Materials Science Research Laboratory

Brief Overview

The Materials Science Research Laboratory promotes research activities on the materials-related issues in the electric power industry. We currently focus on the research such as the understanding of degradation mechanisms of the structural materials for nuclear and thermal power plants, improvement of life prediction methods and nondestructive inspection technologies, and development and evaluation of functional materials like secondary batteries, semi-conductors and super conducting materials.

Achievements by Research Theme

Materials for Nuclear Power Plants

【Objectives】

Research for the reduction of radiation exposure through water chemistry management and the evaluation of components structural integrity in terms of corrosion has been performed to support the operations of nuclear power plants.

【Principal Results】

・Effects of dissolved hydrogen (DH) concentration on pressurized water reactor (PWR) fuel crud deposition were investigated under a PWR condition simulating core fluid and fuel cycle chemistry. The result reveals that the amount of deposited crud layer is independent of DH concentration, ranging from 7 to 25cm^3-STP/kg-H_2O.

Materials for Fossil Power Plants

【Objectives】

Research has been conducted to develop advanced thermoelectric materials for application to the effective use of waste heat energy in power plants, and to understand the behavior of water wall tube materials of coal-fired boilers under the environment of operation conditions.

【Principal Results】

・ Doping functional elements were found to improve the thermoelectric properties of silicon clathrates through computer simulations using first-principles and molecular dynamics calculations [Q10010] [Q10014].

・ A new method was developed to predict the corrosion rate of water wall tube materials under the sulfidation corrosion environment of coal-fired boilers [Q10018].

Batteries and Electrochemical Materials

【Objectives】

Materials required for innovative energy conversion and storage systems, such as noble electrochemical synthesis process to transform CO_2 into industrial materials or fuels and efficient hydrogen generation units, are being developed and evaluated.

【Principal Results】

・ Common physicochemical properties were found in the ratio of Molecular van der Waals volume / void volume and the optical refractive index for 12 typical room-temperature ionic liquids (RTILs) with various chemical structures. Various applications of RTILs are expected for selective CO_2 stabilization and molecular selection in optical applications [Q10032].

・ We have developed a method to predict the power yields of photovoltaic power generation systems with a consideration of solar irradiation and photovoltaic temperature. We have succeeded in reducing the prediction error of power yields down to 2% (Fig. 1) [Q10004] [Q10033].

Advanced Functional Materials

【Objectives】

We aim to develop a next generation of electric functional materials, such as new superconductors and/or semiconductors, with innovative performance using state-of-the-art technologies of crystal growth and fundamental physical property control.

【Principal Results】

・ We have established a thin-film growth technique of iron-chalcogenide superconductor and succeeded in improving several superconducting properties of these films by substituting fluoride substrates to conventional oxide substrates [Q10025].

・ High-performance n-type single-crystal field-effect transistors were developed with ionic-liquid electrolyte used for gating. With high carrier mobility of 5.0 cm^2/Vs that is an order of magnitude larger than that of amorphous silicon devices, pronounced current amplification is achieved at the gate voltage of only 0.2 V[1)].

PD Center

【Objectives】

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

【Principal Results】

・Analysis of the PD tests database as of February 2011 revealed that mean error and standard deviation on the crack depth measurements were found to be 0.31mm and 1.9 mm, respectively. The Phased Array technology contributes greatly to the improvement of the measurement accuracy.

References 1) S. Ono *et al.*, Appl. Phys. Lett. 97 (2010) 143307.

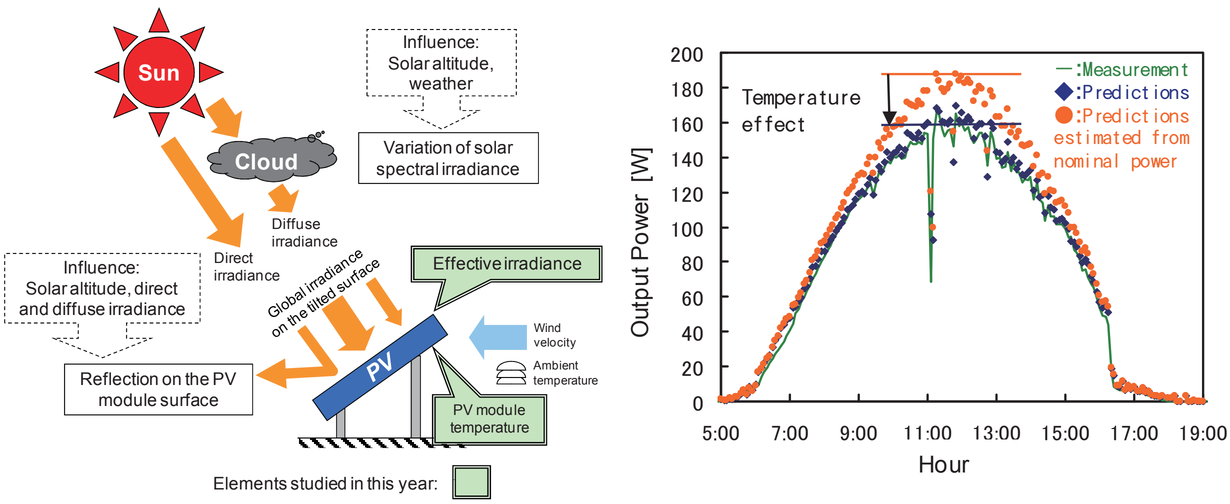

Fig. 1 A schematic of predictions of power yields of a photovoltaic module (left) and an example of the predictions in summer (right)

The power yield of photovoltaic modules depends on the solar irradiance and the module temperature. Prediction errors were improved by considering the module temperature in the predictions.