Materials Science Research Laboratory

Brief Overview

The Materials Science Research Laboratory is conducting research on various material-related issues the electric power industry is facing. They include identification of damage and aging mechanism of structural materials at nuclear and fossil power plants as well as improvement in life prediction and nondestructive evaluation techniques for the components. Efforts are also being made in the development and evaluation of materials which consist of functional devices such as secondary batteries, semi-conductors and superconducting devices.

Achievements by Research Theme

Materials for Nuclear Power Plants

【Objectives】

In order to support the sound operation of nuclear power plants from the aspects of radiation reduction and material integrity, basic technologies in the field of water management at light water reactor plants and the environmental effects on material corrosion are being developed.

【Principal Results】

(1) A shut-down procedure bringing about radiation reduction was proposed based on the understanding of dissolving behavior of various oxides during the shut-down of PWR plants.

(2) The relationship between water quantity and adhesive amount of radioactive corrosion products to fuel cladding tubes under environments simulating PWR cores was clarified and guidelines for radiation reduction were obtained.

Materials for Fossil Power Plants

【Objectives】

In order to contribute to the improvement in efficiency of fossil power plants, developments of new materials which can be applied to ultra high temperature plants or thermal barrier coating are being pursued. Material evaluation techniques including the application of evolutionary sensors are also being studied in order to enhance the reliability of plants.

【Principal Results】

(1) A technique of forming a porous ceramic thermal barrier coating by plasma spraying process was developed and superior performance in thermal insulation was found to be achieved when deposited onto the surface of gas turbine blades [Q09004].

(2) Equipped with a probe and scanner applicable to boiler piping system with complicated geometry, a portable ultrasonic defect evaluation system which can automatically and two-dimensionally scan damage within welded joints was developed [Q09002].

Batteries and Electrochemical Materials

【Objectives】

Materials required for innovative energy transformation and storage systems, such as efficient hydrogen generation and solar power generation units, are being developed and evaluated.

【Principal Results】

(1) Steam electrolysis by reverse operation of solid oxide fuel cell (SOFC) is one of the most promising tech-

nologies for hydrogen production and the devices based on this principal are called solid oxide electrolysis cell (SOEC). The SOEC, which is made with a thin electrolyte and high performance electrodes, showed the world's highest performance of 1.32V at 0.57A/cm2 at 650℃ [Q09008].

(2) For the first time, we were able to theoretically explain weather variations in a diffuse solar spectral form, which is important for photovoltaic performance evaluation [Q09009].

Materials with Innovative Functions

【Objectives】

Aiming at the realization of innovative functions in superconducting or semi-conducting devices, next-generation electronic materials are being developed, fully utilizing basic crystal growth and property control techniques.

【Principal Results】

(1) We have attempted to grow a thin film of a new iron-based superconductor, Fe (Se, Te), and have successfully obtained films with superconducting transition temperatures (Tc) as high as 10K. Hall-effect measurements were carried out to reveal their fundamental electronic states in detail (Fig.1).

(2) We have introduced binary ionic-liquid electrolytes for the future development of high-speed organic field-effect transistors with very low operating gate voltages. Inclusion of small amount of inorganic salts in the ionic liquids accelerates formation of the electric-double layers in response to gate voltage, and fast-switching operation as fast as 100 Hz of organic field-effect transistors is achieved as the result.

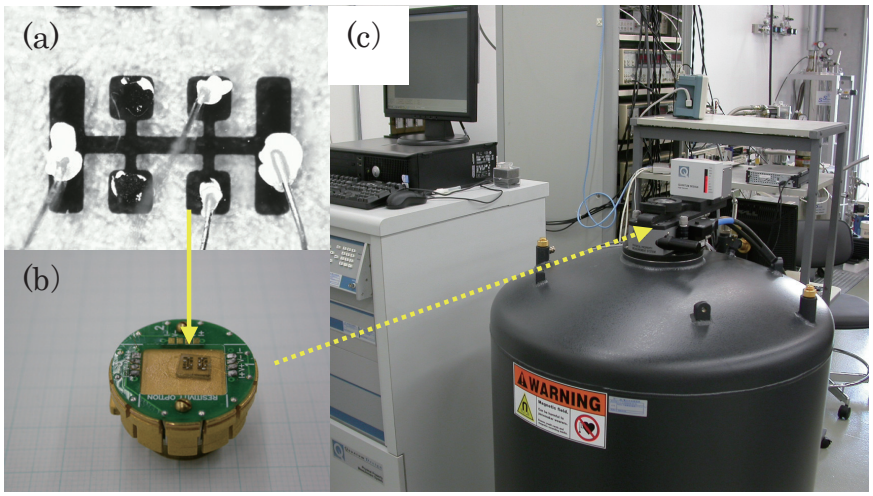
PD Center

【Objectives】

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

【Principal Results】

Analyses of the results of the PD tests conducted until May 2009 revealed that mean error and standard deviation on the crack depth were found to be ±1mm and 2mm, respectively. These performances are considered to be top level when compared to the worldwide scale [Q09020].



(a) Superconducting thin film of Fe (Se, Te) (Black part) with electrodes, (b) Mounted on a specimen holder, (c) Inserted into a superconducting magnet for the measurement of low temperature property.

Fig.1 Measurement of properties of $FeSe_{0.5}Te_{0.5}$ thin film formed by pulsed laser deposition technique on MgO base plate