Forum E: Information Materials and Devices

E01 (Invited)

The Hand-held Night Vision Color Infrared Camera and Security Monitoring Color Infrared Telecamera System

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Visible light is made up of the wavelengths that range from 400 nm to 700 nm. Infrared (IR) is invisible radiant energy with longer wavelengths extending from 700 nm to 400μm. All objects at a temperature greater than 0 K emit infrared radiation. Infrared imaging is a technique of capturing invisible infrared radiation with optoelectrical thin films focal plane arrays (FPAs). Infrared imaging system designing has to be considered comprehensively about photosensitivity and response time as well as thermal conductance. Recently, uncooled IR imaging system has been developed with optical ROIC and adaptive focal plane arrays (AFPAs). Multi-spectral tunable IR imaging, night vision color infrared imager and continuous monitoring infrared telecamera system have been increasing prosperous.

E02 (Invited)

Growth of Wafer-scaled VO_2 Thin Films Using a Chemical Solution Approach

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Vanadium oxide (VO2) has many potential applications due to its unique properties related to the metal-insulator transition. However, due to the multi-valance states of V ions and the diversity of VOx (1<x<2.5) phases, the control of the oxygen stoichiometry of VO2 is difficult. Recently, highly stoichiometric VO2 thin films in a broadened growth window can be successfully achieved using a chemical solution deposition technique named polymer-assisted deposition by introducing moisture into the growth ambiance. The as-grown VO2 thin films exhibit excellent metal-insulator transition behavior of a giant resistance drop of 5 orders of magnitude with an ultra-sharp transition width of less than 1K. Especially, it is demonstrated that this is a scalable technique to achieve a 3-inch wafer-scale VO2 films with uniform properties. Our experimental

results have demonstrated an effective approach to control the oxygen stoichiometry of VO2 and reduce the difficulty in the fabrication of high quality VO2 thin films with scale-up properties for practical device applications.

E03

Large High-quality CdSe Single Crystal Growth and its preparation Method of Infrared Wave Plate

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The mid-infrared precision polarization observations is very important in many areas including astronomy. Considering the needs of the infrared solar polarization measurements as object, the development of technology of large-diameter and high-precision mid-infrared wavelength plate have been carried out. Due to the high infrared transmittance, moderate birefringence coefficient, chemical stability and good mechanical properties, etc., CdSe single crystals have been the best materials to product infrared wave plate. The growth parameters will be optimized by studying the thermal dynamic mechanism. CdSe single crystal with high-quality and big size have been grown, and waveplate with high precision in phase delay and high infrared transmittance have been obtained by high-precision machining process. Through further work, it is hoped to get the preparation methods of large CdSe crystals and mid-infrared plate based on achievement in our laboratory, which will provide the technical support for the future construction of large infrared telescope.

E04

Surface Modification of Layered Structure Cathode Materials for Lithium Ion Battery

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The flourishing development of lithium-ion batteries (LIBs) has accelerated the manufacturing of potable electric devices, electric vehicles (EVs) and hybrid electric vehicles (HEVs). Lithium-rich layered oxide (LLMO) cathode materials are receiving international attention because they can deliver an exceptionally high rechargeable capacity of 250 mAh/g between 2.0 V-4.8 V. However, this high capacity cathode material still faces challenges, such as transition

metal (TM) dissolution occurs at high electrode potentials (>4.5V *vs.* Li/Li^+), and the evolution from layered structure to spinel-like upon cyling leads to the poor cycle life. Therefore, we have tried to synthesis LLMO cathode materials by sol-gel method and modify them via surface coating approach in this paper.

The mechanisms and effects of three typical chelating agents, namely glucose, citric acid and sucrose on the sol-gel synthesis process, electrochemical degradation and structural evolution LLMO cathode materials are systematically compared. Electrochemical tests further prove that the LLMO material obtained from sucrose maintains 258.4 mAh/g with 94.8% capacity retention after 100^{th} cycle at 0.2 C. The superior electrochemical performance can be ascribed to the exceptional complexing mechanism of sucrose, compared to those of the glucose and citric acid. X-ray diffraction, scanning electron microscopy, X-ray photoelectron spectroscopy and high-resolution transmission electron microscopy analysis indicate that the sample synthesized from sucrose owns well structure, homogenous distribution, low Ni^{3+} concentration and good surface structural stability during cycling, respectively. This discovery is an important step towards understanding the selection criterion of chelating agents for sol-gel method, that chelating agent with excellent complexing capability is beneficial to the distribution, structural stability and electrochemical properties of advanced lithium-rich layered materials.

Surface coating has been considered as the most promising method to protect cathode materials from the damage by decomposition of electrolyte. Herein, highly-ordered Al_2O_3 coatings from the hydrolysis of aluminium isopropoxide are coated on LLMO cathode material with controlling the growth of Al_2O_3 crystals. The coin cell with bare cathode material delivers a high discharge capacity over 268.2 mA h/g between 2.0 V-4.8 V, while the Al_2O_3 coated cathode material shows the excellent cycling stability corresponding to 98% capacity retention after 100^{th} cycle at 1 C. More importantly, the highly-ordered Al_2O_3 coated cathode materials exhibit a significantly lower discharge voltage decay compared to the bare cathode materials, which could be ascribed to the suppression of the layered-to-spinel transformation by compact Al_2O_3 layer. The results here will shed light on developing cathode materials with special structures and superior electrochemical properties for high-performance lithium ion batteries.

A double-shelled architecture consisting of the inner conductive polyacene (PAS) layer and the outer mesoporous Al_2O_3 layer is constructed. Although the cycle life of LLMO cathode material can be enhanced by highly crystalline Al_2O_3 coating, the capacity is decreased by this insulating layer. A PAS layer with high electron conductivity is first coated on the surface of LLMO cathode material. However, this single PAS layer can not effectively suppress the errosion effect from the electrolyte, while the double-shelled architecture has protected the PAS layer and the

bulk of LLMO cathode material. The results show that electrochemical capacity is greatly improved, reaching to 280 mAh/g (2.0V-4.8V at 0.1C) and the transition from layered phase to spinel is delayed, leading to the superior capacity retention of 98% after 100^{th} cycle.

E05 (Invited)

Ultrafast Coherent Control of the Electron Spins in the Topological Insulators

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Topological insulators (TIs) are characterized by an unusual electronic structure exhibiting both insulating bulk and robust Dirac-like surface states (SSs). This unique electronic structure combining external light excitation leads to TIs a great promise for opto-spintronics and ultrafast spintronics applications. Here, we will discuss in detail the ultrafast charge and spin dynamics in a prototypical TI Bi2Se3 under photoexcitation. We demonstrate experimentally that ultrafast manipulation of the coherent spin states in TIs can be realized by varying the photon polarization state and/or the photon energy.

E06

Single-mode lasing from wurtzite CdSe/CdS core/shell quantum dots

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Due to the quantum confinement effect, colloidal semiconductor quantum dots (QDs) exhibit various advantageous properties as optical gain media. However, the development of lasers based on colloidal QDs is hindered by Auger recombination (AR). Here, phase-pure wurtzite (WZ) CdSe/CdS core/shell QDs with controlled shell thickness are successfully synthesized, which exhibit more than 2 orders of magnitude decrease in AR rates with increasing shell thickness from 4 to 19 monolayers (MLs). As a consequence, the threshold of amplified spontaneous emission (ASE) of the films of this series of QDs decreased dramatically with the CdS shell growth towards 11 MLs (16 μJ/cm2). The lifetime and bandwidth of optical gain of the QDs with a 11 ML CdS shell exceed 1000 ps and 600 meV, respectively. The threshold of ASE increased

with the further shell growth because the ultrathick-shell would slow down the relaxation of holes from the shell to the core. Moreover, the low-threshold gain of the QDs is exploited to fabricate coffee-ring micro-lasers that display single-mode operation and a very low threshold of 2 μJ/cm2.

E07

Multiferroism and Colossal Magneto-Capacitance of La Modified M-type Lead Hexaferrite

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Multiferroic materials with such magnetoelectric properties that are comparable to the useful ferroelectrics and ferromagnets are exceedingly rare. We report here on integration of ferroelectricity and ferromagnetism in a M-hexaferrite (La0.2Pb0.7Fe12O19), which simultaneously exhibits colossal magnetocapacitance effect. Ferroelectric polarization and magnetic properties in La modified M-type lead hexaferrites (La0.2Pb0.7Fe12O19) will be presented. The remnant polarization of the La0.2Pb0.7Fe12O19 ceramic reaches as high as 132μC/cm2, exhibiting large spontaneous polarization hysteresis loop with full saturation at room temperature. Subsequent annealing of the La0.2Pb0.7Fe12O19 ceramics in oxygen atmosphere plays a key role on the saturation of its polarization hysteresis loop due to the great enhancement of its electric resistance. Two current peaks in I-V curve reveal the switching of polarization, which provides an effective evidence for the ferroelectricity of the LaPbFe12O19 ceramics. The ceramics also exhibit strong ferromagnetic characterization. The coexistence of the off-centered FeO6 octahedron and electron spins in partially filled Fe 3d or La 3f orbits is supposed to be responsible for mergence of mutually exclusive electric and magnetic orders. Five magnetoelectric phases and boundaries have been built up by the permeability profile. By applying a magnetic field (B), the capacity or dielectric constant demonstrates giant oscillations, whose maximum amplitude exceeds 1.90×105% at 80 Hz. The huge oscillations are associated with the variable component and orientation of the cycloid conic spins at the boundaries between two neighboring magnetic phases, where the cycloid cone axes align themselves parallel or reversal parallel to the direction of B field. Thus the dielectric constants are systematically enhanced to reach a giant value of $\varepsilon'_{m\pm}$ =+58270 or -84866 due to the great promotion of spin-current induced polarization. These combined functional responses in La0.2Pb0.7Fe12O19

ceramics present an opportunity to create electric devices that actively couple the magnetic and ferroelectric orders.

E08

Growth of GaN by Plasma-enhanced Atomic Layer Deposition at Low Temperature

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III-group nitride GaN is a very significant semiconductor material, which has been extensively used in the applications such as high-brightness blue-ultraviolet LED, blue laser diodes, HFETs and DRAM and thusly been reputated as the third generation semiconductor. However, the high temperature for GaN growth used in the conventional deposition methods , such as MOCVD and MBE, is not only compatible with the existing CMOS techniques but also the temperature-sensitive layer based devices. Plasma-enhanced atomic layer deposition (PE-ALD) is a promising technique for GaN growth at low temperature with high comformity, uniformity and precise sub-angstrom thickness control. Here in this work, GaN thin films deposited at low temperature (250℃) will be reported, and the effects of the kinds of nitrogen source, such as NH3 and N2/H2 gas mixture, and the flow rate of the N2 or H2 in the gas mixture on the GaN thin films will be discussed.

E09 (Invited)

Preparation and Photoluminescence of KSr4(BO3)3:Pr3+ phosphors

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Luminescent materials (KSr4(BO3)3 ： Pr3+ and KSr4(BO3)3: Pr3+, R+ (R=Li, Na, K)) were successfully prepared by the high-temperature solid-state method. The crystal structure, morphology and spectrum were characterized by the XRD, SEM and spectroscopy, respectively. The XRD patterns of the samples were compared with the relevant literature's report, there is no

other impurity phase. The peak of the excitation spectrum of the sample is located at around 449 nm， corresponding to 3H4→3P2 transition of Pr3+. The peak of the emission spectrum of the sample is located at around 606 nm，corresponding to 3P0→3H6 transition of Pr3+, and the color is red. The replaced sites of Pr3+ in the sample are Sr2+ and K+. The strongest luminescence intensity of the substituted Sr2+ site was 1.5 mol%， and the strongest luminescence intensity of the substituted K+ site was 1 mol%. Doping charge compensation agent (KSr4 (BO3)3: Pr3+, R+, R=Li, Na, K) of the samples， the luminescence intensity is higher than that of the single doped case. Among them, the luminescence of the Li+ and Pr3+ co-doped sample is optimal.

E10 (Invited)

Development on High Thermal Conductive Diamond-metal Composites

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With the development of electronic information technology, the heat flow density of powered devices increases dramatically. Traditional heat dissipating materials cannot meet the thermal conductivity requirements of advanced electronic devices. Development of a new generation of heat dissipating material is highly requested for thermal management purpose. Due to ultra-high thermal conductivity and low coefficient of thermal expansion (CTE) of diamond, metal matrix composites reinforced by diamond particles could obtain high thermal conductivity and tailored coefficient of thermal expansion which have drawn great attention.

In order to improve the thermal properties of the composites, metal matrix alloying, surface metallization of diamond particles and advanced fabrication techniques have been investigated on Al and Cu matrix composites. For Al/diamond composites, a thermal conductivity of 760 W/mK, and a coefficient thermal expansion of 4.56×10-6/K could be obtained by using an optimized gas pressure infiltration (GPI) process. A 0.5wt.% Si addition to Al matrix will improve mechanical properties and keep high thermal conductivity of the composites. A tensile strength of 150 MPa, bending strength of 404 MPa, compressive strength of 424 MPa, and TC of 727 W/mK) was obtained. For the Cu/diamond composites, by using Zr-alloyed Cu matrix, the highest TC of 930 W/mK with CTE of 5.18×10-6/K can be achieved.

Interface between diamond and matrix plays a crucial role in determining the properties of composites. A better understanding on the interfacial microstructure could be helpful to further improve the properties of composites. Nucleation and growth mechanisms of aluminum carbide

in Al/diamond composites were carefully investigated. To effectively adjusting the interfacial structure in diamond particles reinforced metal matrix composite, the mechanism of heat transfer across the interface should be well understood. Molecular dynamics simulation and experimental measurement of thermal boundary conductance in the diamond/metal system were also performed.

E11 (Invited)

Triboelectric Nanogenerators and Self-powered Sensing for Intelligent Traffic System

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Abstract: Wireless traffic detectors play a critical role for current Intelligent Traffic System. However, the traditional battery-based wireless safety monitoring system are suffering from the intrinsic shortcomings such as short lived and frequent renewal, especially in the remote area and wide distribution. Here, we report the lawn structured triboelectric nanogenerators for scavenging sweeping wind energy on rooftop, the self-powered active wireless traffic volume sensor by using a rotating-disk-based hybridized nanogenerator of triboelectric nanogenerator and electromagnetic generator as the sustainable power source, and the self-powered safety helmet based on hybridized nanogenerator for emergency. These researches further expand the applications of triboelectric nanogenerators for high-performance ambient mechanical energy harvesting and self-powered wireless intelligent traffic sensors.

E12

Study on Noble Metal Modified 3D Porous Single-Crystalline ZnO Nanosheets and Their Gas Sensing Properties

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Metal oxide gas sensors have been extensively exploited to detect volatile organic compounds (VOCs) because of their advantages including compact size, easy production, low cost and simple measuring electronics. They possess currently the highest market share for commercial gas sensors. However, their sensitivities are generally low which restrict their further applications. Nanomaterials have been investigated for gas sensors because of their advantages such as large specific surface area, abundant active sites, etc. Here, Porous single-crystalline ZnO nanosheets

have been assembled to 3D hierarchical structures and then noble metal nanoparticles have been midified onto their surfaces. Gas sensing measurement results reveal that those noble metal modified porous single-crystalline ZnO nanosheets exhibited highly sensitivity to VOCs and the detection limits might reach ppb levels which were 2-3 orders higher than the commercial gas sensors. Gas sensing mechanism has been speculated as below. Porous structure may provide plenty of active sites for surface chemical reactions. The single-crystalline structure of each nanosheet is advantageous for electronic transport and structure stability. 3D hierarchical structures may improve the gas diffuse ability in the inner of the sensing materials. Noble metal modification plays a very important role in increasing sensitivity because it possesses high catalytic activity and consequently increases the reaction activity of the space-charge layers.

E13

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.

E14(Invited)

Preparation Method and Sensitive Properties of the Nanometer Gas Sensitive Materials

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It is an urgent security problem to detect and monitor the combustible and toxic gas. The research of nanometer gas sensitive materials has an important significance in improving the sensitivity, selectivity and long-term stability. It is also meaningful that how to reduce the working temperature and shorten the time of response. This report makes a brief review on the preparation methods and their sensitive properties of the current nanometer gas sensitive materials. As two examples, the semiconductor and optical gas sensing materials and devices are illustrated.

E15

Study on (In, Pb) doped CdZnTe crystal for radiation detector applications

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CdZnTe (CZT) has been considered as the most promising radiation detector materials operated in room temperature. Intentionally deviated stoichiometry is usually used which gives a Cd-rcih or Te-rich growth condition, increased the growth instability. The reason for co-doping is to acquire high quality crystal under near-stiochiometric condition, with high resistivity, excellent charge transport properties, to compensate deep level defects and to effectively improve the performance of detector. In the current research work, we evaluated the influence of co-doping of Lead and Indium on the electronic properties of CZT:(In,Pd) crystals, using current-voltage measurements, thermally stimulated current (TSC) and transient current measurements (TOF). High resistivity CZT:(In,Pd) crystal without inclusions larger than 1 um has been proved to be grown by modified vertical Bridgman method. Thirteen deep energy levels were identified in co-doped CZT samples by TSC and PL, which is more than single element doped CZT. The carrier life was found to be influenced. Better uniformity on high energy response was proved for

co-doped samples.

E16

Photo-stable Giant Mn-doped Nanocrystals with Ultra-long-lived and Bright Type-II Emission

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The thick shell (～10 monolayers (MLs)) of the giant type II Nanocrystals (NCs) can improve the type II photoluminescence (PL) lifetime by two orders of magnitude, leading to the ultra-long-lived type II PL resulting from better charge-separation. But the ultra-long-lived (～10 μs) type II emission from undoped NCs, with seeded cores prepared by one-pot heating-up strategy, exhibits a low quantum yield (QY) of less than 1%. Interestingly, as Mn2+ dopants were introduced into these seeded NCs, the QY of CdS:Mn/ZnSe NCs, with Mn-doped cores prepared by growth-doping strategy, can be higher than 10%. After additional ZnS-capping was introduced to improve QY and the stability, the QY can be furtherly improved to more than 30%. Furtherly the QY of giant Mn-doped CdS/ZnSe/ZnS NCs, with Mn-doped cores prepared by nucleation-doping strategy, can be up to ～60%. The emissions from giant Mn-doped NCs is identified as type II emission by measuring PL and PL decays. Mn2+ ions, as a long-lived energy storage, were firstly introduced to improve the QY of type-II emissions. Deep-seated Mn2+ dopants, far away from the traps, can reserve the energy for type-II emission and then improve the corresponding QY significantly. Meanwhile, Mn2+ dopants, combined with ZnS shell, improve the stability for bright type-II emissions. This study forms the optimum stable structure to store energy for charge-separation state efficiently, throwing light on the acquirement of high QY and good charge separation in optoelectronic devices.

E17

Preparation and Properties of Light-Cured Plastic Scintillator

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A new type of light-cured plastic scintillator was prepared. The optimum preparation conditions were confirmed, and the light yield, fluorescence

property and decay time were detected. The maximum emission wavelength was 420n, relative light yield amounted to 7.1%, and decay time 2.58ns. The light-curing method was considered as a good way for preparation of plastic scintillator.

Keywords： Scintillator, light-cure, light yield, decay time