Forum A Nano Materials and Technology

A01 (Invited)

The Growth of Micro- and Nanocrystals

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Based on the given reaction condition and medium, the growth of micro- and nanocrystals can be divided into four types, growth in solution at normal pressure, hydrothermal growth, solvothermal growth, and molten-salt growth. When the water or organic solvent as the reaction medium, surfactant, such as sodium dodecyl benzene sulfonate, can be added to regulate the growth process of nanocrystals. Research was carried to disclose the transformation between colloidal and nanocrystals. Moreover, radiation source, such as γ-ray or ultrasound, can influence the reaction process. If the water or organic solvent are both unfavorable as intermediate medium, inorganic salt can be chose as a medium for the growth of micro- and nanocrystals, which is called as the molten salt method.

A02 (Invited)

Regulation of Differentiation of Physical Signals Mediated by Nanostructures, and Their Application in Tissue Regeneration

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Besides the biological growth factors, small organic molecules, and chemical ions, physical signals is the other category of very important factors to tune/regulate the fate of stem cells. Recent years, more attention has been paid on the differentiation of stem cells on the physical signal, including, electric or magnetic field, surface topology of biomaterials, photo irradiation, and even pressure and strain from the materials. With progress of research in this field, some cues of connection between physical signal and bio pathway for differentiation have been discovered. However, more phenomena have still not been understood. Because the physical signals possess controllability and can be localized in a specific area, they are benefit to be used in tissue engineering for tissue regeneration. Therefore, finding new physical approaches for regulation fate of stem cells is a great challenge for alive biomaterials design and applications.

Recent year, some novel phenomena about the effect of physical signal on stem cell

differential has been noticed. For example, nano-network morphology of HAP film can differentiate bone marrow mesenchymal stem cells (MSCs) to vascular endothelial cells, surface charges on LiNbO3 wafer can regulate MSCs differentiate to osteogenic cells, and a pressure from biomaterials can differentiate MSCs to neural cells.

In this talk, we will report the above works, and try to explain the reasons for physical signal induced differentiation from both physical mechanism and bio pathways. We believe that the regulation effect of physical signal will attract more attention, and will have great impact for design and application of biomaterials, especially for tissue engineering scaffold, and will bring great progress in tissue regeneration medicine.

A03

Rapidly Synthesis of Nanocrystalline Diamond Films by Helicon Wave Plasma

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A new technique of the synthesis of Nanocrystalline Diamond (NCD) Films by helicon wave plasma (HWP) chemical vapor deposition at room temperature was reported. The growth morphology and the roughness of NCD samples was characterized using filed emission scanning electron microscopy(SEM-SU8010) and atom force microscopy(AFM), respectively. The results show the growth rate of the film was very fast, about 833nm/min. Typical G, D bands were identified by Raman spectroscopy. ID/IG was about 2.5, which means that the high purity of NCD film was very high. A series of plasma diagnosises were used,such as Langmuir probe, an optical spectrometer system and EQP were used to get detailed characterization of the helicon wave plasma discharge. The relationship between the plasma parameters and the NCD films was discussed.

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A04

High-yield Synthesis of Two-dimensional BN Nanosheets for Effective Mechanical Reinforcements of Polymer Film

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With the birth of graphene with fasnicating properties, novel two-dimensional nanomaterials have obtained considerable developments in the last decade. Among them, BN nanosheets have been intensively investigated because of their large elastic modulus, high melting-point, superb thermal conductivity and large direct bandgap, which can be used in ultraviolet-light emitter, advanced ceramic composites, electrical insulator, solid lubricants and ideal substrate for graphene. Although many groups reported the succesfully growth of two-dimensional BN nanostructures [1-2], the low-yield or complicated ways don't meet the basic requirements of practical applications. In our work [3-5], we designed a novel and simple substitution technique to fabricate BN nanosheets with high crystallinity by using common and cheap graphite sources. The as-grown two-dimensional nanostructures are indexed as h-BN single crystals. These nanosheets have a mean lateral size of several hundred nanometers and their thickness ranges from 5 nm to 40 nm. Moreover, the BN sheets exhibit intrinsic UV emission at 218 nm or 228 nm. Further mechanical reinforcement experiments show that the Young's modulus of the composite film gains an obvious increase of 20 % (up to 2.16 GPa) after only 2 wt.% BN is added into the PMMA film. So it implies that the as-grown BN nanosheets is a decent reinforcement material for polymer matrix composites.

A05

Synthesis and Optoelectronic Properties of Quaternary Heterostructure and Solid-solution Semiconductor Nanowires

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Heterostructure and solid-solution semiconductor nanostructures comprised of two different binary compounds represent new members in the family of nanomaterials and may exhibit unexpected properties, as well as the potential application in diverse fields.[1] For two elements or compounds, they can easily form a radial or axial heterostructure, or a core-shell heterostructure if they have close lattice constants along a shared crystalline plane, whereas their crystal structures are not confined to the same.[2] If their crystal structure and symmetry are confined to the same and their lattice constants are also matching so well, the two elements or compounds can mix mutually and uniformly in composition and thus form the solid-solution structure. Based on this principle, a series of pseudobinary solid-solution nanowires and heterostructure nanowires made of group II-V and II-VI elements (GaP-ZnS, GaN-ZnO, GaP-ZnSe, GaN/SiC etc) have been synthesized.[3] Interestingly, some unconventional phenomenon such as drastic electric conductivity increase and band-gap shrinking has been observed. Finally, the formation mechanism and optoelectronic properties of these nanostructures have been systemically studied using a variety of characterizations like HRTEM, EDS and CL.

A06

Transmetallation at the Solid Interface between Self-assembled Cobalt Phthalocyanine and Cu(111) Substrate

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Fabrication of controllable on-surface structures has been an appealing topic in the field of molecular electronics. Herein, we investigate the self-assembly of cobalt phthalocyanine (CoPc) on a Cu(111) surface with the focus on the interface electronic structures, via photoelectron spectroscopy (PES). Interestingly, the substitution of cobalt ion in the center of CoPc molecule was discovered at the interface, which is most probably induced by the strong interaction between the CoPc and the Cu(111) substrate, and accomplished by the jumping of surface Cu adatom into the molecule. In addition, post annealing treatment makes the ion substatution process much more visible. While the conventional metallation of phthalocyanine has been demonstrated regularly, our report of transmetallation between cobalt and copper may propose an effective approach towards the artificial tuning of on-surface nanostructures and the related electronic properties.

A07

Honeycomb-like Three Rlectrodes Based Triboelectric Generator for Harvesting Energy in Full Space and as a Self-powered Vibration Alertor

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A novel honeycomb-like triboelectric generator (HTEG) based on three electrodes has been designed for harvesting mechanical energy in full space. It has symmetric and periodic arrangement of the three electrodes in plane or on the inner surface of ball, which can harvest sliding energy along arbitrary direction without off state because each electrode is always surrounded by the electrodes different from itself.

Meanwhile, the device can effectively scavenge ambient vibration energy as an independent generator in full space by working at both contact-separation mode and sliding mode without contacting with the ground.

The maximum output current density, voltage and power density can reach 16.4 mA/m2, 413 V, and 2.1 W/m2, respectively, by working in plane sliding mode, and the maximum output current to be 0.55 μA by working in sliding modeonan inner surface of a spherical shell. The HTEG can charge a 100 μF commercial capacitor to 2.1 V in 80 s. The football-like HTEG is used as a vibration alertor, which could be applied in vibration monitor or geologic hazard alertor for bridges and buildings.

The idea of multi electrode in HTEGs would be an effective strategy to achieve multi-function in scavenging energy.

A08

Correlation between Phase Composition, Microstructure, and Electrochemical Behavior of Cobalt Compounds

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Cobalt compounds with different phase compositions and microstructure are promising in

solving the energy storage and conversion problems. Herein, the graphene-like α-$Co(OH)_2$, ultra-layered α-$Co(OH)_2$ stacked with hexagonal nanosheets, and needle-like $Co(CO_3)_{0.5}(OH)\cdot 0.11H_2O$ were hydrothermally synthesized without using surfactant and templates by increasing the reaction temperature or prolonging the reaction time in the same system. The synthetic products were employed as the electrode materials of supercapacitors for evaluating their electrochemical behavior. The results demonstrated that the graphene-like α-$Co(OH)_2$ exhibited better electrochemical properties with specific capacitance of 594.6 F g^{-1} than needle-like $Co(CO_3)_{0.5}(OH)\cdot 0.11H_2O$ with specific capacitance of 278.3 F g^{-1} at a current density of 1 A g^{-1}. Furthermore, the asymmetric supercapacitor is assembled with graphene-like α-$Co(OH)_2$ nanosheets and PVA–KOH polymer electrolyte, which exhibits an energy density of 13.6 Wh kg^{-1} at the power density of 235 W kg^{-1}. The excellent electrochemical property can be attributed to the mechanism related to the phase composition and microstructure of materials.

A09 (Invited)

Self-propelled Micro-/Nanomotors: Design Strategies, Motion Properties and Potential Applications

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Micro-/nanomotors have fascinating capabilities to pick up, transport, and release various micro/nanocargoes because of the autonomous motion behaviors in liquid media, and can be used to perform complex tasks, including drug delivery, protein and cell separation, microsurgeries and environmental remediation, etc. This presentation firstly shows a biocompatible Magnesium-based Janus micromotor, which not only could autonomously move in $NaHCO_3$ solution, simulated body fluid and human blood plasma, but also can effectively uptake, transport and temperature-controlled release of drug molecules by taking advantages of the partial surface-attached thermoresponsive PNIPAM hydrogel layers. Secondly, it demonstrates the the design, large-scale preparation and propulsion mechanism of single-layered

light-controlled TiO_2 tubular microengines, phototropic isotropic semiconductor micromotors and magnetically adjusted pot-like $MnFe_2O_4$ micromotors. They not only show the reversibly, swiftly and wirelessly controlled motions in aqueous media by regulating the UV irradiation or external magnetic field, but also can act as effective platforms to capture, transport and deliver cargoes at will, offering new strategies for water remediation, micro-/nano sensors and microfactories etc.

A10 (Invited)

Design, Interface Control and Synergistic Lithium Storage of 2D Oxide-based Ternary Heterostructures

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Nano-sized transition metal oxides (TMOs), featured by such merits as high lithium storage capacities, rich resources and low cost, can realize low cost efficient lithium storage. Especially, 2-dimensional (2D) TMO nanosheets can provide larger electrode-electrolyte contact areas and shorter lithium diffusion pathways than their bulk forms. However, the low conductivity and strong aggregation inclination of 2D TMO nanosheets result in the poor rate capacity and cycling performance. Recently, based on a thorough understanding of the interactions among TMO supermolecules, we developed a facile oxide nanosheets-based hierarchical self-assembly strategy. A delicate morphological and functional design and interface control is developed to construct novel, multifunctional ternary heterostructures composed of 2D TMO nanosheets, low-dimensional TMO nanostructures and conductive dopants, whose synergy in lithium storage is explored. An ideal “trio” is developed: the 2D TMO nanosheets serve as a substrate to provide some prominent functions and buffer the strain associated with repeated lithation-delithation due to their large surface areas and high flexibility, the low-dimensional TMO nanostructures serve as a spacer to isolate the nanosheets from restacking as well as make up the functional defects of the 2D TMO nanosheets, and the conductive dopants offer sufficient percolation pathways for the fast transmission of electrons. Both the morphological and functional synergies of the ternary heterostructures, will lay theoretical and experimental bases for fabricating high-capacity electrode materials for next-generation, high-power LIBs.

A11

All-solid Light-driven Charging and Storage Textile for Wearable Applications

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Developments in wearable electronics, have brought a revolution to our way of life. In order to power them sustainably and flexibly, novel technologies have been developed to harvesting commonly existed clean and renewable energy, such as solar irradiance, wind, rain. Herein, we have come up with the idea of wire-shaped solar cell, which has provided a new solution to get rid of expensive TCO substrates. Progresses have been made by introducing low-cost metals, including Mn, Ni, Zn, and largely reduced its cost and weight. In order to make it more compatible for the hybrid power system, the device structure has been further expanded to mesh, vein and spike ever since. In addition, photovoltaic textile with the outlook of real scarf and cloth have been also weaved out for the first time. Its capability of powering up various electronic devices has also been demonstrated. By combining with flexible acoustic-energy-harvesting nano generator and energy-storage devices such as fiber-like super capacitor, hybrid nano, power system can be formed and provide a more flexible solution for driving wearable electronics.

A12

Microstructure and Thermal Properties of Aluminum/Graphene Composite

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Aluminum matrix composites reinforced with different content of graphene nanoplatelets (GNPs) were prepared via ball-milling and microwave sintering process. The contents of graphene nanoplatelets (GNPs) were varied from 0.5 ~ 2.0vol.% in aluminum matrix. The impacts of graphene content on microstructure, mechanical performance, electrical and thermal properties were investigated. The results show that, for microstructure, GNPs was unfolded and distributed homogeneously in aluminum matrix. With the fraction volume of graphene increasing, the compressive strength was enhanced. However, graphene addition showed little negative impact on electrical conductivity and thermal conductivity.

A13

Thermally Conductive Nanocomposites based on Epoxy Modified with Nano-Sic and POSS

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OPAS/SiC/EP, SiC/EP, A151-SiC/EP composites were prepared and their impact properties, flexural properties, thermal conductivity and insulation, dielectric properties and thermal stability were investigated. The comparison of three different composites showed that OAPS/SiC/EP composites had best properties. Thermal conductivity of OAPS/SiC/EP composites increased with increasing filler content. The thermal conductivity of OAPS/SiC/EP composites with 20 wt% SiC was 0.343 W/mK and was 55% higher than that of unmodified EP.

A14

Zno Nanowires Network Synthesis and Its Applications on Transfer-Free UV Photodetector

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Horizontally ZnO nanowires and 3D nanowires network were synthesized on dielectric silicon substrate and SiO2 insulate substrate by catalyst-free CVD(chemical vapor deposition) method. Both the micro structure and the roughness of the substrate surface by the photoetching method and RIE ethingmethod play a significant role on the horizontally ZnO nanowires network growth when the gold catalyst are not sputtered on the substrate surface as usual. The reason of horizontally nanowires network growth on the catalyst-free substrates is that the surface micro structure and the roughness changed the nutrient gas flow and make the ZnO seeds nuclei on the substrate easier. And also, the ZnO nanowires synthesis working temperature is deceased to 600℃ from 960℃ with nanodiamond as reductant because nanodiamond reactant exhibites higher activity than graphite powder which is usually used in in the CVD synthesis process. An in-situ UV sensor based on three dimensional ZnO nanowires network was fabricated via a catalyst-free CVD method on the bare silicon substrate surface. The nanowires networks device showed fast response time around 20ms, which can be attributed to the nanowire-nanowire junction barrier dominant conductance. The network-enabled fast response as well as facile fabrication processes can be readily for large scale integration and low cost UV sensor system.

A15

Triboelectric Nanogenerators based on Spring Steel Plates for Practical Applications

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Triboelectric nanogenerators (TENG) that harvest energy from ambient environment have attracted great attention since they were first reported. However, the structures of TENGs working in the vertical contact-separation mode are considerably monotonous and energy loss cannot be avoided during the working process. In this study, we design four novel TENGs based on spring steel plates, by which we achieve high current output under low-velocity motion and improve energy conversion efficiency by using the Newton's cradle energy transmission mechanism. Besides, we successfully applied those TENGs to some practical applitions. The creative idea to bring the Newton's cradle energy transmission mode to the vertical contact/separation TENG leads to a new structure/material design for TENGs, which greatly improves their capacity.

A16

Nano-engineered Strong, Durable and Multifunctional/Smart Concretes

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Micro/meso scale modification can bring big changes in macroscale property. The addition of nanofillers makes materials strong, durable and multifunctional/smart. This paper aims at studying mechanical property, durability, electrical property, electromagnetic property and piezoresistivity of concrete with nano silica(NS), carbon nanotube(CNT), botryoid hybrid carbon material (BHCBM), nano graphite platelet(NGP) and nano-tip

material(spiky spherical nickel particles), respectively. Results demonstrate that the compressive and flexural strengths of concrete show significant increases with the increasing contents of NS. The addition of CNT obviously enhances the transport property of concrete. The BHCBM endows the excellent electrical conductivity with concrete. Both shielding effectiveness and electromagnetic wave absorbing performance of concrete can be achieved by adding NGP. The concrete with nano-tip material has ultrahigh piezoresistive response to stress and strain.

A17

The Preparation of Nano-Materials

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ultra-fine grinding technology, mechanical grinding method, wet milling of nano-scale powder

12 With the intensive application of nano-materials & functional materials, how to apply ultra-fine grinding technology in the production and dispersion of nano-materials has become an important contemporary issue. Usually there are two kinds of nano powder methods. The first method is chemical processing so called bottom-up method, such as chemical precipitation, sol-gel method.... The second method is physical processing, where the small powders turned into small particles, such as mechanical milling method. So far, the chemical or mechanical grinding method is the most popular ways to get the batch product of nano-powders. Such as graphene prepared by chemical vapor deposition, mechanical stripping Method to generate black phosphorus-ene. Sometimes the manufacturing cost is so high and so difficult to be massive, and the result of particle size distribution is also too wide. So far, the real production to obtain nano powder based on mechanical grinding method yet. Mechanical grinding method is easier to get the much narrower the particle size distribution of nano powder, while production costs are relatively low, the parameters are easy to control. R & D enlarge lab scale machine to the production application, the sample can be ground to<100 nm, to meet the needs of the industry. Here we discusses the way to get wet milling of nano-scale powder, how to choose a suitable solvent, dispersing agent and drying method then the nano-material can be approached successfully.

A18(Invited)

Design of Electrode and Maximizing Surface Charges for Tribonanogenerator

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Self-powered sensing technology by collecting energy from ambience is an idea strategy to realize the application of wireless sensors in large scale. Triboelectric nanogenerator (TENG) is a device for harvesting mechanical energy from ambience to transform the energy into electricity. Since the first report of the TENG in 2012, it has been developed very rapidly. Up to now, various TENGs and self-powered wireless sensing prototype devices have been achieved by collecting energy from environment. Herein, we report the work in our group in investigation of tribonanogerators based on novelt electrode designs for releasing multifunctions and self-powered sensors, such as triboelectric generator based on checker-like two and honeycomb-like three electrode systems for harvesting mechanical energy in all directions, and spiral-interdigital-electrode-based multifunctional device with dual-functional triboelectric generator and dual-functional self-powered sensor. These nanogenerators can also be used as self-powered mouse system, vibration alertor and momentum sensor, etc. In material designs, the influence of dielectricity and porosity on the output performance is discussed experimentally and theoretically, which indicates that both the surface charge density and the charge transfer quantity have a close relationship with the relative permittivity and porosity of the tribo-material. In addition, we also design numerous microcapacitors and alterable microcapacitors embedded in PDMS.

A19(Invited)

$Nacro_2$ Electrode for Rechargeable Sodium Ion Batteries

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Layered lithium intercalation compounds $LiMeO_2$ (Me:transition element) materials have been widely studied and applied as cathode materials for practical lithium ion batteries. Cost of lithium resource, however, has doubled since commercialization in 1991, and tight supply is expected due to the ever increasing demands of electric vehicles and energy storage systems. Indeed, the lithium

resource is unevenly distributed in Southern America. Meanwhile, sodium resources are abundant and unlimited everywhere. Recently, layered NaMeO2 materials are being intensively studied because of reversible Na+ insertion/extraction, in particular, $NaCrO_2$ (R-3m) in Na cell. Here, we report physical and electrochemical properties of $NaCrO_2$.

The $NaCrO_2$ powder was synthesized by solid-state method. Stoichiometric mixture of Na_2CO_3 and Cr_2O_3 powders were pelletized, and the pellet was heated at 900 ^oC in Ar. All chemicals and products were handled in an Ar-filled gloved box to avoid air exposure. Phase identification of the products was made using X-ray diffraction (XRD) with Cu Kα radiation and the collected XRD data were analyzed by the Rietveld refinement. Electrochemical test were carried out in coin type sodium cells. Galvanostatic electrochemical charge and discharge tests in 1M $NaClO_4$ in PC solution were carried out at room temperature.

XRD pattern of the produced $NaCrO_2$ demonstrated a phase-pure product and it was crystallized to O3 type layer structure with space group of R-3m. The delivered capacity was approximately 110 mAh g^{-1} in voltage range of 2–3.6 V and 97 % of the capacity was retained during 50 cycles. Also, the Na/NaCrO2 cell exhibited surprising high rate properties, namely, 84 % of capacity retention at 100 C-rates. Details will be discussed in the conference site.

A20

Effect of Graphene Oxide on Cement-Based Materials Working and Corrosion Resistance Performance

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GO prepared by Hummers method was added to cement paste and the effect of different dosage of GO on the cement paste physical properties and corrosive properties were investigated. XRD results show that GO can participate in the hydration reaction, which favor the enhancement of mechanic strength. The mechanical testing analysis show that the 28 days flexural strength and compressive strength respectively increased by 33.1 percent and 29.1 percent at the dosage of 0.06% compared with the reference cement mortar. The effect of different dosage of GO in different salt solution respectively after long soaking and wet-dry cycle function on the cement-based materials corrosion resistant were further investigated. The results indicated that dosage of GO play an important role in the corrosion resistance after long-soaking and wet-dry cycle function. By analyzing the specimen mass loss rate, flexural strength and compressive strength corrosion coefficient shows that, the cement-based materials corrosion resistant were significantly improved when

the dosage of GO was 0.03% and 0.06%. Detailed characterization (SEM, EDS, etc.) shows results show that the corrosions under different conditions was highly reduced upon the addition of GO because more compact internal structure in the paste was formed.

A21

Novel Synthesis of Noble Metal-based Alloy Nanoparticles and Their Electrocatalytic Activities

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Noble metal nanoparticles are attractive catalytic materials on account of their novel optical, electrical and magnetic properties compared with bulk solids. Nanosized alloys attract considerable attentions due to the increasing demands, and outstanding chemical and physical properties via cooperative interactions for high performance catalysts. In this research, carbon-supported PtAu and PdAu alloy nanoparticles were successfully fabricated from their metal wire electrodes via a one-step solution plasma process in water at atmospheric pressure. These alloy nanoparticles with the average size of 2-5 nm were uniformly and highly dispersed over the KB surface. These alloy nanoparticles showed good electrochemical activities. And their electrochemical stability in alkaline and acidic solution was addressed. Multi-scan cyclic voltammetry indicated that alloy nanoparticles have better electrochemical stability in alkaline than in acidic solution.

A22

Photocatalytic Preparation of Nanostructured MnO_2-(Co_3O_4)/TiO_2 Hybrids and Their Catalytic Application in SCR deNOx Reaction

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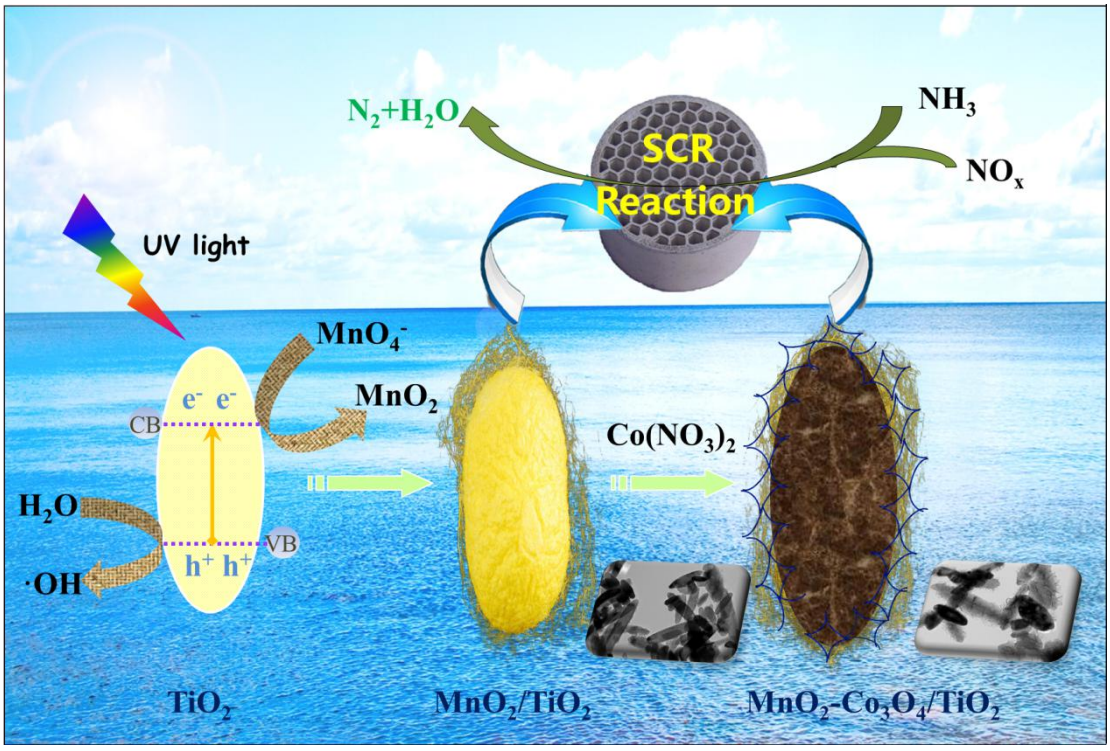
Photocatalysis has already triggered enormous researches in the areas of solar energy

transfer, environmental purification, organic synthesis and etc. In this work, the photocatalytic reactions were applied to controllably prepare nanostructured MnO_2-(Co_3O_4)/TiO_2 hybrids with highly distributed active components (Scheme 1). The loading of flocculent MnO_2 over TiO_2 nanorods was rapidly achieved through the redox reactions between the MnO_4^- and photoexcited electrons. Three steps were involved in the formation of MnO_2-$Co3O_4$ hybrids, namely the oxidation of Co^{2+} to Co^{3+} by the photogenerated holes, the deposition of intermediate CoOOH over MnO_2 and finally the decomposition of CoOOH by calcination to form Co_3O_4. Selective catalytic reduction of NO with NH_3 (NH_3-SCR) has been chosen as a model reaction to explore its application. It was found out that the unique MnO_2-(Co_3O_4)/TiO_2 hybrids exhibited promoted low temperature performance compared to that of prepared via impregnation, which was attributed to the abundant MnO_2 species, surface active oxygen, surface Ti^{3+} species and acid sites. We believe the MnO_2-(Co_3O_4)/TiO_2 hybrids were also interested in other applications of environmental catalysis.



Scheme 1. The formation procedures of MnO_2-(Co_3O_4)/TiO_2 hybrids and their catalytic application in SCR deNO_x reaction.

A23

Carbon-based Electrocatalysts for Hydrogen Evolution Reaction Modulated by Embedded Metals

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Development of effective technologies for clean and sustainable hydrogen energy has been attracting great attention lately, as hydrogen is hailed as a promising energy source to reduce our dependence on fossil fuels and benefit the environment by reducing the emissions of greenhouse and other toxic gases. Toward this end, an effective and promising approach is based on the electrolysis of water for hydrogen production. Recently, the studies about carbon catalysts with a low overpotential for HER have stimulated a great deal of interest. Actually, the density of carbon electronic states may be modulated by transition metal nanoparticles, such that carbon may serve as active sites for HER. This was ascribed to the carbon shell that helped protect the metal core as well as to the catalytic contributions from surface carbons due to interfacial charge transfer.

A24(Invited)

Mass production and application of highly-dispersed nanocrystals

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To realize the mass production of highly-dispersed nanocrystalline materials is one precondition for their industrial applications. In this work, the preparation methods and reaction mechanisms developed by our group were introduced. By the engineering amplification, a series of highly-dispersed nanocrystals were produced on batch production. Based on the key nanocrystalline materials, and key technologies, such as designing of water-based organic/inorganic hybrid resin, process optimization, coating composition optimization, and high-efficient curing, etc, the multi-functional coatings with advantages of low VOCs, abrasion resistance, high corrosion resistance, high shock resistance, and high hardness, etc were successfully developed. A series of highly-dispersed nanocrystals were realized industrial applications in the cathode materials of lithium ion batteries with high voltage, high-performance insulation materials, optical coatings with high transparency and high refractive index, etc.

A25

Growth of Branched Carbon Nanomaterials from Catalyst Prepared by Spray-coating Method

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Conventional catalyst preparation for growth of carbon nanomaterials (CNMs) mainly consists of atomic layer deposition (ALD) and sol-gel method, among which ALD can control the size of metal catalyst though it is time- and energy-consuming with high cost, while sol-gel method is always accompanied with much undesirable metal impurities as a result of powder catalyst, making the purification of products troublesome. Spray-coating method, which is newly developed for catalyst preparation for synthesis of CNMs, has been demonstrated to be a more feasible alternative with low cost and high quality products.

Herein, controllable growth of CNMs by substrate chemical vapor deposition (CVD) is presented, spray-coating method was adopted for catalyst preparation. Metal catalyst nanoparticles were obtained by decomposition and reduction of catalyst precursor film on SiO2/Si substrate fabricated by spray-coating method. Acetylene and gas mixture of Ar/H2 were used as carbon source and carrier gas, respectively. With the increase of number of spray-coating time for catalyst preparation, the helicity of as-prepared carbon nanocoils (CNCs) increases whereas the average line diameter and coil pitch decrease. Compared with dip-coating, spray-coating method can prepare more uniform catalyst nanoparticles, resulting in more CNCs and carbon nanomaterials. Moreover, via optimizing experimental parameters, various kinds of Y-junction CNCs were obtained. Additionally, hierarchical chrysanthemum-flower-like carbon nanomaterials were synthesized directly by thermal CVD method. The flower looks like a blooming chrysanthemum with a stem instead of a spheral flower reported in literatures. Formation mechanisms of Y-junction CNCs and flower-like carbon nanomaterials were elaborated detailedly.

A26

Fabrication and Application of Organic/Inorganic Hybrid Thin Films on the Pore Wall of Microporous Polyethylene Separator

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Polyolefin materials, such as polyethylene and polypropylene, are the most widely used separators materials in lithium ion batteries due to low cost, proper pore structure, good mechanical strength and favorable thermal shutdown property. However, the major disadvantages lie in their intrinsically hydrophobic surface character, leading to poor wettability

and retention for polar liquid electrolyte. As a result, the migration of Li^+ ions through polyolefin separators is impaired.

In this work, the organic/inorganic hybrid films on the pore surface of polyethylene separator were fabricated by a Layer-by-Layer method. In the hybrid films, the organic and inorganic components were exposed as the outmost layer by turns. Based on the model structure, the interactions between organic/inorganic components and electrolyte were investigated by measuring the ion conductivity, Li^+ ion transfer number, in-situ Raman, etc. The results reveal that the organic/inorganic hybrid film modified PE separators have higher ionic conductivity, larger Li^+ transference number and LiC_OO_2-Li metal cells with excellent capacity retention at high C-rates and superior cycling performance. The reasons were all discussed.

A27

Synthesis of Metal-Organic Frameworks Derived Composite Nanomaterials and their Properties

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Metal-organic frameworks (MOFs) are a new class of crystalline porous materials with periodic network structures, which are formed by self-assembly between metal ions and bridging organic linkers. Due to high surface areas, large pore volumes, and tunable surface properties, MOFs present promising application in gas storage and separation, drug delivery, heterogeneous catalysis, etc. Recently, MOFs are found to be ideal supports or templates for fabricating inorganic nanomaterials with porous or core-shell structures.[1] On the one hand, the as-prepared hybrids built with MOFs and other functional nanomaterials (such as noble metal catalysts and metal oxide semiconductors) could be endowed with enhanced performances and even new functions compared to their single-component counterparts due to the synergism effect between two materials. On the other hand, MOFs as template precursors can be readily be transformed into various porous nanomaterials including carbon, metal, oxide, and their hybrids by means of the pyrolysis of MOFs under controlled atmospheres.

Herein, we investigated the fabrication of MOFs-derived functional nanomaterials through template-engaged reaction. By using ZnO nanorods as self-sacrificial template, different zeolitic imidazolate frameworks (ZIFs) sheathed ZnO heterostructures (ZnO@ZIFs, ZIFs = ZIF-7, ZIF-8, ZIF-71, etc) and their arrays were successfully fabricated. Because the guest molecule diffusion is greatly limited by the pore size of MOFs, the heterostructure arrays exhibited distinct

molecular-size-related photoelectrochemical response for the addition of different-sized foreign molecules in solution.[2] Furthermore, based on thermal decomposition of Co-based or Cu-based MOFs, we successfully fabricated a series of porous nanomaterials, including Co_3O_4, Co/C, CoO/Co/C, Co_3O_4/ZnO, Cu_2O/CuO composites and $Zn_{1-x}Co_xO$ diluted magnetic semiconductors, and systematically explored their applications in gas sensing, lithium ion battery, electromagnetic wave absorption, etc (see Fig. 1). [3-5]。

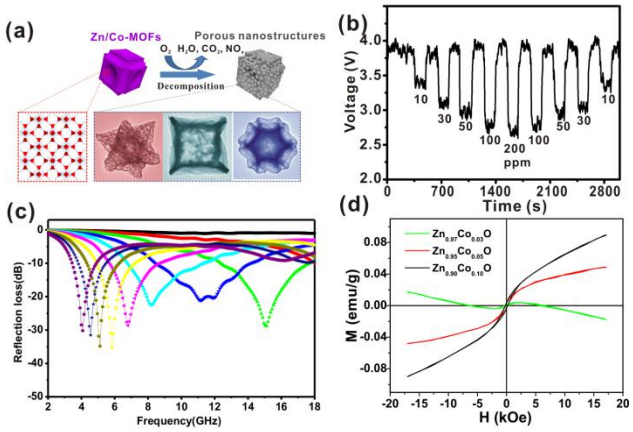

Fig. 1 MOFs templated syntheses and applications of porous nanostructures

A28

A Photodetector based on ZnO Nanorods

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In this work, a photodetector based on ZnO nanorods array was vertically grown on the nano-ZnO film. ZnO nanorods playing two roles in the photodetector, as the materials of absorbing UV light and carrier transport path. We used the sol-gel method to prepare the ZnO seed solution and annealed to get nano-ZnO film. Then, ZnO nanorods array were fabricated by hydrothermal method using the dihydrated-zinc-acetate and hexamethylenetetramine. The morphology of the growth of ZnO nanorods at different temperatures and concentration of reaction solution was studied with scanning electron microscope (SEM) and X-ray diffraction (XRD). The current density-voltage (J-V) characteristics were tested with a Keithley 2400 source meter. We calculated the photocurrent and responsivity of the device, the result showing that the device has a great potential in optoelectronic applications.

A29(Invited)

iTENG in Self-powered Implantable Medical Electronic Devices

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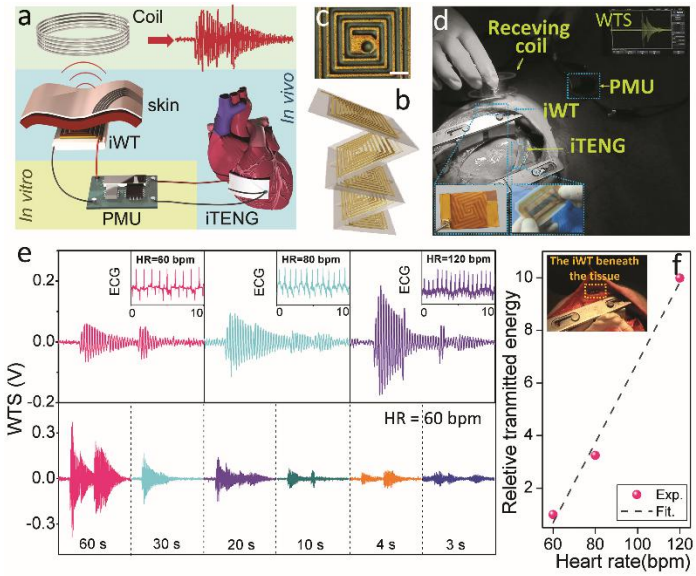
Recently, triboelectric nanogenerator (TENG) has attracted much attention and been considered as another potential solution for harvesting mechanical energy. With its high output performance, outstanding biocompatibility and low cost, TENG has been studied for powering implantable medical electronic devices.

Here, we demonstrated an *in vivo* biomechanical-energy harvesting using a TENG. An implantable triboelectric nanogenerator (iTENG) in a living animal has been developed to harvest energy from its periodic breathing. We also developing an encapsulation method for protecting iTENG from the contamination or liquid infiltration of the surrounding environment. We also designed viable inner connections and universal outlet connectors for the system. The power management elements and NG were integrated on a flexible substrate; therefore, the entire system could be a “Plug and Play” mobile power source. The system was also packaged by PDMS as a waterproof implantable full energy unit for implantable medical electronic devices.



The energy generated from breathing and body moving was used to power a prototype pacemaker and a low-level laser cure (SPLC) system, respectively. It was found that the self-powered system could regulate the heart rate of a rat and significantly accelerated the mouse embryonic osteoblasts' proliferation and differentiation. This is a significant progress for fabricating self-powered implanted medical electronic devices using TENG as a power source.

A30(Invited)

The Large Scale Colloidal Synthesis of Cu_5FeS_4 Compounds and Their Application in Thermoelectric

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Here, we report a large scale colloidal synthesis (CS) of Cu_5FeS_4 (Bornite) at different temperature (493 K, 533 K and 553 K) followed by spark plasma sintering for the first time. It is found that the carrier density of CS samples exhibits four orders of magnitude higher than that of samples synthesized by traditional solid states reaction methods (SS). The higher carrier density in CS Cu_5FeS_4 yields enhanced electrical conductivity and power factor over a wide temperature range. As a result, a ZT value of 0.56 is achieved in Cu_5FeS_4 compound synthesized at 533 K during the colloidal synthesis process, about 47% higher than that of bulk SS counterparts. Moreover, these samples show better mechanical performance compared to SS samples, demonstrating great potential of Bornite based compounds for thermoelectric commercial application.

A31

The Design and Preparation of Multi-dimensional Nanostructured Materials and Electrochemical Energy Storage

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Herein, we report some facile and general methods to directly grow metal oxide (TiO_2, SnO_2, NiO, Co_3O_4 and $NiCo_2O_4$) nanosheets on 0-dimensional sulfonated polystyrene spheres, one-dimensional CNTs, polymeric nanotubes or mesoporous carbon fibers and two-dimensional graphene oxide. After calcinations in air or inert atmosphere, these materials were converted into metal oxides hollow spheres assembled from nanosheets and metal oxides nanosheets@carbon (graphene and CNTs) materials. Due to the porous structure (derived from the pile of nanosheets) and internal voids, these metal oxide nanosheets can store more lithium ions, have more fast lithium ions transfer rate and thus exhibit improved lithium storage capability. The carbon hollow spheres, CNTs and graphene support serves as a highly conductive substrate that is beneficial to the better lithium ions storage performance.

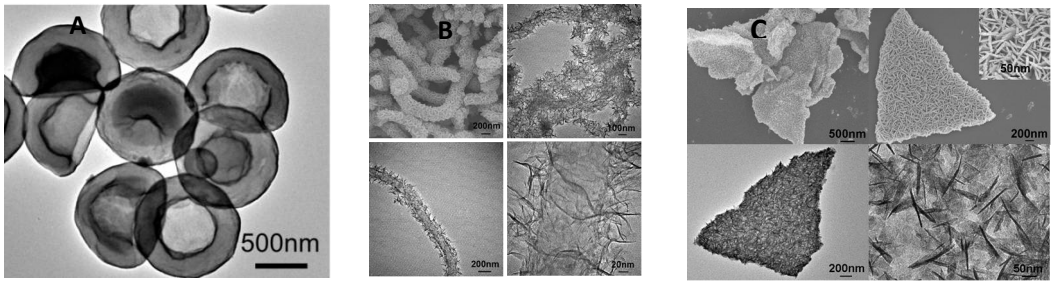

Fig. 1 SEM and TEM images:

A) SnO_2 bowl-like hollow spheres; B) TiO_2 nanosheets@CNTs; C) SnO_2 nanosheets@graphene.

A32

Synthesis of Hierarchical Nanostructures for Electrochemical Energy Storage

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(1) Electrochemical energy storage devices having high power density and energy density with robust cycle life are necessary to addressing ever-growing global energy demand. In order to realize a high-performance electrode, we designed and fabricated metal oxides-based supercapacitor electrode materials with hierarchical nanostructure. Strategies for hierarchical nanostructures are conducted to meeting criteria such as large active ion accessible surface area, optimized electronic and ionic conductivity and various Faradic redox reactions, as well as mechanical and chemical stability. These electrodes including 3D Mn-based honeycomb frameworks, Co-based hierarchical porous nanostructures, and nitrogen doped grapheme-based composite frameworks exhibit outstanding electrochemical performance with high specific capacitance, excellent rate capability and superior cycling stability. Moreover, supercapacitors based on the hierarchical nanoarchitectured electrode can be scaled up to the industrial level.

A33

New nanoplatform based on upconversion nanoparticles for sensitive detection of acute promyelocytic leukemia

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Acute promyelocytic leukemia (APL) is a special leukemia accounting for above 10% of adult acute myeloid leukemia. The t(15; 17) (q22; q21) is a specific chromosome reciprocal translocation of APL, resulting in the generation of a fusion gene between a retinoic acid receptor alpha (RARα) and promyelocytic leukemia (PML) at the molecular level. Many research demonstrate that PML/RARa fusion gene can be regarded as the molecular biology pathogenesis of APL. In this work, a novel luminescence "Turn-On" nanoplatform based on luminescence resonance energy transfer (LRET) from aptamer ssDNA (5'-NH_2-TCTCAATGGCTGCCTCCC-3') functionalized hydrophilic upconversion nanoparticles (Cit-UCNPs-ssDNA, energy donor) to single-walled carbon nanohorns (SWCNHs, energy acceptor) was prepared for sensitive detection of PML/RARα fusion gene. In the presence of the target DNA, a PML/RARα fusion gene of acute promyelocytic leukemia (APL), the π-π stacking interaction between the energy donor Cit-UCNPs-ssDNA and energy acceptor SWCNHs weakened and their distance enlarged. Therefore, the luminescence of Cit-UCNPs-ssDNA would be recovered (turn on) due to the inhibition of the LRET process. Based on this fact, a sensitive method was developed for the turn-on detection of APL with a detection limit as low as 0.28 nM. To the best of our knowledge, this is the first time that upconversion nanoparticles and SWCNHs were used as a donor-acceptor pair to detect PML/RARα fusion gene sequences through a LRET process.。

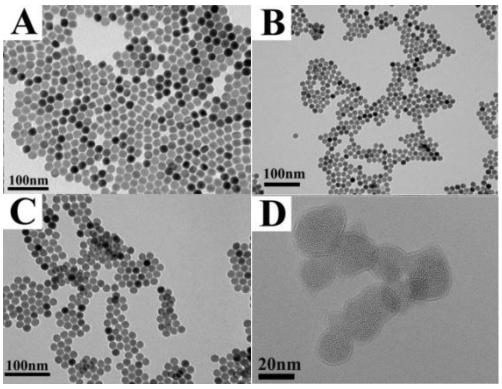

Fig1.：TEM images of (A) CS-UCNPs，(B)Cit-UCNPs，(C) Cit-UCNPs-ssDNA and(D)single-walled carbon nanohorns.

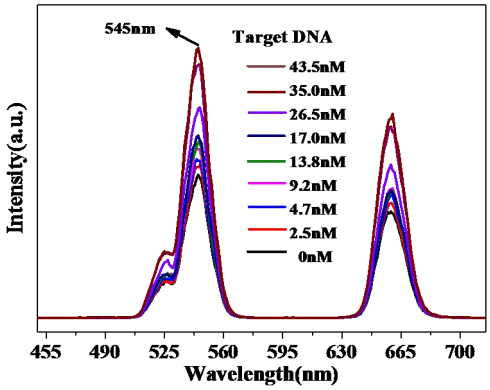

Fig2.: The luminescence spectra of multiplexed Cit-UCNPs-ssDNA-SWCNHs nanoplatform with various concentrations of target DNA (PML/RARα fusion gene).

A34

Studies on Preparation and Supercapacitive Property of Mos_2 Nanoflake Arrays

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The hexagonal MoS_2 nanoflake arrays (MNFs) has been synthesized on a Cu substrate by using a hydrothermal method with $(NH4)_6Mo_7O_{24}\cdot4H_2O$ as molybdenum source, CN_2H_4S as the sulfur source and reductant, and $(CH_3)_2CHOH$ as the dispersant. The morphology and crystal structure of the MNFs were characterized by SEM, XRD, XPS and TEM. The morphology evolution and growth mechanism of MNFs were investigated, basing on the samples at different reaction times. Moreover, the supercapacitive properties of MNFs have been examined. It is found that MNFs exhibit good cycling stability (87%), relatively high specific capacitances of 404, 231.3, 138, 70 and 38 F/g at current densities of 0.5, 1, 2, 5 and 10 A/g, respectively, indicating that the MNFs is a good supercapacitor electrode material.

A35

Preparation and Properties Characterization of WO_3 Nanorod Arrays

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Among the numerous compound semiconductors, WO_3 is typically a kind of multi-functional and multi-purpose material which has been found useful in gas senesors, photocatalysis, electrochromic materials, solar cells and supercapacitor electrodes. The morphologies and structures of the WO_3 nanoscale materials have significant impacts on their related properties. Therefore, much effort has been focused on the preparation of WO_3 nanoscale materials with different morphologies and structures, especially oriented WO_3 nanorod arrays (WNRs). One dimensional hexagonal WNRs and their composite structures were prepared on different conductive substrates in this report. The growth mechanism of well-aligned WNRs was intensively studied. Moreover, the electrochromic, photocatalytic and supercapacitive properties of WO_3 nanoscale materials and their composite structures were studied.

A36

Simplified Synthesis and Luminous Mechanism of Eu^{2+}-Doped A-Si_3N_4 Nanowires with Strong Green Luminescent Properties

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Ultra-long, single crystal, Eu-doped α-Si_3N_4 nanowires were prepared by a simple approach involving nitriding Eu-doped cryomilled nanocrystalline Si powder in NH_3 flow at 1350 ^oC for 4 h. Phases, chemical composition and microcosmic feature were tested by X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), transmission electron microscopy (TEM/HRTEM), respectively. The results suggest that Eu successfully introduced into Si lattice after the cryomilling process and then entered the lattice of α-Si_3N_4 with the nitridation process. The as-synthesized Eu-doped α-Si_3N_4 nanowires have highly uniform dimension with 30~50 nm in diameter and ~10 μm in length The room temperature photoluminescence (PL) spectrum of as-synthesized nanowires shows a broad band emission center at 570 nm which is attributed to the $4f^65d–4f^7$ transition of Eu^{2+}. The transition from Eu^{3+} to Eu^{2+} during nitridation process was tested by X-ray photoelectron spectroscopy (XPS).

A37

One-Pot Potassium Oxalate-Assisted Synthesis of Biomass-Derived Activated Carbon with Enhanced CO_2 Uptake

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Highly microporous activated carbon for enhanced CO_2 adsorption were prepared by one-pot potassium oxalate ($K_2C_2O_4$)-assisted synthesis of the biomass raw materials (BRM) peanut shell, walnut shell and pecans shell. The carbons were prepared via hydrothermal carbonization of the BRM in the presence of $K_2C_2O_4$, The resulting $K_2C_2O_4$-containing hydrothermal chars were simultaneously carbonized and activated at 600-800℃ in flowing nitrogen. Carbons derived from pecans shell activated at the $K_2C_2O_4$/BRM ratio of 3 at 700℃ exhibit best CO_2 uptake capacity at 25℃ of up to 4.31 mmol/g at 1 bar. The present carbons are the first examples of biomass-derived porous materials through one-pot direct activation with enhanced CO_2 uptake performance, which arises due to the fine micropores (pores below 1 nm) even for samples with very high surface area. Also, the samples could be easily regenerated with superior cyclic stability after multiple cycles. These results suggest that the obtained biomass-based activated carbon is promising for CO_2 capture.

A38(Invited)

Piezophototronic Devices

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Multifunctional micro/nano devices and systems are of important applications in smart electronics for health care, human-machine interfacing, infrastructure monitoring and security. In recent years, piezophototronic effect is developed fast since it offers a new method to improve/tune the optoelectronic properties dramatically. The key characteristic of the piezo-phototronic effect is that the carrier generation, transport, separation and/or recombination at the heterojunction/interface can be tuned by modulating the piezopotential which created and further tuned by externally applied strain. Therefore, one method to enhance piezo-phototronic effect is increasing piezoelectric charge at the interface. Another method to improve piezo-phototronic effect is reducing charge carrier recombination probability, the design of semiconductor composites heterojunction/interface should take into account their band positions and band gap. By interface engineering the p-n junction, piezo-phototronic effect can be improved.

Piezophototronic effect can enhance the sensitivity of photodetector dramatically. Here, we show a self-powered GaN flexible film-based metal-semiconductor-metal (MSM) UV photoswitch. The asymmetric MSM structure was designed to suppress carrier recombination and enhance carrier transport. At self-powered condition (no external bias voltage), its UV on/off ratio reaches up to $4.67*10^5$ with high reliability of on/off switching response. Also its UV detection shows an excellent sensitivity ($1.78*10^{12}$ $cmHz^{0.5}W^{-1}$). In particular, strain modulation can improve the UV on/off ratio (~154%) by piezo-phototronic effect.

Besides photoelectric conversion and electroluminescence, photoluminescence can be tuned by piezoelectric charge as well. Here have developed a new method of pressure sensing by using pressure/strain induced piezoelectric charge to tune PL intensity of InGaN/GaN MQW under small strain (0~0.15 %). Such modulation effect is distinct, linear and ultrafast. Based upon it, an all optical pressure sensor array by the piezo-phototronics effect has been developed to measure dynamic pressure distribution without the need of electricity. Beyond the limitations of electrical connection, our all-optical device offers a novel and suitable way for large-area, high-uniform, high resolution, ultrahigh speed pressure/strain distribution sensing.

A39

Highly Conductive Zinc-Tin-Oxide Buffer Layer for Inverted Polymer

Solar Cells

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Thin-films of Zinc Tin Oxide (ZTO) with an extremely high charge carrier mobility and superior optical transmittance are synthesized using a simple solution method. These ZTO films have been systematically studied for the application in inverted polymer solar cells (PSCs). The Hall effects measurements show that the charge mobility of the ZTO semiconductor is over 16.5 $cm^2.V^{-1}.S^{-1}$, which is the highest mobility value ever reported for oxide buffer made by using solution process. By applying the ZTO buffer layer in the inverted PSCs of P3HT:$PC_{61}BM$, the power conversion efficiency of the device is 30% higher than that of the devices made with other common buffer layers such as ZnO and TiO_2. Light intensity-dependent JV studies and PL measurements also indicate that ZTO buffer layer reduces surface recombination. This work demonstrates that the solution-synthesized ZTO is a promising new buffer layer with superior electron extraction capability for the solar cells.

A40

Electric Field Assisted Atomic Layer Deposition of Ultra-thin Al2O3 films on Graphene

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Ultra-thin and continuous Al_2O_3 films have been deposited on chemically inert graphene by electric field assisted atomic layer deposition (ALD) using trimethylaluminium (TMA) and DI-water as reactants. For the strong polarity of the reactants, the electric field can act as reactant cluster inhibitor which remarkably reduced the nucleation on the areas other than

defects and step edges. However, while voltage is applied to the ends of the graphene, electric field induced charge accumulation on the surface effectively modulated the graphene's surface potential, which enhanced the bonding energy between the reactant molecule and the graphene, and then promoted the nucleation density of Al_2O_3 on graphene. Our approach not only demonstrated a simply way to obtain ultra-thin and continuous high-k dielectrics on graphene, but also offered a large prospect for the deposition of a wide kind of thin films on 2D materials using ALD.