8. Material Science Research Laboratory

◆Basic hydrogen technologies

[Objectives]

To clarify the approaches of electricity businesses to new technologies relating to the production, transportation, storage and use of hydrogen when a hydrogen-based society is realised.

[Principal Results]

- Using the Japanese version of a hydrogen energy model developed by the Laboratory for the assessment of energy technologies, the roles of hydrogen technologies in an entire energy system were assessed in terms of economy, environmental performance and energy security along with competing technologies.
- For the development of a SOFC (ceramic reactor) aimed at achieving a high output density at around 600℃ at which mass-produced inexpensive metals can be used, single cell pressurisation assessment was conducted and a high output density was produced with a high fuel utilisation rate under pressure conditions (～0.7 MPa). In addition, a silver nano-particle coating technology was developed and its application to air electrode materials improved the output density by 1.8 times compared to uncoated cell in the low current region where high efficiency operation is possible.

◆Structural material assessment

[Objectives]

To understand the strength characteristics and develop a life assessment method and a corrosion reduction technology to contribute to the solving of various problems of materials used for thermal and nuclear power generation from the aspect of structural material assessment.

[Principal Results]

- A new method was proposed to assess the multi-axial fatigue and residual life of Ni-based polycrystal super-alloys and uni-directionally solidified super-alloys, all of which are materials for gas turbine rotor blades, and the suitability of this method was verified. In addition, a convenient life assessment programme was developed to assess the residual life of initial stage rotor blades of a 1,300℃ class gas turbine or PC.
- For the development of an integrity assessment method for new types of nuclear reactors, long-term creep fatigue test data for high chrome steel was obtained and the basic design of a structural integrity assessment system was conducted.

◆Water chemistry management technologies

[Objectives]

To reduce the cost of light water reactors by means of reducing the radiation exposure and to improve the safety through the implementation of SCC control measures from the viewpoint of water chemistry by means of advancing and standardising water chemistry technologies.

[Principal Results]

- An experiment on the relationship between the boiling conditions as well as water chemistry and the amount of deposited crud to the fuel claddings found that crud tends to be deposited on the boiling surface of sub-cooled claddings and that the amount of deposited crud is smaller with a higher pH value of the water.
- The slow strain rate test (SSRT) conducted to examine the SCC of hardened low carbon stainless steel in hot water found that intragranular SCC occurred on the surface in hot water containing dissolved oxygen and that intragranular SCC on the surface would progress to grain boundary SCC in hot water containing a minute quantity of sulphate ion in addition to dissolved oxygen.

◆Coating assessment

[Objectives]

To develop assessment technologies for the heat-resistant cycle properties and corrosion resistance, etc. of the coating for gas turbines to achieve cost reduction and assured reliability through the rationalisation of maintenance technologies.

[Principal Results]

- The thermal cycle test for the thermal barrier coating (TBC) of which the temperature gradient is equivalent to that of an actual gas turbine established the impacts of the growth of an oxidated layer produced at the boundary between the top coat and bond coat on thermal cycle defects.
- A corrosion test device using pressurised high speed combustion gas flow was developed to clarify the corrosion behaviour of various types of coatings due to the present impurities in the flow.

◆Energy conversion and storage material technologies

[Objectives]

To establish a safe and maintenance-free power storage technology which tolerates the time difference between the generation and consumption of electric energy and to achieve a higher efficiency of dye-sentitized solar cells as the launch pad for the practical use of solar cells as thee cells can make the low cost introduction of solar cells possible.

[Principal Results]

- A mixed composite material membrane production device to fabricate electrodes using a cathode active material clad with a non-

organic solid electrolyte membrane was developed to improve the cycle characteristics of composite-type solid lithium polymer secondary cells and to enlarge the cell size.

・A simulation model for the prediction and assessment of the performance of dye-sentisized solar cells, incorporating all recombination paths, was developed to quantitatively clarify the effects of these paths on the current-voltage characteristics of the cells.

◆Analysis of the mechanism of functional oxides

[Objectives]

To develop an understanding of the mechanism for the emergence of useful functions and to create new functional oxides based on such understanding.

[Principal Results]

・The Hall coefficient for a $La_{2-x}Sr_xCuO_4$ single crystal was measured up to a high temperature of 1,000 K to calculate the charge-transfer excitation energy between copper and oxygen. This was followed by clarification of the importance of charge fluctuations on the transport characteristics of copper oxide high temperature super-conductors.

・It was discovered that the doping of electrons could be achieved by the strong oxygen reduction of the La-doped Y series high temperature super-conductors. It was then established for the first time that it would be possible to continually change the carriers from holes to electrons in the same substance system of a high temperature super-conductor.

・Using a high quality $La_{2-x}Sr_xCuO_4$ membrane, the relationship between the sign reversal of the Hall coefficient and the disappearance of super-conductivity in the excessive doping region was clarified.

・It was clarified that a huge thermo-electromotive force with layered cobalt oxide $GdBaCO_2O_{5.5}$ originates from a large entropy accompanying the degeneracy of the spin state.