques have been developed in various fields of science, much of the research on polymeric insulating materials does not fully make use of these advances. One of the results of my research done with the intention of clarifying basic phenomena occurring in polymeric materials is the estimation of mean free paths of electrons injected into the materials. By building a kind of spectrometer that enabled us to measure the distribution of energy loss of electrons photo-injected into a very thin polymer film, we found that the mean free path of electrons is shorter in polyethylene than in paraffin. This result gives a clear explanation to the fact that the dielectric breakdown strength is higher in polyethylene than in paraffin.

The third example deals with more practical issues such as water treeing in polyethylene. In pursuing the research of this relevance, measurements of space charge distributions have very often played significant roles. By measuring

temporal changes in space charge distribution in water-treed polyethylene under ac voltages with a time resolution of 25  $\mu\text{s}$ , the conductivity and permittivity of the water-treed region was estimated. From this, it has become clear that the conductivity of the treed region depends on the water content and could reach more than  $10^{10}$  times that of the untreed polyethylene. Several other important results such as those dealing with the water tree growth under inverter surges, growth mechanism of water trees, and the nature of space charge carriers accumulated at layer interfaces in printed circuit boards will be introduced in the lecture.