Adjustable and ultrahigh photothermal effect response of TiN films achieved by adjusting plasmonic structure in one-step method

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Keywords: photothermal effect; TiN film; ultrahigh light absorption peak; one-step method

Owing to the ability of conversion of light energy into heat energy, photothermal materials have attracted more and more attention of researchers in materials science. However, low cost and high efficiency of manufacturing the films with the ability of adjustable and ultrahigh response to light still pose challenges. Herein, assisted by the oblique incident deposition technology of unbalanced magnetron sputtering, the thermodynamic and dynamic behaviors of sputtered particles were utilized to fabricate the TiN films with different microstructure by controlling the deposition time. And the films with three different microstructures (“thin layer”, island-like and tilted columnar structures) respectively were deposited in one-step method. The TiN films with “thin layer” structures showed ultrahigh light absorption peaks (near 99%) in ultraviolet and visible rang, and the films with island-like structures showed this property in visible and near-infrared range. The TiN films with tilted columnar structures showed a high level (about 90%) of light absorption during 200-1200 nm. And finite element analysis method was applied to investigate the mechanism of the phenomenon in this study. The present study demonstrates a one-step method of fabricating photothermal films with adjustment photothermal property which is appropriate for many different application scenarios.

Investigation of the influence of metallic nanoadditives on the structure and properties of semiconductor organic thin films..

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Keywords: electric properties, elipsometry, nanoparticles (NPs), organic properties, organic solar cells (osc)

The aim of the work was to create and investigate the structure and physical properties of polymer layers containing a bulk organic p-n heterojunction (donor-acceptor) for applications in organic photovoltaic cells. The organic layered systems containing a mixture of polymeric materials PCPDTBT and DPP4T were produced. Additionally, hybrid layers were made by combining polymer material with highly conductive inorganic nanostructures (Au). The analysis of the structure and surface topography of the produced layers was carried out using electron microscopy (SEM) and atomic force microscopy (AFM). The obtained results allow the conclusion that the mixture layers have a predominance of a granular structure and an average surface roughness (RMS) of 150 nm. Additionally, phase images indicate a uniform distribution of the component materials as well as a relative homogeneous and dispersive distribution of Au nanoadditives. The produced layers were subjected to tests of optical and electrical properties (optical absorbance and the width of the energy gap). Then optical coefficients and dielectric constant values were determined. Based on the results obtained, it can be concluded that the refractive index and extinction index change with the percentage composition of the blend components, which is related to the ratio of their percentage content. An important element of the conducted research from the application point of view was the determination of phase transitions in the produced layers and the influence of nano-additives on the temperature of phase transitions. The temperature dependencies of Au composites show transitions at different temperature values, and there are more of them, which suggests that the presence of Au nanoparticles favors the phase separation of mixtures and pure materials. The research confirmed the influence of the addition of nano-Au on the structure and the most important properties of hybrid structures (organic-inorganic) that determine the effective operation of electrical devices, including photovoltaics.

Large boost in the pressure sensitivity of the transition metal doped ZnO thin film based piezoelectric energy harvesting device

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Keywords: Piezoelectric pressure sensor, R.F magnetron sputtering, Transition metal doped ZnO thin films

Self-powered piezotronic strain/stress sensors having ultrahigh sensitivity are indispensable nanoelectronic devices harvesting energy from the environment by the conversion of the nanoscale mechanical energy from minute mechanical vibrations to electrical energy. Piezoelectric pressure sensor is based on the principle of piezoelectricity where the application of external stress leads to the generation of the piezopotential at the interface of the metal electrode and the semiconductor that modulates the Schottky barrier height as well as the charge transport. Piezoelectric potential is the most important parameter in the piezotronic devices and that depends strongly on the piezoelectric coefficient of the material. However, piezoelectric coefficient of ZnO is relatively low (12.4 pC/N) that hinders its future applications in high end piezoelectric devices. We demonstrate significant enhancement of the piezoelectric pressure sensitivity in the transition metal doped (Fe as dopant) ZnO thin films fabricated by r.f magnetron sputtering. Fe doping was changed by varying the r.f power of the Fe_2O_3 target and the elemental analysis revealed an increase in the Fe doping concentration as 0.1-0.2 at. % (10 W), 0.81 at. % (30W), 1.40 at. % (40W), and 2.2 at. % (60W), respectively. Fe doping led to enhanced piezoelectric coefficient to 41 pC/N and a large boost (10 times) in the pressure sensitivity as compared to the un-doped ZnO thin film. The as prepared $Fe_xZn_{1-x}O$ thin films were highly oriented along c-axis displaying columnar nanorod (film) like morphology at low (high) Fe doping concentration with the co-existence of both Fe^{2+} and Fe^{3+} ions..Fe doping increased the band gap from 3.28 eV for un-doped ZnO to 3.35 eV (1.40 at.% of Fe) and 3.42 eV (3.5 at.% of Fe). Here, we have done a detailed investigation about the enhancement of the piezoelectric property in $Fe_xZn_{1-x}O$ thin films with Fe doping concentration.

Laser ablation-induced convenient fabrication of platinum nanospheres structures with surfactant-free surface for enhanced electrocatalytic methanol oxidation

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Keywords: Platinum nanospheres, enhanced electrocatalytic activity, laser ablation

Platinum (Pt) is the most promising catalyst for hydrogen oxidation and oxygen reduction. However, the residual surface-stabilizing agents capped on Pt-based nanomaterials via traditional chemical approaches will significantly reduce their catalytic activity. Herein, a new one-step strategy for the facile synthesis of surfactant-free Pt nanospheres with clean surface structures is developed by laser ablation of Pt target in distilled water. The distinctive advantage is that the pure water-dispersed Pt nanospheres can be obtained without any extra purification procedures, and the obtained catalyst exhibits enhanced electrocatalytic activity compared with Pt nanospheres capped with polyvinyl pyrrolidone or cetyl trimethyl ammonium bromide, which are most regular stabilizers or surfactants in traditional nanoparticles synthesis method. Importantly, the mass-normalized cyclic voltammetry (CV) curves for the methanol oxidation reaction show that the measured value of peak current is nearly 610 and 1050 times higher than that of Pt/PVP and Pt/CTAB samples. Moreover,the chronoamperometric (CA) measurements reveals that the steady-state current density is about 1.28 mA/cm^2, while which of Pt/PVP and Pt/CTAB are 1.07 and 0.017 $\mu A/cm^2$, respectively. It is no doubt that the application of laser beam as an environmental friendly tool for sculpting pure functional metal-based nanomaterials is a breakthrough in the additive problems that arise from standard chemical fabrication.

Optical properties of SeO2 thin films prepared by spin coating

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Keywords: optical properties, selenium oxide, spin coating

Due to their wide use in photovoltaics and optoelectronics, transparent conductive oxides have been widely studied by scientists for years. The one of them is the extremely promising - SeO2, which, despite its advantages such as high transparency and wide band gap (3.7 eV), is very poorly described in the literature. Herein, SeO2 thin films were deposited by spin coating on silicon and glass substrates and characterised. A solution based on the SeCl4 precursor, polyvinylpyrrolidone polymer and appropriate solvents was used to manufacture thin films. After obtaining the polymer layers, they were subjected to a calcination process at the temperature of 500 and 600°C in order to remove the polymer and obtain thin, crystalline oxide layers.
Analysis of the morphology of the SeO2 thin films using electron microscopy showed that they were homogeneous with visible small cracks on the surface. The structure and chemical composition of the manufactured thin films were confirmed using Raman, Energy-dispersive X-ray and X-Ray photoelectron spectroscopy. The UV-VIS spectrophotometer was used to analyse optical properties of prepared thin films. The optical studies showed that the films exhibited strong absorption of light in middle ultraviolet.

Research on the near-infrared quantum dot thin film solar cells for tandem photovoltaics

by Mingyu Li | Doctor

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Keywords: Nanocrystral, Near-infrared, Tandem, Thin film solar cell

Perovskite-based tandem solar cells have demonstrated high potential for overcoming the Shockley–Queisser limit. Routine bandgap (RBG, ≈1.55 eV) perovskites have achieved a perfect balance between efficiency and stability. The narrow bandgap (NBG) candidates for RBG perovskite-based tandem devices are very limited. Lead sulfide (PbS) colloidal quantum dots (CQDs) are a promising partner due to their broad absorption spectra. However, the efficiency of NBG (< 1.1 eV) QD thin film solar cells still lag behind. Herein, energy-level aligned magnetron sputtered ZnO thin film is introduced to replace sol-gel ZnO for electron extraction, organic halide salt phenethylammonium iodide/bromine (PEAX, X = I/Br) additive ligands are employed to cooperate with traditional lead halides for sufficient QD plane passivation, a high transmittance sputtered ITO and band-aligned AZO layers were also synergistically developed. Finally, the power conversion efficiency (PCE) of 0.95 eV QD solar cells realized stepwise improvement from certified 10.08%[1], 11.98%[2] to 14.14%[3]. Integrated with the front semi-transparent perovskite solar cells, the efficient RBG perovskite/QDs four-terminal tandem photovoltaics are successfully implemented and reached a record efficiency of 26.12%. Meanwhile, the monolithic perovskite/QD tandem solar cells were also studied based on a concise “n-i-p” structure, the inorganic QD back subcells provided sealing protection for the perovskite front subcells. Over 17% PCE was achieved and maintained 90% of their initial efficiency after 1214 h storage in ambient atmosphere. We believe that the promising avenue and photovoltaic technology offer a viable route toward further practical application and commercialized development.

Structural Properties of He-Irradiated Zr/Nb Multilayer

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Keywords: He-Irradiated, High radiation resistance, Structural Property, Zr/Nb Multilayer

Zr/Nb nanoscale multilayers are regarded as one of the important candidate materials used in next-generation reactors. Understanding structural evolution induced by ion bombardment is crucial for the evaluation of lifetime performance. Magnetron sputter-deposited Zr/Nb multilayers with a periodicity of 7 nm were subjected to 300 keV He ion irradiation with three different fluences at room temperature, Fig.1 shows the Zr/Nb multilayers micrographs. The depth-resolved strain and damage profiles in the Zr/Nb multilayers were investigated by grazing incidence X-ray diffraction. The tensile strain was found in the deposited Zr/Nb films. After He ion irradiation, the intensity of diffraction peaks increased. The change in diffraction peaks depends on He fluence and incident angle. Irradiation-induced pre-existing defect annealing was observed and the ability to recover the microstructure was more significant in the Zr films compared to the Nb films. Furthermore, the efficiency of defect annealing depends on the concentration of pre-existing defects and He fluence. When the He fluence exceeds the one for pre-existing defect annealing, residual defects will be formed, such as 1/3<1210> and 1/3<1100> dislocation loops in the Zr films and 1/2<111> dislocation loops in the Nb films. Finally, introducing deposited defects and interfaces can improve the radiation resistance of Zr/Nb nanoscale multilayers. These findings can be extended to other multilayers in order to develop candidate materials for fusion and fission systems with high radiation resistance.

Structure changes in multilayer polymer films obtained by developed blow molding

by Marcin Bilewicz | PhD Eng

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Keywords: blow molding, polymer composites, polymer flms

Polymer processing of films becomes widely developed recent years and evolved in different directions to obtain more complex structures including mono- and multilayer films and films filled with different fillers like micro- and nano-sized particles. Achievements in polymer chemistry and polymer processing through more advanced technologies equipped with precise sensors and computer controlled brings possibility to obtain more advanced structures of polymer composites. Multilayered films are used recently for many applications like packaging, materials with special barrier properties or with resistance for specific liquids or radiation, e.g. UV. The investigation aims to obtain the composite in form of 3-layer polymer film. Structure of the composite contains polymer based layers. To obtain the film was used blow molding technology on 20 meter high machine with advanced, rotating basket, gravimetric dosing and precise sensors. Tensile strength of 3-layer films can be even doubled comparing to single layer film. Additionally material composition and arrangement can brings additional improvement of properties.

Superaerophobic 0D nickel – 2D ceria supported 316L for enhanced OER and HER activity

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Keywords: Aerophobic, HER, Heterostructure, Interface Engineering, OER

Cost-effective and high efficient bi-functional electrocatalyst for water splitting is essential for sustainable energy conversion. In the recent years, the search over optimal design strategies for non-noble metal electrocatalyst gained significant attention in the energy conversion sector. Due to the advantages of dimensionally controlled nanostructured materials, efforts are being devoted to develop nanostructured materials for efficient bi-functional electrocatalyst. The present work is targeted to increasing active site density and to enhance the electrode-electrolyte interface area. In this target, multi-dimensional (0D – 2D) nanostructured stainless steel (316L) electrodes were fabricated for enhanced OER and HER activity in alkaline solution. A simple two-step electrodeposition technique was adopted to fabricate multidimensional Ni/CeO_2 nanocomposite on SS316L electrode. The nanocomposite electrode provided enhanced specific surface area and superaerophobic wetting (water contact angle ~ 0°) without surface post-processing. The multidimensional nanostructured electrodes presented a tafel slope of 130 mV/dec and 94 mV/dec for OER and HER respectively. Furthermore, electrochemical active surface area is observed to have increased in the nanocomposite electrodes compared to commercial nickel foil. The cost-effective methodology reported here could inspire for future development of economical nanocomposite electrodes for high performance sustainable water-splitting energy systems.

Uncovering Thin Film Structural Evolution through In-situ Spin-Coating and GISAXS/GIWAXS Analysis

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Keywords: □GIWAXS□spin-coating□thin film□GIWAXS□spin-coating□thin film

Advancements in nanotechnology have led to the development of thin films with unique properties, making them essential for various applications. Taiwan Light Source 23A beamline focuses on unraveling the intricate nanostructures within thin films through simultaneous grazing-incidence small/wide-angle X-ray scattering (GISAXS/GIWAXS) measurements, coupled with controlled heating and spin-coating and other techniques. These cutting-edge methods provide invaluable insights into nanostructure morphology, crystallinity, and orientation in thin films. GISAXS analysis elucidates the nanostructures, while GIWAXS offers a deeper understanding of the crystal features. By incorporating controlled spin-coating, we can observe the structural evolution of polymer blend thin films during film formation. Furthermore, through the application of controlled thermal processing, we achieve precise control for optimal structural configuration, thereby enhancing the properties of the films. The combined utilization of these techniques enables a comprehensive characterization of thin film structure, contributing to the optimization of film fabrication processes and enhancing their functional performance in diverse applications, such as electronics, photonics, and sensors.

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Vacuum co-evaporation for high reproducible and stable hybrid perovskite thin film solar cells by cation doping

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Keywords: Co-evaporation; Perovskite; Thin films; Reproductiblity; Cation doping

Vacuum evaporation technology stands out as a prospective method for the large-scale production of perovskite (ABX_3) solar cells (PSC). But the co-evaporation process with PbI_2 introduces complexity in achieving accurate doping of A-site cations, adversely affecting the performance and stability of perovskite (PVK) thin films. Here, we propose an innovative engineering approach combining PbI_2 solvent deposition and co-evaporation of FAI and PEAI to prepare PVK thin films. Compared with PSC fabricated by solvent deposition, it reveals significant enhancement in reproductiblity of PSC by vacuum co-evaporation. The doping of PEAI substantially improves the stability of 3D PVK in the environment of moisture and heat. Therefore this method achieves not only accurate doping of A-site cations, but also reproducible high-quality PVK thin films.