§5. Reliability of Cryogenic Composite Electrical Insulation for LHD

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The world's largest class superconducting coil is used for the "Large-scale Helical Device". 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 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 500 waveforms of the PD current at 77 K under AC voltage of 10 $kV_{0\text{-}p}$ or 15 $kV_{0\text{-}p}$ with the frequency of 50 Hz. were continuously measured by a digital oscilloscope.

Figure 2 and Figure 3 show the half value width distribution under the voltage of 10 $kV_{0\text{-}p}$ and the half value width distribution under the voltage of 15$kV_{0\text{-}p}$, respectively. The horizontal axis's in these figures indicate the time after the first PD occurred. It was recognized that higher voltage and/or longer time from occurrence of first PD brought higher probability of the PD containing longer half value width. It is thought that the larger half value width and smaller half value width in Fig.2 indicate the PD in micro bubble and in LN_2, respectively. It was considered that higher voltage and/or longer time from occurrence of first PD lead bigger magnetite and/or more number of the PD in micro bubble, and the bigger magnitude and/or the more number of the PD in micro bubble lead to more residual micro bubble, bringing the higher probability of the PD in micro bubble.

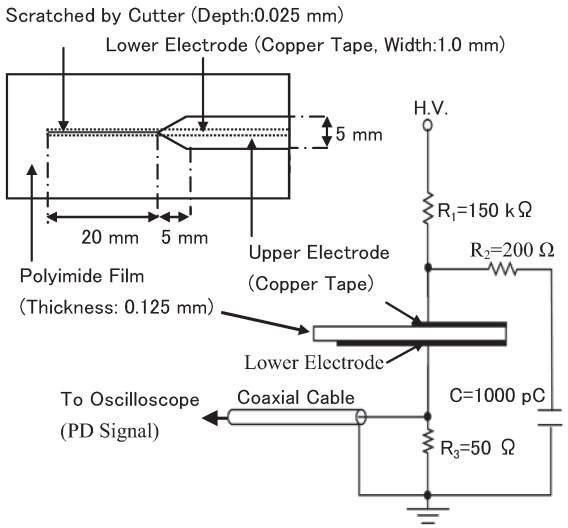

Fig.1 The electrode configuration and the experimental setup.

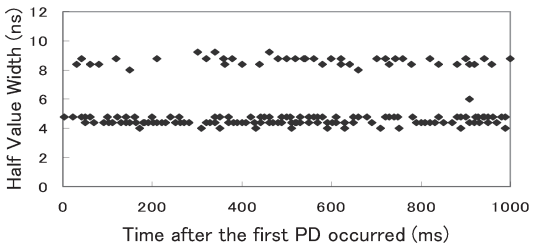

Fig.2 The half value width distribution under the voltage of 10 $kV_{0\text{-}p}$

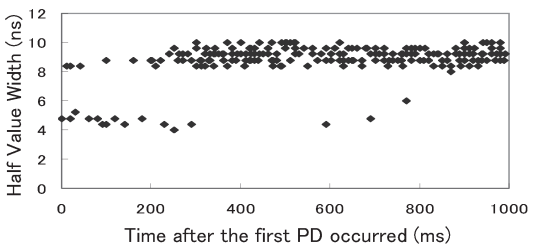

Fig.3 The half value width distribution under the voltage of 15 $kV_{0\text{-}p}$

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2) Tanaka Y., Murakami.Y, Yamada S. and Nagao.M., THE 2008 ANNUAL MEETING RECORD I.E.E. JAPAN [2], p.97 (2008)