Material Science Research Laboratory

Brief Overview

The Material Science Research Laboratory conducts wide-ranging R & D activities designed to achieve the duel purposes of providing engineering solutions to enable the highly efficient operation of energy equipment from the viewpoint of creating materials which can bring about technological innovations in the energy industry.

Achievements by Research Theme

Hydrogen-Related Basic Technology

[Objectives]

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

[Principal Results]

- The change of the current collector for small SOFC from Pt to Ag has more than trebled the electric conductivity, achieving the highest performance of hydrogen production through water steam electrolysis in the world.
- With the molten salt electrolytic synthesis method which may be able to reduce energy consumption in the ammonia production process, the technical challenges were clarified, including the factors impeding the reaction in the nitrogen-hydrogen system and the factors causing a decline of the synthetic ammonia production efficiency in the nitrogen-water steam system.

Evaluation of Structural Materials

[Objectives]

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

[Principal Results]

- The lifetime characteristics of steam turbine materials under the condition of multi-axial creep fatigue resembling the actual operating conditions were clarified to improve the accuracy of the remaining life assessment of steam turbines.
- The corrosion characteristics of carbon steel under the condition of treatment by low concentration sodium hydrate were clarified to advance the water treatment technology for heat recovery steam generator at combined power plants (change of the substance in the treatment water from low concentration phosphoric salt to low concentration sodium hydrate).

Water Chemistry Management

[Objectives]

To reduce the cost of light water reactors by means of reducing the radiation exposure through the advancement and standardisation of water chemistry technologies and to improve safety by means of implementing measures to prevent SCC (stress corrosion cracking) from the viewpoint of water chemistry.

[Principal Results]

- The desolution of corrosion products under the simulated condition of PWR plant shutdown was investigated to establish an appropriate water quality management regime under such condition to reduce the exposure to radiation. The assessment results indicate that Ni and Fe oxides exist in the form of fine particles of less than 0.45 μm.
- A test on the deposition of crud on the fuel claddings was conducted under the simulated condition of boiling water at the PWR core. The test results indicate that the amount of deposited crud tends to increase with an increase of the Ni concentration. [Q08404]

Coating Evaluation

[Objectives]

To develop evaluation technologies for the resistance to thermal cycling and corrosion of the coating for gas turbines in order to achieve cost reduction and to ensure reliability through the rationalisation of maintenance technologies.

[Principal Results]

- Thermal cycling tests on the conventional thermal barrier coating (TBC) established the relationship between the deterioration of

the texture at the boundary of the top coat (ceramic layer) with the bond coat (alloy layer) and damage to the ceramic layer. The impact of the spraying conditions for TBC on the strength of the ceramic layer was also clarified. [Q08005]

- It was established that the simple quantitative appraisal of the characteristics of the ceramic layer thinning can be conducted using the small electric furnace for testing which was developed by the Laboratory to simulate the ingredients of combustion gas. [Q08033]

Energy Conversion and Storage Materials Technology

[Objectives]

To establish a safe and maintenance-free energy storage technology which permits a time lag between the generation and consumption of electric energy to achieve a high efficiency in dye-sensitized solar cells for practical use of the low cost solar cells.

[Principal Results]

The development of a safe, low cost composite type all-solid-state lithium polymer secondary battery are strongly desired for electric power levelling for customer use. The applicability of a carbon-based negative electrode (Fig. 1) was confirmed in a laboratory experiment. [Q08012]

- The impacts of the cell design and fabrication conditions on the energy conversion efficiency in dye-sensitised solar cells were experimented and analysed for the ultimate purpose of manufacturing high efficiency dye-sensitised solar cells with excellent reproducibility. An efficiency of 8.6% (under standard indoor conditions) was achieved, opening the way for further improvement of the efficiency of dye-sensitised solar cells. [Q08019]

Micro/Nano Science of Advanced Materials

[Objectives]

To develop technologies for the refining and integration of functional oxides on a microscopic scale and to apply them to the development of innovative materials.

[Principal Results]

- By measuring a heat capacity of “non-superconducting” three-dimensional copper oxides (Fig. 2) with their hole concentrations controlled precisely from zero, and by comparing the results with those of high-T_c cuprates, we could establish how the electronic states evolve from parent Mott insulator to a superconducting state in cuprates by doping holes.
- A field-effect transistor (FET) with high mobility even at a very low voltage was successfully produced as part of the efforts to develop an organic single crystal FET using ionic liquid.

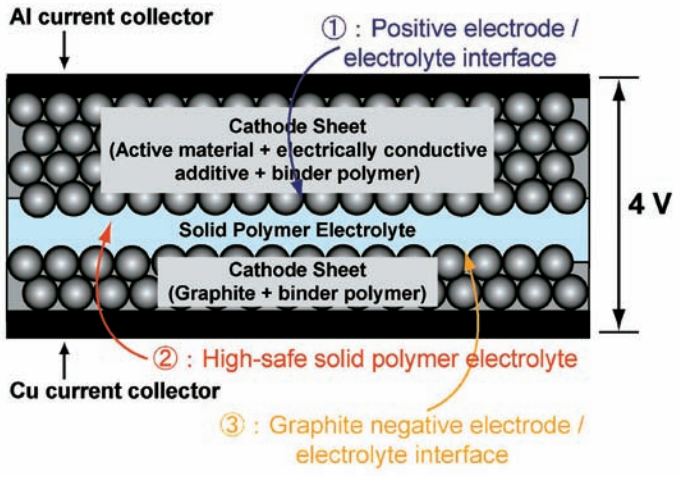

Fig.1 Cross sectional image of all-solid-state lithium-ion secondary battery.

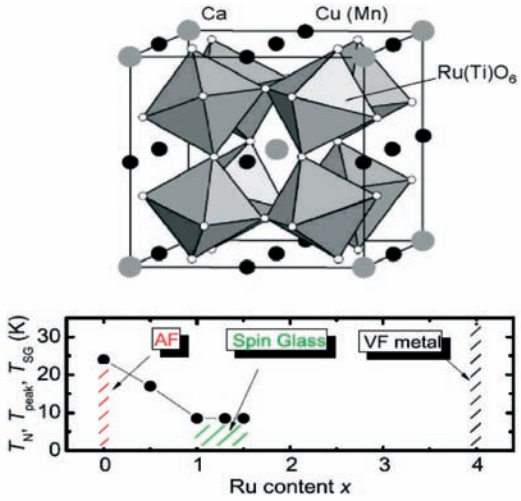

Fig.2 Crystal structure of $CaCu_3$ $(Ti_{4-x}Ru_x)$ O_{12} and its electronic phase diagram.