SMES of the 10,000kW for the power control in power system has been manufactured, and connected to a real power grid. In addition, innovative basic researches, for example, low cost converter, maintenance-free cryo-coolers, inter-locks system and so on, have also been developed. The SMES was installed in the metal rolling factory with hydro power plant. Field test has been carried out for load fluctuation compensation. SMES was able to compensate for the active power according to the fluctuating load, and confirm the situation with a smooth load change of 11kV bus of hydro power stations.

Field test of 10MVA/20MJ SMES for load fluctuation compensation had been carried out successfully and following items were confirmed.

Figure 1 shows Superconducting Coil Cryostat of the SMES.

(1) Active Power Control
It was confirmed that the fluctuation load was reduced due to the input/output of SMES active power at the connection point with the 11kV medium voltage network.

(2) Reactive Power Control
It was confirmed that the reactive power control of the generators was reduced due to the input/output of SMES reactive power.

It was also confirmed that the field current and the field voltage of the generators were lowered.

(3) Number of Operations for Load Fluctuation Compensation
It was confirmed that over 50,000 operations were executed.

(4) The perfection level and reliability of the system were confirmed through protected operation, control, and normal operation.

(5) Verification of High-Speed Response
Confirmed high-speed following capability up to several Hz. Step responses for active power and reactive power was less than 20ms. Regarding the status of the amplitude ratio and phase differences of the frequency response, high-speed following capability up to several Hz was confirmed.

In the future, it will be necessary to develop improved technologies that can contribute to power system control by establishing the optimal integration of the SMES system with existing power sources, dispersed power sources, which are expected to become more common, and wind power plants. In addition, it will also be important to improve the related technologies in order to reduce SMES costs by developing coils using next-generation wires, and to promote the verification of high reliability necessary for power equipment.

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SEM Photos and Space Charge Distributions before and after Electrochemical Migration Growth in a Printed Wiring Board

Electrochemical migration is a kind of electrochemical phenomenon, in which conductor materials are ionized and migrated to and through the insulation layer by electric field. Nowadays, insulating materials for printed wiring boards (PWBs) must have even higher resistance to electrochemical migration in order to maintain long-lasting high reliability. Therefore, to study characteristics of migration, a reliable non-destructive method to detect its growth in the thickness direction is required.

A paper/phenol-resin composite PWB was set between a copper anode and an aluminum earthed cathode at 85 °C and 85 %RH, and a dc electric field of 3 kV/mm was applied for 98 hours to induce electrochemical migration. Upper and middle four figures show surface and cross sectional microscopic images.
observed for a PWB before and after the migration experiment. Growth of electrochemical migration with a length more than 1 mm along the surface direction from an anode edge is clearly shown in the two left optical microscopy images. Furthermore, penetration of migration through the adhesive layer and its extension into the bulk is clearly seen in the right scanning electron microscopy (SEM) images, which are superposed by energy-dispersive spectroscopic images showing the presence of Cu atoms by red dots.

The lower figure shows space charge distributions obtained by the pulsed electroacoustic (PEA) method for the PWB before and after the aging. Note that repetitive oscillatory signals appearing in the paper/resin composite are caused by eight-layered lamination of prepreg. Before the aging, a large amount of negative charge is observed on the interface between the composite and adhesive layer. After the aging, the negative charge disappears and positive charge appears, indicating that migration penetrates the adhesive layer. To conclude, these figures clearly demonstrate that growth of electrochemical migration along the thickness direction in the paper/resin composite PWB can be detected by the PEA method.

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