Basic Technology Subjects

Materials Science Research Laboratory

Brief Overview

The mission of the Materials Science Research Laboratory is to contribute to reliable electric power supply and the promotion of a low-carbon society through fundamental materials research, for field applications to electric power plants, renewable energy utilization, and new materials development for energy conservation.

Achievements by Research Theme

Materials for Nuclear Energy

In order to decrease radiation exposure and secure material integrity, we develop fundamental technologies to investigate water chemistry and environmental effects on corrosion in nuclear reactors.

- We have organized an expert committee to discuss seawater effects on the corrosion of spent fuel pools at Fukushima Daiichi Nuclear Power Station and have summarized the results of the committee discussion. Mitigation methods are proposed based on the discussion and experiments.
- Zinc injection does not influence the solution of corrosion products on SG tubes under the simulated shutdown conditions of a PWR primary system.
- Measured electrochemical potential is almost independent of the Ni/NiO ratio. Then, the Ni/NiO electrode is the most appropriate candidate for a reference electrode to evaluate the electrochemical corrosion potential of reactor internals. The integrated Ni/NiO electrodes manufactured in this study exhibit almost the same theoretically expected pH value.

Materials for Thermal Power Plants

We aim to improve the efficiency of thermal power generation through the establishment of evaluation techniques for environmental resistance and structural integrity. We also contribute to improve the operating reliability of thermal power plants through the application of advanced non-destructive inspection techniques.

- Corrosion tests for boiler tube materials were performed with additive HCl on the assumption of a coal biomass co-combustion condition. The effect of HCl on corrosion behavior was experimentally examined (Q11001).
- For the unified prediction of the fracture behavior of modified 9Cr steel, a model was newly developed to represent the dependency of fracture energy on temperature, the deformation rate, and stress multiaxiality (Q11012).
- An ultrasonic phased-array technique was applied to the open rack vaporizers in LNG thermal power stations, and the technique could detect fatigue cracks due to thermal fluctuation (Fig. 1).

Batteries and Electrochemical Materials

Research based on materials for alternative energy and energy conservation has been conducted, focusing on the development of evaluation methods for the outdoor performance of photovoltaic (PV) systems for future mass installation and research on material for high-efficiency solid-oxide fuel cells (SOFCs).

- For the future mass installation of grid-connected PV systems, we have presented a prediction model of regional PV power generation by integrating elemental methods, such as the spatial interpolation of solar irradiance (Q11013).
- In order to make clear the SOFC performance determinative, we have evaluated the commercially available cells using an AC impedance measurement method at open circuit voltage. The total cell resistance was found to consist of four types of resistances. Among these four, Nernst loss resistance exhibits a correlation with the changes of the gas elements and its measured values show good agreement with the calculated values, especially at a low gas flow rate (Q11010).

Advanced Functional Materials

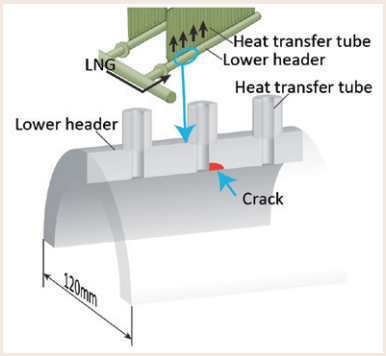
Our mission is to explore functional electronic materials for the next generation, e.g., new superconductors and/or new organic semiconductors with extreme properties, by utilizing excellent techniques for crystal growth and by measuring basic physical properties.

- We have revealed that a fluoride substrate is far better for the epitaxial growth of Fe (Se, Te) superconductor thin films than conventional oxide substrates, and have proposed a guiding principle for selecting substrate materials.
- We have succeeded in fabricating a new type of light-emitting device made of a simple mixture of ionic liquid and light-emitting organic polymer, which can be driven by relatively low voltage and can respond very quickly.

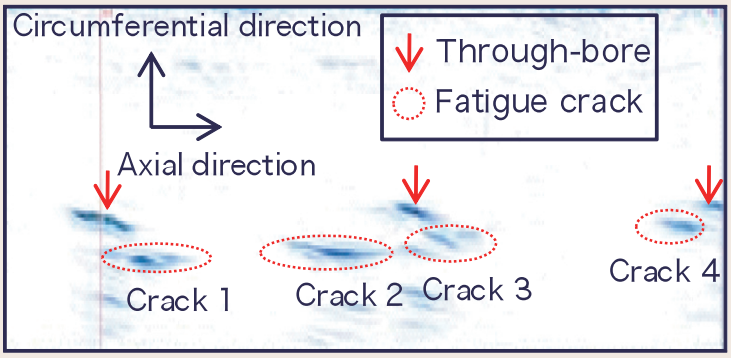
PD (Performance Demonstration) Certification System

In order to enhance the reliability of the nondestructive evaluation for nuclear power plants, statistical analyses are made on the results of performance demonstration tests (PD tests) on the ultrasonic measurement of the depth of stress corrosion cracks in welded joints in recirculation piping systems.

- An analysis of the results of all candidates passes PD tests reveals that the mean value and the standard deviation of the crack depth measurement error were 0.32 mm and 1.93 mm, respectively. However, the standard deviation of the recent three years was 1.80 mm, alluding to a technological improvement in the industry.



(a) Structure of an open rack vaporizer



(b) Example of the detection of cracks in an open rack vaporizer

Fig. 1: Fatigue crack in an open rack vaporizer and an example of an inspection result

An ultrasonic phased-array technique had been successfully applied to detect fatigue cracks at the bottom of the heat transfer tubes in open rack vaporizers, with high accuracy.

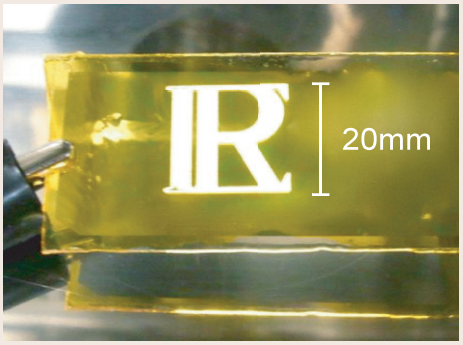


Fig. 2: Prototype device of the new light-emitting device made of ionic liquid and light-emitting organic polymer

By applying E=3V to the electrodes, the device turns on and the CRIEPI logo shows up. Device response speed is very fast, and a long lifetime is also expected.