

Energy Harvesting & Storage

Room: Mauka - Session EH-WeP

Energy Harvesting & Storage Poster Session

EH-WeP1 Lifetime Prediction of Encapsulated Organic Photovoltaic Modules in Accelerated Conditions, SungHyun Kim, N. Kim, Korea Electronics Technology Institute (KETI), Republic of Korea

Organic photovoltaic (OPV) modules consisting of ITO/ZnO/photoactive layer/PEDOT:PSS/Ag inverted structure were fabricated using slot-die coating method and encapsulated by a barrier film deposited on polyethylene terephthalate (PET). Effective water vapor transmission rate was measured in both the transient and steady-state regimes of PET with a barrier layer. Acceleration tests were conducted under 65°C and 85% relative humidity to investigate the degradation of OPV modules. Total amount of water vapor into OPV module was calculated and correlated with the degradation rate of it. The lifetime of encapsulated OPV module under ambient condition is calculated and will be presented in the conference.

EH-WeP2 Effect of Surface Roughness on the Contact Resistance between the Gas Diffusion Layer and Bipolar Plate in a Polymer Electrolyte Membrane Fuel Cell, Changhee Choe, J.J. Lee, Seoul National University, Korea, Republic of Korea

In a polymer electrolyte membrane fuel cell (PEMFC), one of the most important factors affecting the performance is ohmic loss arising from the contact resistance at the interface of the gas diffusion layer (GDL) and bipolar plate (BP). As a method to reduce the contact resistance between the bipolar plates and gas diffusion layer, the contact area of the bipolar plates were increased by inducing roughness on the surface. The environment of the highly porous GDL being pressed by an external compaction pressure was simulated, and the contact area between the GDL and bipolar plates was calculated. The calculated contact resistance using the contact area was compared with the experimental contact resistance results of the bipolar plates polished with various grades of abrasive paper. As the average surface roughness increased, the contact resistance values decreased, which is in good agreement with the results of this study. In a single cell test, the efficiency of the cell increases when the rough bipolar plate is used.

EH-WeP3 Fully flexible and Transparent Piezoelectric Touch Sensor is based on ZnO nanowires with BaTiO₃, MoolKyul Kang, J.H. Park, K.I. Lee, Korea Electronics Technology Institute (KETI), Republic of Korea, **B.K. Ju,** Korea University, Republic of Korea, **C.S. Lee,** Korea Electronics Technology Institute (KETI), Republic of Korea

ZnO nanowires (NWs) can be grown by chemical approach at low temperature (<100 °C) on any substrate and any shape substrate. A relatively small force is required to induce the mechanical agitation, so that it can be fabricated sensitive devices.[1] But piezoelectric device based on ZnO NWs, which can not improve the piezoelectric properties of a single material due to a low piezoelectric d constant of ZnO NWs ($d \approx 12\text{pC/N}$).

In this paper, we demonstrated fully flexible and transparent piezoelectric touch sensor based on ZnO NWs, and composed that touch sensor with BaTiO₃ of Perovskite structure for improving piezoelectric properties. In order to maintain the flexibility of sensing spot, the BaTiO₃ (10 wt%) are dispersed in flexibility-improved SiO₂ capping solution and coated on ZnO NWs surface as a capping layer by spray coating method. Also, By replacing Indium tin oxide (ITO) electrodes with transparent flexible CNT-Ag nanowires electrode, the flexibility of the entire structure was enhanced. ITO is commonly used as transparent electrodes. However due to its high cost and limited supply of indium, the fragility and lack of flexibility of ITO layer, its alternative are being sought. It is expected that conductive films using carbon nanotubes and Ag NWs could be a prospective replacement of ITOs.

The ZnO NWs based sensor generated the output voltage of ~ 50 mV. The sensor with BaTiO₃ generates a higher output voltage (~1.2 V) than a ZnO NWs based sensor. We confirmed that the output voltage of sensor with ZnO NWs and BaTiO₃ was dramatically increased. We measured the resistance of capping layer and CNT-Ag NWs electrode during the periodic bending. When bent and flexed over 1,000 cycles, the films did not show significant degradation in sheet resistance compared to Ag thin film and ITO film on the same PET substrate. The bending test results conducted to confirm the mechanical stability of capping layer and CNT-Ag NWs as a electrode. The measurement results suggest that the our Piezoelectric touch sensors are suitable for flexible device such as flexible touch sensor, wearable and rollable touch panel.

[1] Zhong Lin Wang, "Piezopotential gated nanowire devices: Piezotronics and piezo phototronics", *Nano Today*, 5, 2010, pp.540-552

EH-WeP4 Analysis of Steam Reforming Reaction by Vibrationally-Excited Methane Based on First-Principle Molecular Dynamics Simulation, Naoki Yokoyama, Y. Higuchi, N. Ozawa, H. Yugami, M. Kubo, Tohoku University, Japan

For an environmentally-friendly energy system, hydrogen is expected as a resource to replace fossil fuels. Recently, steam methane reforming (SMR) is mainly used for hydrogen production. However, the promotion and the cost reduction of hydrogen production in SMR is strongly desired for stable supply of hydrogen because SMR requires a large amount of heat. To increase hydrogen production, Maegami et al. proposed the vibrationally-excited method, in which infrared light vibrationally excites a C-H bond of a CH₄ molecule [1]. While hydrogen production is promoted by the vibrational excitation of a CH₄ molecule, the detailed analysis at atomic scale is necessary for higher efficient hydrogen production. Thus, by using the first-principles molecular dynamics (FPMD) simulation method, we examined the effect of vibrational excitation of the C-H bond on chemical reaction dynamics for hydrogen generation from CH₄ and H₂O.

To reveal the chemical reaction dynamics, we simulated collision process of a H₂O molecule with a CH₄ molecule in the vibrationally-excited state by using our development FPMD code "Violet" [2]. The vibrationally-excited state was reproduced by extending a C-H bond. After the collision, a dissociation of C-H bond was observed. Moreover, the H atom of the dissociated C-H bond reacted with a H atom of the H₂O molecule, and H₂ and CH₃OH were generated. Next, to examine the effect of vibrational excitation, we simulated collision processes with the collision angle from -60° to 60° and collision energy from 9 eV to 20 eV in the ground state and the vibrationally-excited state. In the ground state, hydrogen molecules were generated in the range of collision angle from -50° to -10° and collision energy from 17 eV to 20 eV. On the other hand, in the vibrationally-excited state, hydrogen molecules were generated in the range of collision angle from -60° to 0° and collision energy from 14 eV to 20 eV. Therefore, in the vibrationally-excited state, H₂ molecules were generated in a wider range of collision angle and lower collision energy than those in the ground state. This simulation result suggests that the H₂ generation was promoted by vibrational excitation, which is consistent with the experiment [1]. We also examined the later process after the H₂ and CH₃OH were generated. Accordingly, CH₂(OH)₂, HCHO, HCOOH, and CO were observed as intermediate products. Consequently, we indicated the chemical reaction dynamics of H₂ generation from H₂O and vibrationally-excited CH₄ in gas phase.

[1] Y. Maegami, F. Iguchi, and H. Yugami, *Appl. Phys. Lett.*, **97**, 231908 (2010).

[2] T. Shimazaki and M. Kubo, *Chem. Phys. Lett.*, **503**, 316 (2011).

EH-WeP7 The Integration of XPS and Ar-Gas Cluster Ion Sputtering to Study the Corrosion of Stainless Steel Surfaces, D. Surman, Kratos Analytical Inc., **Helen Brannon, J. Counsell, S. Hutton,** Kratos Analytical Ltd., UK, **J. Morrison,** University of Birmingham, UK, **C. Blomfield,** Kratos Analytical Ltd., **A. Roberts,** Kratos Analytical Ltd., UK

Stainless steels are vital construction materials in all areas of industry, combining excellent corrosion resistance with good mechanical properties. For these reasons, stainless steels are used extensively in power stations of all varieties – of particular interest is the use of stainless steel in Pressurised Water Reactor (PWR) type nuclear power plants, such as the Sizewell B power station, Suffolk, UK.

The corrosion of steel in contact with hot, pressurised water in a PWR is a common problem. This side reaction is undesirable due to the reduced heat transfer efficiency caused by the deposited oxide layers.

Stainless steel's corrosion resistance is derived from the formation of a passivation layer at the surface of the material. Under atmospheric conditions this is thought to be a vanishingly thin layer of Chromia (Cr₂O₃), however, under conditions found in the coolant cycles of a PWR, it is thought that the passivation layer grown forms a double layer – the inner layer consisting of corrosion resistant, non-stoichiometric Chromite (FeCr₂O₄), while the outer layer consists of non-stoichiometric Nickel Ferrite (NiFe₂O₄). The thickness of this film is believed to vary with the steel surface finish, and the Environment Degradation Group at the University of Birmingham has recently begun a programme to study the dependence of corrosion rate and passivation layer thickness on surface finish, system chemistry and temperature.

The samples were ground to a 120 and 1200 grit finish using silicon carbide paper to produce samples with significantly difference roughness levels

(approximate R_a values of 1050 and 110 nm, respectively), before being inserted into a flowing rig, where they were exposed to deoxygenated water at pH 10 and 300°C at a pressure of 10 MPa. Sets of samples were removed from the rig every 250 hours, up to 1000 hours total exposure time.

X-ray photoelectron spectroscopy (XPS) was used to determine the type of corrosion chemistry that occurs. It was combined with a high energy, medium sized argon gas cluster source, which is shown to be advantageous compared to a conventional monatomic argon when depth profiling such layered structures, causing reduced structural and chemical damage from the ion beam sputtering process. Data acquisition at small analysis areas gives well resolved spectra, revealing the multi-layered oxide structures produced from the corrosion process. [1] Depth profiling of the Passive Layer on Stainless Steel using Photoelectron Spectroscopy, Wendy Fredriksson, Uppsala University [2] Applied Surface Science, 257, (2011), 2717–2730 [3] The Radiochemistry of Nuclear Power Plants with Light Water Reactors, By Kark-Heinz Neeb

EH-WeP9 Current Enhancement in Hybrid Solar cells prepared with Quantum Dots and PFN, D. Esparza, J. Oliva UC, T. Lopez, I. Zarazua, Elder De la Rosa, Centro de Investigaciones en Optica A.C., Mexico

This work presents a hybrid solar cell made with quantum dots and poly [(9,9-bis(3'-(N,N-dimethylamino)propyl)-2,7-fluorene)-alt-2,7-(9,9-dioctylfluorene)] (PFN), which is commonly used as electron transport layer in organic solar cells. Those cells were fabricated by Successive Ionic Layer Adsorption and Reaction (SILAR) method and spin coating. The configuration used in this work was: TiO₂/PbS/PFN/CdS/ZnS. The presence of PFN produced an increase of 33% in the short circuit current (J_{sc}) respect to the sample of reference: TiO₂/PbS/CdS/ZnS. Such increase in current caused an increment of the cell efficiency from 2.6% to 3.6%. PTB7 was also used as donor in our hybrid solar cells instead of quantum dots, when the PFN is added in this system, the current increased 60% respect to the cell of reference and the efficiency increased from 1.1% to 3.0%.

EH-WeP11 On the Role of Plasma System for CO₂ Dissociation, H.Y. Chang, Korea Advanced Institute of Science and Technology (KAIST), South Korea

The CO₂ capture and storage technology (CCS technology) needs immediate action, but does not have complete solutions yet due to the efficient and economical CO₂ conversion problems. In this presentation, the governing fundamental quantities will be identified to obtain the maximum energy efficiency and capacity for CO₂ dissociation. Several CO₂ conversion ideas will be introduced, describing the advantages and disadvantages of each conversion techniques. The plasma reactor has been known as one of the most promising candidate for CO₂ dissociation. However, the problems on how to achieve high efficiency, stable discharge at atmospheric pressure, and reliability at high power density should be solved. The ICP(Inductively coupled plasma) source will be introduced along with other sources such as microwave, DBD(Dielectric barrier discharge), and DC for the efficient CO₂ dissociation. In this presentation, the technical issues for the mass production of CO₂ conversion will also be discussed.

EH-WeP15 Positive Temperature Coefficient of CdS/Cu(In,Ga)(S,Se)₂ Solar Cell, Sangmok Kim, C.-W. Jeon, Yeungnam University, Republic of Korea

In the recent years, Cu(In, Ga)Se₂ (CIGS)-based thin-film solar cells with efficiency of readily over 20% have been reported by several groups, therefore, it is strongly expected to replace the crystalline silicon solar cell rapidly. Unlike crystalline silicon cell of a homo-junction, CIGS thin-film solar cell consists of hetero-junction between absorbing layer and CdS buffer layer. In CBD (Chemical Bath Deposition)-CdS, which is commonly used for a high efficiency CIGS solar cell, the kind and concentration of source materials and bath temperature is known to affect the characteristics of the CIGS/solar cell as well as CdS film properties. In general, the efficiency of solar cell decreases with increasing ambient temperature due to the reduction of band gap energy of absorber layer and higher reverse saturation current at an elevated temperature. In other words, temperature coefficient (TC) of a solar cell is normally negative. [1] While this tendency is observed in the CIGS/CdS solar cells, according to this study, it was confirmed that the behavior of TC depends on the synthesis conditions of the CdS. In this study, we prepared several solar cells of ZnO/CdS/CIGS/Mo/glass with different CdS deposition conditions by changing [Cd] and [S] in the solution over the range of [Cd]=15~135mM, [S]=12.5~50mM. And the variation of TC's were monitored by measuring IVT (Current-Voltage-Temperature) in the temperature range of 10~50°C. Some of solar cells with high [Cd] of low [S] were found to have positive TC's. In these devices, while Voc decreased as expected with increasing temperature, fill factor increased on the contrary. The enhancement of fill factor stemmed from the lower series resistance at higher operating

temperature. The thermal characteristics of the solar cells depending on the [S]/[Cd] composition ratio in the solution will be discussed with the results of IV, CV, QE measurements. Acknowledgement This research was financially supported by the Ministry of Knowledge Economy(MKE), Korea Institute for Advancement of Technology(KIAT) and Dae-Gyeong Leading Industry Office through the Leading Industry Development for Economic Region. References [1] A.Virtuani, D. Pavanello, and G. Friesen, 25th European Photovoltaic Solar Energy Conference and Exhibition/5th World Conference on Photovoltaic Energy Conversion. 2010, p6-10

Authors Index

Bold page numbers indicate the presenter

— B —

Blomfield, C.: EH-WeP7, 1
Brannon, H.: EH-WeP7, **1**

— C —

Chang: EH-WeP11, **2**
Choe, C.: EH-WeP2, **1**
Counsell, J.: EH-WeP7, 1

— D —

De la Rosa, E.: EH-WeP9, **2**

— E —

Esparza, D.: EH-WeP9, 2

— H —

Higuchi, Y.: EH-WeP4, 1
Hutton, S.: EH-WeP7, 1

— J —

Jeon, C.-W.: EH-WeP15, **2**
Ju, B.K.: EH-WeP3, 1

— K —

Kang, M.K.: EH-WeP3, **1**
Kim, N.: EH-WeP1, 1
Kim, S.: EH-WeP15, **2**
Kim, S.H.: EH-WeP1, **1**
Kubo, M.: EH-WeP4, 1

— L —

Lee, C.S.: EH-WeP3, 1
Lee, J.J.: EH-WeP2, 1
Lee, K.I.: EH-WeP3, 1
Lopez, T.: EH-WeP9, 2

— M —

Morrison, J.: EH-WeP7, 1

— O —

Oliva UC, J.: EH-WeP9, 2
Ozawa, N.: EH-WeP4, 1

— P —

Park, J.H.: EH-WeP3, 1

— R —

Roberts, A.: EH-WeP7, 1

— S —

Surman, D.: EH-WeP7, 1

— Y —

Yokoyama, N.: EH-WeP4, **1**
Yugami, H.: EH-WeP4, 1

— Z —

Zarazua, I.: EH-WeP9, 2