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Editorial

Solar Energy and Clean Energy: Trends and Developments 2014

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Solar energy and other clean energy are emerging and growing rapidly in the globe nowadays. Solar energy with less carbon emission is renewable and clean energy for our living environment. Solar energy can be converted to electricity in photovoltaic (PV) devices, solar cells, or solar thermal/electric power plants.

It is a current trend that solar energy becomes the important renewable energy. This special issue addresses the role of the development of solar energy. The themes include dye-sensitized solar cells (DSSCs), organic solar cells (OSCs), copper indium gallium diselenide (CIGS), zinc, crystalline silicon solar cells, light-emitting diode (LED), semiconductor sensors, photovoltaic generation system (PVGS), solar cell applications, solar cell, and LED development trend. From 60 submissions, 33 papers are published in this special issue. Each paper was reviewed by at least two reviewers and revised according to review comments.

Dye-Sensitized Solar Cells (DSSCs). The design of light-absorbent sensitizers with sustainable and environment-friendly material is one of the key issues for the future development of dye-sensitized solar cells (DSSCs). In this work, a series of organic sensitizers incorporating alkoxy-substituted triphenylamine (tpa) donors and binary π-conjugated bridges were investigated using density functional theory (DFT) and time-dependent DFT (TD-DFT). Molecular geometry, electronic structure, and optical absorption spectra are analyzed in the gas phase, chloroform, and dimethylformamide (DMF) solutions. In S. Wei et al.'s paper, the authors show that properly choosing the heteroaromatic atoms and/or adding one more alkoxy-substituted tpa group can finely adjust the molecular orbital energy. In H. J. Jo et al.'s paper, a new multicarbazole based organic dye (*C2A1, C2S1A1*) with a twisted structure was designed and synthesized, and the corresponding dye (*C1A1*) without the twisted structure was synthesized for comparison. They were successfully applied in dyesensitized solar cells (DSSCs). The results showed that the nonplanar structure of *C2A1* and *C2S1A1* can efficiently retard the dye aggregation and charge recombination. TiO_2 compact layers are used in dye-sensitized solar cells (DSSCs) to prevent charge recombination between the electrolyte and the transparent conductive

substrate (indium tin oxide, ITO; fluorine-doped tin oxide, FTO). In H. C. Chang et al.'s paper, the authors presented that thin TiO_2 compact layers are deposited onto ITO/glass by means of radio frequency (rf) magnetron sputtering, using deposition parameters that ensure greater photocatalytic activity and increased DSSC conversion efficiency. The photoinduced decomposition of methylene blue (MB) and the photoinduced hydrophilicity of the TiO_2 thin films are also investigated. In H.-C. Chang et al.'s paper, the authors presented that a series of compact TiO_2 layers are prepared using radio frequency (rf) reactive magnetron sputtering. The films are characterized using X-ray diffraction (XRD), atomic force microscopy (AFM), scanning electron microscopy (SEM), and UV-Vis spectroscopy. The results show that when the $A_r/O_2/N_2$ flow rates are 36 : 18 : 9, the photoinduced decomposition of methylene blue and photoinduced hydrophilicity are enhanced. After annealing at 450°C in an atmosphere ambient for 30 min, the compact TiO_2 layers exhibit higher optical transmittance.

Organic Solar Cells (OSCs). In Z. Wang et al.'s paper, the authors investigated ITO-free semitransparent organic solar cells (OSCs) based on MoO_3/Ag anodes with poly(3-hexylthiophene) and [6,6]-phenyl-C61-butyric acid methyl ester films as the active layer. In M. Ito et al.'s paper, the authors presented that organic thin film solar cells (OTFSCs) were fabricated with blended active layers of poly[[4,8-bis[(2-ethylhexyl)oxy]benzo[1,2-b:4,5-b′]dithiophene-2,6-diyl][3-fluoro-2-[(2-ethylhexyl)carbonyl]thieno[3,4-b]thiophenediyl]] (PTB7)/[6,6]-phenyl-C71-butyric (PC71BM). The performances of active layers are prepared in chlorobenzene (CB) with different additives of 1-chloronaphthalene (CN) and 1,8-Diiodooctane (DIO) by a wet process with spin coating technique.

Copper Indium Gallium Diselenide (CIGS). In C.-H. Huang and D.-C. Wen's paper, the authors presented a dense chalcopyrite CIGS film with a thickness of about 1.5-1.6 μm, with large grains (~1.2 μm) and no cracking or peeling is obtained after selenizing at a temperature of 550°C, an Ar pressure of 300 Torr, a heating rate of 60°C/min, and a soaking time of 20 min. By adequate design of the stacked precursor and controlling the annealing parameters, single-stage annealing of the solid Se-coated In/Cu-Ga bilayer precursor is simplified for the fabrication of fully crystallized chalcopyrite CIGS absorber layers with good crystallization and large grains. CIGS polycrystalline thin films were successfully fabricated by one-step cathodic electrodeposition on Mo-coated glass. In R.-W. You et al.'s paper, the authors applied a galvanometry mode with three-electrode potentiostatic systems to produce a constant concentration electroplating solution, which were composed of $CuCl_2$, $InCl_3$, $GaCl_3$, and SeO_2. Then these as-electrodeposited films were annealed in argon atmosphere and characterized by X-ray diffraction. The results revealed that annealing treatment significantly improved the crystallinity of electrodeposited films and formed CIGS chalcopyrite structure, but at low applied deposition voltage (−950 mV versus SCE) there appeared second phase.

Zinc. Zinc aluminum alloy nanowire was fabricated by the vacuum die casting. Zinc aluminum alloy was melted, injected into nanomold under a hydraulic pressure, and solidified as nanowire shape. In C.-G. Kuo et al.'s paper, the authors presented that zinc aluminum oxide nanowire array was produced using the thermal oxidation method and designed for the photoelectrode application. 1.5 wt% zinc fluoride (ZnF_2) was mixed with zinc oxide powder to form the F-doped ZnO (FZO) composition. In F.-H. Wang et al.'s paper, the authors show that using H_2-plasma-treated and HCl-etched FZO thin films as transparent electrodes would improve the efficiency of the fabricated thin film solar cells. In P. W. Chi et al.'s paper, the authors presented the microstructure morphology and UV photoirradiation coupling effects of the *c*-axis-oriented zinc oxide (ZnO) columnar films. Highly aligned *c*-axis-oriented films have been deposited onto glass substrates at room temperature by radio-frequency (RF) magnetron sputtering without introducing any oxygen source under different sputtering powers ranging from 50 to 150 W.

Crystalline Silicon Solar Cells. In C.-T. Li et al.'s paper, the authors presented demonstration of the performance improvement of p-type single-crystalline silicon (sc-Si) solar cells resulting from front surface passivation by a thin amorphous silicon (a-Si) film deposited prior to phosphorus diffusion. The conversion efficiency was improved for the sample with a-Si film of ~5 nm thickness deposited on the front surface prior to high-temperature phosphorus diffusion, with respect to the samples with a-Si film deposited on the front surface after phosphorus diffusion. For the textured solar cell, the surface was much rougher than that of the plain glass, which also contributes to the improvement of the efficiency. In S. J. Moon et al.'s paper, the authors presented block shaped light trapping structure for the first time by wet etching of the glass substrate, which enables the high efficiency thin film solar cell with the aid of the good step coverage deposition. Nanocrystalline diamond (NCD) films are promising materials for widespread applications due to their outstanding characteristics of chemical, physical, and highly smooth surface. In C. R. Lin et al.'s paper, the authors presented that the electrical property and photoconductivity of the fabricated devices were tested for UV detection application. It was found that the NCD films possessed high sp^3 fraction of 68.6%, low surface roughness of 9.6 nm, and good hydrophobicity, as deposited under working pressure of 40 Torr. Also, the NCD/Au structure annealed at 500°C exhibited a good ohmic contact characteristic, high detection efficiency, and fast response to UV irradiation in air ambient.

Light-Emitting Diode (LED). In J.-C. Wang's paper, the authors used thermal performance experiments with the illumination-analysis method and window program (vapour chamber thermal module, VCTM V1.0) to investigate and analyze the high-power LED (Hi-LED) lighting thermal module, in order to achieve the best solution of the fin parameters under the natural convection. The computing core of the VCTM program employs the theoretical thermal resistance analytical approach with iterative convergence stated in this study to obtain a numerical solution. Results showed that the

best geometry of thermal module is 4.4 mm fin thickness, 9.4 mm fin pitch, and 37 mm fin height with the LED junction temperature of 58.8°C. In K.-Y. Peng and D.-H. Wei's paper, the authors presented a single-monolayered hexagonal self-assembled photonic crystal (PC) pattern fabricated onto polyethylene terephthalate (PET) films by using simple nanosphere lithography (NSL) method which has been demonstrated in this research work. The patterned nanostructures acted as a scattering medium to extract the trapped photons from substrate mode of optical-electronic device for improving the overall external quantum efficiency of the organic light-emitting diodes (OLEDs).

Semiconductor Sensors. The potentiostatic deposition and pulse electrodeposition (PED) processes were used to deposit the $(Bi,Sb)_{2-x}Te_{3+x}$-based materials. Field-emission scanning electron microscope and energy dispersive spectrometers were used to analyze the compositions of the deposited $(Bi,Sb)_{2-x}Te_{3+x}$-based materials. In C.-G. Kuo et al.'s paper "Growth of Anodic Aluminum Oxide Templates and the Application in Fabrication of the BiSbTe-Based Thermoelectric Nanowires," the authors found that optimal deposition parameter of the PED process the AAO nanotube arrays were used as the templates to deposit the $(Bi,Sb)_{2-x}Te_{3+x}$-based thermoelectric nanowires.

In C.-G. Kuo et al.'s paper "Fabrication of a Miniature Zinc Aluminum Oxide Nanowire Array Gas Sensor and Application for Environmental Monitoring", the authors presented that a miniature n-type semiconductor gas sensor was fabricated successfully using zinc aluminum oxide nanowire array and applied to sense oxygen. The present study provided a novel method to produce zinc aluminum alloy nanowire 80 nm in diameter by the vacuum die casting technique and then obtain zinc aluminum oxide nanowire array using the thermal oxidation technique. In S.-C. Hung et al.'s paper, the authors presented a novel technique which can more efficiently fabricate different spans of nanobeams on the same substrate. It requires less time to prepare specimen and further shortens the process of aligning, clamping, and testing. Also, the authors probe into the elastic deformation properties of clamped freestanding GaN nanobeams with different spans.

In C.-H. Hsu et al.'s paper, the authors presented white light source. An yttrium aluminum garnet (YAG) phosphor incorporated zinc oxide (ZnO) (ZnO : YAG) film is deposited on a silicon substrate by ultrasonic spray pyrolysis to form a nanostructure diode. A nanoflower consisting of a hexagonal nanopetal is formed on the surfaces of the silicon substrate. A white broad band at the room temperature photoluminescence ranging from 420 to 650 nm for the ZnO : YAG/silicon nanostructure diode was observed. Diamond-based antireflective (AR) coatings were fabricated using a spin coating of diamond suspension at room temperature as nucleation enhancement procedure and microwave plasma enhanced chemical vapour deposition. Various working pressures were used to investigate their effect on the optical characterization of the as-deposited diamond films. Scanning electron microscopy (SEM) and atomic forced microscopy (AFM) were employed to analyze the surface properties of the diamond films. Raman spectra and transmission electron microscopy (TEM) also were used for analysis of the microstructure of the films. In C.-R. Lin et al.'s paper, the authors showed that working pressure had a significant effect on thickness, surface roughness, and wettability of the as-deposited diamond films.

Photovoltaic Generation System (PVGS). A large PV array (several MW) may incur several operation problems, for example, low power quality and reverse power. In Y.-Y. Hong et al.'s paper, the authors presented a method to reconfigure the distribution feeders in order to prevent the injection of reverse power into a substation connected to the transmission level. Moreover, a two-stage algorithm is developed, in which the uncertain bus loads and PV powers are clustered by fuzzy-c-means to gain representative scenarios; optimal reconfiguration is then achieved by a novel mean-variance-based particle swarm optimization. In Y.-K. Wu et al.'s paper, an experimental database of solar power output, solar irradiance, air, and module temperature data has been utilized. It includes data from the Green Energy Office Building in Malaysia, the Taichung Thermal Plant of Taipower, and National Penghu University. Based on the historical PV power and weather data provided in the experiment, all factors that influence photovoltaic-generated energy are discussed. Moreover, five types of forecasting modules were developed and utilized to predict the one-hour-ahead PV output. They include the ARIMA, SVM, ANN, ANFIS, and the combination models using GA algorithm. The maximum allowable photovoltaic generation system (PVGS) installation capacity is obtained by executing load flow analysis without violating the voltage magnitude and voltage variation ratio limits. However, the estimated power generation of PVGS is applied to know its impact on the power system according to the hourly solar irradiation and temperature. In C.-T. Hsu et al.'s paper, the authors presented that the cost-benefit analysis of payback years (PBY) and net present value (NPV) method is derived considering the cash flow from utilities annual fuel and loss saving, the operation and maintenance (O&M) cost, and the capital investment cost. The power network in Kiribati (PUB DNST) is selected for study in C.-T. Hsu et al.'s paper.

Solar Cell Applications. In Y.-L. Chen et al.'s paper "On-Road Driver Monitoring System Based on a Solar-Powered In-Vehicle Embedded Platform," the authors presented an on-road driver monitoring system, which is implemented on a stand-alone in-vehicle embedded system and driven by effective solar cells. The driver monitoring function is performed by an efficient eye detection technique. Through the driver's eye movements captured from the camera, the attention states of the driver can be determined and any fatigue states can be avoided. This driver monitoring technique is implemented on a low-power embedded in-vehicle platform. In Y.-L. Chen et al.'s paper "Experimental Investigation on Thermoelectric Chiller Driven by Solar Cell," the authors presented experimental explorations on cooling performance of thermoelectric chillers being driven by solar cells, as well as comparison results to the performance being driven by fixed

direct current. Solar energy is clear and limitless and can be collected by solar cells. In T.-C. Hung et al.'s paper, the authors presented that the study is to collect energy on the waste heat from air produced by solar ventilation systems. This heat used for electricity generation by an organic Rankine cycle (ORC) system was implemented. The advantages of this method include the use of existing building's wall, and it also provides the region of energy scarcity for reference. In X. Qin et al.'s paper, the authors took West Lushan highway low-carbon service area in Jiangxi Province of China as the case study, and the advantages, technical principles, and application methods of solar energy technology for highway service area including solar photoelectric technology and solar water heating technology were discussed based on the analysis of characteristics of highway low-carbon service area. In H. Wang's paper, the authors presented a novel modular system combining cooling, heating, and power generation (CCHP). This modular CCHP system can simultaneously provide 10 kW electricity, −15~5°C coolant, and 60°C hot water to meet the requirements of cooling, heating, and electricity in a general family or other fields.

Solar Cell and LED Development Trend. In C.-G. Kuo and C.-C. Chang's paper "Building Professional Competencies Indices in the Solar Energy Industry for the Engineering Education Curriculum," the authors presented professional competency indices and their subindices as needed by the solar energy industry, to establish a basis for development of the engineering education curriculum. The methodologies adopted by the study are literature analysis, expert advisories, and focus groups. In C.-G. Kuo et al.'s paper "Constructing Employability Indicators for Enhancing the Effectiveness of Engineering Education for the Solar Industry," the authors presented a set of employability indicators that capture the competency requirements and performance expectations that solar energy enterprises have of their employees. In the qualitative component of the study, 12 administrators and 32 engineers in the industry were interviewed, and meetings with focus groups were conducted to formulate a questionnaire for a survey of Taiwanese solar energy companies for the confirmation and prioritisation of the employability indicators. In Y.-S. Su and H.-C. Chang's paper "Bridging Photonics and Optoelectronics Curriculum for the Solar Photovoltaic and LED Industries," the authors presented the study and collected the current 103 course programs from all optoelectronics-related departments in 36 Taiwanese colleges and universities and sorted these curriculums by three domains of education objectives theory. This theoretical framework was verified on the basis of samples from 150 Taiwanese industrial experts and 354 optoelectronics-related undergraduates and postgraduates.

In Y.-S. Su's paper "Competing in the Global LED Industry: The Case of Taiwan", the author found that Taiwanese LED companies specialize and achieve an optimal efficiency by vertically disintegrating across the upstream, midstream, and downstream sectors in the value chains. Taiwanese LED companies create economies of scale and economies of scope through a complete industrial value chain.

These papers represent an exciting, insightful observation into the state-of-the-art as well as emerging future topics in this important interdisciplinary field. We hope that this special issue would attract a major attention of the peers.

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