Next Generation Electric Power Equipment for Distribution System

Background and Objective

Next generation electric power transmission and distribution system must be flexible enough to deal with changes such as connection of large amount of solar cells to build a low carbon emission society. Moreover, in near future replacement of electric power equipment will be significant problem. Therefore, technology menu for replacement should be prepared.

In this project, super conductive fault current limiters and equipment for transformer substrate are developed to add to a list of technology menu for replacement.

Main results

1. Development of superconductor for fault current limiter

The optimum condition to fabricate Bi2223 superconductor for magnetic field shield type fault current limiter which is adequate for a large system was obtained. Detachment of Bi2223 superconductor film from a substrate can be suppressed with conserving superconductivity performance, by using a substrate with rough surface for producing superconductors (Fig. 1). Moreover, with optimizing temperature and number of baking during a sintering process, critical current density of each crystal forming a sinter of superconductor was improved to 8,000A/cm^2 which has margin of 2,000A/cm^2 against the minimum value for fault current limiters (Fig. 2, [H09019]). Bulk performance of super conductor will be improved by reducing electrical resistivity between each crystal.

2. Development of element technology for an all solid insulated transformer

All solid insulated transformers are very attractive because of its high safety, compact and low environmental loading due to their oil-free insulation (Fig. 3). However, to develop an all solid insulated transformer with operation voltage of more than 33kV, new insulation material with high electrical insulation property and thermal conductivity, and material property suitable for molding process must be invented. Moreover, molding method of metallic conductors as coils and metallic plates as ground plates with high precisions must be developed. In this project, new transformer structure which can be produced by molding process without reducing electrical insulation performance by optimizing material and configuration of spacers supporting conductor coils and ground metallic plate. Using this structure, a 60 kV-class 20 MVA all solid insulated transformer with the same size with conventional oil insulated transformer can be designed by selecting material (such as nitride aluminum particle) and concentration of filler.

3. Development of hybrid gas-insulated transmission line

CRIEPI is developing a new type of electric insulation method called hybrid gas-insulation. The hybrid gas-insulation is expected to have the electrical insulation performance close to that of conventional gas-insulation, without using SF6 which has a high global warming potential. However, in this insulation method, connection of conductor can be a weak point lowering electrical insulation property. So far, detailed electric field of conductor connection has been analyzed, and design and fabrication of model electrodes simulating configurations of real hybrid gas insulated transmission line were performed. Electrical insulation properties of model electrodes are being evaluated experimentally for designing a prototype model of 257kV class hybrid gas-insulated transmission line.

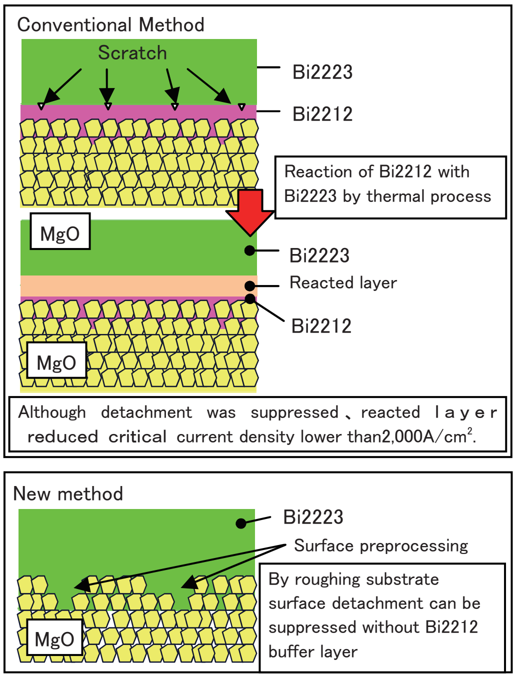

Fig. 1 Suppression of superconductive thick film

By roughing substrate surface, detachment of superconductive film can be suppressed without lowering property of superconductor.

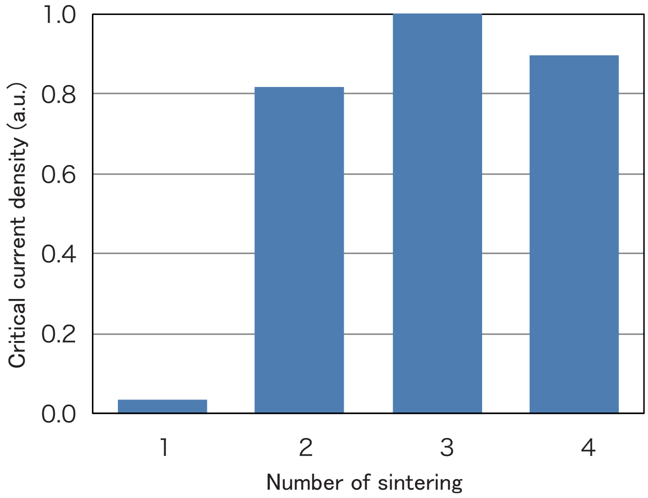

Fig. 2 Dependency of critical current density on number of sintering process

Critical current densities are normalized by the value after the 3rd sintering process. The maximum critical current density was obtained after the 3rd sintering.

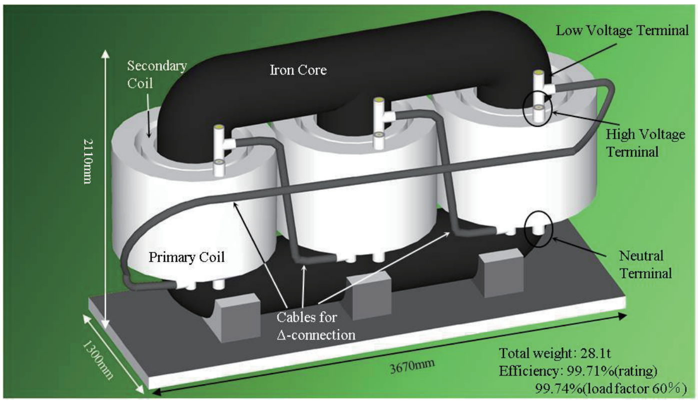

Fig. 3 Conceptual design of 60kV class all solid insulated transformer

Transformer model designed on the basis of the electric insulation property under high temperature of epoxy resin filling with AlN nano-structured particle, which is developed by CRIEPI.

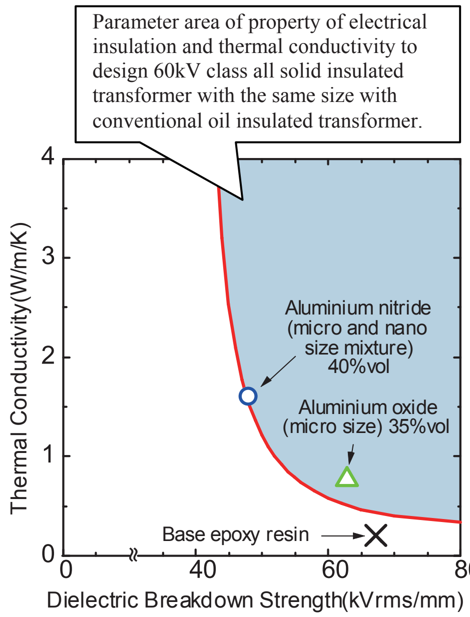

Fig. 4 Insulation material for molding all solid insulated transformer

60 kV class 20 MVA all solid insulated transformer can be designed by using epoxy resin filled with AlN composite particles or AlN fractured particles.