§8. Establishment of Partial Discharge Protection Technology for Reliability Improvement of Electrical Insulation of LHD

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The world's largest class superconducting coil is used in the "Large-scale Helical Device" in NIFS. Its electrical insulation system might be exposed to considerably severe multiple stresses including cryogenic temperature, large mechanical stresses and strong magnetic fields. It is therefore very important to study its electrical insulation performance under these severe conditions in order to establish the reliability of the coil. If a superconductor quenches from superconducting state to normal state, the liquid coolant vaporizes very easily and turns into high-density gas at cryogenic temperature. In these bubbles partial discharge (PD) easily occurs and would lead to the breakdown. So it is required to clarify the influence of the PD on the electrical insulation performances.

Figure 1 shows the electrode configuration and the experimental setup. The polymer employed was a polyimide film of about 0.125 mm in thickness. A copper tape, the edge of which was cut to an equilateral triangle shape, was installed on one side of the film. The groove of about 0.025 mm in deepness was also installed using a cutter along the extension line from a top of the equilateral triangle. On other side of the film, a back electrode was formed by a copper tape. The electrode system can restrict occurrence position of the PD into the groove by the groove and the back electrode. The 1000 waveforms of the PD current at 77 K under AC voltage of 10 $kV_{0\text{-}p}$ with the frequency of 50 Hz or under positive half-wave rectification voltage of 17.5 $kV_{0\text{-}p}$ were continuously measured by a digital oscilloscope.

Figure 2 shows the half value width distribution (a) under positive half-wave rectification voltage of 17.5 $kV_{0\text{-}p}$ and (b) the half value width distribution under AC voltage of 10 $kV_{0\text{-}p}$, respectively. When phases of 90° or -90° were standardized in both Figs, the first PD which has smaller half value width was only observed under positive half-wave. On the other hands, the first PD's which have smaller and longer half value was observed under AC voltage. It is considered that the larger half value width and smaller half value width in Figs.2 and 3 indicate the PD in micro bubble and in LN_2, respectively [1]. It is considered that a micro bubble charged to positive generates under positive half-wave, and the micro bubble charged to positive was removed by Coulomb force between the micro bubble and the applied voltage. In case of the PD under positive half-wave, the difference of the time between the first PD in this cycle and the following PD's in a previous cycle is longer compared to that under AC voltage. It is suggested that the longer time also brings to this phenomena observed only under positive half-wave.

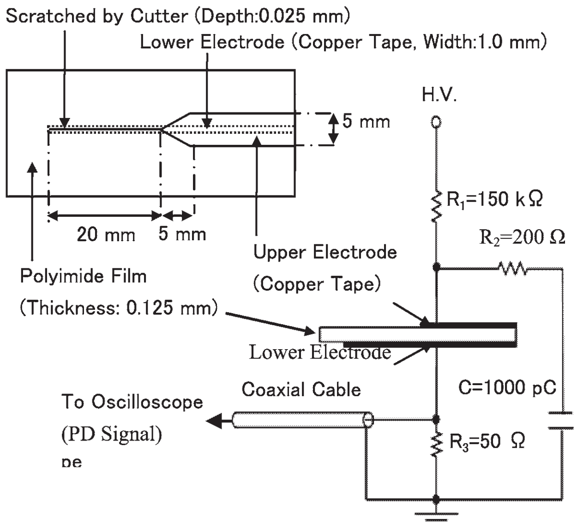
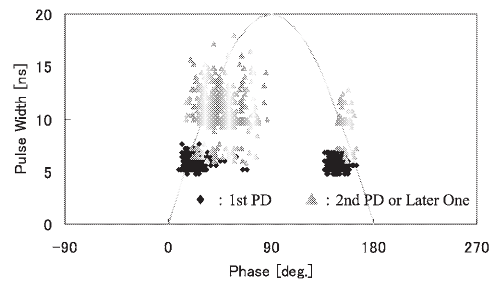
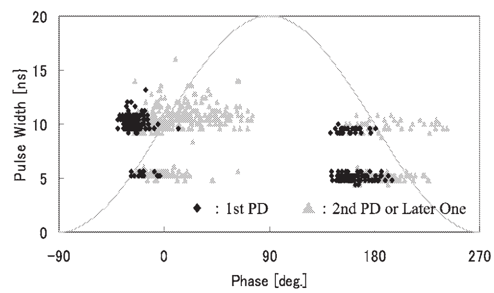


Fig.1 Electrode configuration and experimental setup.



(a) under positive half-wave rectification voltage of 17.5 $kV_{0\text{-}p}$



(b) under AC voltage of 10.0 $kV_{0\text{-}p}$

Fig.2 Half value width distribution.

1) Tanaka, Y., et.al.: ISEIM (2008) 135-138