**Reduction of moisture sensitivity of PbS quantum dot solar cells by incorporation of reduced graphene oxide**

Publication date: 15 August 2018  
**Source:** Solar Energy Materials and Solar Cells, Volume 183  
**Author(s):** Beatriz Martín-García, Yu Bi, Mirko Prato, Davide Spirito, Roman Krahne, Gerasimos Konstantatos, Iwan Moreels

PbS nanocrystals are an important narrow-gap material for solar cells and photodetectors. Nevertheless, their application may be limited because device performance can be affected by atmospheric conditions. Indeed, the presence of oxygen and/or water can degrade the active layers, possibly leading to device failure. Strategies to address this issue are therefore actively explored. Here we report a solution-processed PbS quantum dot solar cell, consisting of a PbS-silane functionalized reduced graphene oxide (PbS-rGO) layer on top of the PbS absorber film, which enhances device stability, especially when the solar cells are exposed to moisture. Power conversion efficiency (PCE) measurements demonstrate a slower degradation under continuous illumination for solar cells with PbS-rGO. When storing the samples under saturated water vapor, differences are even more remarkable: with PbS-rGO the solar cells essentially maintain their initial PCE, while the PCE of the PbS reference devices is reduced by 50% after 5 days. Scanning electron microscopy, energy dispersive X-ray and X-ray photoelectron spectroscopy reveal the damage to the PbS films and the formation of PbSO$_x$ crystals in the PbS reference devices. Such crystals are not observed in the PbS-rGO devices, further supporting the importance of the PbS-rGO barrier layer.

**Graphical abstract**

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**Atomic layer deposition of Zn(O,S) buffer layers for Cu(In,Ga)Se$_2$ solar cells with KF post-deposition treatment**

Publication date: 15 August 2018  
**Source:** Solar Energy Materials and Solar Cells, Volume 183  
**Author(s):** F. Larsson, O. Donzel-Gargand, J. Keller, M. Edoff, T. Törndahl

We investigate the possibility to combine Zn(O,S) buffer layers grown by atomic layer deposition (ALD) with KF post-deposition treated Cu(In,Ga)Se$_2$ (CIGS-KF) in solar cells. It is shown that the beneficial effect on open-circuit voltage from the post-deposition treatment is essentially independent of buffer layer material. However, a wet-chemical surface treatment is required prior to ALD in order to achieve competitive fill factor values. A water rinse is sufficient to create an absorber surface similar to the one formed during a conventional CdS chemical bath deposition process. However, it is observed that CIGS-KF/Zn(O,S) devices made with water-rinsed absorbers systematically result in lower fill factor values than for the corresponding CIGS-KF/CdS references. This effect can be mitigated by decreasing the H$_2$S:H$_2$O precursor ratio during ALD initiation, indicating that the fill factor limitation is linked to the initial Zn(O,S) growth on the modified CIGS-KF surface. The best CIGS-KF/Zn(O,S) devices were fabricated by etching away the KF-modified surface layer prior to ALD, followed by a low-temperature anneal. The thermal treatment step is needed to increase the open-circuit voltage close to the value of
the CdS devices. The results presented in this contribution indicate that the main beneficial effects from KF-PDT in our devices are neither associated with the CdS CBD process nor due to the formation of a K-In-Se rich phase on the CIGS surface.

**Graphical abstract**

Efficient photocatalytic degradation of methylene blue dye by SnO2 nanotubes synthesized at different calcination temperatures

Publication date: 15 August 2018

**Source:** Solar Energy Materials and Solar Cells, Volume 183

Author(s): A. Sadeghzadeh-Attar

A template-based liquid phase deposition was applied to fabricate SnO2 nanotube arrays. The prepared SnO2 nanotube photocatalysts were characterized using X-ray diffraction (XRD), field-emission electron microscopy (FE-SEM), transmission electron microscope (TEM), UV–Vis absorb spectrum, and Brunauer-Emmett-Teller (BET) measurements. The results showed that the well-crystalled rutile-SnO2 nanotube arrays with an inner diameter of about 60 nm and a wall thickness of about 20 nm can be fabricated at calcination temperature of 600 °C. In addition, the photocatalytic activity of the SnO2 nanotubes calcined at different temperatures for degradation of methylene blue (MB) dye under UV light illumination was investigated. The results clearly indicated that the samples calcined at 600 °C exhibited the highest photocatalytic activity, which makes them ideal for applications in environmental remediation. It was suggested that the enhanced photocatalytic efficiency of the SnO2 nanotubes may be due to their high specific surface area as-well-as their increased crystallinity with increasing calcination temperature. On the basis of the characterization results, we proposed a possible mechanism for the photocatalytic degradation on SnO2 nanotubes.

**Graphical abstract**
VO₂-based thermally active low emissivity coatings

Publication date: 15 August 2018

Source: Solar Energy Materials and Solar Cells, Volume 183

Author(s): Bill Baloukas, Simon Loquai, Ludvik Martinu

Vanadium dioxide is one of the likeliest candidates for future smart window applications due to its self-regulating nature and potentially simple implementation. However, the material is plagued with multiple drawbacks which need to be addressed before its commercialization. Amongst these, its low luminous transmittance has been the subject of many studies. In the present work, we propose to integrate a VO₂ film into a traditional silver-containing low emissivity coating architecture. We first model and discuss the theoretical performance of such a coating in comparison with more standard configurations and demonstrate that the addition of silver offers many advantages for thin VO₂ coatings; mainly an increase of luminous transmittance due to the presence of antireflective coatings while maintaining a high solar transmittance variation vs. temperature. The latter is shown to be the result of a displacement of the maximum transmission variation to lower wavelengths where the solar intensity is higher. We then fabricate prototype samples which confirm the predicted performance. Indeed, a silver-containing sample based on the following architecture Si₃N₄ [57 nm] | VO₂ [27 nm] | Ag [11 nm] | Si₃N₄ [66 nm] is shown to possess the unique combination of a high luminous transmittance of 58.2% in its low temperature state, a solar transmittance variation of 7.1% with the added benefit of a low emissivity of 10%.

**Graphical abstract**

A direct measurement of higher photovoltage at grain boundaries in CdS/ CZTSe solar cells using KPFM technique

Publication date: 15 August 2018

Source: Solar Energy Materials and Solar Cells, Volume 183

Author(s): Manoj Vishwakarma, Deepak Varandani, Christian Andres, Yaroslav E. Romanyuk, Stefan G. Haass, Ayodhya N. Tiwari, Bodh R. Mehta

A direct mapping of photovoltage in a complete Mo/CZTSSe/CdS/ZnO/Al:ZnO solar cell device is carried out using Kelvin probe force microscopic (KPFM) measurements in surface and junction modes. Four cells having different values of open circuit voltage (VOC) have been studied, and nanoscale variation of photovoltage have been obtained from the difference of surface potential (SP) images in the two modes. The maps exhibit a higher photovoltage at grain boundaries in general. Observed SP image of pristine CZTSe layer reveals downward band bending resulting in reduction of carrier recombination, and thus, lower Jdark at grain boundaries (GB). The observed downward band bending resulting in low Jdark at GB in CZTSe layer is used to explain the increase in photovoltage (VOC) at the GB. KPFM measurements of CZTSe and CZTSe/CdS layers show that the surface potential of CZTSe layer and its variation can be
ScienceDirect Publication: Solar Energy Materials and Solar Cells

affected by CdS deposition and further device processing, in addition to surface adsorption and contamination effects. The photovoltage mapping obtained from Kelvin probe force microscopic measurements on the final device without any interfering effects, is an important advantage of the present method.

**Graphical abstract**

The role of hydrogen bonding in bulk-heterojunction (BHJ) solar cells: A review

Publication date: 1 August 2018
Source: Solar Energy Materials and Solar Cells, Volume 182
Author(s): Zeyun Xiao, Tainan Duan, Haiyan Chen, Kuan Sun, Shirong Lu

Bulk-heterojunction (BHJ) solar cells have attracted tremendous attention in the recent years due to their potential to provide an earth-abundant and low cost solution to solar energy conversion. Unlike inorganic solar cells, BHJ solar cells use small molecular or polymeric light absorbers which can be delicately designed and assembled. With the aim of facilitating light absorption and improving morphology for efficient charge separation and transfer, hydrogen-bonding (H-bonding) has been employed in BHJ solar cells due to its relatively strong non-covalent interactions, highly directional and specific characteristics. The current review aims to summarize H-bonding in small molecule and polymer based donor materials as well as acceptor materials in BHJ solar cells. Emphasis will be placed on the molecular design of incorporating H-bonding in the donor and acceptor materials. The morphology optimization and power conversion efficiency (PCE) improvement in the presence of H-bonding will be the central topics of this review.

Flexible kesterite Cu2ZnSnS4 solar cells with sodium-doped molybdenum back contacts on stainless steel substrates

Publication date: 1 August 2018
Source: Solar Energy Materials and Solar Cells, Volume 182
Author(s): Kaiwen Sun, Fangyang Liu, Jialiang Huang, Chang Yan, Ning Song, Heng Sun, Chaowei Xue, Yuanfang Zhang, Aobo Pu, Yansong Shen, John A. Stride, Martin Green, Xiaojing Hao

In this work we report the Na incorporation from Na-doped Mo (Mo-Na) back contact for kesterite Cu2ZnSnS4 solar cells on flexible stainless steel substrates. It is demonstrated that Na can be effectively incorporated into CZTS by inserting Mo-Na layer at back contact. Direct contact of CZTS and Mo-Na layer leads to poor homogeneity and adhesion. The thickness of MoS2 formed at the back contact depends on the presence of Na and whether Mo contacts with CZTS directly. Back contact configuration with a Mo capping layer on Mo-Na layer is found to be helpful to maintain the advantages of Mo back contact and control the thickness of MoS2 interface. As a result, CZTS device fabricated on this configuration yields higher conversion efficiency of 6.2%. However, this efficiency is still far lower than
that on traditional soda lime glass substrate which shows efficiency over 8%. The loss mechanism of device fabricated on stainless steel is investigated and analyzed according to the device performance and electrical parameters.

**Thermal properties and friction behaviors of slag as energy storage material in concentrate solar power plants**

Publication date: 1 August 2018

**Source:** Solar Energy Materials and Solar Cells, Volume 182

Author(s): Yizhu Wang, Yang Wang, Heping Li, Junhu Zhou, Kefa Cen

Thermal energy storage (TES) system is greatly used in concentrated solar power (CSP) plants to collect energy for later need. It is proposed that slag is suitable for energy storage in CSP plants, however, little has been studied in this field. In this paper, the thermal stability, specific heat capacity, thermal conductivity and microstructures of two electric arc furnace (EAF) slag samples were studied. In TES system, as heat storage material, slag will meet with high temperature and low temperature environment. The wear resulted from heat expansion and cold contraction of slag with storing and releasing energy process was addressed. The results revealed that slag is a good candidate to be used as heat storage material for TES system. Revalorization of slag into TES material is a cost-effective solution to the CSP plants and the industry waste recovery.

**Chemical environment and functional properties of highly crystalline ZnSnN₂ thin films deposited by reactive sputtering at room temperature**

Publication date: 1 August 2018

**Source:** Solar Energy Materials and Solar Cells, Volume 182


Zinc tin nitride (ZnSnN₂) thin films have been deposited on glass and silicon substrates using a reactive co-sputtering process. Although the deposition temperature was limited to the room temperature, the films show a highly crystallization level and a strong preferred orientation in the [001] direction. The film composition, measured using energy dispersive X-ray spectroscopy and electron probe microanalysis, indicates a possible tin understoichiometry (or a zinc and a nitrogen overstoichiometry). As confirmed by transmission electron microscopy, the main oxygen contamination of the films results from oxidation of the grains boundaries after air exposure of the samples. X-ray photoelectron spectroscopy and Mössbauer spectrometry have been used to determine the chemical environment of atoms in the ZnSnN2 crystals. Both methods confirm that Sn⁴⁺ ions are bonded to nitrogen atoms and that the oxygen contamination results in the formation of Sn²⁺ ions. Zinc tin nitride exhibit an electron mobility at room temperature close to 3.8 cm² V⁻¹ s⁻¹ and an optical band gap of 1.8 eV as measured independently from UV–visible spectrometry and ellipsometry. The results obtained in the present study confirm the suitability of ZnSnN2 thin films as an Earth abundant material for absorber layer in photovoltaic devices.
**Boosting the efficiency of AgInSe2 quantum dot sensitized solar cells via core/shell/shell architecture**

Publication date: 1 August 2018  
**Source:** Solar Energy Materials and Solar Cells, Volume 182  
**Author(s):** Mulu Alemayehu Abate, Jia-Yaw Chang  
Interfacial engineering of the photoanode has been one of the most important strategies in designing high-performance quantum dot (QD)-sensitized solar cells (QDSSCs). In this work, we demonstrated a promising route to enhance the photovoltaic performance by inserting an additional CdS inner shell between AgInSe2 (AISe) QDs and a ZnS outer shell to obtain an AISe/CdS/ZnS core/shell/shell QDSSC. These double passivation shells prevent current leakage from the QDs to the electrolyte. The results of electrochemical impedance spectroscopy confirmed that the CdS/ZnS double passivation shell in the AISe QDSSC contributes greatly to suppression of charge recombination. As a result, the AISe QDSSC with CdS/ZnS double passivation shells exhibited a remarkably high conversion efficiency (6.27%), which is significantly higher than those of devices without a passivation shell (1.02%) and with CdS (4.37%) or ZnS (5.23%) single passivation shells. To the best of the authors’ knowledge, this efficiency is one of the highest values obtained for an Ag-based QDSSC.

**Graphical abstract**

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**Simultaneous enhancement of short-circuit current density, open circuit voltage and fill factor in ternary organic solar cells based on PTB7-Th:IT-M:PC71BM**

Publication date: 1 August 2018  
**Source:** Solar Energy Materials and Solar Cells, Volume 182  
**Author(s):** Yansheng Sun, Guang Li, Lixin Wang, Zhaoxiang Huai, Rui Fan, Shahua Huang, Guangsheng
ScienceDirect Publication: Solar Energy Materials and Solar Cells

Fu, Shaopeng Yang

Recently, studies on ternary organic solar cells (OSCs) have revealed their potentials for achieving the improved device performances. However, owing to the trade-off between the short-circuit current density \(J_{SC}\) and open circuit voltage \(V_{OC}\), the mismatch of the energy levels between donors and acceptors leads to a large energy loss and then leads to a lower \(V_{OC}\) in most ternary systems. In this study, we incorporated 3,9-bis(2-methylene-(3-(1,1-dicyanomethylene)-5-methylindanone)-5,5,11,11-tetrakis(4-hexylphenyl)-dithieno[2,3-d:2',3'-d']-s-indaceno[1,2-b:5,6-b']-dithiophene (IT-M) into a PTB7-Th:PC\(_71\)BM host system as the third component, which has a higher energy level of the lowest unoccupied molecular orbital (LUMO) than that of PC\(_71\)BM. The introduction of IT-M adjusts the energy-level cascade, enhances the absorption intensity and modulates the film morphology, which facilitate the charge generation, enhance the charge transport, and suppress the charge recombination, as manifested by the significantly enhanced \(V_{OC}\), \(J_{SC}\), and fill factor (FF). Therefore, the results indicate that a simultaneous enhancement of \(V_{OC}\), \(J_{SC}\), and FF can be achieved by incorporation of IT-M in ternary OSCs, providing a higher efficiency.

Experimental study on a novel form-stable phase change materials based on diatomite for solar energy storage

Publication date: 1 August 2018
Source: Solar Energy Materials and Solar Cells, Volume 182
Author(s): Zhonghao Rao, Guangtong Zhang, Taotao Xu, Kun Hong

PCM has been investigated for solar energy storage in recent years. The magnesium nitrate hexahydrate was chosen as PCM due to the suitable melting temperature and high latent heat for solar thermal energy in this paper. In order to prevent the leakage during the phase transition, a novel form-stable composite PCM based on diatomite was prepared by the vacuum impregnation method. The micromorphology, chemical structure, crystalloid phase, thermal properties, supercooling degree, thermal conductivity and thermal reliability were investigated by SEM, XRD, FT-IR, DSC, self-designed device and hot-wire method. FT-IR spectra indicated that there was no chemical reaction during the preparation process. The supercooling tested by the self-designed device was just 0.3 °C which can be neglected. The melting and freezing temperature measured by DSC and step-cooling curve method were 88.89 °C and 83.5 °C, respectively. Furthermore, the latent heat was 69.39 J/g and the adsorptive capacity was 46.78% according the pure PCM used in this study. The thermal reliability test was performed and the results showed that the thermal properties basically unchanged after 2000 thermal cycles.

Assessing high-temperature photovoltaic performance for solar hybrid power plants

Publication date: 1 August 2018
Source: Solar Energy Materials and Solar Cells, Volume 182
Author(s): Joya Zeitouny, Noémie Lalau, Jeffrey M. Gordon, Eugene A. Katz, Gilles Flamant, Alain Dollet, Alexis Vossier

Hybrid solar photovoltaic/thermal power systems offer the possibility of dispatchable, low-cost, efficient and reliable solar electricity production. A key design strategy capable of fully exploiting the heat generation stemming from both solar cell thermalization and sub-bandgap photons involves an integrated photovoltaic/thermal absorber operated under concentrated sunlight, at temperatures conducive to efficient turbine operation, to wit, hundreds of degrees C. A pivotal aim is attaining the highest efficiency possible while ensuring a substantial fraction of the total power derives from the turbines, with gas-fired backup heating and/or thermal storage mitigating the ephemeral character of
solar availability. However, the performance of solar cells at unprecedented elevated temperatures remains an open question. Key issues include (a) whether the efficiency loss stemming from high-temperature solar cell operation can be maintained acceptably small, as well as how optical concentration affects it, and (b) whether the solar thermal contribution can constitute a significant fraction of total electricity production. Here, we try to establish upper bounds on photovoltaic and system performance, covering a broad range of cell temperature and concentration levels, for single- and multi-junction cells operating at the radiative limit. We demonstrate that (1) the use of highly concentrated sunlight markedly diminishes photovoltaic - as well as thermal - efficiency losses at high temperature, and (2) the extent to which high operating temperature affects cell efficiency strongly depends on cell architecture. The implications for future generations of high-temperature/high-concentration solar cells are also addressed.

Understanding arsenic incorporation in CdTe with atom probe tomography
Publication date: 1 August 2018
Source: Solar Energy Materials and Solar Cells, Volume 182
Overcoming the open circuit voltage deficiency in Cadmium Telluride (CdTe) photovoltaics may be achieved by increasing p-type doping while maintaining or increasing minority carrier lifetimes. Here, routes to higher doping efficiency using arsenic are explored through an atomic scale understanding of dopant incorporation limits and activation in molecular beam epitaxy grown CdTe layers. Atom probe tomography reveals spatial segregation into nanometer scale clusters containing >60 at% As for samples with arsenic incorporation levels greater than 7–8 × 10^{17} cm^{-3}. The presence of arsenic clusters was accompanied by crystal quality degradation, particularly the introduction of arsenic-enriched extended defects. Post-growth annealing treatments are shown to increase the size of the As precipitates and the amount of As within the precipitates.

Characterization of thermal performance, flux transmission performance and optical properties of MAX phase materials under concentrated solar irradiation
Publication date: 1 August 2018
Source: Solar Energy Materials and Solar Cells, Volume 182
Author(s): J. Sarwar, T. Shrouf, A. Srinivasa, H. Gao, M. Radovic, K. Kakosimos
In this study, thermal performance and optical properties of MAX phase materials subjected to high concentrated flux are characterized. A new indoor facility is developed that allows for investigation of the independent effect of irradiance and temperature on the thermal performance of the material. Two MAX namely, Titanium Aluminum Carbide (Ti2AlC) and Chromium Aluminum Carbide (Cr2AlC) are examined in this study. Both materials are exposed to high concentrated homogenized flux in the range of 527.2 kWm^{-2} – 917 kWm^{-2} for 1000 s and 3000 s using a high flux solar simulator while their temperatures are maintained at 60 °C ± 5 °C via water-cooled heat flux gage. Materials’ surface characterization before and after irradiation is carried out using X-ray diffraction, scanning electron microscopy and X-ray fluorescence analysis. It is found that both materials have excellent resistance to high concentrated flux, but that Ti2AlC shows higher light scattering due to the oxidation of its surface. It is also found that the variations in the optical properties over time do not depend on the selected incident flux level. The thermal performance of Ti2AlC and Cr2AlC was found to varies in the 0.56 – 0.68 and 0.60 – 0.67 range, respectively, for selected flux levels. Flux transmission performance of both materials is not affected by exposure to high concentrated flux.
**Graphical abstract**

![Graphical abstract image](image)

**Influence of Cu on Ga diffusion during post-selenizing the electrodeposited Cu/In/Ga metallic precursor process**

Publication date: 1 August 2018  
Source: Solar Energy Materials and Solar Cells, Volume 182  
Author(s): Jinlian Bi, Qing Gao, Jianping Ao, Zhaojing Zhang, Guozhong Sun, Yi Zhang, Wei Liu, Fangfang Liu, Yun Sun, Dong Xiang

Gallium accumulation, caused by faster reaction of indium with Se than gallium with Se, is a critical issue for post-selenization process, which limits the optimization of surface energy bandgap and open circuit voltage of CIGSe thin film solar cell. In this study, large-grained and compact CIGSe thin film was successful fabricated by electrodeposition and a three-step vapor Se/N$_2$/vapor Se reaction process. The influence of the Cu content on gallium diffusion and grain growth of CIGSe thin film was studied. The compositions, element distributions, and morphologies of CIGSe thin films were studied. The results revealed that the gallium diffused homogenizely through the film with Cu/(In+Ga) < 0.9, while accumulated at the back contact region with Cu/(In+Ga) > 0.9. Single phase and large-grained CIGSe thin films were obtained with Cu/(In+Ga) ratios between 0.78 and 0.9. Cu(In,Ga)Se$_2$ solar cells made with the CIGSe thin films presented highest efficiency of 11.22%. The solar cell based on the single phase and large-grained CIGSe absorber with Cu/(In+Ga) = 0.85 presents highest conversion efficiency of 11.22%, fill factor of 63.83% and V$_{OC}$ of 514 mV.

**Light and elevated temperature induced degradation in p-type and n-type cast-grown multicrystalline and mono-like silicon**

Publication date: 1 August 2018  
Source: Solar Energy Materials and Solar Cells, Volume 182  
Author(s): Hang Cheong Sio, Haitao Wang, Quanzhi Wang, Chang Sun, Wei Chen, Hao Jin, Daniel Macdonald

We compare light induced degradation behaviours in lifetime samples and fully fabricated solar cells made from p-type boron-doped high performance multicrystalline silicon, p-type boron-doped mono-like silicon, n-type phosphorus-doped high performance multicrystalline silicon and p-type boron-doped Czochralski-grown silicon. Our results confirm that the degradation in multicrystalline silicon is triggered by the rapid cooling after the firing process. All cast-grown silicon samples subjected to fast cooling show lifetime reduction after light soaking. Interestingly, the degradation rate in n-type multicrystalline silicon is found to be orders of magnitude slower than in p-type multicrystalline silicon, suggesting that the defect formation mechanism could be affected by the positions of the quasi fermi
**Analysis of grain structure evolution based on optical measurements of mc-Si wafers**

Publication date: 1 August 2018  
**Source:** Solar Energy Materials and Solar Cells, Volume 182  
**Author(s):** Theresa Strauch, Matthias Demant, Patricia Krenckel, Stephan Riepe, Stefan Rein  
Within this work, we present a method for fast characterization and statistical analysis of structural and electrical crystal properties. By this, we investigate the impact of grain size and grain shape distribution in the lower part of the brick on the defect development in the upper part of the brick. Our method is based on fast measurements on as-cut wafers, namely photoluminescence imaging and reflection or infrared transmission images. We combine the extracted information and isolate dislocation structures from recombination active grain boundaries via image-processing. Two large data sets (more than 40 bricks) of different materials allow us to quantify the assumed correlation between grain structure and dislocation development. The results confirm that the relative length of dark lines as a part of dislocation clusters in the upper brick part shows a locally linear correlation with the square root of a meaningful grain area measure in the lower brick part (Pearson coefficient R between 0.80 and 0.88). It also correlates with the inhomogeneity measures for grain area and shape (Pearson coefficient R about 0.88). As a result, changes in the crystallization process may be targeted according to the grain structure in the lower part of the brick. In the future, this method may serve to improve the prediction of solar cell results based on wafer-data.

**Oxygen vacancy-rich mesoporous ZrO2 with remarkably enhanced visible-light photocatalytic performance**

Publication date: 1 August 2018  
**Source:** Solar Energy Materials and Solar Cells, Volume 182  
**Author(s):** Jingji Zhang, Yafeng Gao, Xuanrui Jia, Jiangying Wang, Zhi Chen, Yu Xu  
Introducing oxygen vacancies is an effective strategy to tail the absorption band-edge of ZrO\(_2\) photocatalyst into visible-light region and modifying its surface feature can promote the adsorption affinity toward organic molecules, resulting in the enhancement of visible-light photocatalytic degradation of organic pollutants. Herein, we prepared mesoporous ZrO\(_2\) with rich oxygen vacancy through a template-free solvothermal method followed by an annealing process, which was used as a catalyst to photodegrade tetracycline hydrochloride (TCH). The photocatalytic performance was found to be dependent on both oxygen vacancies and adsorption affinity. Comprehensive analysis revealed that, despite a certain reduction in both specific surface area and the amount of charged oxygen vacancy after annealing at 350°C in air, the increased adsorption affinity toward TCH could promote its visible-light photocatalytic properties, along with good recyclability. Finally, a possible pathway and mechanism for the degradation of TCH was proposed.
For almost sixty years, solar energy for space applications has relied on inorganic photovoltaics, evolving from solar cells made of single crystalline silicon to triple junctions based on germanium and III-V alloys. The class of organic-based photovoltaics, which ranges from all-organic to hybrid perovskites, has the potential of becoming a disruptive technology in space applications, thanks to the unique combination of appealing intrinsic properties (e.g. record high specific power, tunable absorption window) and processing possibilities. Here, we report on the launch of the stratospheric mission OSCAR, which demonstrated for the first time organic-based solar cell operation in extra-terrestrial conditions. This successful maiden flight for organic-based photovoltaics opens a new paradigm for solar electricity in space, from satellites to orbital and planetary space stations.