Q. Multifunctional Composites and Metamaterials

Organizers: Runhua Fan, Wei-Hsing Tuan, Soon-Yong Kwon

Q-01
Tailoring composite microstructures for multiple functionalities
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Q-02
Unusual wave phenomena in zero-index media
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Zero-index media (ZIM) refers to materials with permittivity or permeability approaching zero. Unique properties of ZIM include tailoring of wave front, tunneling waveguides, defect tuning effects, perfect absorption, etc. In this talk, we review some recent advances that we developed in ZIM. The first one is arbitrary flux control effect in anisotropic ZIM. The second one is unusual percolation behavior of electromagnetic waves in random media with a zero-index background. The third one is cloaking in transmission geometry based on ZIM and metasurface. The last one is the realization of Coherent perfect absorber (CPA) and laser with energy-balanced ZIM. These advances show that ZIM is a promising new kind of material with unique and important properties.

Q-03
Synthesis of porous magnetic materials and their electromagnetic absorption performances
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We present a template-free approach to prepare porous magnetic materials by combining solvent-thermal route with chemical reduction process. The synthesized cobalt microspheres with diameter of ca. 2-4 μm have a shell thickness of about 150 nm. The hollow Co microsphere is built from particle-like ligaments with diameter of ca. 80-150 nm and there are a lot of pores with size of several tens nm on shell. The hollow porous cobalt spheres exhibited the saturation magnetization (Ms) of 163.0 emu/g and coercivity (Hcj) of 307.9 Oe. The epoxy resin composites with 30 wt% and 60 wt% hollow porous cobalt sample showed efficient electromagnetic wave absorption characteristics (RL < -20 dB) in ranges of 11.3-18.0 GHz and 4.0-12 GHz over absorber thicknesses of 1.4-2.0 mm and 1.4-4.0 mm, respectively. By the similar approach, we also fabricated the hollow magnetite spheres with diameter of ca. 500 nm and a shell thickness of ca. 150 nm, which exhibited a high saturation magnetization of 90.6 emu/g. The epoxy resin composites with 68 wt% hollow magnetite spheres provided superior electromagnetic wave absorption (RL < -20 dB) in the range of 1.6-3.0 GHz over the absorber thickness of 5-9 mm. A minimum RL value of -42.7 dB was observed at 2.0 GHz with a thickness of 6.9 mm. Our researches demonstrate the potential application of porous ferromagnetic materials as efficient and lightweight electromagnetic wave absorber.

Q-04
Enhanced Electron Collection in Perovskite Solar Cells Employing Thermoelectric Coaxial Nanofibers
Driven by the imperative demand for low-cost, easy fabrication, and high-efficiency solar cells, organometal halide perovskite solar cells (PSCs) have recently received tremendous attention. As for PSCs, the diffusion length of electrons in m-TiO$_2$ ETL is significantly shorter than that in TiO$_2$ bulk single crystal ($\approx$10 $\mu$m), due to the electron scattering at the surface, the grain boundaries, and the defects, which also result in more charge recombination at the interface and grain boundaries. Considerable efforts have been made to improve the efficiencies of electron transfer and collection by design and control of the morphology and crystal structure of TiO$_2$. Herein, NaCo$_2$O$_4$/TiO$_2$ coaxial nanofibers were used to improve the electron transfer of PSCs, and promoted the electron injection and transport by virtue of an efficient electrostatic force, which was induced by thermoelectric energy conversion of NaCo$_2$O$_4$ under illumination. The device applying 9.1 wt% NaCo$_2$O$_4$/TiO$_2$ demonstrated the best photovoltaic performance with an enhancement of $\approx$20% in PCE in comparison with pristine one. The synergistic effects of fast electron transport rate, reduced charge recombination, and high efficiencies of electron injection made it possible to increase $J_{sc}$ and further result in an improved overall PCE. This study provides a new way to improve the charge injection and transport for highly efficient PSCs of practical significance.

Q-05
Electromagnetic properties of Si-C-N ceramics fabricated by PDC route
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Si$_3$N$_4$ and SiC ceramics possess not only excellent mechanical properties but also attractive electromagnetic wave (EM) response characteristics, which make them promising materials in various applications relating to EM radiations. Owing to the tunable EM properties, the Si-C-N ceramics based on Si$_3$N$_4$ and SiC are attracting extensive interest in recent years. Si-C-N based materials and structure with EM properties ranging from transparent to shielding offer a high potential for light-weight, wide bandwidth, and multifunctional EM devices. Various processes have been developed to fabricate the above structural/functional ceramics. Compared with other methods, polymer derived ceramics (PDC) route not only have the potential to in-situ form the new type ceramics, but also make it possible to realize the ceramics-based hybrid structure at lower temperature. The key developments and future challenges in this field are summarized. The main issues regarding permittivity of high-temperature Si-C-N ceramics are discussed, with an emphasis on the EM transmission, shielding and absorption mechanisms that are responsible for EM properties.

Q-06
Acoustic Metamaterial with Tunable Band Structure
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Phononic crystals and acoustic metamaterials have attracted considerable attention in the past decades. These materials are of special interest because they may give rise to acoustic band gaps, in which the waves can be strongly dispersed or effectively reflected. It can be used to design acoustic filters, noise insulators, and
vibrationless environment to house sensitive instruments.

In this paper, a layered periodic metamaterial is presented and then piezoelectric layer shunted by an inductor L is adopted. Transfer matrix method is used to calculate the band structure of the layered periodic composites, and the physical insights on the change of band structure using LC circuit changing are investigated.

Consider one unit cell of an infinite layered periodic structure, consisting of N different homogeneous layers. E(j), \( \rho(j) \) and d(j) are the elastic modulus, density and thickness of the j-th layer, respectively. The displacement, u, and stress, \( \sigma \), at the right boundary of the N-th layer in the unit cell, xNR, can be related to those left boundary of the first layer x1L, by

\[
x_{NR} = Tx_{1L}
\]

where T=TN TN-1…T1 is the transfer matrix of the unit cell and Tj is the transfer matrix of the j-th layer given as

\[
T11 = \cos (k(j)d(j))
T12 = -Z(j)\sin (k(j)d(j))
T21 = (1/Z(j))\sin (k(j)d(j))
T22 = \cos (k(j)d(j))
\]

where \( Z(j) = k(j)E(j) \), \( \omega \) is the angular frequency and \( k(j) \) is the wave number in the j-th layer.

Further, piezoelectric layer shunted by an inductor L is adopted, which makes the band structure tunable by changing the external connected inductance. \( c_{33}, e_{33}, \varepsilon_{33} \) and \( \rho \) are the elastic constant, the piezoelectric stress constant, the permittivity and the mass density of the piezoelectric material, respectively. The transfer matrix of the piezoelectric layer, \( Tp \), is given as

\[
T_{p11} = \cos (kpdp) - m \sin(kpdp) \left[ \cos (kpdp) - 1 \right]/\left[ Zpdp (\omega^2/\omega_0^2) + m \sin(kpdp) \right]
T_{p12} = \sin (kpdp) - m \sin^2(kpdp) \left[ \cos (kpdp) - 1 \right]/Zp
T_{p21} = \sin (kpdp) - m \sin^2(kpdp) \left[ \cos (kpdp) - 1 \right]/Zp
T_{p22} = \cos (kpdp) - m \sin(kpdp) \left[ \cos (kpdp) - 1 \right]/\left[ Zpdp (\omega^2/\omega_0^2) + m \sin(kpdp) \right]
\]

where

\[
Z = kp (c_{33} + m)
m = e_{33}^2/\varepsilon_{33}
\omega_0^2 = 1/(Lc_{33}S/d)
\]

\( \omega \) is the angular frequency, kp is the wave number in the piezoelectric layer, S is the cross section of the layer.

The sample designed for this study is a 3-phase structure consisting of periodic layers of steel, polyurea, and PZT. Band structure for this sample from 0 to 80 kHz is calculated. As we found, there is two wide stop bands and a narrow stop band. Changing the inductor L to change the resonant frequency \( \omega_0 \), the location of the stop band is changed.

In conclusion, a layered periodic structure consisting of periodic layers of steel, polyurea, and PZT is presented. The PZT layer in this structure is shunted by an inductor L. Transfer matrix method is used to calculate the band structure. For the sample designed in this study there is two wide stop bands and a narrow stop band. And the narrow stop band is in the charge of the inductor L. This result will be used to design acoustic filters or noise insulators by changing the parameters of structure.

Q-07

Reconfigurable EIT-like effect in metamaterial integrated with varactor diode
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Electromagnetically induced transparency (EIT) was originally observed in atom systems. In 2008, Zhang et al. firstly observed EIT-like effect in metamaterials. The EIT-like characteristics in metamaterials and nanostructures have attracted great interest in recent years. However, in most cases, the EIT-like characteristics in metamaterials and nanostructures cannot be dynamically tuned, limiting the practical applications of EIT-like effect. In this work, we introduce varactor diode into wire/ring structure, and investigate the tunable EIT-like effect. Our work may lay foundation for intelligent devices based on EIT effect.

The EIT structure is fabricated with the standard PCB technology. To tailor the EIT-like effect, a varactor diode is soldered at the bottom gap of SRR. By applying reverse bias voltage on varactor diode via bias wires to alter the capacitance, the magnetic resonance frequency and accordingly the EIT-like window can be manipulated. We investigate the tunable EIT-like effect of wire/ring structure inside a standard rectangular waveguide of BJ32 by both experiment and simulation.

The transmission spectrum of single wire exhibits a remarkable electric resonance at 3.2 GHz with a transmittance below -40 dB. To examine the magnetic resonance of single SRR, it is rotated by 90° to ensure that the magnetic field is perpendicular to it and therefore the magnetic resonance can be excited by incident wave. The dip at 3.11 GHz in the transmission spectrum of single SRR rotated by 90° suggests a magnetic resonance. By combining the wire with the SRR, a prominent EIT-like window with a bandwidth of 0.14 GHz emerges at 3.07 GHz and the transmittance is up to -0.92 dB.

When the bias voltage varies from 0 V to 8 V, and accordingly the capacitance of varactor diode ranges from 2.63 pF to 0.76 pF, the measured transmission spectra of single SRR rotated by 90° demonstrate that the magnetic resonance frequency shifts from 3.08 GHz to 3.33 GHz, exhibiting a blueshift of 0.25 GHz; the measured transmission spectra of wire/ring structure show that the frequency of EIT-like effect varies from 3.04 GHz to 3.26 GHz, exhibiting a blueshift of 0.22 GHz. The experimental results agree well with the simulated results, verifying the effective manipulation of magnetic resonance and EIT-like effect by varactor diode.

Owing to the sharp transmission spectrum arising from EIT-like effect, the transmission of wire/ring structure is subject to considerable variation around the frequency of EIT-like effect as the bias voltage varies. At the frequency of 3.09 GHz, for example, the transmission of wire/ring structure varies from the maximum -2.4 dB to -34.4 dB via the maximum -1.2 dB as the bias voltage varies from 0 V to 8 V, demonstrating a transmission modulation with a modulation depth of 97%. From this point of view, the wire/ring structure can act better as a switch for microwave controlled by bias voltage.

In summary, we propose a wire/ring structure integrated with varactor diode and investigate the tunable EIT-like effect. The frequency of EIT-like effect have a blue shift of 0.22 GHz as the bias voltage varies from 0 V to 8 V, validating the effective tunability of EIT-like effect by bias voltage. The wire/ring structure may act as a microwave modulator.

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Q-08
Tailoring the structural, electrical and low-field magnetoresistance properties of Cu-doped La0.67Sr0.33MnO3 composite coatings
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In this article, we report our investigations on the doping effect of metallic Cu on the performance of manganite coatings. Composites of La$_{0.67}$Sr$_{0.33}$MnO$_3$/xCu (x=0, 0.02, 0.05, 0.08, 0.10, 0.15) were synthesized by the sol-gel based screen printing method. Part of Cu dopant can substitute into the La$_{0.67}$Sr$_{0.33}$MnO$_3$ lattice without changing the rhombohedral structure, resulting in the slight lattice shrinkage and the decrease of lattice parameters. XRD and SEM measurements reveal that another part of Cu is oxidized and generate CuO with monoclinic structure mainly distributed at the surfaces and grain boundaries of La$_{0.67}$Sr$_{0.33}$MnO$_3$. All the samples exhibit a dense microstructure with an average particle size of 1–10 μm. The particle sizes of samples are refined with addition of a small amount of Cu and then improved due to the augment of grain connectivity with a higher concentration of Cu. As the Cu content increases, the resistivity of the samples increases while the metal–semiconductor transition temperature reduces in sequence, which is explained as the increment of energy barriers and electron scattering centers. The magnetoresistance values of the samples at low temperature (5 K) and at room temperature are firstly enhanced then decreased with increasing Cu content, and the respective maximum value of 25.55% and 5.96% is obtained at the critical threshold x=0.08. The enhanced low-field magnetoresistance effect related to the spin-dependent scattering and the inter-grain spin-polarized tunneling process is attributed to the increase of magnetic inhomogeneity and local spin disorder at grain boundaries by the introduction of Cu. The results demonstrate that the Cu doped manganites are promising candidates for magnetic sensors and devices.

Q-09
Establishment and application of low-temperature TEM platform composed of electromagnetic multi-field coupling
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Atomic structure design is a key issue for the application of smart materials. In this talk, we summarized the recent development of our group about the in situ TEM study of several important magnetic smart materials. Within recent years, a novel set of multi-functional in situ TEM instrument was established in our laboratory: applying electric/magnetic field, heating, cooling, flowing liquid reactant and so on. Therefore, many important scientific issues can be directly studied depending on this special system.

The influences of the Li$^+$/Ni$^{2+}$ replacement modulated by minor Co dopant on cyclic capacity and rate performance of lithium-rich cathode material Li$_{1.2}$Ni$_{0.2-z/2}$Mn$_{0.6-z/2}$Co$_z$O$_2$ (z=0, 0.02, 0.04, 0.10) were investigated. Co played a vital role in decreasing the Li$^+$/Ni$^{2+}$ replacement ratio in the hexagonal layered Li$_{1.2}$Ni$_{0.2-z/2}$Mn$_{0.6-z/2}$Co$_z$O$_2$ (R3m). An evident cationic ordering in the transition metal layers and stacking sequence vertical to the Li$^+$ diffusion orientation were observed from Li$_{1.2}$Ni$_{0.2-z/2}$Mn$_{0.6-z/2}$Co$_z$O$_2$ (z>0) system rather than Li$_{1.2}$Ni$_{0.2}$Mn$_{0.6}$O$_2$ system. Three superstructure vectors modulated by $1/4\vec{q}$, $2/4\vec{q}$, $3/4\vec{q}$ ($\vec{q}=\{011\}$) were simultaneously observed from Li$_{1.2}$Ni$_{0.18}$Mn$_{0.58}$Co$_{0.04}$O$_2$, indicating a high-degree ordering.

Reference
Photonic crystals include two kinds of materials with different dielectric constant that were orderly arranged in space. Photonic crystals existence in many forms in nature such as butterfly wings, skin of beetle shell, opal gemstone etc. Synthetic microspheres and colloidal crystals were used to simulate the structure of butterfly wings to prepare many kinds of photonic crystals, including the opal structure of silica and polystyrene.

We have developed method to self-assemble 2D and 3D colloidal crystals. 2D colloidal crystals are monolayer arrays of colloidal microspheres or nanospheres. They are usually assembled on planar substrates or at air/water interface with ordered arrangement. For the preparation of 3D colloidal crystals, the vertical deposition by evaporation technique has been used; the method relies on the balance between sphere sedimentation and evaporation of the colloidal suspension. Evaporation of solvent from the meniscus region draws colloidal spheres into the area of film formation and inter-particle capillary forces assemble the spheres into close packed arrays (Fig. 1). By using spray method, large area PCs could be self-assembled. Colloidal crystals are employed as the templates to structurally direct the formation of inverse opal structures.

Based on this template, electrochromic materials of highly ordered and three-dimensional porous structure (3DOM) was prepared such as WO3, PEDOT, V2O5 etc, as showed in Figure 2, and the influence of the introduction of the microstructure on the photo-thermal properties was studied in detail. The results showed that due to the presence of ordered porous structure, the material specific surface area was enhanced, the ion diffusion distance was reduced, the ion diffusion coefficient was improved, so the electrochromic materials photochromic properties were significantly improved, such as enhancing the color contrast, shorten the response time and increased coloration efficiency; In addition, due to the adjustable pore size, the continuous control performance of light and heat can be realized.

We used V2O5 of 3DOM to obtain the controllable morphology and structure of one-dimensional electrochromic materials, 3D nanorods can be obtained by pore size of 250nm amorphous three-dimensional ordered macroporous structure of vanadium oxide in heat treatment of 350℃. After heat treatment at 450℃, the structure of 3D nanowires can be obtained (Fig. 3). In electrodeposition process, polystyrene microspheres induced heterogeneous nucleation and anisotropy of the orthogonal V2O5 crystal structure were the two important factors causing 3DOM structure change to 3D nanorods packing structure on heat treatment conditions. Due to the higher specific surface area, shorter ion diffusion distance and better electrolyte wetting, these two kinds of one-dimensional structures all showed electrochromic properties of multiple color changes.
Reference
Z.Q. Tong; H.M. Lv; J.P. Zhao; Y. Li, Near infrared and multicolor electrochromic device based on polyaniline derivative, Chinese Journal of Polymer Science, 2014, 32, 1040-1051.

Key words: photonic crystal 3DOM electrochromic

Q-11
Silicon integrated magneto-optical oxide thin films and nonreciprocal photonic devices
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Nonreciprocal photonic devices including optical isolators and circulators are indispensable components of photonic systems. Recently, there is an increasing demand of integration of such devices in silicon photonic systems, which will enable a couple of important functionalities including optical isolation, circulation and all optical information processing.[1-3] Magneto-optical nonreciprocal photonic materials, being linear, passive and broadband, have attracted great research interest for such applications. Monolithic integration of high quality magneto-optical materials on silicon needs to overcome the challenges of lattice mismatch, thermal mismatch and fabrication thermal budget between magnetic oxides and the semiconductor substrates; whereas nonreciprocal photonic devices on silicon needs to be designed to meet the isolation ratio, insertion loss, operation bandwidth, temperature stability, device footprint and fabrication tolerance requirements of state-of-the-art silicon photonic technologies. So far, these challenges are still under active research. Magneto-optical thin films on silicon with strong magneto-optical effects, high figure of merit, and compact, broadband nonreciprocal photonic devices based on these thin film materials are still lack.

In this presentation, we introduce our recent progress on monolithic integration of magneto-optical thin films and nonreciprocal photonic devices on silicon. Using first principle calculations, we demonstrate the strong influence of the oxygen stoichiometry to the magneto-optical properties of Ce doped Y3Fe5O12 films (Ce:YIG).[4] By using a two step pulsed laser deposition and low oxygen partial pressure fabrication method, we increased the Ce solubility in the Ce:YIG lattice up to 50 at.% at the yttrium site on silicon, therefore demonstrating a record high Faraday rotation of this material up to -6000 deg/cm at 1550 nm wavelength, which exceeds the value (-4500 deg/cm) of epitaxial Ce1Y2Fe5O12 thin films on Gd3Ga5O12 (100) substrates.[5] We also demonstrate the design of a compact, broadband optical isolator based on nonreciprocal multimode interferometers (MMI) using these materials. We designed a silicon/CeYIG/silicon sandwich waveguide structure for the MMI device. For proper device dimensions, the fundamental and first order TM mode of this device show opposite signs of nonreciprocal phase shift (NRPS), therefore significantly enhances the device nonreciprocity which exceeds devices using the NRPS of only the fundamental TM mode.[5] A large NRPS difference of 10.1 rad/mm is achieved in this structure, leading to an overall device length of only 310.4 mm (multimode region). The 20 dB isolation bandwidth of this device is 1.6 nm centered at 1550 nm wavelength. The insertion loss is calculated to be 0.841 dB including the coupling and material losses. The fabrication tolerance and influence of a YIG seed layer is also discussed for this device. The strong magneto-optical effect of silicon integrated Ce:YIG films and broadband MMI isolators make monolithically integrated magneto-optical nonreciprocal photonic devices highly promising for silicon photonic integrated circuits.

Q-12
Low frequency dielectric properties of polymer composites near percolation
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2. Shandong University

Percolation phenomenon has great significance in multi-components material science community owing to the fact that when the content of minor component reaches a critical value (percolation threshold), the physical
properties of the composite may undergo significant changes, leading to various fascinating properties and applications. As we know, there exist significant different dielectric properties between conductors and insulators. Therefore, it is interesting to explore the properties of conductor-insulator composites near percolation. In this paper, the low frequency (1 kHz – 1 MHz) dielectric properties of conductor/polymer composites are investigated in detail. Conductor/polymer composites with tailored dielectric properties were prepared. Plasma-like negative permittivity behavior is observed when the volume fraction of conductive fillers becomes above but still near percolation. And the influences of the composites’ compositions and microstructures on their dielectric performances were further investigated. The composites with tailored negative-k or positive-k can be used as metamaterials, microwave attenuation, absorbing materials and dielectric capacitors, etc.

**Q-13**

*The physical properties of the meta-crystal with noble metal nanoparticles*

Peng Yang
Yunnan University

**Q-14**

*Ti3C2 MXenes with modified surface for high-performance electromagnetic absorption and shielding*

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Electromagnetic absorbing and shielding composites with tunable absorbing behaviors based on Ti3C2 MXenes are fabricated via HF etching and annealing treatment. Localized sandwich structure without sacrificing the original layered morphology is realized, which is responsible for the enhancement of electromagnetic absorbing capability in the X-band. The composite with 50 wt% annealed MXenes exhibits a minimum reflection loss of -48.4 dB at 11.6 GHz, owing to the formation of TiO2 nanocrystals and amorphous carbon. Moreover, superior shielding effectiveness with high absorption effectiveness is achieved. The total and absorbing shielding effectiveness of Ti3C2 MXenes in wax matrix with a thickness of only 1 mm reach 76.1 and 67.3 dB, while those of annealed Ti3C2 MXenes/wax composites are 32 and 24.2 dB, respectively. Considering the promising performance of Ti3C2 MXenes with the modified surface, this work is expected to open the door for the expanded applications of MXenes family in electromagnetic absorbing and shielding fields.

**Q-15**

*Multiresonance behavior and interface transformation for enhanced microwave-absorption properties of core double-shell nanocomposites*

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Microwave absorption materials to reduce electromagnetic (EM) pollution, EM interference and information leakage are enriched of abundant fundamental physics and potential applications. EM parameters characterized by the complex permeability ($\varepsilon_r=\varepsilon-i\varepsilon''$) and the complex permittivity ($\mu_r=\mu-i\mu''$) and microstructure are important for designing microwave absorption materials [1,2]. Microwave absorption properties of core double-shell nanocomposites may obtain a great breakthrough by taking advantage of their interface polarization effect to improve the EM impedance matching and to gain an excellent synergistic effect of the dielectric- and the magnetic-losses in these magnetic/dielectric heterogeneous composites. In-situ interface transformation to affect
the EM parameters and thus microwave absorption properties is seldom outguessed. Here, EM response and microwave absorption properties of core double-shell \((x)\text{FeCo/C/CoFe2O4}\) and \((x)\text{FeCo/C/(FeCo,CoFe2O4)}\) composite with an interface transformation were investigated in the range of 2-18 GHz by Agilent 8722ES vector network analyzer. Outer shells of CoFe2O4 or mixed FeCo and CoFe2O4 were obtained by changing the heat-treatment temperature of the precursor consisting of FeCo/C, CoFe2O4 xerogel and co-surfactant polyvinyl pyrrolidone (PVP). Multiple-resonance phenomena are observed in the complex permeability/permittivity-frequency curves. New dielectric relaxation peaks at 10.5 and 14.4 GHz and loss peaks at 4 and 16.4 GHz are found which are ascribed to the interface effect in the \((x)\text{FeCo/C/CoFe2O4}\) nanocomposites, where \(x\) is the weight fraction of FeCo/C nanocapsules in the \((x)\text{FeCo/C/CoFe2O4}\) nanocomposites. Good EM matching between the \(\varepsilon_r\) and the \(\mu_r\) can be obtained by increasing the interface polarization and varying the weight fraction of the components in the core double-shell \((x)\text{FeCo/C/CoFe2O4}\) and \((x)\text{FeCo/C/(FeCo,CoFe2O4)}\) nanocomposites. An optimal absorption bandwidth with RL values exceeding -10 dB covering the 10.8–18 GHz frequency range was observed in the (80 %)FeCo/C/CoFe2O4-paraffin composite with a minimum RL value of -25.8 dB at 16.7 GHz. Obvious enhancement of microwave absorption is obtained in (60 %)FeCo/C/(FeCo,CoFe2O4) composite with a minimum RL value of -38.1 dB at 13.4 GHz. The synergetic effect of magnetic/dielectric losses and interface-polarization loss in the core double-shell composites improves the microwave-absorption properties.


Q-16
Transmission loss of thin membrane-type acoustic metamaterial with negative effective mass
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Membrane-type acoustic metamaterial is constructed on the basis of locally resonant acoustic metamaterials (LRAM), which decreases sound transmission by 500% over mass law predictions in the frequency range of 100Hz to 1000Hz. The transmission loss (TL) and vibration features of thin membrane-type acoustic metamaterial consisting of mass and viscoelastic membrane are studied in this paper.

In order to verify negative mass density, a equivalent mass-spring model is established for a single element of thin membrane-type acoustic metamaterial, in which the membrane has characters of the damping force and the spring force. At first, we put forward a simple mass-spring system without the damping force, the theoretical analysis presents that effective mass appears negative on some loaded vibration frequencies. In general, the membrane of membrane-type acoustic metamaterial is chosen as rubber or other viscoelastic materials, so we introduce the damping force in mass-spring system and express the damping force with complex number on the basis of complex damping theory. We demonstrate that effective mass density of this membrane-type acoustic metamaterial is negative in the band gap range, and the magnitude of effective mass is closely related to the damping ratio. The energy of total vibration system is slowly dissipative because the expression of effective mass includes an imaginary part.

Based on the theory of plane wave propagation, the sound insulation properties of the membrane-type acoustic metamaterial are studied by FEA(COMSOL Multiphysics is adopted). In this paper, the thin membrane-type acoustic metamaterial is consisted of square membrane, rigid mass and supporting frame. The central mass is chosen as lead with high mass density, and the weight of the central mass is 3.5g. The square membrane is chosen as high density polyethylene(HDPE) with the side length of 50mm and the thickness of 0.16mm. The mass
density, Young’s modulus, the Poisson’s ratio and prestress for the HDPE membrane are 1200kg/m3, 3.6×108Pa, 0.32 and 1MPa, respectively. The mass density, Young’s modulus, the Poisson’s ratio for the supporting frame are 2700kg/m3, 7.1×1010Pa, and 0.346, respectively, with the edge width of 2mm and the height of 4mm. The results show that this thin membrane-type acoustic metamaterial follows the principle of dipole resonance, and has high reflection and low transmission in the band gap range, which make it achieve the aim of reducing noise. Numerical simulation shows that this membrane-type acoustic metamaterial element has strong sound insulation at frequencies (20Hz-100Hz) and broadens the range of low frequency sound insulation greatly. For this membrane-type acoustic metamaterial, TL exceeds 20dB in a frequency range from 42Hz to 64Hz. TL arrives the maximum value of 41.19dB when the sound frequency is 52Hz, but it is only 1.86dB by mass law prediction, the difference is an order of magnitude. When the frequency of sound is 16Hz, TL is small, closely to 0dB, TL magnitude of membrane-type acoustic metamaterial is dependent on structural vibration features. The vibration direction of central mass and the membrane is the same when TL tends to the first valley; while the vibration direction of central mass and the membrane is opposite when TL arrives the peak. The central mass remains static while the membrane vibrates at the second valley of the TL.

The sound has bigger influence on vibration of thin membrane-type structure because the stiffness of the membrane is small and interaction area is relatively wide, so we have a natural mode analysis of this membrane-type structure. The modal analysis indicates the top four natural frequencies of this membrane-type acoustic metamaterial element are 15.56Hz, 47.88Hz, 48.89Hz, and 295.41Hz, respectively. The membrane and central mass vibrate simultaneously in the first mode and the vibration direction is the same. At the fourth mode, the membrane vibrates while central mass remain static. The natural frequencies at the second mode and the third mode are almost identical, and the vibration modes that central mass makes the membrane vibrate in one direction are similar.

By coupled acoustic-structural analysis, the distribution of sound intensity and vibration features of this membrane-type acoustic metamaterial element at the optimum transmission frequency and the best reflection frequency are obtained. The best sound insulation frequency is matched with the second-order natural frequency and the third-order natural frequency of this thin membrane-type acoustic metamaterial element, though the vibration feature is different from the second mode and the third mode. At the best sound insulation frequency, the sound energy is concentrated at the joint of central mass and the membrane, and the sound intensity diffuses from central mass to membrane edges but other space of the air cavity has no distribution of sound intensity. TL of this thin membrane-type acoustic metamaterial element appears two valleys, and the frequencies at valleys are matched with the first-order natural frequency and the fourth-order natural frequency, and vibration features at valleys are similar with the first mode and the fourth mode. At valleys of TL, the sound intensity is evenly distributed across total air cavity, and the transmission loss is the smallest, and the sound energy is distributed across total membrane.

Q-17
Multifunctional Polymer Nanocomposites
John Zhanhu Guo
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With the required miniaturization, the materials combining different functionalities have become interesting. In this topic, a variety of advanced polymer nanocomposites will be introduced. Methodologies to prepare nanocomposites and their effects on the produced nanocomposites will be introduced. Unique properties including mechanical, electrical, magnetoresistance etc. and the applications for environmental remediation, energy
Q-18
Fabricating micro-nanometer porous polymer/inorganic hybrid materials
Qiuyu Zhang
Northwestern polytechnical university

Q-19
Carbon aerogels-based ultra-black materials
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Owing to its diverse chemical compositions and unique properties (mainly due to its hierarchical, fractal and ultralight structure) which could fill the gap between condensed- and gas-state matter aerogels are now regarded as a new state of matter.[1] Much work discussed the influence of density on the physical properties, but rare work talks clearly about the microstructure/properties relationship. Recently, we found that subwavelength microstructure obviously affect the diffuse reflectivity of the carbon aerogels. These were prepared with different nanostructure by carbonizing the resorcinol-formaldehyde (RF) aerogels and showed ultralow reflectivity in the UV-Vis-NIR spectra. Modifying concentration (W%) and catalyst ratios (R/C) of the RF colloid, leads to a roughly positive correlation between reflectivity and density (42~328 mg/cm^3). Moreover, R/C parameter which determined the microstructure of the aerogels affected significantly the reflectivity. By tuning their nanostructure, we got the minimum at about 0.19 % which approached the measuring limit of our equipment. The value is just 1/10 of inverse V-type structured film and 1/40 of that of glassy carbon conventionally used as a black standard. Carbon aerogels were activated using CO2 at 1000oC to induce the micropore (< 2 nm). The reflectivity of carbon aerogels decreased sharply after activating for 2 h, indicating that the structure much smaller than the wavelength (< 2 nm) could affect the light propagation greatly. We attribute this behavior to the indirect interactions including electromagnetic-electron interaction and electron-microstructure interaction. The subwavelength structure of the conductor strongly decreases the mean free path of the electrons inside, leading to an extra absorption besides considering the Joule's heating. Thus we induced nanostructured metal to increase the hot electron loss, in order to further reduce the diffuse reflectivity. In addition, since the reflectivity of the improved samples was lower than the detection limit of the spectroscopy, we have built a system with the power-adjustable lasers, integrating sphere and other elements to precisely characterize the diffuse reflectivity and other properties including polarization behavior and nonlinear phenomena.

Q-20
Effect of orientation on the complex permeability and microwave absorption properties for planar-anisotropy Ce2Fe17N3-δ/Silicone composite
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Dielectric-magnetic hybrids: Interface engineering, electronic structure and microwave absorption
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Extraordinary electron systems may be generated at well-designed interfaces of hybrids where the novel charge layers are induced and the carrier density are varied. The derived synergetic properties can endow the hybrids with enhanced properties and novel functions not available in the single-phase nanostructures. By controlling the nuclei site-selective anchoring location and subsequent growth behavior of nanoparticles, we have synthesized dielectric-magnetic core-multishell hybrids of MWCNT/Fe3O4, Fe3O4@ZnO, MWCNT/Fe3O4-ZnO, MWCNT/Fe3O4@ZnO, SiC/Co and SiC/Co@SiO2. Their electronic structures were studied by analyzing their C K-edge, O K-edge, Fe L-edge, Zn L-edge Si K-edge and Co L-edge X-ray absorption near-edge structures. It is found that charges are redistributed in the hybrids through covalent bondings. Multiple electronic phases at the interfaces are generated. These redistributions result in the complementarity between the dielectric loss and magnetic loss. Under an altering electromagnetic field, the spawned interfacial polarization and synergetic interaction between magnetic and dielectric components extensively attenuate microwaves, protecting biological systems from the destroying of electromagnetic waves on the immune system and DNA strands. The excellent microwave absorption ability of the prepared hybrids makes them attractive candidate as materials for microwave absorption applications. The continued development of other high-performance microwave absorbers could be further expanded based on current report.

Soft magnetic medium based metacomposite and the applications
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An important application of soft magnetic composite is microwave absorption for stealth and EMI. This application mainly pursues high permeability and impedance match in operating frequency or broadband frequency. However, almost all kinds of the soft magnetic materials can not meet the microwave absorption requirement for that the ferromagnetic resonance frequency is a little low leading to the small value permeability in GHz. Most of the narrow band absorption phenomena is due to the interference. Here, we present a novelty soft magnetic material and the soft magnetic medium based metacomposite. The soft magnetic material shows two dimensional morphology and is built by the non conductive ferrite. The metacomposite is constructed by pasting the metasurface on the soft magnetic medium which can regulate the permeability and permittivity and thus can absorbing the microwave in selective or broadband frequency. Besides, the non conductive ferrite coated soft magnetic composite can also be used in electricity and electronics. The saturation induction of this kind magnetic core prepared by this soft magnetic composite can reach to 2.2T. The performance of the soft magnetic composite highly depends on the distribution and composite of the crystalline grain and boundary.
Q-23
Spin dependent tunneling behavior in perpendicular magnetic multilayered structures
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Spintronics including the exploration of novel materials, the research of physical properties, and the design and development of related devices is one of hottest topics in the condensed matter physics and the materials science/engineering since the discovery of giant magnetoresistance (GMR) effect in 1988. There are experiencing a lot of challenges although great progress has been achieved in industrial applications. My talk will give a brief introduction about the recent progress together with challenges, including the ultrahigh storage density, ultrahigh thermal stability and the breakthrough of two-state bottleneck. The focus will be put on the Fe/MgO/Fe magnetic tunnel junctions (MTJs) with in-plane magnetic anisotropy, L10-FePt/MgO/FePt MTJs with perpendicular magnetic anisotropy (PMA), and the Hall balance with PMA.

Q-24
Periodically structure-modulated semiconductors for enhanced optical absorption
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High index semiconducting nanostructures have received considerable attention not only for their interesting optical properties to manipulate light-matter interactions at a subwavelength scale based on various optical resonances, but also for their potential applications in next-generation optoelectronic devices. In particular, individual semiconductor nanowires could enable efficient light trapping, thereby giving rise to enhanced optical absorption at specific resonance wavelengths depending on their size, and they could be readily integrated into semiconductors for the production of high performance devices, such as photodetectors and solar cells. In this work, we will discuss a novel approach to enhancing optical absorption by modulating the diameters of semiconducting nanowires, in which the diameter changes periodically in a sinusoidal manner along the long axis of the wire. Using conventional semiconductor processes, diameter-modulated silicon nanowire arrays were successfully fabricated to allow their unique optical properties to be examined experimentally. Furthermore, the ability to transfer intact nanowire arrays into transparent polymer films allowed us to quantitatively study the optical resonance and absorption behavior of the diameter-modulated nanowires while excluding the effect of the light-absorbing substrate. In a comparative study of the optical absorption in diameter-modulated and simple cylindrical nanowire arrays together with numerical simulations, we found that such diameter modulation introduces stronger and more closely spaced optical resonances, leading to the tight confinement of light and enhanced optical absorption over a broad spectral range. Our results highlight the unique capability of semiconductor nanowires with periodically modulated diameters to offer enhanced broadband optical absorption beyond that of simple nanowire geometries.

Q-25
Fundamental study on oxide interfaces in nano-structured ferritic alloys and some inspiration for designing new cermet composites
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Nano-structured ferritic alloys (NFAs) constitute a very promising class of developing structural materials,
especially for advanced fission and fusion energy applications. The remarkable high temperature strength and unique irradiation tolerance of NFAs are largely enabled by an ultrahigh density of thermally stable nanoscale oxides, primarily pyrochlore \( Y_2Ti_2O_7 \), that precipitate during hot consolidation from a solid solution created by mechanical alloying. The interface structure of the nano oxides with the ferrite matrix and associated energies play critical and ubiquitous roles in the functionality of the nano oxides and NFA. Transmission electron microscopy (TEM) measurements of embedded nano-oxides are still very challenging, thus a close interplay between first principles calculation and experimental characterization is needed to develop better understanding. Based on which, the following aspects of nano-oxides and their associated interfaces are clarified: (i) the structure and bulk properties of \( Y_2Ti_2O_7 \); (2) its free surface structure and energetics, including the effects of termination chemistry; (3) the enormously higher solubility of helium in the oxide compared to the surrounding ferrite matrix; (4) quantification of the role of the nano oxide interface on the NFA helium management. It is hypothesized that the ultra high number density of nano-sized oxides can effectively trap and sequester helium in ultra-fine bubbles in a low fluid-gas energy state, up to very high concentration levels. The formed ultra high number density of nm-sized helium bubbles also acts as a sink, or recombination (self healing) site, for displacement damage defects. This imbues NFA with their observed remarkable irradiation tolerance. Enlightened by this study, some new cermet composites are designed, including a cermet composite coating with gradient composition and microstructure.

Q-26

Design of miniaturized dielectric antennas using BaTiO3-based ceramics
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Due to the continuous trend for integration and miniaturization, modern electronics are highly sensitive and vulnerable to the electromagnetic wave interference. Especially, the threat from high power microwave weapons has promoted the pursuit of new resistance to electromagnetic radiation technologies. Among which, dielectric antenna is considered the best candidate because it captures the free-space signals by resonance of the low-loss dielectric materials. Thus the whole structure is insulated and the antenna parameters can be tuned by the material properties. In this report, we prepared a series of high-performance BaTiO3-based ceramics for the antenna design. The as-prepared ceramics are characterized by XRD (X-ray diffraction), SEM (scanning electron microscope), EDS (energy dispersive spectrometer) and confirmed to be dense, uniform with a typical perovskite structure. Moreover, by optimized doping, dielectric loss of the ceramics can be dramatically decreased and the dielectric constant can be tuned from 80 to 150. Based on this, we designed several frequency tunable slot-coupled dielectric resonators antennas (DRAs) by using BaTiO3-based ceramics. The electromagnetic properties of the proposed DRAs strongly depend on the dielectric property of the BaTiO3-based ceramic. The frequencies of the DRAs can be dynamically controlled by tuning the dielectric constant, size and relative location of the dielectric ceramics. The reflection coefficient, antenna gains and radiation patterns are simulated by CST Microwave Studio. To verify the simulations, measurements are carried out and reasonable agreement between simulated and measured results is obtained.

Q-27

Carbon Nanotubes-Adsorbed Electrospun PA66 Nanofiber Bundles with Improved Conductivity and
Robust Flexibility
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Electrospinning with its simplicity and versatility has produced fibers with diameter ranging from micrometers
down to a few nanometers. Nowadays, electrospun fibers are generally collected in the form of nonwoven mats,
and fibers in nonwoven mats are randomly arranged and non-uniform. Such a chaotic structure and relatively low
mechanical strength have prohibited their applications. In order to solve the aforementioned problems, nanofiber
bundles or yarns with macroscopic length have been elaborately fabricated recently. The macroscopical nanofiber
bundles are desired for a wide range of applications, including tissue scaffolds, reinforced composites, and
ultrasensitive sensors. On the premise of enhanced mechanical properties, the applications of electrospun polymer
nanofiber bundles can be significantly expanded once they are endowed with electrical property. Carbon nanotube
(CNTs) are known to exhibit superior structural, mechanical, chemical, electrical, and thermal performance. CNTs
are always directly added into electrospun solution to prepare ultrafine fiber composites with improved electrical
conductivity. However, the easy aggregation of CNTs in the nanofibers will deteriorate the nanofiber
performance. Therefore, to prepare the electrospun ultrafine fibers with simultaneous improvements in mechanical
property and electrical conductivity is still a challenge.

In this study, electrospun polyamide (PA) 66 nanofiber bundles with high conductivity, improved strength, and
robust flexibility were successfully manufactured through simply adsorbing multiwall carbon nanotubes
(MWNTs) on the surface of electrospun PA66 nanofibers. The highest electrical conductivity (0.2 S/cm) and
tensile strength (103.3 MPa) were achieved for the bundles immersed in the suspension with 0.05 wt% MWNTs,
indicating the formation of conductive network from adsorbed MWNTs on the surface of PA66 nanofibers. The
decrease of porosity for the bundles immersed in the MWNT dispersion and the formation of hydrogen bond
between PA66 nanofibers and MWNTs suggest a superb interfacial interaction, which is responsible for the
excellent mechanical properties of the nanocomposite bundles. Furthermore, the resistance fluctuation under
bending is less than 3.6%, indicating a high flexibility of the nanocomposite bundles. The resistance of the
nanocomposite bundle had a better linear dependence on the temperature applied between 30 and 150 °C. More
importantly, such highest working temperature of 150 °C far exceeded that of other polymer-based temperature
sensors previously reported. This suggests that such prepared MWNTs-adsorbed electrospun PA66 nanofiber
bundles have great potentials in high temperature detectors, conductive textiles, wearable electronics, etc. Our
work opens a new door toward fabricating flexible electronic devices with excellent mechanical property by using
electrospun nanofibers.

Q-28
Mechanical properties of oil well cement stone reinforced with fiber and whisker
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Oil-well cementing is one of the important part for contacting the drilling and exploitation in oil and gas project.
With the difficulty increase in oil-gas filed development, it becomes harder to make a better interlayer isolation, in
which keeping a good work on mechanical properties for cement sheath is the most significant factor. Due to the
brittleness of cement paste, it would fail to protect the interlayer isolation owing it broken down when something stress on it, such as drilling and fracturing operation.

For solving the problem and improving the properties of cement sheath, the current paper did a investigation about the brittleness cause of cement paste. According to the results, a research was been proceeded, which was about the influence on the mechanical properties of cement composites by adding silicic and zincate whiskers. The results showed that both of the whiskers could do good effect on the mechanical properties of cement composites. The silicic whiskers could improve the mechanical properties of oil-well cement composites and decrease the elasticity modulus. The properties of cement paste hydrated for 28 days was greatly improved for the increasing to 125.7%, 35.1% and 17.5% on the tensile strength, flexibility and compressive strength respectively. And the elasticity modulus was decreased to 28.0% compared with the virgin cement. Otherwise, the same effect was happened to the zincate whiskers cement composites, such as the tensile and flexibility increased to 132.1% and 28.8%, with the 24.6% due to elasticity modulus. In addition, this paper used kinds of technology to analyzing the difference on the different composites by X-ray diffraction and IR. And the results indicated that there was nothing new become after adding the either whiskers, with something different in zincate composites observed by SEM. According to the results two improving mechanism were concluded. For the first one is that the silicic whiskers can not do effect on the hydrations of cement composites, but can improve the mechanical properties by cracking-bridge, crack-deflection and pull-out of whiskers. Due to the special three-dimensional structure of zincate whiskers, the unformed hydration structure can be altered into “flowerlike” hydrations. And the special hydrations can improving the mechanical properties by minishing the stress the composites suffered.

Q-29

Novel alloy-type hollow nanostructured anode materials for lithium-ion batteries

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Currently, lithium-ion batteries (LIBs) are playing a critically important role in portable electronic devices and electric vehicles due to their high capacity and long cycle life. Nevertheless, there are still many critical challenges to be overcome for their broad and practical applications including further increasing their capacity and power density, improving their safety, and lowering the cost.

Silicon or aluminium is regarded as one of the most promising anode materials for next generation lithium-ion batteries due to its high theoretical capacity among all the anode materials. However, silicon or aluminium-based anode undergoes significant volume expansion (□ 300% for Si-based and ~96% for Al-based) and contraction during Li⁺ insertion/extraction, resulting in pulverization and the loss of electrical contact and therefore great deterioration in electrochemical properties. Herein, we designed and fabricated new hollow core-shell nanostructures to solve such problems. Si or Al spheres are used as core materials and C or TiO₂ is used as shell, which is fast Li ion and electron conductive and also good mechanical properties. Some void space is introduced into the interface between the shell and core (also called yolk-shell structure) or into inner of the core (also called hollow core-shell structure), which allows Si or Al to expand freely without breaking the outer C or TiO₂ shell during Li⁺ insertion/extraction. Ultra-high capacity, long cycle life, and high Coulombic efficiency have been realized in this hollow nanostructured Si or Al-based anode materials for lithium-ion batteries.

Keywords: lithium-ion batteries, anode materials, hollow structure, silicon, aluminium

Q-30
Smart piezoceramic/polymer composites for sensing and actuating applications
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Piezoelectric ceramics are one of the most attractive smart materials in modern society and play critical roles in many well-known applications, such as medical ultrasonic imaging, structural health monitoring, adaptive structure, precision motion, energy harvesting, etc. Piezoceramic / polymer composites have shown superior properties over their bulk counterparts, particularly in aspects of flexibility, impact resistance, and optimized performance. Fine scaled structures of the active piezoelectric phase in the composites generally determine the main properties of such devices, e.g. the operational frequency of a 1-3 typed piezocomposites. Till now, the most frequently used technique for fabricating fine scaled piezoceramic / polymer composites remains to be dice-and-fill, by which bulk ceramics are diced to element arrays and then infiltrated with polymer. Recently, we have made much progress in fabricating micro-scaled fine ceramic structures via combining the advantages of colloidal process, viscous plastic process, moulding and lamination. In this talk, fine scaled 2-2 and 1-3 PZT (lead zirconate titanate) / polymer composites were presented and evaluated to demonstrate the potential for high frequency ultrasonic transducer applications. Piezoelectric fiber composites (PFCs) with interdigitated electrodes (IDEs) were also presented to illustrate the strong structure / property correlation for improving the actuation capability.

Q-31
Sub-nanometre metal@carbon functional composites
Xuefeng Zhang
Northeastern University

Q-32
High-Index-Contrast Photonic Elements for Practical Energy Applications
Sun Kyung
Ulsan National Institute of Science and Technology

Two-dimensional (2D) dielectric gratings, which are generally characterized by their refractive index contrast and pitch, have been integrated as reflecting or antireflecting elements in photonic applications including semiconductor lasers and solar cells. For light-emitting diodes (LEDs), rationally-designed 2D dielectric gratings diffract optical modes trapped in high refractive index active media, thereby enhancing the outcoupling efficiency. Most commercial GaN-based LED devices have adopted few-micron-pitch patterned sapphire substrates. However, breakthroughs in light extraction are limited because the refractive index contrast between GaN and sapphire is predetermined. Here, we report a new class of strong-diffraction, high-index-contrast cavity engineered substrates that act as monolithic growth templates to overcome the limitations typically encountered with patterned substrates. A standard photolithography process, in conjunction with a simple atomic layer deposition technique, enables fabrication of well-designed high-index-contrast patterns in which hexagonally-arranged air cavities are covered with a thin dielectric shell. These diffracting elements will have the potential to be exploited in organic LEDs, solar cell devices, and the III-nitride semiconductor LEDs.

Q-33
Novel Functional Nanostructures Produced by Laser Ablation in Liquid
Laser ablation in liquid is a newly developed synthetic strategy for preparing nanomaterials. In this talk, we introduce some progress on the laser synthesis of several interesting nanostructures including clean nanoparticles, mesocrystals, nanowires and hierarchical nanowires. We show that the growth of nanostructures is dominated by target material, laser type and liquid medium, and the final morphology can be well controlled by carefully tuning the experimental parameters. The products exhibit unique physical and chemical properties, demonstrating that laser ablation in liquid is powerful on the synthesis of novel functional nanostructures.

Q-34

Tunable magneto-optical properties in Co doped Ce1-xHfxO2 thin films

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Magnetic semiconductors, such as Mn doped CdTe, Mn doped GaAs, Co doped ZnO or TiO2 etc. show distinctively different magneto-optical spectrum due to the sp-d exchange interaction between the host matrix and doped magnetic ions. The major electric dipole transition takes place at the absorption band edge of the host matrix, which leads to a variety of tunable and designable magneto-optical materials depend on the dopant concentration, the band gap of the host matrix, and the applied electric field to the semiconductor. So far, such tunable magneto-optical spectrum has only been observed in room temperature paramagnetic semiconductors, which show relatively low magneto-optical properties under low magnetic fields, and also require strong and accurately control of magnetic field for device fabrication. In this paper, we present a novel magneto-optical material: Co doped Ce1-xHfxO2, which shows room temperature ferromagnetic properties, tunable magneto-optical spectrum depending on the host matrix band structure.

Ce0.95-xHfxCo0.05O2-δ (made from targets with x = 0, 0.15, 0.35, 0.475, 0.60, 0.80, 0.95) films were grown by pulsed laser deposition (PLD) on SiO2 substrates. The depositions were carried out in vacuum (1.3×10-4 Pa base pressure) with a substrate temperature of 700℃. The distance between target and substrate was 5.5 cm.

X-ray diffraction result shows that samples x=0.95 to x=0.15 show peaks corresponding to the CeO2 phase only. Sample x=0 indicates HfO2 monoclinic phase only, which suggests that Co forms a solid solution with CeO2 in x=0.95 to x=0.15, with HfO2 in x=0. In samples x=0.95 to x=0.15, these films have a (111) preferred orientation of ceria. The incorporation of Hf leads to evident shifts of the diffraction peak position towards the right. The lattice parameter decreases from 5.412 Å in x=0.95 to 5.261 Å in x=0.15 as the Ce concentration decreases from 0.95 to 0.15, which indicates that the Hf incorporated substitutionally into the CeO2 lattice. All the samples show hysteresis loops at room temperature. The doped films have high magnetic anisotropy with an out-of-plane easy axis. By introducing Hf into the CeO2 lattice, we systematically tuned the optical band gap of the host material from 3.5 eV to 5.5 eV. The magneto-optical spectrum, i.e. the Faraday rotation or magnetic circular dichroism (MCD) versus wavelength also show simultaneous blue shift with larger band gap energies.

In summary, we have successfully fabricated the Co doped Ce1-xHfxO2 thin films with tunable magneto-optical properties, this kind of novel magneto-optical materials allow one to design the best figure of merit wavelength for such materials.

Keywords: Tunable magneto-optical properties; Room temperature ferromagnetism; Optical band gap
Fe5C2 Nanoparticles: a Multifunctional Nanoplatform for Cancer Theranostics

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Multifunctional nano-probes for targeted cancer diagnostics and therapeutics with good biocompatibility have received widespread attention in recent years. Fe5C2 nanoparticles (NPs) are nano-intermetallic compounds that consist of carbon atoms occupying the octahedral interstices between close-packed iron atoms. High magnetism from iron offers the NPs of high resolution for diagnosis by T2-weighted magnetic resonance imaging (MRI), with the r2 value improved by 1 fold compared to clinically applied Resovist. It also endows NPs of sensitive response to magnetic field for magnetic targeting. By loading anti-cancer drug DOX, the NPs are able to selectively delivery the drug under the guidance of magnetic field, reduce the side effect, and monitors the theranostic effect by MRI as well. Benefiting from the carbon containing, the NPs are near infrared (NIR) absorbable. Through the conversion of NIR into heat, photothermal therapy (PTT) are feasible for Fe5C2 NPs to completely ablate tumor without appreciable side effect. The NIR-response also provide the NPs with a burst drug release when exposed to NIR light to realize the controllable synergistic effect between PTT and chemotherapy. Further transporting heat into ultrasound, photoacoustic tomography (PAT) was achieved as a complementary diagnosis for MRI. In addition, the carbon insertion protects Fe5C2 NPs from oxidation and/or corrosion, which prolongs their life time and reduces their toxicity in physiological environment. Our investigation showed the great promise of Fe5C2 NPs in multi-modal cancer diagnosis and therapy.

References:

Q-36
Preparation, microstructure and mechanical properties of consolidated Al2O3-ZrO2-Gd2O3 nanopowders with a eutectic composition synthesized by chemical co-precipitation

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Objective: Al2O3-ZrO2 based eutectic composites are attractive promising candidates in engineering materials for the applications at high temperatures to fulfill the requirements of the turbo-engines for aerospace and stationary power generation. Many efforts have been made on these composites due to excellent thermo-mechanical properties. For commercial thermal barrier coatings (TBCs) applications, yttria stabilized zirconia (YSZ) is the most commonly used material where a high operating temperature is allowed. Thermal insulation properties have been further improved by co-doping of YSZ with other rare-earth oxides such as Gd without adversely causing the degradation in thermal stability. Thereby, a pyrochlore or defective fluorite structure may form in the ZrO2–Gd2O3 system which exhibits a low thermal conductivity comparatively to YSZ, making
Al2O3-ZrO2-Gd2O3 highly competitive for advanced TBCs in future turbines.

Methods: Multicomponent oxide nano-powders of Al2O3-ZrO2-Gd2O3 with a eutectic composition have been prepared via a chemical co-precipitation method through the formation of intermediate precipitates by carefully controlling the solution conditions. The phase transition underwent by the powder precursor, the morphology and size of the nanoscale oxide ceramic powders were investigated in a calcination temperature range of 400 °C to 1500 °C. Microstructure morphology and mechanical properties of the as-sintered composite were characterized to obtain a better understanding on the densification and toughening mechanisms.

Results: GdAlO3 (GAP) and ZrO2 oxides show a complete crystallization as compared to Al2O3 as identified from the XRD patterns of the precursor and fine powders. However, the coexistence of perovskite GdAlO3 and garnet Gd3Al5O12 is also found, where Gd3Al5O12 phase is unstable at temperatures higher than 1300 °C, which will decompose into GdAlO3 perovskite and α-Al2O3. The composite powders calcined at 1300 °C exhibit spherical primary particles with a good dispersion and uniform particle morphologies; the crystallite size of the calcined powder is in the range of 20-200 nm. Fully densified Al2O3-ZrO2-GdAlO3 ceramics were hot-pressed from the synthesized eutectic powder by tailoring the sintering parameters. The as-sintered ceramic has been examined by XRD and SEM, and consists of α-Al2O3, GAP and Gd-stabilized ZrO2, however, no Gd3Al5O12 phase identified after sintering. The as-sintered Al2O3-GdAlO3–ZrO2 ceramic exhibits high mechanical properties with the room temperature flexural strength of 485 MPa, the fracture toughness of 6.5 MPa.m1/2, and the Vickers hardness of 17.5 GPa.

Conclusion: Nanoscale Al2O3-ZrO2-GdAlO3 composite nano-powder with a eutectic composition has been successfully synthesized by chemical coprecipitation. Dense Al2O3-ZrO2-GdAlO3 in situ composite ceramics free of macroscopic defects have been achieved by hot pressing, and exhibit a high mechanical performance.

Q-37
Hierarchically Porous Materials as Electrodes for Energy Storage Batteries
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The increasing demand for higher energy density storage devices steers scientific researches on high capacity electrode materials. Carbon aerogel (CA) represents a novel and special type of porous carbon material with interconnected structure, and higher electrical conductivity than other materials. The principal features of CA materials are a high surface area (400-900 m2/g) and a high pore volume (1-3 cm3/g). Due to its controllable three-dimensional porous structures, CA is considered to be an ideal electrode material for supercapacitors and rechargeable batteries due to their unique three-dimensional nano-network, high specific surface area, abundant mesopores and high electric conductivity. Metal-organic frameworks (MOFs) or coordination polymers have drawn much attention for their applications as electrodes for energy storage applications. MOFs consisting of organic ligands and metal ions, can transform into carbon materials and metal species with proper methods. Carbon materials derived from MOFs by simply carbonization of organic ligand and removal of metal species have shown good electrochemical performance in lithium-sulfur batteries and lithium-selenium battery applications. MOFs derived tailorable metal oxides or metal oxide/carbon nanomaterials with unique nanostructures exhibit outstanding electrochemical performance when used as LIBs anodes.

We report on the hierarchically porous materials as electrodes for high performance lithium secondary batteries. In the present work, nitrogen-doped carbon sponges (NCS) composed of hierarchically micropores carbon layers, a sandwich-like structure with reduced graphene oxide (RGO) wrapped MOF-derived ZnCo2O4-ZnO-C polyhedrons on nickel foam as an anode for high performance lithium ion batteries (LIBs), core@shell structure
of Fe2O3@Co3O4 hollow structures from MOFs precursors are synthesized. Three dimensional S/carbon aerogel (CA), spinel ZnMn2O4/CA, Co3O4/CA hybrids with abundant pores and large surface area, are designed and synthesized. The electrochemical energy storage performance and related mechanism, the relation between the microstructure and the electrochemical performance are systematically investigated. offers a new way and provides guidelines for designing electrode architectures and cell configurations to achieve high-energy-density batteries.

Q-38
Low Thermal Conductivity and High Thermoelectric Figure of Merit of bulk PbTe alloys via Optimizing Nanostructuring
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PbTe alloys is famous as the promising thermoelectric material for waste heat recovery, therefore, it has been the subject of extensive research and high thermoelectric figure of merit have been obtained. Here, we will show the low thermal conductivity and high thermoelectric figure of merit by optimizing nanostructuring. At first, we systematically investigate the relationship between size of nanostructure and thermoelectric properties. It is found that the thermoelectric figure of merit, zT, strongly depends on the synthesis condition and that its value can be enhanced to ~2.0 at 773 K by optimizing the size distribution of the nanostructures in the material. The smallest sizes (2~6 nm) of nanostructures are responsible for effectively scattering the wide range of phonon wavelengths to minimize the lattice thermal conductivity to ~0.5 W/m K. Therefore, the zT enhancement is attributed to the reduction of both the lattice and electronic thermal conductivities. Secondly, we propose a heterogeneous nanostructure for bulk thermoelectrics. By varying the quenching time of Na doped PbTe, followed by hot pressing, we synthesized heterogeneous nanocomposites, a mixture of nanodot nanocomposites and nanograined nanocomposites. It is found that figures of merit, zT, of those heterogeneous nanocomposites exhibited a zT around 2.0 at 773 K, which is a 25% increase compared to zT of a homogeneous nanodot nanocomposite in our experiment. The power factor increase is 5%, and the thermal conductivity reduction is 15%; thus, zT increase mainly comes from the thermal conductivity reduction. All in all, the thermoelectric properties is strongly depended on the nanostructuring and optimizing the size of nanostructure and heterogeneous nanostructure should be the better way to enhance the thermoelectric performance of bulk PbTe alloys.

Q-39
How to Improve the Power Factor of Thermoelectric Composite
Ruizhi Zhang

Thermoelectric (TE) materials are of considerable interest because they can convert waste heat to useful electrical energy and will contribute to reducing the global energy crisis. To achieve a high heat-to-energy conversion efficiency, TE materials are urgently required that have both low thermal conductivity and high power factor. TE composites are such materials, in which interfacial phonon scattering lowers the thermal conductivity, while the power factor is maintained from the matrix. As the lattice thermal conductivity of state-of-the-art TE composites is approaching the minimum value, further TE property improvement is likely to come from the power factor enhancement.

In this presentation, two approaches are proposed to enhance the power factor of TE composite. In one approach, a “double Schottky barrier” type interface was designed to utilize both quantum confinement and energy filtering
effects. By taking SrTiO3 as an example, power factor enhancement was predicted by using first principles calculations and Boltzmann transport equations and the prediction was partially proved by later experiments. In the other approach, a 2-phase composite was designed to make its power factor higher than that of each phase. The composite was further optimized by 1) high throughput screening from TE material databases for the most suitable material pair as the 2 phases; 2) a genetic algorithm based global search for composite geometry with the highest power factor enhancement. This work will help the design of next generation TE composites.

Q-40

Atomic Scale TEM Study on Structure and Defects of 2D Materials
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The unique properties of 2D materials significantly rely on the atomic structure and defects. Thus study on structure and defects at atomic scale is crucial for in-depth understanding of 2D materials and provides insights into its future applications. Using modern aberration-corrected transmission electron microscopes, we are able to see individual light atoms at sub-angstrom regime. We achieve the atomic structure of monolayer and multilayer graphene, hBN and other 2D materials including transition metal dichalcogenides and reveal the atomic defects in these materials. In addition, the dynamics of defect formation has been unveiled.


Q-41

Solution Plasma Synthesis of Metal Functional Nanomaterials and Their Electrocatalytic Properties
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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 Pt, Pd, Au and PtPd 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 nanoparticles with the average size of 2-5 nm were uniformly and highly dispersed over various carbon surface. And their electrochemical stability in alkaline and acidic solution was addressed. Alloy nanoparticles showed good electrochemical activities. Multi-scan cyclic voltammetry indicated that alloy
nanoparticles have better electrochemical stability in alkaline than in acidic solution. And many functional metal/metal oxide/C nanomaterials can be facile synthesized by this solution plasma technique.

Q-42
A New Mosaic Structure in Cu2Sn1-XZnxS3 Revealed by Atomic-resolution EDS Mapping
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Cu2SnS3 (CTS), a p-type direct band-gap semiconductor, has attracted great research interest due to its potential applications in photovoltaic devices and thermoelectric devices. The band gap of CTS is tunable by doping with Zn. However, these compounds adapt complicated crystalline phases because all three metallic ions can occupy the same site competitively with similar free energy and form different ordered structures. To help unravel this complexity, atomic resolution spherical aberration-corrected scanning transmission electron microscopy (STEM) and X-ray energy dispersive spectroscopy (EDS) mapping techniques was applied to investigate a series of Cu2ZnxSn1-xS3 polycrystalline ceramics.

The Cu2ZnxSn1-xS3 (x=0.00, 0.05, 0.10, 0.15, 0.20) thermoelectric ceramics were synthesized with solid phase reaction and followed with a spark plasma sintering (SPS), which shows a low thermal conductivity. The microstructures of the ceramics were investigated by a high-angle annular dark-field STEM (HAADF-STEM: JEM-ARM200CF) equipped with double SDD-EDS detectors. And the solid angle for the whole collection system was about 1.7 sr.

The Zn-doped CTS ceramics formed cubic structure, in contrast to the monoclinic phase of the undoped sample. Especially, crystal grains in Zn-doped Cu2SnS3 formed a diamond-shaped mosaic nanostructure comprising 5 nm-thick boundary regions with semi-ordered cation sublattices and 10 nm-wide inner regions with fully disordered cation sublattices. Analysis of the boundary phase shows it to have composition Cu4ZnSn2S7, which is a previously unknown phase in the Cu-Zn-Sn-S system. The interweaving of the electronically conducting mosaic boundaries with phonon-scattering inner regions represents a new kind of “phonon-glass electron-crystal” nanostructure that appears to be the chief origin of the excellent thermoelectric performance.

Q-43
DFT Calculations of Single Water Molecule’s Adsorption on KDP (100) and (101) Surface
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First-principles DFT calculation was carried out to study the adsorption of single water molecule on KDP (100) and (101) surface. The stable configurations are found according to the adsorption energy and on this basis, we calculated the difference electron density and partial density of states to study the detail of bond formation. The most favorable single water molecule adsorption sites are found to be P top site and P-K bridge on (100) surface with two hydrogen bond or a hydrogen bond and a O-K bond formed and O-K positions on (101) surface with a hydrogen bond and a O-K bond formed. We believe the structure of the surfaces and the pulling effect of two parts of high energy on the surface play an important role in the adsorption process of single molecule on KDP (100) and (101) surface.
Q-44

Microstructure and wear properties of Fe-based alloy composite coatings reinforced by Spherical WC Particles using plasma transferred arc

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In recent years, the development of Fe-based wear and corrosion-resistant, metal matrix composite coatings (MMCs) for use by shipping and petrochemical industries is of high scientific and industrial interest. Such high-performance Fe-based coatings are regarded as promising materials in corrosion and wear environments, because of their excellent wear resistance, good hardness and high bonding strength, and they might replace more expensive Ni-based or Co-based alloys.

It is well known that Tungsten carbide (WC) particles can offer a good resistance, so WC has been widely used as the reinforcing phase in MMCs. MMCs reinforced by WC particles have high wear and fatigue resistance, low thermal expansion coefficient, which make the MMCs a good candidate for application in the wear aggressive environment.

To apply MMCs coatings on the surface of mechanical parts to improve the wear and corrosion resistance in aggressive working environments, three main surface hardfacing approaches are widely used: plasma transferred arc (PTA), thermal spray and laser cladding. Compared with other surface deposition processes, PTA exhibits many advantages such as a lower production cost, easy to operation and no need for special surface treatment. Furthermore, the PTA overlays are generally thicker than laser cladding overlays and allow the production of high quality coatings, e.g. a good metallurgical bonding between the substrate and the coating and low levels of porosity. Therefore, PTA is an efficient and promising technology normally used for the production of wear-resistant hardfacings.

In this work, Fe-based alloy composite coatings reinforced by WC particles on 304 stainless steel using PTA are investigated. The friction and wear behavior of Fe-based alloy composite coatings and Fe/WC coatings (containing wt.30% and wt.60% of WC) are compared. Changes in microstructure, microhardness and wear resistance are examined.

The microscopic morphology and distribution of WC particles were characterized by a JSM 7500F field emission scanning electron microscopy (SEM) equipment with energy-dispersive spectrometer (EDS). The phase compositions of the powders and composite coatings were identified by using PANalytical X’Pert PRO X-ray diffraction (XRD) with Cu-Kα radiation source (40 kV, 10 mA, and in a scanning range of 2θ from 20° to 80°).

Reciprocating wear tests were performed by using BRUKER UMT TriboLab. The counter-body was WC ball, with a diameter of 8 mm and hardness of 94 HRA. A 50 N load was applied on the surface of the tested specimens for 120 minutes dry test, the reciprocating frequency was 2 Hz and the amplitude was 5 mm. Three repeated wear tests were undertaken for each specimen to get the mean value. After the tribological test, the wear debris were collected by using a carbon double sided tape, the worn surfaces were cleaned with ethanol and dried with an electrical power. The wear mass loss was measured by using a TG328A electric balance with accuracy of 0.1mg. The friction coefficient value was continuously recorded by the test system and the wear volumes were determined by using a BRUKER ContourGT 3D non-contract optical profilometer. The morphologies of the worn surfaces and wear debris were analyzed by SEM and surface mapping profiler. The chemical composition of the wear debris was investigated by using energy dispersive spectrometer (EDS) attached to the JSM 7500F scanning electron microscope (SEM).

Based on the experimental results, the following remarks can be drawn:
The surface SEM morphologies of Fe-based PTA coatings are free of pores and cracks. And at the same time they are metallurgically bonded to the substrate. Fe/WC composite coatings contain dendritic solid solution Fe-based matrix, interdendritic eutectics precipitation and block precipitations. Spherical reinforced WC particles are well embedded in Fe-based matrix. While, the microstructure of pure Fe-based coating contains only dendritic solid solution Fe-based matrix and interdendritic eutectics precipitation.

Adding WC Particles to Fe-based alloy powders can enhance the wear properties of these composite coatings. However, the high density of the reinforced WC Particles mean that they are tend to precipitate and concentrate at the bottom of the coatings during the solidification process, leading to the non-homogeneous distribution of WC Particles at different depths of the coating.

The addition of WC Particles dramatically improved the wear resistance of the composite coatings by almost 35% when wt. 60% of WC was used. The matrix microhardness and precipitates distribution played an important role in the wear resistance of the composite coatings.

In the Fe-based matrix without reinforced WC Particles, the main wear mechanism is the combination of adhesive and oxidative wear with small plastic deformation on the edges of the wear tracks, although a slight two-body abrasive wear is also observed. With the increasing percentage of reinforcement WC particles, the three-body abrasion wear mechanism is predominating due to the fractured WC micro-particles, although adhesion wear still presents.

Key words: plasma transferred arc (PTA), MMCs, Tungsten carbide, Fe-based alloys, wear resistance

Q-45
Design of Ceramic Reinforcement using a Biomimetic Concept
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In this report, a novel concept from one biological system is adopted to design ceramic reinforcement. The applications of ceramics are limited by their brittleness. Though the toughness of ceramics can be improved by adding hard and strong toughening agents, their damage tolerance is still poor. Novel concept derives from fish scale is explored and used to design alternative toughening reinforcement. The microstructure of fish scale exhibits hierarchical complexity. There are many weak interfaces within the scale. As fish scales are used directly as the toughening agent, the toughness of ceramics can be enhanced. The toughness enhancement can be related to the crack deflection within fish scale. Based on the observation, the ceramic reinforcement with internal weak interfaces is recommended as the toughening agent. A feasibility study of using such concept for engineering application is proposed.

Q-46
Biomimetic Surface Design Inspired by Nature
Tongxiang Fan
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Nature provides a blueprint for dealing with energy crisis and environmental pollution and Bio-mimetic is an efficient strategy for material design inspired by nature. In this presentation, I would like to introduce some recent works in our research group concerning bio-inspired and biomimetic materials based on butterfly wing and green leaf, and propose 5 kinds of working prototypes from nature which may broad the horizon for the design of artificial photosynthetic systems based on biological paradigms and provides some working prototypes to exploit
solar energy, biosensor and architecture materials.

Q-47
Fabrication of Sandwich Structure via Pulsed Laser Deposition with Metallic Mesh
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Shandong University

Metamaterials are artificial periodic structures with negative permittivity and permeability. Several interesting properties can be obtained in metamaterials, such as negative index behavior, which can be used for building perfect lenses, cloaking, antennas, etc. As the metamaterial’s properties are determined by its structure, the key challenge is to reduce the fabrication cost of the periodic structure on the micrometer or nanometer scale for realistic applications. In this paper, we experimentally demonstrate a new one-step method for the fabrication of a large-area infrared metamaterial at extremely low cost. A metallic mesh is used as a shadow mask during the pulsed laser deposition (PLD) process to fabricate a FeNi/SiC/FeNi multilayer sandwich structure on Si substrate (cm2 level). The sample shows a strong absorption peak in the infrared frequency range, and the absorption intensity changes with the sample’s geometry.

Q-48
Effect of TiC addition on the arc erosion resistance of Ag/ZnO contact material
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To clarify the effect of TiC addition on the arc erosion resistance of Ag/ZnO contact material, the Ag/ZnO composites with 0, 0.5 wt.% and 1.0 wt.% TiC contents addition were prepared by powder metallurgy. The arc-erosion morphologies of Ag/ZnO composites were observed by scanning electron microscopy (SEM). Observations show that there are serious arc erosion and deep erosion pits on the surface of Ag/ZnO composite without TiC addition, while the erosion pits become more and more small and shallow with the increase of TiC addition contents from 0.5 wt.% to 1.0 wt.% Accurate weighing was done before and after arc erosion. The experimental data show that the mass loss rate decreases with the increase of TiC addition contents. The electrical breakdown strength of Ag/ZnO composites is significantly increased with the increase of TiC addition contents. It suggests that the addition of TiC can effectively improve the arc erosion resistance of Ag/ZnO contact material.

Q-49
Effect of magnesium aluminum silicate glass on the thermal shock resistance of BN matrix composite ceramics
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The effect of magnesium aluminum silicate (MAS) glass on the thermal shock resistance and the oxidation behavior of h-BN matrix composites were systematically investigated at temperature differences from 600 °C up to 1400°C. The residual strength rate of the composites rose with increasing addition of MAS showing a maximum value at the 60 wt. % MAS. Compared with the original strength, the residual strength of the specimen after thermal shock increases 77 % (ΔT = 1000 °C). The strengthening effect of MAS and the surface
microstructural evolution of composites are responsible for the improved thermal shock resistance. Surface oxidation of the composites during the thermal shock process plays a positive role in enhancing the residual strength with self-healing cracks and the appearance of the compressive stress. The oxide layer also acts as a thermal-barrier to decelerate the actual thermal stress. Furthermore, this dense layer also improved the oxidation resistance of h-BN matrix composites by prevent diffusion of oxygen. These results indicate that short-term surface oxidation during thermal shock process is favorable to the enhancement of the thermal shock resistance of BN-MAS composite ceramics.

Q-50
Low frequency dielectric properties of PANI/PVDF composites
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Polymer dielectrics as energy storage devices have attracted increasing attention recently owing to their advantages such as flexible, lightweight, and high efficiency, etc. To obtain high permittivity materials, the ceramics with high permittivity or conductors has often been selected as fillers which are introduced into the polymers matrix. Especially for the conductor/polymer composites, the dielectric properties will vary significantly near percolation with the increase of conductor content. In this paper, conductive polyaniline (PANI) and poly(vinylidene fluoride) (PVDF) were chosen as filler and matrix respectively to prepare high permittivity composites. The influences of PANI content and microstructure on low frequency dielectric properties (100Hz-1MHz) of composites were investigated. The results showed that PANI/PVDF composites were promising candidates as high energy density capacitor materials applied in low frequency region.

Key Words: Polymer dielectrics, dielectric properties, PANI/PVDF composites

Q-51
Novel Techniques of Ion Electronless Copper Plating on Surface of Alumina Ceramics
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The composite surface technology is one of the trends of surface engineering in the 21st century. Ion implantation-assisted electronless plating technology can get uniformly plated layer, attractive appearance and high ability of plating deep holes. Superficial metallization can confer both ceramic and metallic advantages onto ceramics. It is the key to improving the quality of the plating layer.

To explore possibilities for improving the plating layer, Ni was selected as the ion to be implanted on the surface of ceramic by selective electronless copper plating. The Al2O3 ceramic substrate with thickness of 1 mm. Ion implantation was performed on an Omni-directional and multi-functional ion implantation device. The electronless treatment was carried out according to the parameters described for normal electronless copper plating techniques. The plating character and the microstructures were analyzed by a XSAM 800 Multifunctional Surface Analysis System. The characteristics and microstructures of the plating were studied.

The analyses indicated that the ion implantation parameters are key factors which influence the electronless plating process. The plating obtained at a higher ion dosage was dense, smooth, and the grain in the plating was fine. The structure of the plating obtained at a low ion dosage, where it is apparent that although the plating quality looks good, it has holes, the grain is thick and the plating is not smooth. The plating quality under critical dosage, where besides being able to clearly see the substrate structure, it can also be observed that the plating is
discontinuous and has only a scattered distribution of copper grains. The results also showed that the electronless plating time greatly impacted the plating structure under the same implantation condition. While the sample surface looked gray to the naked eye, no copper grains could be observed apart from some tiny particles by electron microscopy. Specifically, when the plating time was 10 min, copper grains were present on the ceramics surface, but they were discontinuous under the microscope, while a continuous copper layer with pores on it was present when the plating time 15 min was. When the plating time was 20 min, a continuous copper plating formed on the ceramics surface, the size of the particles was smaller than that seen at 15 min, and the number of pores was reduced. Finally, when plating time was 25 min, the copper layer was plated and smoothed with nanoscale particle size.

In addition, the results revealed that the plating layer shows better merging with the substrate when implanted at low energy and high dose level, peeling is not found after the breakage. When implanted at high energy, whether at high or low dose, the substrate shows poor merging with the copper film, and obvious cracks can be seen along the interface, which implies that the copper film has peeled during breakage. Furthermore, at high energy, the penetration range of the implanted ions is large and hence can deeply penetrate the substrate, which leads to lower density of Ni ions on the surface of the ceramics even though the whole dose is high. On the other hand, the higher the energy, the more serious the sputtering, so few nucleation sites can be formed and the distribution is not homogeneous, as a result, the cohesion of the plated layer is not good. The structure of the cross section of the plated layer has a typical sandwich structure, that is to say, the plated layer grows in the shape of a sandwich during the experimental process.

Additionally, well-distributed microstructures of the plating layer can be obtained by this technique and even nano-plating can be realized by optimizing the technique parameters. The main factors that influence the characteristics of copper plating are the ion implantation energy, dosage and the time of electronless copper plating. The optimum implantation parameter was found. Under above implanting condition, the nuclei of copper only started to form when the plating time was 2 min.

We got the main conclusions as follows:
(1) The Ni ion implantation can replace the traditional complicated pretreatment of electronless plating and assist the electronless copper deposit on the surface of Al2O3 ceramics. Continuous, compact and homogeneous copper films can be obtained by controlling the technique parameters of the Ni+ ion implantation.
(2) The ion implantation parameters are key factors that affect the subsequent electronless plating. There is a critical ion implantation dose level for the electronless plating test. Lower energy and higher dose level (about 15 KeV- 2.2E17 ions.cm-2) favor both, the growth of the copper film and the merging of the copper film with the substrate, whereas it does not favor high energy implantation for the plating of copper.
(3) The electronless plating time has a great effect on the structure of copper film. Under proper implantation parameters, the copper film becomes more compact and the particles become finer with plating time. Nano-plating copper film can be realized when the plating time reaches 25 min.

**Q-52**

**Development and Applications of Plastic-Ferrite Composite Magnetic Materials**

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Bonded Magnetic Compound is a composite of Polymer(PA6, PA12 or PPS) and Magnetic powder (Ferrite or Rare-earth magnet), it can be used as the raw material to form complicated parts of motors, sensors and many electronic equipments with a normal injection technique. In order to achieve better magnetic performances, many
efforts have been made to increase the amount of magnetic powder fillers without decreasing the fluidity necessary for manufacturing. Modification of both the surface of filler powder and resin were made to improve the interface between inorganic particles and polymer.

Q-53
Tensile properties and fracture reliability of melt-extracted Cu-based amorphous wires
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The tensile properties and fracture reliability of melt-extracted Cu-Zr-Ti amorphous wires have been investigated. And the mechanical properties were evaluated through tensile tests, and their fracture reliability was estimated by using two-, three- and lognormal parameter Weibull statistical analysis. Experimental results indicated that the Cu-based microwires have entirely amorphous microstructure, a smooth surface and circular cross-section, and exhibit a relatively higher working temperature (crystallization temperature). The Cu-based microwires with a mean diameter of 40um exhibit a maximum tensile strength of 2300 MPa (2.3GPa). Moreover, the tensile two-parameter Weibull modulus of the amorphous microwires is 8.43 and the three-parameter Weibull modulus is 1.86 with a threshold value as high as 1236.94 MPa, which also indicate that Cu-Zr-Ti amorphous microwires exhibit excellent tensile properties and fracture reliability. Therefore, it can be concluded that the Cu-based microwires as the ideal candidates including miniaturized components are used for potential electronics engineering and biomedical implantation applications.

Q-54
Why the permittivity and permeability can be negative for magnetic metal composites
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Q-55
Polyaniline Stabilized Multifunctional Epoxy Nanocomposites
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In this work, the multifunctional epoxy nanocomposites filled with different nanofillers including magnetite, silica, barium ferrite, and multi-walled carbon nanotubes were prepared. The conductive polymer polyaniline was introduced on the surface of nanofillers through surface initiated polymerization method to improve the interfacial interaction between nanofillers and epoxy matrix. The improved mechanical property of magnetite/epoxy nanocomposites was obtained due to the well-dispersed magnetite nanoparticles covered by polyaniline. The tensile strength in polyaniline stabilized multi-walled carbon nanotubes/epoxy nanocomposites was enhanced by 85% compared with that of pure epoxy. The introduction of phosphoric acid doped polyaniline and silica decreased the heat release rate peak of epoxy, providing the flame retardant property to epoxy. The permittivity transition from negative to positive was observed in the polyaniline stabilized barium ferrite/epoxy nanocomposites.
Enhanced Catalytic Methane Combustion over MxCo3-xO4 (M=Co, Cu, Mn) Nanowire Arrays by Cation Substitution
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Cobalt oxide is an attractive earth-abundant catalyst for methane combustion, and its high catalytic activity has been attributed to the Co3+ cations surrounded by Co2+ ions. By using a simple hydrothermal method, large scale Co3O4 nanowire catalysts have been grown onto stainless steel mesh substrates to increase the catalyst utilization efficiency. To further enhance the catalytic activity, Cu and Mn are alloyed into Co3O4 respectively for the substitution of Co cations in the lattice to modify the activity of reactive sites. Detailed microstructure characterizations and catalytic performance evaluation have been carried out, and we found that this elemental alloying strategy can significantly improve the catalytic properties of Co3O4 nanowires towards methane combustion at low temperature with appropriate amount of Cu or Mn species. Further increase Cu concentration would lead to formation of CuO phase, while further increase Mn concentration would result in drastically decrease of specific surface area, both of which have adverse effect on catalytic properties of Co3O4 nanowires. This study provides a feasible approach for scalable synthesis and rational optimization of nanotructured metal oxide catalysts applicable for various catalytic applications.

Poster

Q-P01
Enhanced photocatalytic hydrogen evolution from water splitting of titania based photocatalysts
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The efficiency of photocatalytic hydrogen evolution from water splitting by utilizing titania (TiO2) as the photocatalyst can be limited by many factors. We design corresponding theories to optimize the above limitations in order to help achieve effective photocatalytic hydrogen evolution by utilizing TiO2 as the photocatalyst. Noble metal deposition and biotemplate approach were employed to optimize the internal and external structures of TiO2 photocatalyst. The wings of Troides Helena with inverse V-type scales and silver bromide (AgBr) were utilized as the templates or the source of Ag, respectively, to synthesize inverse V-type AgBr/TiO2 photocatalyst with well distributed AgBr and TiO2. To accurately duplicate the template and uniformly distribute AgBr, a crosslinking extraction method was designed to synthesize a crosslinked titanium precursor material with uniform hydrolytic rate, good liquidity, and low viscosity from TiCl3 solution. The quantum yield of inverse V-type AgBr/TiO2 at 340 nm wavelength is 7.3 %, which is higher than inverse V-type TiO2 (1.3 %), non-inverse V-type AgBr/TiO2 (3.8 %), and AgBr/TiO2 (2.8 %) by deposition of AgBr on inverse V-type TiO2, indicating the cooperation of inverse V-type structure and well distributed Ag nanoparticles is able to promote the activity of TiO2 photocatalyst.

Q-P02
Synthesis of Three-Dimensionally Hierarchical Silica as A Catalyst Support for Gold nanoparticles
Silica with three-dimensional hierarchically porous structures was prepared with a dual-templating method, where three-dimensional ordered porous carbon serves as the hard template and an amphiphilic triblock copolymer (poly(ethylene oxide-propylene oxide-ethylene oxide), P123) serves as the soft template. The hierarchical silica consists of mesoporous silica nanospheres, which have a multilayered interior structure, arranging in three-dimensional ordered arrays. The pore size of the carbon hard template determines the size of the silica nanospheres, the number of their interior layers, and the size of the interparticle voids. The soft template P123 determines the mesopore texture of the materials, which have IV-type isotherms, narrow pore size distributions within 6.8-7.8 nm, and high BET surface area of 453-502 m²/g. Small-angle XRD patterns of the materials show sharp diffraction peaks with a periodicity of 7.0-7.4 nm, indicating highly regular nanostructures. This should be the ordered mesopore structures since the XRD-derived periodicity is consistent with the size range of pore size distributions. The three-dimensional hierarchical silica was employed as a catalyst support for gold nanoparticles through post-modification with 3-aminopropyltrimethoxysilane followed by in-situ reduction. The catalytic performance of gold-loaded silica was evaluated with the reduction of 4-nitrophenol.

Q-P03
Synthesis of shape-control iron oxide nanocrystals and their dispersity
Yue Hou, Feng Dang*, Jun Wang, Runhua Fan
Shandong University

Nanomaterials have drawn greater attention of many researchers, which is due to their quantum size effect, macroscopic quantum tunneling effect, specific surface effect, volume effect and a series of new physical and chemical characteristics. Fe3O4 is known as a kind of magnetic materials with low toxicity, good stability and excellent magnetic properties, which is the most commonly used in the preparation of magnetic fluids. What’s more, its nanocrystals have become a hot in the research of magnetic nanomaterials as a result of its superparamagnetic, high surface activity and other characteristics, which have made them widely used in the field of magnetic fluid, microwave absorption, water treatment, photo catalysis, bio-medicine, biological separation and so on. In this study, we use the liquid-liquid interface method to prepare the iron oxide nanocubes and the effects of different reactants, solvents and additives were studied using XRD, SEM, HRTEM, VSM and so on. Finally we succeeded in preparing iron oxide nanocubes and controlling the morphology and dispersion of iron oxide. Next we expect to control their properties to make it widely used in various fields.

Q-P04
Study of titanium dioxide nanofiber and its photocatalytic performance
Yanjie Zhai, Runhua Fan, Jun Wang, Feng Dang*
Shandong University

TiO2 nanofibers have a very wide range of applications in the fields of photo-catalysis, sensors and lithium ion batteries. We explored the fabrication of two-dimensional microarray of TiO2 nanowires in the experiment. Anatase nanowires which is compositied by titanium(IV) bis(ammonium lactato) dihydroxide with lengths of greater than 15 μm and widths of ~20 nm were synthesized by hydrothermal reaction method.
Incomplete hydrolysis of the Ti precursor triggered the alignment of the hydrolyzed T-O octahedral species to form one-dimensional nanostructures. One-dimensional TiO2 nanofibers were prepared via electrospinning and high temperature calcination, using TiO2 nano-wires and the polyvinylpyrrolidone (PVP). Then TiO2/NbCl5 nanofibers were prepared by doping NbCl5 in TiO2 nanowires. The samples were characterized by energy dispersive spectra, scanning electron microscopy, X-ray diffraction and transmission electron microscope. Photocatalytic measurements on Rhodamine B (RB) solution are performed. The result shows that the TiO2 nanowires synthesized by ratio of 1:2:4 Ti/OLA/hydrazine have the best length. Nanofiber of TiO2/NbCl5 is a cluster of aligned TiO2 nanowires. Degradation of Rhodamine B solution by using TiO2 nanowires synthesized by ratio of 1:2:6 Ti/OLA/hydrazine as photocatalytic material, the Rhodamine B solution, which concentration was 10 mg/L, was decomposed 70% by the samples with better photocatalytic efficiency than P25 titanium dioxide nanoparticles after 60 minutes of UV irradiation.

Q-P05
Preparation of vanadium dioxide nanosheets and its electrochemical performance
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Humans’ demand for energy is increasing with the development of society. Therefore, it is important for us to search for new energy to replace the traditional fossil fuels. Supercapacitor is attracting more and more attention as a new energy storage device with large capacity, high energy density and friendly to environment. Electrode material is the key to energy storage device. The physical performance of the material is determined by its composition and microstructure. Therefore, it is hot to prepare high performance electrode material with large specific surface area and special microstructure.

In this paper, hydrothermal synthesis method was used to prepare VO2 nanosheets with special structure. 15 mL deionized water, 0.75 mL H2O2 solution and 0.053 g V2O5 powder were used to prepare inorganic solution. And then, 15mL toluene, 0.6 mL oleic acid and 0.15 mL tert-butylamine were mixed to organic solution. Pour the inorganic solution and organic solution into 50 mL Teflon-lined stainless steel autoclave liners respectively. After keep the autoclave at 200 ℃ for 48h, the VO2 nanosheet was obtained. Finally, the samples were exposed in ultraviolet rays for 1 h and annealed at 200 ℃ for 2 h. The morphology and composite are evaluated by SEM, TEM and XRD respectively. The obtained VO2 nanosheet, PVDF and carbon black were mixed to prepare the electrode and the electrochemical performance of the electrode was evaluated by GCD, CV and EIS with three-electrode system. We know its specific capacity and cycling stability.

The results of XRD show that the samples are composed with VO2(B) and VO2(A). We can see the (110) diffraction peak of VO2(B). The results of SEM show us that the surface of the nanosheet are rugged and composed with nanoparticles, the special structure expands the specific surface area of the nanosheets and improve their electric conductivity. And the picture of TEM show that the microstructures of the nanosheets are crystallographic.

The results show that yellow V2O5 can be reduced to black VO2 by the two-phase method. But the nanosheet’s composition and morphology are satisfying and its electrochemical performance is good as expected.

Q-P06
Synthesis Process of Morphology Controlled BaTiO3 Nanoparticles under Hydrazine Assistant
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Nanocube, spherical and polyhedral particles with narrow size distribution were synthesized in solution by using hydrothermal synthesis method under the assistant of hydrazine, bis(ammonium lactate) titanium dihydroxide (TALH) as Ti source in the presence of oleic acid. Hydrazine raised and accelerated the formation of BaTiO3 phase in this synthesis process. The morphology of BaTiO3 nanoparticles was controlled through changing the NaOH concentration under a critical molar ratio of hydrazine to oleic acid. A dissolution–precipitation growth mechanism for the formation of BaTiO3 nanoparticles was indicated by the formation kinetics. A high-quality self-assembled particulate film with a uniform structure was prepared, it providing a novel low-temperature route for the preparation of perovskite films.

Q-P07
Three-dimensional of porous graphene loaded with iron phthalocyanine for oxygen reduction reaction
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A simple method was developed to fabricate three-dimensional porous graphene loaded with iron phthalocyanine for oxygen reduction reaction (ORR). The FePc-PGR composite was fabricated by immersing the PGR into the FePc ethanol solution through impregnation as a non-precious-metal electrocatalyst for ORR. The composition of the obtained FePc-PGR composite was investigated by XPS, which indicated that FePc molecules were successfully loaded on the PGR. Compared with the commercial 20% Pt/C catalyst, the FePc-PGR composite had excellent electrocatalytical activity and tolerance to methanol crosses for ORR in the KOH solution. Diffusion limiting current density of FePc0.2-PGR was 3.5 mA cm⁻² at -0.6 V, and nearly unchanged in the presence of 3 M methanol. The electron transfer number was evaluated to be 3.2, following the mechanism of two electronic process and direct four electronic process for ORR. Our proposed method provides a simple route to prepare non-noble-metal electrocatalysts based on PGR towards ORR, fuel cells and metal-air batteries.

Q-P08
Preparation of graphene aerogels and their ability towards oil adsorption
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Since graphene was found, because of its excellent physical and chemical properties, it has been closely watched. Graphene has stable chemical properties, large specific surface area, high mechanical strength, strong surface chemical activity, and the distribution range of pore structure is wide, so it can provide a lot of adsorption sites, and graphene can be reused, so it can be a good adsorbent materials. The research work of this paper is: Freeze drying method is used for the preparation of different concentrations of graphene oxide (GO), and then through the heating method to get graphene. Respectively, we used different concentrations of graphene as the adsorbent, adsorbed organic matter such as ethanol, acetone, cyclohexane, in order to determine which concentration of graphene has the best adsorption effect, and then reuse the graphene after evaporation, to observe the repeated adsorption of the graphene. With scanning electron microscope (FESEM), X-ray photoelectron spectroscopy (XPS), laser Raman spectroscopy (Raman), X-ray diffraction analysis (XRD), to do the characterization of the structure and adsorption properties of graphene. Results show that: The adsorption capacity of graphene with 7 mg/ml on methanol is the largest, up to 179.22 g/g; the adsorption capacity of ethanol is up to
114.2 g/g, the adsorption capacity of cyclohexane is up to 98.17 g/g, the adsorption capacity of acetone is up to 70.83 g/g, and graphene can be reused after evaporation, and maintain a high adsorption rate.

Q-P09
Preparation of agarose for porous carbon electrode materials of supercapacitor
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We studied the gelling mechanism of Agarose Gel (AG), verified the influential factor of the gelling process and finally chose the proper concentration of AG to prepare porous carbon material (PC) with high specific area throughout freeze-drying method and high temperature carbonization. Field-effect scanning electronic microscopy showed that our PC possessed a structure of high porosity thus a high specific area, which granted the PC with large amount of area of electric double layer and significantly improve the storage of electricity. X-ray Diffraction spectrum indicated that there’s only one diffraction peak at approximately 26°, which matched the (002) crystal plane of graphite. According to this spectrum, we can draw a conclusion that the PC we prepared is pure and uniformed. Then we ran electrochemistry examination towards the PC whose concentrations are 10 mg/ml, 20 mg/ml and 50 mg/ml, cyclic voltammetry and galvanostatic charge–discharge were carried out and demonstrated that PC prepared from AG have great charge-discharge property. In the meantime, the cooperation with bare electrode indicated that the PC prepared from AG improved the transmission of electron much better than the control group because of the high specific area. Under the current density of 0.05 A/g, the specific capacitance reached 43.3 F/g, 190 F/g, 433.8 F/g and the PC prepared from 50 mg/ml AG showed particularly great property, still remained the specific capacitance of 83.3 F/g at the current density of 1 A/g. Also, the cyclical stability of PC prepared from AG was relatively high, after 1000 times of cyclical charge-discharge process, the specific capacitance dropped merely 12%. We believe that this work show new methods to develop new electric double layer supercapacitors.

Q-P10
Tunable permittivity and design provess parameters of graphene/alumina composite materials
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This paper researches the impact of graphene (GR) content on the permittivity of the graphene/alumina composite material and the effect of heat treatment on its dielectric properties. We used the impedance analyzer to detect the samples with different GR contents and the samples with same GR contents but different heat treatment to obtain and analyze data, including the real and imaginary parts of the permittivity, impedance, conductivity and dielectric loss tangent. Data analysis showed that with the increase of GR content in composite material negative permittivity behaviour and capacitive-inductive transition occurs in the composite material. Dimensional conductive carbon network structure resulted in the negative permittivity behaviour of composite material when it is beyond the percolation threshold. The increase of GR content in composite material resulted in the increase of conductivity, and in the vicinity of the percolation threshold the conductivity had a sharp increase. Data analysis also showed that the dielectric loss tangent sharply increased with the increase of GR content. 800 ℃ heat treatment can increase the percolation threshold of composite material, making the permittivity of the same GR content material composite, which used to be negative before the heat treatment positive. It also can be seen that it is entirely possible by controlling the GR content of the composite materials and the temperature of heat treatment.
to achieve the permittivity adjustment of graphene/alumina composite material. Since the negative permittivity appears with an appropriate GR content, it is possible to develop to the double negative material and it is expected to be applied to electromagnetic absorption and shielding areas.

**Q-P11**

**Design of metal nanoparticles-loaded porous graphene towards oxygen reduction reaction**

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Porous graphene (PGR) is expected to become one of the best catalyst carriers for oxygen reduction reaction (ORR), owing to its high surface area, abundant mass transfer channels, high pore volume, high electronic conductivity, good thermal stability, excellent mechanical strength, etc. The main investigation of this article is preparing PGR using freezing-drying method, fabricating metal (gold, silver and palladium) nanoparticles loaded porous graphene composites via impregnation and reduction, and testing and analyzing the microstructures, phase and electrocatalytic properties of the composites. Morphologies and phases are characterized by field-emission scanning electron microscopy and X-ray diffraction. According to the X-rays diffraction spectrum, we draw a conclusion that metal nanoparticles present as elementary substance. The scanning electron microscope photos show that the metal nanoparticles loaded on the PGR are polyhedral or cluster shapes. Electrochemical and electrocatalytical properties of the composites were investigated by cyclic voltammogram and linear sweep voltammogram. The results indicate that the composites have electrocatalytic capacities towards oxygen reduction reaction, and the lowest concentration of the metal nanoparticles loaded PGR has the most excellent catalytical activity towards ORR. In conclusion, metal nanoparticles loaded PGR contribute to the study of porous materials for ORR.

**Q-P12**

**The Viscosity and structure Study of KDP Aqueous Solution**

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The corresponding relationship among the KDP solution viscosity, heterogeneous doping amount, deuterium content and temperature are researched respectively, to explore the mechanism of the change of viscosity. The results show that the viscosity increases with the increase of temperature and ionic strength. When doped with \( \text{Cr}^{3+}, \text{Ca}^{2+} \), solution viscosity first has no significant changes and then increases with the increased amount of doping amount. By contrast, the influence of \( \text{Cr}^{3+} \) is greater than \( \text{Ca}^{2+} \). When doped with EDTA, solution viscosity increases significantly, and viscosity also increases after deuteration. The X-ray diffraction analysis show that, with the increase of the mass fraction, the internal structure of KDP solution has changed.

**Q-P13**

**Low frequency dielectric properties of multi-layer MWCNTs/PVDF composites**

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Nowadays, increasing attention has been paid to high performance dielectric materials owing to their huge
potential for wild applications, such as dielectric capacitors, dielectric elastomers, antennas and double negative materials. In our present work, we designed and fabricated a series of multi-layer MWCNTs/PVDF composites with different composites and microstructures. It is shown that, the percolation threshold of the composites is very low due to the high aspect ratio of MWCNTs. The dielectric permittivity, loss and dielectric strength of composites can be adjusted easily by varying the volume fraction of MWCNTs and the number of single layers. Both positive and negative permittivities were obtained. The influences of compositions and microstructures on the dielectric performances of the composites were investigated in detail.

Q-P14
High frequency electrical properties of Al/Epoxy composites by hot press process
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In this paper, Al/Epoxy composites with different Al content were prepared by hot press process. The electrical properties including ac conductivity, permittivity and reactance were investigated in detail. The results showed that the frequency dispersions of ac conductivity follow the power law, indicating the hoping conduction behavior. The real part of permittivity for composites increased with higher Al content, which was attributed to the more interface between Al and epoxy. Besides, Debye-like dielectric relaxations were observed, and the Debye-like loss peak appeared blue shift as increasing the Al content.

Key words: hot press, electrical property

Q-P15
Preparation of the cobalt/silicon nitride composites with negative permittivity and permeability via facile wet chemical approach
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Cobalt/silicon nitride (Co/Si3N4) composites with tailored microstructures and electromagnetic properties, were synthesized via a facile impregnation-calcination process. In this composites, Co particles, which randomly hosted in porous Si3N4, gradually largened and interconnected with increasing Co content. The electrical conductivity studies revealed that a percolation phenomenon appeared, and the conductive mechanism varied from hopping conduction to metal-like conduction due to the formation of Co networks. The composites above the percolation threshold exhibited the negative permittivity and negative permeability behavior. The frequency region of negative permittivity and negative permeability overlapped with higher Co content. It is indicated that, the preparation of Co/Si3N4 composites by the impregnation-calcination approach offer wide possibilities of facilitating tunable negative permittivity and negative permeability.

Q-P16
A Novel Strategy to Synthesize a High Performance Anode materials for Lithium Ion Batteries - MnO@carbon Cubic Cages within Particles Coated by Carbon Network
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A lot of attention was paid to MnO among variety transition metal oxides that were used as anode materials for lithium ion batteries, due to its relatively high theoretical capacity, appropriate electromotive force, low cost and environmental-friendliness. A novel and controllable approach is developed for the synthesis of MnO@carbon cubic cages within particles coated by carbon network through a bio-inspired process accompanied with freeze drying and carbonation process. The cubic structure presented excellent electrochemical performances with excellent cyclability, high specific capacity, and superior rate performance. The unique carbon cubic boxes and carbon network can not only act as a conductive matrix, but also work as a buffer material to mitigate volume effect of MnO. The present strategy is inexpensive, easy to preparation and highly effective, offering a promising route for electrode development for lithium ion batteries.

Q-P17
Iron Cobalt / Polypyrrole Nanocomposites with Tunable Broadband Electromagnetic Wave Absorption
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Magnetic nanoparticles (NPs) /conducting polymer nanocomposites are of great potential candidates for advanced electromagnetic wave absorbents due to their unique physical properties such as strong absorption, low density and good anti-oxidation. Herein, Iron Cobalt nanoparticles (FeCo NPs) were prepared by a modified chemical reduction method and FeCo/polypyrrole (PPy) nanocomposites were synthesized by in situ chemical oxidative polymerization.

The detailed procedure was carried out as follows: FeCo particles and 0.2 g sodium linear-dodecylbenzenesulfonate was dissolved in 80 mL of distilled water under sonication, followed by slowly injecting 2 ml of pyrrole monomers into the mixture to form a uniform solution. Subsequently, pre-cooled (NH₄)₂S₂O₈ solution was added dropwise into the reaction system with vigorous mechanical mixing and the mixture was cooled in 278 K under stirring. The precipitation was centrifugalized and washed with distilled water and ethanol until the supernatant became colorless. The composite materials were dried under vacuum for 2 h. Pure PPy was prepared by the same conditions without FeCo nanoparticles. The FT-IR spectra of pure PPy and FeCo/PPy composites could prove the existence of a strong interaction between the FeCo nanoparticles and pyrrolie moieties in PPy polymers.

The nanocomposites exhibited excellent electromagnetic wave absorbing performance. The maximum reflection loss (RL) reaches -52.30 dB at 13.40 GHz with an absorber thickness of 2.15 mm and the effective absorbing width (RL<-10 dB) is located at 11.31~16.37 GHz. The dipole polarization, interface polarization and space-charge polarization of the nanocomposites contribute to the dielectric loss to electromagnetic wave. Moreover, the natural resonance, exchange resonance and eddy current loss of the nanocomposites contribute to the magnetic loss to electromagnetic wave. It is the synergetic effect between dielectric loss and magnetic loss of the nanocomposites and the good electromagnetic match that result in excellent electromagnetic wave absorption. These FeCo/PPy nanocomposites have good properties like wide absorbing frequency, strong absorption, good compatibility, low density, and small thickness. The present research provides a competitive pathway to make novel composite materials for controllable absorbing of the broadband electromagnetic wave.

Q-P18
Organic functionalization of ZnO nanosheets with polymer containing N-vinyl carbazole and their properties
Recently, the demands of energy and environmental promoted the great progresses of advanced functional materials, especially carbon nanomaterials, metal oxides, metal sulfides, noble metals, functional polymers, et al. Among metal oxides, ZnO is multifunctional material, and has a great potential to be applied in UV detector, new energy, photocatalysts, water splitting, treatment of organic pollutants, different devices due to low-cost, synthesis simple, unique properties. The disadvantage of ZnO is only UV region active. This is not favor to make full use of the visible light. To utilize the visible light more effectively, many studies are focuses on ZnO based nanocomposites include morphology tailoring, band-gap engineering, C,N,B doping, modification with carbon nanotube, carbon dot, graphene and its oxide, polymer, noble metals, metal oxides, metal sulfides, p-n junction, heterostructures, core/shell structured nanocomposite, et al. As a good photocatalyst for treatment of organic pollutants, some key issues of photocatalysts are needed, such as, good adsorption to visible light, charge generation, separation, transfer of nanocomposites easily under irradiation of visible light, delaying the time of recombination of photo-induced charge generation, and so on. To improve adsorption properties to visible light and pave the effective conductive channels for charge transfer and separation is possible to enhance the efficiency of photocatalyst for treatments of organic pollutants.

Reviewed the modified methods to ZnO nano/micro-structures, the core/shell structured ZnO based nanocomposites have more attractive because of nanocomposites holding combination properties of core and shell materials. To prepare the shell layer is more simple and effective selecting appropriate functional polymer, which it can be constructed with nano-coating approach. For many years, the authors are very interested in organic functional materials or organic-inorganic nanocomposites. It is well known that PVK (N-vinyl carbazole polymer) is typical organic functional materials, which is generally used as charge transfer materials for the applications of several organic electronic devices. In this paper, surface modification of ZnO nanosheets with polymer containing –COOH group and N-vinyl carbazole was performed with self-assembly process for improving the adsorption to visible light and properties of charge transfer in nanoscale.

Raw Materials used in the experiment. Zinc nitrate (AR), hexamethylenetetramine (AR), sodium hydroxide (AR), acrylic acid (AR), ammonium persulfate (AR), N, N-dimethyl acrylamide (AR), styrene (AR), N-vinyl carbazole (AR), di-benzoyl peroxide (AR), ammonia (CP, the purity is 25%), rhodamine B (AR), methylene blue (AR), et al. were commercially available.

ZnO nanosheets was synthesized by a hydrothermal approach according to the previous report. The synthesis of polymer containing N-vinyl carbazole was utilizing radial polymerization of acrylic acid, N, N-dimethyl acrylamide and styrene monomer (N-vinyl carbazole is dissolved in styrene monomer).

Assembly of polymer containing N-vinyl carbazole and –COOH groups on the surface of ZnO nanosheets containing –OH group is as follow: In the experiment, about 0.5-1 g ZnO nanosheets was added in 300-500 mL glass vessel, 3-10 mL polymer containing N-vinyl carbazole and –COOH groups solution and 100 mL water were added, mixed with ultrasound for 15-30 min, standing for 5-15 days, then filtrated, washed repeatedly 5-6 times, dried at room temperature.

Comparison of the nanocomposites to the removal of organic pollutants: In 50 mL transparent of vials, about 0.05g as-prepared nanocomposite was added respectively into 40 mL of 10^{-5} M rhodamine B solution or methylene blue (rhodamine B and methylene blue were selected as simulating organic pollutants). 10^{-5} M rhodamine B or methylene blue solution were used as the reference one. The above mentioned of transparent of vials were placed with 2-3 days under exposure to natural sunlight indoor and at room temperature.
A series of characterizations were performed by SEM (scanning electron microscopy) (using Hitachi S-4800), the Fourier-Transform Infrared (FTIR) spectra, The UV-Vis (Ultra-violet visible spectroscopy) (the samples were using suspension), XRD characterization (The powders' X-ray diffraction (XRD) patterns were carried out), et al. The images of SEM showed that a very layer of polymer was deposited on the surface of ZnO nanosheets. The results of FTIR are also supported that the main adsorption bands of acrylic acid, N, N-dimethyl acrylamide, N-vinyl carbazole, and styrene were present in the nanocomposite. The curve of UV-Vis of resulting nanocomposite indicated that the adsorption was extended to the visible light. It illustrated that the organic-inorganic nanocomposites can utilize the visible light for environmental applications, and have good activity to visible light.

The photoconductivity response to visible light with low-power were studied based on interdigital electrodes of Au on flexible PET (polyethylene terephthalate) film substrate with casting method. The results indicated that the photoreponse of ZnO nanosheets modified with the polymer containing N-vinyl carbazole to weak visible light were also changed greatly. This illustrated that the organic-inorganic nanocomposite showed good activities to weak visible light, which it can be easily produced photo-induced charge generation, avoiding the recombination of charges produced by visible light. Photocatalytic efficiency was examined by selecting typical organic pollutants, some good results were obtained. These results also supported above view-points. We believed that the resulting nanocomposite looked like nanoreactors, and ZnO nanosheets were the center of treatment of organic pollutants as factory, the polymer layer on the surface of ZnO nanosheets acted as polymer nets extracting organic pollutants continuously from solution, N-vinyl carbazole took harvesting visible light and transferring charge in nanoscale, styrene and N, N-dimethyl acrylamide polymer chain segment were favor to organic pollutants with hydrophobicity, the acrylic acid polymer chain segment were anchored on the surface of ZnO nanosheets, and have good affinity to organic pollutants with hydrophilic. It can capture the different organic pollutants with adjusting the ratio of different polymer chain segments. Therefore, it would be developing organic-inorganic nanocomposites with external stimuli response, nanoreactors, photocatalyst, treatment of organic pollutants, et al. This method is also extended to modify other metal oxides. Some similar results were obtained.

In summary, the polymer containing N-vinyl carbazole were synthesized. ZnO nanosheets modified with above water-soluble polymer containing N-vinyl carbazole holding –COOH groups by self-assembly process was carried out. The photoconductivity response of organic-inorganic nanocomposites to visible light with low-power were examined based on interdigital electrodes of Au on flexible PET film substrate. The results showed that the ZnO nanosheets modified with the water-soluble polymer containing N-vinyl carbazole produced photo-induced charge generation very easily to weak visible light and possessing good visible light activities. This would be good applications in photocatalysts, nanoreactors, self-cleaning films, coatings, and treatment of environmental fields.

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We declare that we have no conflict of interest.
By means of three-dimensional finite element method (FEM) which is based upon the micro-mechanical model of fiber-reinforced composites, this paper selects representative volume elements and studies the effect of the five factors, namely, cooling rate, matrix elastic, fiber elastic, interface elastic and fiber volume fraction, on the interface thermal residual stress and its distribution law in epoxy resin NPEF-170/unidirectional glass fiber composites. The results indicate that thermal residual stress is mainly distributed on the fiber and the matrix of neighboring interface; the thermal residual stress on the fiber and the matrix declines as the distance to the interface layer grows; and it tends to zero at the distance of 1.5 times the radius of the fiber away from the interface. The increase in any of the four factors, namely, cooling rate, matrix elastic, fiber elastic, and fiber volume fraction would trigger the rise of thermal residual stress in epoxy resin NPEF-170/unidirectional glass fiber composites. The additional flexible interface layer can eliminate and transfer thermal residual stress effectively, whose effectiveness mainly depends on the difference between interface elastic and fiber elastic.

Q-P20

Silicon Carbide Whiskers: Good Oxidation-Resistance and Enhanced Microwave Absorption Properties
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Owing to the light-weight and the increased microwave absorption properties in high-temperature environment, silicon carbide (SiC) is regarded as a promising high-temperature electromagnetic wave absorbing materials. Most recently, SiC whiskers has been found to exhibit higher dielectric permittivity and microwave absorption properties than those of the granular SiC, which shows great application potential. However, there is little work on the intrinsic oxidation behavior of SiC whiskers under higher temperature. And compared with carbon and ferromagnetic absorbing materials, it is expected that the electromagnetic wave absorbing ability of SiC whiskers could be further improved. In this work, the oxidation behavior of SiC whiskers with a diameter size of 50-200 nm has been investigated at 600-1400 °C in air. Experimental results reveal that SiC whiskers exhibit a low oxidation rate below 1100 °C while a significant larger oxidation rate after that. This can be attributed to the small diameter size of whiskers, which determines that it is hard to form a protective SiO$_2$ layer thick enough to hamper the diffusion of oxygen effectively. But the SiC whiskers still have a higher heat resistance than carbon and ferromagnetic absorbing materials. In order to further improve the microwave absorption properties, SiC whiskers doped with metal and non-metal elements have been synthesized via microwave heating. Experimental results indicate that the doped SiC whiskers show a higher dielectric permittivity than that of undoped SiC whiskers. Meanwhile, both the dielectric permittivity and the microwave absorption properties of doped SiC whiskers increased significantly with the increase in dopant concentration. First-principle calculation reveals that doping tunes SiC to be half-metallic or reduce the band gap and thus its electric conductivity is enhanced. And a 3D network of conductive path for the dissipative current can be formed through whiskers connecting. In this way, the conduction loss was increased significantly through the enhanced electrical conductivity. Besides that, the transmission electron microscopy suggests a large number of stacking faults were formed in the doped SiC whiskers, which can induce the dipolar loss. So both the dielectric permittivity and microwave absorption
properties of doped SiC whiskers were significantly improved due to the synergistic effect of the enhanced conduction loss caused by doping and the dipolar loss induced by stacking faults.

Q-P21

Microwave magnetic and dielectric properties of M-type hexaferrite BaFe12-xScxO19 at 0.5-18 GHz

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The hexagonal ferrites have been widely used because of their magnetic properties and microwave applications. Pure BaFe12O19 M-type hexaferrite (BaM) has strong magnetic anisotropy field and high natural resonance frequency which is about 42.5 GHz. By the replacement of Fe3+ with other ions (e.g. Co3+, Ti3+), BaM can be used for microwave absorption in multiple bands because of the adjustable magnetic anisotropy field. Also, BaM can obtain smaller anisotropy field through partial replacement of Sc3+ for Fe3+, which has the potential applied in low-frequency microwave equipment at 0.5-18 GHz.

The ceramics of Sc-doping BaM (BaFe12-xScxO19, x = 1, 1.4, 1.8) are prepared through conventional ceramics techniques. The high-purity powders of BaCO3, Fe2O3 and Sc2O3 are weighed, mixed and grounded. Then, the mixture is calcined at 1000°C in air for 12h and pulverized. After that, the resulting mixture is remixed and sintered in air for 48h at 1175°C. The crystal structures, static magnetic properties, microwave magnetic and dielectric properties (0.5-18 GHz) are investigated.

The results show that the crystal structures of BaFe12-xScxO19 are composed by spinel blocks (S) and hexagonal blocks (R). In the case of Sc3+ substituted ferrites, Sc3+ occupies 4f and 2b sublattice sites in the R-block. The unit cell parameters c and a show an increase with the concentration of Sc3+ (radius = 0.73 ) whose radius is bigger than the radius of Fe3+ (radius = 0.64 ). The Fe3+ of 2b site in the M-type barium ferrite gives a considerable contribution to the high magnetocrystalline anisotropy. The number of 2b site occupied by Sc3+ is increased with increasing x. As a result, the overall magnetocrystalline anisotropy of BaM reduces effectively, and the natural resonance frequency (fr) gradually decreases from 18 GHz to 10 GHz. On the other hand, the mechanism of polarization in hexaferrite can be attributed to the hopping of electrons at the 4f site. When the Sc3+ replaces the Fe3+ at 4f site, the decrease of the hopping electrons results in the reduction of dielectric constant. The values of real part (ε') and imaginary (ε'') part of the permittivity decrease gradually with increasing x in the samples. However, abnormal values of ε' accrues at x = 1.4 which are greater than the values of ε' when x = 1, owing to the conical spiral magnetic ordering. In fact, this magnetic ordering generates the spontaneous polarization which leads to the increase of dielectric constant at alternative magnetic field. Our results should be useful in the design of electromagnetic wave absorber for applications in the field of radar stealth.

Q-P22

Thickness effect of epitaxial BiFeO3–CoFe2O4 nanocomposite films on magnetic properties

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Objective: Perovskite-spinel nanocomposite thin films consisting of two immiscible phases are of great interest for multiferroic devices due to the coexistence of ferroelectric and ferrimagnetic properties and the observation of magnetoelectric coupling between them. The most commonly studied system consists of ferrimagnetic CoFe2O4 (CFO) pillars in a ferroelectric BiFeO3 (BFO) matrix. It is well known that magnetic properties such as coercivity
and anisotropy of the CFO pillars in the nanocomposite are governed by the pillar shape, size, strain state and coupling with the perovskite matrix. The effects of pillar width modulation on the strain state and magnetic properties of CoFe2O4-BiFeO3 nanocomposites are described.

Methods: BFO-CFO epitaxial nanocomposite thin films 30 to 90 nm thick were deposited on (001) SrTiO3 (STO) substrate by alternating ablation of BFO and CFO targets. Some films were deposited at lower temperatures of 480 - 600 °C, and sequential deposition at two different temperatures, 560 and 650 °C, was carried out to obtain pillar shape modulation. Phase identification and strain along the in-plane and out-of-plane directions for the BFO and CFO in the nanocomposite were carried out by X-ray diffraction (XRD) and asymmetric reciprocal space mapping (RSM) using high resolution x-ray diffraction (HRXRD, Bruker-AxsD8). Surface morphology and phase separation were investigated using scanning electron microscopy (SEM, Helios Nanolab 600) and cross sectional SEM images were obtained with focused ion beam (FIB) milling after deposition of carbon and Pt layers. The magnetic properties of the BFO-CFO nanocomposites were investigated with vibrating sample magnetometry (VSM) at an applied magnetic field of -10kOe ~ 10kOe at room temperature.

Results: In this work, the effects of pillar width modulation on the strain state and magnetic properties of CFO-BFO nanocomposites are described. In-depth structural and strain analysis of nanocomposites was performed using high resolution X-ray diffraction, since strain and epitaxy are important in determining the structure and properties of self-assembled nanocomposites. Self-assembled epitaxial CoFe2O4-BiFeO3 nanocomposite films, in which pillars of CoFe2O4 grow within a single crystal BiFeO3 matrix, show both ferrimagnetism and ferroelectricity. The pillars typically have a uniform cross-section, but here two methods are demonstrated to produce a width modulation during growth by pulsed laser deposition. This was achieved by growing a blocking layer of BiFeO3 to produce layers of separated pillars or pillars with constrictions, or by changing the temperature during growth to produce bowling-pin shaped pillars. Modulated nanocomposites showed changes in their magnetic anisotropy compared to nanocomposites with uniform width. The magnetic anisotropy was interpreted as a result of magnetoelastic and shape anisotropies.

Conclusions: Two strategies for modifying the shapes of CoFe2O4 pillars in a CoFe2O4 - BiFeO3 nanocomposite were demonstrated. First, a BiFeO3 layer was introduced as a blocking layer to create layers of disconnected pillars or pillars with constrictions. The former showed magnetic hysteresis dominated by the layer of taller pillars, while the latter had a higher anisotropy. Second, pillars with modulated diameters were made by changing the deposition temperature during growth. High aspect ratio pillars with small width formed at 560 °C stacked on wider pillars grown at 650 °C, and the magnetic hysteresis loops showed lower coercivity and saturation field than uniform-width nanocomposites grown at 650°C. These strategies enable the magnetic properties to be tuned for potential applications in multiferroic devices.

Q-P23

Self-Assembled Epitaxial BiFeO3-MgO and BiFeO3-MgAl2O4 Nanocomposite Films synthesized by Pulsed Laser Deposition
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Objective: We report on the growth of nanocomposites made by combinatorial pulsed laser codeposition of MgO or MgAl2O4 (MAO) and a perovskite BFO, with a focus on examining interdiffusion between the two phases during growth, and the deposition conditions that determine which phase forms. MgO and MAO layers are quite well lattice matched to CoFe2O4 or MgFe2O4, suggesting their possible utility as diffusion barriers to be incorporated within nanocomposite films. CFO/MFO nanocomposites have been reported previously.
Methods: MgO, MgAl2O4, CoFe2O4, and MgFe2O4 (MFO, magnesium ferrite) targets were prepared by a conventional oxide sintering method. A Bi-rich Bi1.2FeO3 target was prepared by Plasmaterials, CA. BFO-MgO and BFO-MAO nanocomposite films were deposited by combinatorial pulsed laser deposition on SrTiO3 (001) substrates. The phases present in each film were investigated by XRD (PANalytical X’Pert Pro). Top view images of the surface morphology were obtained from scanning electron microscopy (SEM, Helios Nanolab 600). In-plane and out-of-plane magnetic hysteresis loops were measured using vibrating sample magnetometry (VSM, ADE model 1660) at a magnetic field of -10 kOe ~ 10 kOe at room temperature.

Results: Phase separation of BiFeO3 and MgO or MgAl2O4 was observed within a very small growth window due to substantial chemical diffusion. Diffusion of iron from BiFeO3 to MgO or MgAl2O4 formed a magnetic spinel ferrite, which led to the formation of magnetic nanocomposites from codeposition of non-magnetic MgO or MgAl2O4 and antiferromagnetic BiFeO3. A BiFeO3-MgO nanocomposite was used as a blocking layer to prevent interdiffusion between a nanocomposite consisting of magnetically hard CoFe2O4 pillars in BiFeO3 and one consisting of soft MgFe2O4 pillars in BiFeO3, but the MgO did not grow selectively on the CoFe2O4 and it led to the merger of neighboring pillars. Chemical reactions between the four phases were investigated by X-ray photoelectron spectroscopy and transmission electron microscopy to understand the evolution of the (BiFeO3-CoFe2O4)(BiFeO3-MgO)(BiFeO3-MgFe2O4) nanocomposite film.

Conclusions: Self-assembled two-phase nanocomposite films were made by codeposition of BFO-MgO and BFO-MAO and phase formation was investigated. The BFO-MgO formed a nanocomposite consisting of spinel MxFO pillars in a BFO matrix within a very small window of deposition parameters, with little or no rocksalt MgO. In contrast, codeposition of BFO with an aluminum spinel, MAO, in which there is a lower lattice mismatch between the pure bulk phases, grew as a two-phase film but did not produce clearly defined crystallographic pillars.

Q-P24
Synthesis and High-Frequency Absorption Property of Flower-Like Nickel-Ferrite Composites
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Three-dimensional flower-like nickel-ferrite composites have been successfully synthesized via decomposition of the nickel-iron alkoxide precursors by varying the ratio of iron and nickel ion in the solution. The overall morphology and size of the particles have no obvious change compared with the precursors. The high-frequency absorption properties of the composites are investigated in a frequency range of 2-18 GHz. The reflection loss and bandwidth vary with the nickel ratio and thicknesses of the compositions, showing valuable prospect in high-frequency wave attenuation. The wave absorbing mechanism is also discussed, which can be attributed to the dielectric loss, magnetic loss, and the synergetic effect.

Q-P25
Surface modification of graphene oxide with pyrene derivatives and their photo-switching behaviors
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Surface and interface of nanocomposites took an important roles in exerting some functional properties and widening new applications. Some low-dimensional materials generally have abundant chemical groups and reaction activities. These surface chemical groups of nanomaterials provided a large platform to develop new materials and applications by surface chemical reaction and surface reconstruction of another typical materials. Recent several years, many advanced nano/micro-structured functional materials have been received considerable attention, and some excellent progresses were obtained. However, to improve their functional properties or chemical properties and widen new applications are still great challenges based on these existing materials. Among so many hot-fields materials, graphene and its nanocomposite were developed rapidly, due to their excellent mechanical and chemical stabilities, high specific surface area, outstanding electrical conductivity, et al. Graphene based nanocomposites involved in graphene/metal oxides, graphene/metal sulfides, graphene/polymers, graphene/metals, graphene/DNA, et al. And they are widely used in various applications, including solar cells, fuel cells, electrodes, conductors, capacitors, chemical and biosensors, photocatalysts, and so on. The most important property of graphene is excellent charge-transfer characteristics. The graphene oxide is not only holding good charge transferring property, but also has abundant chemical groups on its surface, such as, -COOH, -OH, epoxide group. Therefore, graphene oxide is good candidate substrate for further constructing other functional materials in nano-scale. In this paper, graphene oxide and pyrene derivatives were selected as representative materials for studies. Pyrene derivatives selected as model functional materials are based on the following reason. Pyrene is a well-known fluorescent materials with multifunctional properties containing conjugated rings. Pyrene-based nanomaterials are of major interest to design organic electronic devices because of their excellent photo-physical properties. Some typical applications of pyrene include in chemical and bio sensors, light emitting diodes, dye sensitized solar cells or to shed light on the structure of proteins, peptides, lipid membranes, et al. Surface modification of graphene oxide with pyrene derivatives can be increase the conjugation degree of graphene, and result in fine tuning in the band gap of graphene or developing new graphene based nanocomposites and devices.

The preparation of graphene oxide was using chemical method, which is according to the previous report utilizing graphite, concentrated sulfuric acid, concentrated nitric acid, potassium permanganate, et al. Pyrene derivatives were used pyrene compounds containing –NH2 and –COOH groups, which were commercially available. Pyrene derivatives were dissolved in organic solvents in the study. Assembly of pyrene containing –NH2 groups on the surface of graphene oxide is as follow: In the experiment, about 20-50 mL graphene oxide was added in 250 mL glass vessel, 10-20 mL pyrene containing –NH2 groups solution (concentration is about 10 mg/mL) were added, mixed with ultrasound for 15-30 min, standing for 5-10 days, then filtrated, washed repeatedly 5-6 times.

A series of characterizations were performed by SEM (scanning electron microscopy) (using Hitachi S-4800), TEM (transmission electron microscopy) (with a JEM-2000CX), the Fourier-Transform Infrared (FTIR) spectra, The UV-Vis (Ultra-violet visible spectroscopy) (the samples were using suspension), photoluminescence spectra (the samples were using suspension), et al. The images of SEM and TEM showed that a very layer of pyrene was deposited on the slice of graphene oxide. The results of FTIR are also supported that the main adsorption bands of pyrene were present in the nanocomposite. The curve of UV-Vis of resulting nanocomposite indicated that the adsorption was almost covered the whole region of visible light. The results of PL showed fluorescence quenching. It illustrated that the strong interaction between graphene oxide and pyrene.

The photoconductivity response to visible light and 808 nm laser with low-power were studied based on interdigital electrodes of Au on flexible PET(polyethylene terephthalate) film substrate with casting method. The results indicated that graphene oxide modified with pyrene showed the photocurrent increased obviously to visible light, and photoresponse to weak 808 nm laser emerged photo-switching behavior (about two orders of
magnitudes changes, and its recoverability is rapidly). This illustrated that the resulting nanocomposite showed activities to visible light and NIR (near-infrared) light. This is very interesting results. One reason is that in nature, many insects guided their orientation with aid of weak moon-light and near-infrared light. This is helpful to simulate the tentacle of insects for light detector. It would be developing light detector, nano-carriers with external stimuli response, organic photocatalyst, et al. This method is also extended to modify other low-dimensional materials, such as, CNTs, ZnO, et al. Some meaningful results were obtained.

In summary, grapheme oxide modified with pyrene holding –NH2 groups by self-assembly process was carried out. The photoconductivity response to 808 nm laser with low-power were studied based on interdigital electrodes of Au on flexible PET film substrate. The grapheme oxide modified with pyrene derivatives showed good photosresponse to weak 808 nm laser. This method is simple and effective. It would be provided a simple approach to develop some new functional materials based the existing materials utilizing the surface chemical groups. It is also favor to study some key issues of surface chemistry and physics of nanocomposites and extend their applications. It would be developed the light detector to NIR, biomimetic fields or external stimuli driven nano-carriers for biomedical fields.

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We declare that we have no conflict of interest.

Q-P26
Preparation of Monolithic Foamed gold with ultralow density
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Noble metallic foams with low density are desirable in high energy-density physical experiments. In this study, Gold foams with ultralow density were successfully synthesized from a template-dealloying approach. Microspherical silicon dioxide (SiO2) was employed as the sacrificial template. The results indicate that the SiO2 could be coated by gold colloid with average grain size of 4.6 nm which was made in toluene by the electrostatic effect. Au and Ag nanoparticles were sequentially coated onto the SiO2 surface from a three-step deposition process. The casting procedure is analogous to slip-casting of ceramic that results in randomly-packed SiO2/Au/Ag spheres with void spaces between individual particles. The templates were removed and Au-Ag alloy foams were generated after calcination at 400℃. Self-supported Au foams with bimodal porous structure were produced by dealloying of the less noble Ag component. The prepared Au foams are composed of hollow microspherical shells with diameter of about 10 μm, while the shell walls are in wormlike nanoporous structure with centered pore diameter of about 30nm~70 nm. The ultra-low-density gold monoliths with porous structure, cylinder of ~2.3mm, density of 0.23g/cm3, porosity of 98.8% was obtained.

Q-P27
The synthesis and characterization of magnetic Al/NiO composite pigments with low infrared emissivity
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Generally, traditional low infrared coatings based on metallic pigment such as Aluminum flakes have high lightness and high radar reflectivity. However, due to the requirement of VIS/IR/radar stealthy compatibility, the single metallic pigment cannot have low lightness, low infrared emissivity and low radar reflectivity simultaneously. Herein, we use a simple and efficient method to synthesize magnetic Al/NiO composite pigments which possess all these attributes to a degree. The Al/NiO composite pigments are fabricated through mixing aluminum flakes with nickel carbonate (NiCO3) and transforming the NiCO3 shell to NiO by thermal cracking, then altering the shape and forming NiO nanoshell on aluminum flakes in hot flowing liquid. The morphology, phase structure, visible/IR spectra of reflectance and magnetic hysteresis loop are characterized by FE-SEM, XRD, UV/VIS/NIR spectroscopy, Fourier infrared spectrometer and VSM. The results indicate that the covering area of NiO on the aluminum flake can be tuned by the addition amount of NiCO3 and the reaction temperature of hot flowing, both of which pay a key factor on the VIS/IR spectral reflectance and magnetic properties. The magnetic Al/NiO composite pigments with low lightness and low infrared emissivity can be obtained at 130°C for 24 h in hot flowing liquid. The lightness L* can be decreased to 75.94, however the infrared emissivity (8-14μm) is also low to 0.421. Compared with the single Al flakes, Al/NiO magnetic composite pigments present stronger magnetic properties. Therefore, the Al/NiO magnetic composite pigments have offered a new choice for the pigments of multispectral stealth coating.

Q-P28
Low frequency electrical properties of Co/Al2O3 composite
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Porous Al2O3 ceramic was characterized of an excellent insulator, with relative high porosity and certain strength. When some metal particles were added into the ceramic to obtain ceramic-metal composites, some special properties would appear. We investigate the electrical properties of the Co/Al2O3 composite at low frequency range. The alumina matrix was obtained by pressureless sintering; the metal Co was loaded onto the porous ceramic by impregnation-reduction process. When the cobalt content of composites reached 13 wt%, 20 wt%, 24 wt% respectively, then, the composites were put into reaction kettle for 24 h at 350 ℃ for further processing, denoted as chemical method. The purpose of chemical method was to change the microstructure of the composites. Eventually, second reduction process was needed. The microstructure of composite material was analyzed by XRD and SEM. The low frequency electrical properties were tested using the HP4294 impedance analyzer (~20MHz). The results showed that the metal Co with flocculent structure appeared on the pores wall of the porous ceramic. The low frequency electrical properties which include permittivity, AC conductivity and impedance are changed with the increase of the Co content. Generally, the permittivity value of high metal content samples is larger than lower ones. And those samples show capacitive character.

Q-P29
Microwave electromagnetic and absorption properties of Ba3Co2Fe24O41 hexaferrite for GHz application
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Presently, hexagonal ferrite attracts people's great attention because of its application for microwave devices. Ba$_3$Co$_2$Fe$_{24}$O$_{41}$ as a traditional Co$_2$Z type hexagonal ferrite possesses excellent magnetic properties with large permeability and high resonance frequency in the GHz range. Thus it is considered to be a good candidate for the high-frequency applications. In this paper, Ba$_3$Co$_2$Fe$_{24}$O$_{41}$ samples have been prepared by auto-combustion of citric acid sol-gel method, and the XRD results show that Co$_2$Z phase is first formed to the main structure at 1300 °C with less Co$_2$Y phase. However, Co$_2$W is hard magnetic phase which is formed at 1350 °C. Therefore, we obtain pure Co$_2$Z phase by second sintering at 1315 °C. The soft magnetic properties of samples have been measured by VSM, and the most optimal results are that the $M_s$ is almost 42 emu/g and the $H_c$ is about 19 Oe. The microwave electromagnetic and absorption properties of all the samples by second sintering have been investigated. The permeability spectra show that the sample with a high resonance frequency of 3.16 GHz and a large permeability of 3.5 has been obtained. The reflection loss (RL) curves of samples sintering at 1300 °C and second sintering at 1315 °C have been obtained by use of the complex permeability and permittivity spectra. It was shown that the absorption frequency range of the two samples with reflection loss better than -30 dB was from 3.9 GHz to 4.3 GHz and 3.5 GHz to 4.0 GHz respectively for the thickness is 5 mm. However, as for the 3 mm, reflection loss peak value is almost -30dB by second sintering, which is more appropriate for the high-frequency devices applications.

Q-P30

Novel Low-Density Cork Composite Thermal-Insulation Material with High Performance

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Objective: Thermal insulation materials protect normal operation of instruments by blocking heat-transfer. Especially for aerospace instruments, thermal insulations are key structures, which protect spacecrafts from being burned or overheated in aerodynamic heating environments. With the development of modern space technology\cite{1,2}, the performance requirement of thermal insulation material has gradually improved to avoid the thermal damage caused by the aerodynamic heating generating in the process of flight on the surface of spacecraft. Some new requirements, such as light weight, high heat load adaptability, high mechanical strength, low-cost, short production cycle, and so on, promotes the rapid development of high-performance thermal insulation materials.

Results: This novel cork composite exhibits low coefficient of thermal conductivity, high heat resistance, ablation resistance, high suppleness, and excellent mechanical performance. It can be processed into plates and other special-shaped boards, such as U-shaped and cylinders (Figure 1). These features allow conventional application of cork composite as heat-insulating coating for various parts of aerospace equipments.

Figure 1. Novel cork composite in various shapes.

This cork composite is produced from cork grain, modified phenolic resin adhesive, nitrile rubber, reinforced fiber and other ingredients. The modified phenolic resin affords more than 60% carbon debris at 1000 °C, and exhibits excellent properties on high temperature resistance, instantaneous ablation resistance, mechanical performance, and flame resistance. The introduction of modified phenolic resin could greatly enhance the ablation resistance of cork composite, while nitrile rubber improves the suppleness, and reinforced fiber enhances the tensile strength
and impact-resistance strength. The physical and mechanical parameters of cork composite are summarized in Table 1.

When ablated at 800 °C, the flat surface of cork composite with a little cracks indicates its excellent ablation resistance (Figure 2). There is no significant deformation of cork composite under long-term stress, and a rapid elastic recovery rate is observed. The water adsorption rate of cork composite is under 1% after 24 hours of swelling test. The good waterproof performance allows the application of cork composite in humid environment.

Figure 2. The cork composite plates ablated at 800 °C

The excellent mechanical strength and suppleness of cork composite expands its application range. Besides flat products, U-shaped, cylinder, cone, as well as other special-shaped products can also be produced according to the protection requirements of different parts of high-speed flying objects in order to avoid damaging the property of material after secondary processing and assembly.

Conclusion: The cork composite is a novel low-density and highly efficient thermal insulation material. It possesses low thermal conductivity coefficient, high temperature resistance, ablation resistance, high slenderness, and excellent mechanical performance. In addition, it is produced by low-cost raw material and short processing cycle. Therefore, the cork composite will meet various new requirements on modern space technology for high-performance thermal insulation.

References

Q-P31

Tunable skyrmion textures and excitation modes in FePt multilayer films

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A skyrmion crystal is a topologically stable spin configuration which attracts great interest due to the small size and low driven current density as information carriers [1]. So far skyrmion spin textures have been observed in non-centrosymmetric chiral crystal and heavy metal/ultrathin ferromagnetic layers with relatively weak Dzyaloshinskii-Moriya interaction (DMI) [2, 3]. In particular, skyrmion crystal can be stabilized at ambient temperature without DMI via interlayer exchange coupling between soft-magnetic patterned structures and out-of-plane magnetized films. In this letter, we focus on simulations of isolated skyrmion in nanostructured perpendicularly magnetized FePt multilayer. FePt films have variable magnetocristalline anisotropy due to the partially chemically ordered phase. By decreasing the anisotropy of FePt film in the top layer, the magnetic skyrmion textures shift from the Neel skyrmion to the Bloch skyrmion. The corresponding excitations activated by the microwave magnetic field will contribute to the understanding and manipulation of skyrmion for applications.

The nanodisks with two FePt layers and a space layer are used to study the formation and the dynamic of skyrmions in the absence of DMI by OOMMF code [4]. The models were discretized into 2 nm × 2 nm × 1 nm cells. To obtain the static magnetic configuration, a bias field is applied for fully magnetizing the element and then reduced to zero allowing for the magnetization to relax. The dimensionless damping α was chosen to be 0.5 for rapid convergence. As for dynamic simulations, a microwave field perpendicular to the strip was applied and α
was set to 0.01. For the calculation, the Landau-Lifshitz-Gilbert equation is solved with a difference method and a Runge-Kutta method, respectively.

We consider the influence of the magnetic parameters of top and bottom FePt films on the skyrmion generation. The phase diagram of the Neel skyrmion, the Bloch skyrmion and the uniform state are shown for a given thickness and magnetic anisotropy. The magnetization rotates in the plane perpendicular to the radial direction in the Bloch skyrmion. This is due to the vortex state, which is stable in the smaller anisotropy region and prefers in-plane magnetization. However, it rotates along the in-plane radial direction in the Neel skyrmion. For the uniform state, the ground state is a perpendicularly magnetized single domain in which all spins are approximately along z direction. It is obviously observed that the diameter of the skyrmion decreases as the anisotropy increases.

The microwave magnetic field are applied to investigate the spin dynamics. After this perturbation, the time evolution of the magnetization of each cell is calculated. The discrete-time Fourier transform are performed to obtain the excitation spectrum, which consists of a certain number of sharp peaks. Each of them indicates a resolved eigenmode of the system. In order to study the dynamic response, we have further simulated the snapshot of dynamical magnetization for all resonant modes. In the Neel skyrmion, three distinct peaks are observed. The lower frequency peak is identified as the center mode, and higher frequency peak as the edge mode. The modes in the Bloch skyrmion is more complex due to the mode splitting. In addition, varying the anisotropy and thickness can cause nucleation and annihilation of the skyrmion state. For the existence of disordered A phase and ordered L10 phase in FePt films, the perpendicular anisotropy can be effectively controlled by a deposition process. Thus, it should not be hard to experimentally realize our method of skyrmion creation and excitation.

REFERENCES

Q-P32
Tribocorrosion Behaviors of D40 Steel in Artificial Seawater
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Both friction and corrosion are the key phenomena during the interaction of seawater with offshore structures and ships. Therefore, knowledge of the seawater friction laws and a better understanding of this phenomenon are needed for the design of safe and reliable offshore structures and successful operations in seawaters. So it is imperative to develop of the excellent steel materials with good corrosion resistance as well as anti-abrasion performance in seawater. This paper presents experimental studies on tribocorrosion behaviors of D40 steel in Artificial Seawater. The experimental material was D40 steel from Ukraine, with dimension of 10×10×3mm3 by wire cutting, With sandpaper gradually grinding TD planes to 1500# sandpaper, and polished by a polishing machine. The surface of specimens were etched by 3% HCl and 25% HNO3 for approximately 10s to reveal the microstructure. The microstructure and characterization, composition, and morphology of the specimen was carried out prior to and after wear studies and corrosion testing using optical microscopy, scanning electron microscopy (SEM), and
energy dispersive X-ray spectroscopy (EDX) elemental analysis. The XRD test is accomplished by PANalytical X Pert PRO, working voltage and current were 40 kV and 10 mA respectively. With Cu-Kα radiation source, and in a scanning range of 20° to 80°.

The electrochemical and corrosion-wear behaviors of D40 steel in artificial seawater were studied. The reciprocating wear tests were undertaken by BRUKER UMT TriboLab under the room temperature, the selected counterpart was WC balls with a diameter of 5 mm were used as counterbodies. Firstly, the dry friction test continued for 2 hours were performed under a load of 50N, an amplitude of 5 mm and a frequency of 1 Hz. all the specimen of D40 steel were cleaned ultrasonically with acetone for 10 min and dried with an electrical power before the wear test. After the wear tests, the worn surfaces were cleaned with ethanol and dried with hot air. The friction coefficient was continuously recorded by the computer connected to the tester and the wear depth and profile were determined by using a BRUKER ContourGT 3D non-contract optical profilometer. The morphologies and chemical compositions of the worn surfaces were investigated by an optical microscope and SEM.

The potentiodynamic scanning studies in a simulated seawater environment were conducted on the D40 steel. The open circuit potential, alternating current impedance and dynamic potential polarization curves were measured by IviumStat electrochemical workstation. The time of open circuit potential is 50 min, the frequency range of AC impedance measurement is 10^5~10^-2 Hz, the dynamic potential polarization curve is polarized by the cathode to the anode, and the scanning speed is 0.3 mV/s. Using Axio vision microscope on the friction of samples were observed, then using a Bruker contour GT white light interferometer the surface morphology observation of specimens after Tribocorrosion test, the corrosion morphology and corrosion products were also analyzed by SEM.

The microstructure, wear and electrochemical corrosion behaviors of the D40 steel in artificial seawater were investigated. The tribological behavior was characterized in terms of the friction coefficient and wear rate. The corrosion-wear analysis of the D40 steel was fulfilled by methods of mass loss, electrochemical testing and SEM. And the influences of electrochemical state on passive behavior, failure mechanism of passive film and corrosion-wear synergy were emphatically analyzed. The test was carried out both under the condition of no friction or friction circumstance. Based on the experimental results, the following remarks can be drawn.

1. The cathodic shift of open circuit potential and three order of magnitude increase of current density can be obtained during corrosion-wear process. Total corrosion-wear loss increases with increasing applied potential, confirming the synergy between wear and corrosion. High polarisation potential results in low coefficient of friction and high corrosion rate. The relative contribution of pure mechanical wear to total material loss decreases obviously with the increase of potential from open circuit potential to 0.9 V during corrosion-wear.

2. According to the comparison of the corrosion and the corrosion of the samples under the condition of no friction, the electrochemical impedance spectra of the samples can be obtained under the condition of friction and corrosion. At the same time, the similar conclusion can be obtained according to the electrochemical polarization curve.

3. Although the corrosive effects of seawater increased the wearing capacity of D40 steel under the process of corrosion and fretting corrosion in seawater, the seawater as a liquid lubricant reduces the friction coefficient of the D40 steel, with better tribological properties.

4. In comparison with the D40 steel under the condition of friction and corrosion and pure corrosion, the corrosion damage of D40 sample is more serious during the interaction between corrosion and abrasion process. The main reason is that the corrosion rate is accelerated by the friction process, and the two kinds of corrosion are controlled by the diffusion of oxygen.

Key words: D40 steel, seawater, tribocorrosion, open circuit potential, potentiodynamic polarization
Effect of Co,Zr additions on the magnetic properties of nanocomposite Nd$_2$Fe$_{14}$B/α-Fe magnets
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Owing to the rare-earth metal crisis, bulk anisotropic nanocomposite RE$_2$Fe$_{14}$B/α-Fe (RE=rare earth) alloys have attracted much attention in recent years due to their lower rare earth content and attractive hard magnetic properties. However, it is still a great challenge to obtain high-performance nanocomposite alloys with strong c-axis alignment by hot-deformation, since there is little RE-rich phase.

In order to enhance the c-axis texture of RE-lean alloys, various kinds of methods have been tried, the addition of Zn has been proved effective in improving micro-structure and magnetic properties of hot-deformed (HD) RE-Fe-Nb-B magnets. In recent years, additions of refractory metals have been used for the improvement of RE-lean nanocomposite magnets, which are suffering from coercivity deterioration because of the high volume fraction of soft magnetic phases. In this paper, the effect of the additions of Co,Zr on structure and magnetic properties of nanocomposite Nd$_2$Fe$_{14}$B/α-Fe magnets (with 1.5 wt.% Zn) were studied.

The micro-structural studies of nanocomposite Nd$_2$Fe$_{14}$B/α-Fe magnets were carried out by X-ray diffraction (XRD) with a Cu-Kα radiation and scanning electron microscopy (SEM), and the magnetic properties of magnets were measured by SQUID-VSM (superconducting quantum interference device) magnetometer (Quantum Design).

Preparation of anisotropic Nd-lean Nd-Fe-B magnets with improved coercivity
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Anisotropic bulk nanocrystal Nd-lean Nd-Fe-B magnets were prepared by hot-pressing the mixture of Nd$_{11.5}$Fe$_{81.5}$Nb$_3$B$_6$ melt-spun ribbons and pure Zn powder and subsequent hot-deforming. The magnetic properties and microstructure of hot-deformed magnets were also studied. The magnetic properties of hot-pressed (HP) magnets decrease after 2 wt.% Zn addition, but they increase significantly for hot-deformed (HD) magnets due to the formation of good c-axis texture and uniform microstructure. For HD magnets with 2 wt.% Zn addition, with increasing deformation, the remanence and maximal energy product increase and reach their maximal values at 65% deformation due to the increasing orientation. On the other hand, the grains increase and are elongated normal to the press direction gradually with increasing deformation. The variation trend is similar to that of traditional Nd-Fe-B magnets. However, there is an obvious improvement for coercivity in the initial stage of hot-deformation resulting from the adequate Zn diffusion into grain-boundary. When the deformation is larger than 65%, the magnetic properties are deteriorated due to abnormal grain growth. In order to further improve the coercivity, 2 at.% Nd was substituted for Dy and the coercivity of HD Nd$_{9.5}$Dy$_{2}$Fe$_{81.5}$Nb$_3$B$_6$ can increase to 12300 Oe.

Study of Microstructure of AlNiCo Magnetic Materials
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Alnico alloys can be used in harsh environment, such as high temperature (above 800 °C) [1], due to the high
curie temperature of them. However, they have main restriction of relatively low coercivity of \(H_c\). On the other hand, Alnico alloys consist of four major elements of Fe, Co, Ni, Al, and minor elements (e.g., Cu, Ti), which were composed of various micro and nano phases during the spinodal decomposition \([2]\). In this study, we tried to study the microstructure of alnico materials.

The microstructural studies of Alnico materials were carried out by X-ray diffraction, scanning and transmission electron microscopy. The atomic force microscope and SQUID-VSM were used to confirm the magnetic properties of them.

Q-P36
Structure and magnetic properties of Sr(Ti,Fe)O3 - CoFe2O4 nanocomposite thin films
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Objective: Oxide nanocomposite thin films have been extensively explored, in particular BiFeO3-CoFe2O4 (BFO-CFO) self-assembled nanocomposite in which a ferrimagnetic spinel phase (CFO) grows epitaxially as pillars within an immiscible ferroelectric antiferromagnetic perovskite phase (BFO). The nanocomposite shows a strong out-of-plane anisotropy as a result of both the shape anisotropy of the pillars and the dominant magnetoelastic anisotropy of the CFO under out-of-plane compression due to epitaxy with the BFO matrix. However, there is little work on oxide nanocomposites in which both materials are ferro- or ferrimagnetic. Such nanocomposites could combine the properties of both phases, and exchange coupling at the interfaces may lead to nanocomposites with exchange-spring behavior.

Methods: CoFe2O4, and Sr(Ti,Fe)O3 (STF) targets were prepared by a conventional oxide sintering method. STF-CFO nanocomposite films were deposited by combinatorial pulsed laser deposition on SrTiO3 (001) substrates and films were annealed at 800 and 1000 °C. The phases present in each film were investigated by XRD (PANalytical X’Pert Pro). Top view images of the surface morphology were obtained from scanning electron microscopy (SEM, Helios Nanolab 600). In-plane and out-of-plane magnetic hysteresis loops were measured using vibrating sample magnetometry (VSM, ADE model 1660) at a magnetic field of -10 kOe ~ 10 kOe at room temperature.

Results: In this work, nanocomposites made from STF and CFO are described. STF films with ~30% Fe on the Ti sites show a strong uniaxial magnetic anisotropy with out-of-plane easy axis, and a magnetic moment that persists to temperatures of order 1000 K. These results are attributed to magnetoelastic anisotropy, and a positive magnetostriction coefficient was measured for STF. STF-CFO nanocomposite thin films were grown by combinatorial pulsed laser deposition on SrTiO3 (100) single crystal substrates. As-deposited films did not show clear phase separation while rectangular pillars were visible in the matrix after annealing. The pillar density increased with CFO volume fraction. The magnetic properties strongly depend on annealing temperature. Magnetic hysteresis loops showed an out-of-plane easy axis originating from the tensile strain of STF and compressive strain of CFO along the substrate normal and the elongated shape of the pillars. Two-step hysteresis loops were observed in a narrow composition window.

Conclusions: Self-assembled two-phase nanocomposite films were made by codeposition of STF-CFO and phase formation was investigated. The STF-CFO formed a nanocomposite consisting of spinel CFO pillars in a STF matrix after furnace annealing. Magnetic measurements revealed an out-of-plane easy axis originating from the tensile strain of STF and compressive strain of CFO.
Published only

**magnetic behavior of Co substitution on multiferroic hexagonal YMnO3**

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Polycrystalline YMn_{1-x}Co_xO_3 with x ranging from 0 to 0.1 was successfully synthesized via standard solid-state reaction. The X-ray diffraction patterns reveal that those samples maintain single phase which show hexagonal-type with space group of P6_3cm. Effect of Co doping on the magnetic properties was studied. The temperature dependence of magnetization presents that the magnetization increase at low temperature and the magnetic transition at T_N increase from 73K up to 85K with increasing the doping concentration of Co. Meanwhile, the ferromagnetism exhibits stronger with doping. Varied valence distributions of Co and Mn ions led to the effective paramagnetic moment decreasing with Co introduction. These results were ascribed to the suppression of magnetic order and double exchange ferromagnetic interaction between the mixed valence-state of Mn^{3+} and Mn^{4+} ions by Co doping. In addition, the exchange-bias effect at low temperature was also observed and it may originate from exchange coupling at the interface between ferromagnetic and antiferromagnetic orders for the co-existence of these two orders in some temperature region.

**Fluorescent probe for the detection of marine microbe corrosion**

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Marine microbes could adhere on metal surface and form microbial membrane which will cause serious damage to substrate. It will be a great help to corrosion monitor and mechanical research if the metal ion caused by corrosion could be detected in microbial membrane.

In this work, a new type of composite probe forms by the conjugation between upconversion nanoparticles (UCNPs) and rhodamine derivative ligand which was characterized by SEM, TEM, EDS and IR spectra. The nanoparticles NaYF_4:20%Yb,2%Ho (abbreviated as UCNPs) has strong fluorescent emissions at 540 nm and 650 nm under excitation of 980 nm light source, among which the 540 nm wavelength could mostly overlap with the absorption peak of Ritz rhodamine. Therefore, a probe may be built based on the Förster resonance energy transfer (FRET) process between rhodamine and UCNPs, with ratiometric upconversion luminescence emission as output signal. The rhodamine-UCNPs probe has obvious fluorescence recognition to Cu^{2+}, Zn^{2+}, Al^{3+} and Cr^{3+} which could enhance the fluorescent intensity of the probe.

Finally, the probe was utilized to dye the microbial membrane attached on the metal surface for the investigation of the corrosion of marine microbial membrane. LSCM (laser scanning confocal microscope) test found that the probe could well detect the metal corrosion by evaluating the fluorescent intensity and the area of fluorescent spot in microbial membrane. The SEM and AFM observation could also verifies the staining metal surface.

**The Electromagnetic Attenuation Property of Multiphase Fe-Fe_3O_4-Al_2O_3 Cermets near Percolation Threshold**

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Cermets are applied in attenuating materials due to electromagnetic loss. In this paper, multiphase cermets composed of iron, iron oxide and alumina were successfully prepared by a two-step in situ synthesis process. The phase composition and microstructure of cermets were analyzed by XRD and SEM, respectively. It is shown that nano-sized cuboid Fe particles and octahedral Fe₃O⁴ particles were distributed in alumina matrix. The permittivity and permeability of composites were tested with RF impedance analyzer (0.1~1 GHz). The research showed that permittivity presents obvious frequency dispersion. Furthermore, dielectric constants of multiphase cermets get enlarged due to the enhancement of interfacial polarization. On the other hand, there is a magnetic loss peak in permeability spectra, which indicates typical relaxation behavior. It is possible to achieve better electromagnetic attenuation property by adjusting process parameters.

**Formation and characterization of magnetic barium ferrite with low coercivity via sol-gel auto-combustion method**

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The magnetic properties of barium ferrite can be control by changing the morphology and element doped on the magnetic control. Rare elements doped barium ferrite were successfully prepared by the sol-gel auto-combustion method. We analyze the character by X-ray diffraction, scanning electron microscopy and vibrating sample magnetometer. The saturation magnetization of Sr-doped barium ferrite powders prepared by sol-gel auto-combustion method can reach 61.97emu/g. La and Co doping can make the diffraction peaks of barium ferrite powders move. When they are calcined at 1200°C, the size of the grains can reach to micro grade, but as the temperature increase, the coercive force of the sample decreased, and the saturation magnetization intensity increased. the coercive force of samples calcined at 1200°C about 400 Oe which presented some soft magnetic. In addition the saturation magnetization can reach 60 emu/g which is higher than that of no-doped barium ferrite.

**Radio-frequency negative permittivity spectra and magnetic properties of carbon nanotubes/yttrium iron garnet granular composites**

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CNTs/YIG composites with different CNTs content were prepared by the hot-pressed sintering. The dielectric and magnetic properties have been investigated experimentally in the frequency range from 10 MHz to 1 GHz. When the CNTs content exceeded 10 wt%, the carbon particles interconnected with each other, leading to the formation of conductive network. The plasma oscillation of delocalized electrons resulted in the negative permittivity. The negative permittivity behavior was analyzed by Drude model. Meanwhile, CNTs/YIG composites with 10 wt%, 14 wt%, 18 wt% CNTs content presented the negative susceptibility in the frequency range from 300 MHz to 1 GHz due to the diamagnetic response. It is promising for the CNTs/YIG composites to obtain the simultaneous negative permittivity and negative permeability.

**High permeability from directional array of Z type ferrite sheets**
Z type ferrite (Ba₃Co₂Fe₂₄O₄₂) sheets have been prepared by the chemical precipitation method. The Z-ferrite sheets were directionally arranged to study the effect on the permeability. X-ray diffraction and field emission scanning electron microscopy were used to characterize the obtained Z-ferrites. The Z-ferrite exhibited sheet structure with the average diameter of 10.8 μm and thickness of 1.1 μm. It was found that the permeability was obviously improved from the directin array of Z-ferrites. The permeability was also calculated using the Maxwell Garnett equation. It was found that the Z-ferrite array showed strong interaction above 7.5 GHz. Our proposed method is possibly used to modulate the electromagnetic wave in the specific direction.

A novel forming process of bimetallic clad pipes with solid-liquid cast-rolling bonding process

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Bimetallic clad pipes have been widely used in numerous industrial fields (e.g., oil, gas, and marine platforms) owing to their outstanding general performance and the economic benefits derived from their production in form of monolithic parts. Numerous preparation technologies have been proposed which have made significant contributions to the industry. However, three main problems limiting the industrial mass production exist among these, namely the pre-assembled procedure of the substrate and clad pipes, production efficiency, and the bonding effect of the interface. In this study, based on traditional twin-roll casting technology, the solid-liquid cast-rolling bonding (SLCRB) process of bimetallic clad pipe was proposed with solid pipes and liquid metals as the base and cladding materials, respectively. To implement the SLCRB process, the equipment, mainly including the rollers with round grooves and the annular delivery device comprised with three-level stepped shunts and a tapered flow buffer zone, was designed and rebuilt based on the laboratory twin-roll caster. The casting experimental results show that the flow conditions in symmetrical channels is nearly uniform and the stable liquid level in the cast-rolling zone can be established when casting with the annular delivery device, which meets the process requirements. Finally, Al-Cu, Al-304 and Al-Ti bimetallic clad pipes with good bonding quality and an outer diameter of 38 mm were successfully fabricated at the casting speed of 2.2m/min. Besides, macro-morphology of the section and micro-morphology of the interface was analyzed. It shows that the SLCRB process provides an economical way to fabricate bimetallic clad pipes directly, combining high continuities, short process, and low cost.

Numerical Research on The Pull-out Failure of the GFRT Bolt

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The pullout of the fiber is the main failure after the fiber is broken in the tension process of GFRP bolt. The distribution of the fiber normal force and the interface shear stress with different interface were numerical analyzed with secondary development platform of ANSYS14.0 LS-DYNA, using ANSYS parametric design language of APDL, extension program written language of Visual C++, calculating unit of the explicit structural shell 163 units with the fastest Belytschko-Tsay algorithm and element life and death technology. The results showed that: the interface structure plays a key role for the mechanical behavior in the tension process of GFRP bolt. Firstly, there is stress concentration at the fiber broken point on the lower end and the upper end of the matrix and the concentration of the lower end is more distributed widely and seriously. Secondly, the interface with bigger layer thickness and less elastic modulus can make the interface shear stress distributed more evenly with less concentration, meanwhile the plastic deformation ability of the interface is increased, and it means that GFRP bolt should present properties of high-strength and ductility with the nonoccurrence of brittleness failure.

Optimization of calcium silicon for Humic acid treatment by response surface methodology

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The Humic acid was treated by calcium silicate. The reaction factors of calcium silicate dosage, response time, temperature and HA initial concentrations were studied. Optimized of reaction factors was by response surface method (RSM). Results indicated that the effects on UV254 removal efficiency were in order: HA initial concentrations> calcium silicate dosage> temperature> response time. The optimal operation conditions were as follows: calcium silicate dosage of 3.6g/L, 52.5min, 25℃, HA initial concentrations of 32mg/L. Under the optimized conditions, the average of UV254 removal efficiency was 97.5%. The relative deviation of predicted value is 1.8% and it matched well with the predicted value. Calcium silicon can effectively dispose humic acid.

Absorbing performances of polymer-derived SiCN ceramics synthesized by precursor conversion method with nano-Fe2O3

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In this paper, polymer-derived SiCN ceramics were successfully synthesized by precursor conversion method with nanocrystalline iron oxide (nano-Fe2O3). The phase composition and microstructures of the obtained sample with different amounts of nano-Fe2O3 were characterized by X-ray diffraction and scanning electron microscopy with EDX. The result showed that the main crystal phases were a-Fe, FeN and graphite. The electrical and magnetic properties of the pyrolyzation composite material were invested in the frequency band range of 2~18 GHz. The reflectance and magnetic loss of polymer-derived SiCN ceramics were -10dB and 515 with the amounts of ferric acetylacetonate was 50wt% in 16.5GHz, which could meet the requirement of absorbing for radar in X band.

Dependence of peak frequency of microwave absorption for Co2Z composite on the thickn

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Microwave absorbing materials have been used in the telecommunication, household appliances, computers, and military equipment. Microwave absorbing performance of materials strongly depends on thickness of the absorber. As described in reported papers and results, dependence of microwave absorbing performance of metal powders, such as Fe, FeSiAl, FeNi and so on, on thickness of the absorber can be understood by the interference cancellation picture. However, microwave absorbing properties of ferrites such as CoZ ferrite and its composites used widely with excellent high-frequency performance were not clear. Herein, CoZ ferrite was prepared by solid-state reaction route and ball milling. Morphology observed by scanning electron microscope (SEM) shows that CoZ particles are irregular and micrometer-scale. Composition of CoZ determined by X-ray diffractometer (XRD) indicates that as-prepared CoZ is pure. Permeability, permittivity and RL curves (S11) of 30 vol.% CoZ/paraffin with various thicknesses were measured by vector network analyzer (VNA). Peak frequencies and responding numbers depending on thicknesses in measured RL curves (S11) were discussed based on the quarter-wavelength matching model. In quarter-wavelength matching map, the number and the frequency positions of absorbing peaks presenting in measured RL curve for CoZ ferrite composite with a certain thickness can be approximately predicted. From impedance map, the intensity of absorbing peaks in measured RL curves is analyzed. Moreover, the presence of absorbing peak in measured RL curve can be illustrated and understood physically and clearly using a picture of interference cancellation of two EM waves reflected by the absorber layer interface and a backed metal plate.

Numerical Study on the Tension Process of GFRP Bolt
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Such mesomechanics properties as crack propagation and the fiber stress distribution during the tension process of GFRP bolt with weak and strong interface structure were numerical analyzed with secondary development platform of ANSYS14.0 LS-DYNA, using ANSYS parametric design language of APDL, extension program written language of Visual C++, and element life and death technology. The results showed that: the interface structure plays a key role for the reduction of disturbance effect of crack, crack propagation and the stress distribution of the fiber and the matrix in the GFRP bolt. For the weak interface case, cracks propagate along the interface and should not extend into the matrix, stress concentration of broken fiber and adjacent fibers occurs within a larger area and recover in a longer distance, which means GFRP bolt should present properties of ductility. However, for the strong interface case, cracks extend beyond the interface then into the matrix but not far away from the broken fiber, great stress concentration is caused to the unbroken fibers and the matrix adjacent
to broken fiber but within a smaller area and recover in a shorter distance, which means GFRP bolt should present properties of high-strength and brittleness.

Negative Thermal Sensitivity of La$_{1-x}$Sr$_x$FeO$_3$ Films Prepared by Screen-printing Method
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Due to their negative temperature resistance and stable physical and chemical properties, Sr-doped lanthanum ferrite films have caused wide public concern. In this paper, we will systematically discuss the impact of different Sr content on the negative temperature coefficient (NTC) characteristic of La$_{1-x}$Sr$_x$FeO$_3$ (x=0.1~0.6) (LSFO) films, probe into the relationship between phase structure and the NTC thermal sensitivity, and reveal the conduction mechanism of LSFO film at high temperature, which contribute to the development of high-performance LSFO thermo-sensitive film. LSFO films were prepared on the alumina substrate by screen printing method. X-ray diffraction, resistivity-temperature characteristics were used to discuss the effect of substitution on their crystal structure, the activation energy and conductive mechanism at high temperature. The results showed that the crystal structure transformed from orthorhombic (x=0.1~0.3) to rhombohedral (x=0.4~0.6). All the samples presented NTC performance. With increasing the Sr content, B values increased to the maximum 3885 K (x=0.4) and then decreased. Non-adiabatic small polaron hopping mechanism was dominant for their electric transport in the temperature range from 450 K to 873 K. The activation energy was calculated between 0.37 eV and 0.57 eV, and the sample La$_{0.7}$Sr$_{0.3}$FeO$_3$ showed the minimum value of the activation energy. Therefore the La$_{1-x}$Sr$_x$FeO$_3$ (x=0.3, 0.4, 0.5) films have the potential to develop into high-performance NTC resistors.

Synthesis and Thermoelectric Properties of ZnO/Cu$_2$SnSe$_3$ Composites
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As a member of Cu-based thermoelectric materials family, Cu$_2$SnSe$_3$ has gained great attentions due to its partial “phonon glass electron crystal” (PGEC) characteristic. In this study, the nano-ZnO particles were introduced into the Cu$_2$SnSe$_3$ matrix by ball milling method and the ZnO/Cu$_2$SnSe$_3$ thermoelectric composites were fabricated by spark plasma sintering technology. The phase and microstructure of ZnO/Cu$_2$SnSe$_3$ composite were characterized by XRD, FESEM and TEM. The effects of nano-ZnO particles on the thermoelectric properties of ZnO/Cu$_2$SnSe$_3$ composite were investigated. The results showed the nano-ZnO particles distributed on the grain boundary of Cu$_2$SnSe$_3$ matrix. The nano-ZnO particles can significantly reduce the lattice thermal conductivity by scattering middle-long wavelength phonons while have little influence on the electrons. The maximum figure of merit of ZnO/Cu$_2$SnSe$_3$ composites at 700 K was 1.3 times higher than that of Cu$_2$SnSe$_3$ matrix.

Key words: Thermoelectric, Cu$_2$SnSe$_3$, Nano-ZnO, Composite

Effect of Heat-treatment on the Properties of PBO Fibers
Xiaolin Zhu, Weihua Zhong, Ziming Jin, Peng Zhang, Zhongren Guo, Ping Gong, Zhimin Qu

PBO fiber is a kind of fiber that produced by dry-jet-wet-span procedure, PBO fiber is one of the so called rigid-rod polymers named poly (p-phenylene benzobisthiazole) (PBO). Toyobo Co. Japan is the only company which can produce PBO fibers as commercial productions, named Zylon-AS and Zylon-HM. The tension strength of Zylon-AS is 5.8 GPa, the modulus is 180 GPa, while the modulus of Zylon-HM is 280 GPa. Also, it could be
used as inflaming retarding material for its LOI up to 68. Because of the fantastic properties the PBO fibers can be used in armor or aerospace field. PBO fibers have huge commercial potential because the production manufactured by Toyobo are strictly restricted to sell to China and the technology is forbidden to leakage. It is known that the performance of PBO-HM fibers are much more excellent than PBO-AS fibers. So it is necessary to find an appropriate heat-treatment technology for domestic and provide high performance fibers to satisfy Chinese army and domestic market.

In order to achieve the purpose, choose 400 ℃ to 550 ℃ as the heat treatment temperature, the Toyobo Company Zylon-AS fiber has been heat treated under different residence time, and the pre-tension choose 1% elongation. The fibers obtained were tested by SEM, XRD, XPS, FT-IR and mechanical properties testing methods for the analysis and characterization of PBO-HM fibers, in order to know the difference between PBO-AS fibers and PBO-HM fibers.

It could be found by visual observation obviously that PBO-HM fiber would be darkening even bronze when treated under a higher temperature or a longer heat-treatment time at air atmosphere, but it remained smooth at N₂ atmosphere.

First of all, by the means of SEM test, it can be seen that, compared to the smooth surface of PBO-as-spun fibers (PBO-AS), PBO-high-modulus fibers (PBO-HM) showed much more rough surface. On the surface of PBO-HM fiber, it was apparent to find that there were plenty of significant pitting and ravines. It means that after the heat treatment process, the skin of the PBO-AS fiber had a great damage. The higher temperature, the longer resident time, the superficies structure of the PBO fiber have a greater degradation. But on the other hand, theoretically, the improvement of roughness would be beneficial of enhance the Interfacial Shear Strength or interfacial bonding properties, while retaining the strength can be impaired.

Secondly, after the heat treatment, the grain size of PBO fiber would have a significant increase, besides, there was also an increasing of the degree of orientation. It can be seen from the data analysis, the higher the temperature is, the diffraction peak is steeper and the Full Width at Half Maximum is decrease. According to the curve, the growth of (200) lattice plane is the most significant, the grain size of PBO fiber increased from 5.6 nm to 10 nm or more. The crystalline size would be increased at first, but when the resident time of heat treatment prolonged or the temperature of heat treatment risen, it would be decreased. It can be speculate that the internal structure of PBO fiber may be damaged at a high temperature or too long time. It indicated that at an appropriate resident time and a suitable heat-treatment temperature, the heat treatment procedure would be beneficial to the improvement of the regularity of internal structure.

Thirdly, after surface elemental composition of PBO-AS fibers and PBO-HM fibers by XPS analysis, it can be found that, the content of phosphorus in PBO-AS fibers was significantly higher than PBO-HM fibers, indicating that at the washing stage of spinning, the polyphosphoric acid could not be removed completely. But in the heat treatment stage, it may promote the removal of phosphoric acid. It can be surmised that the phosphoric acid will be break down more than 400℃. The heat treatment is almost an more than 400℃ temperature process and it is an high temperature modification process. It can be seen from the data that the higher the temperature was, the lower content of phosphoric was. But combined with the SEM test, the surface performance would be worse under higher temperature treatment. The procedure of removal of impurity phosphorus can benefit the improvement of the internal molecular structure of PBO fibers, at the meantime, the modulus of PBO fibers would increase but the strength would lost.

Fourthly, through the FT-IR test, in the vicinity of 1720 cm⁻¹, the curve of spun yarns has a weak absorption peak, while the high modulus fibers disappeared. The peak is the telescopic vibration of -C=O-, according to the mechanism of PBO reaction, it can be known that the reaction of formation of PBO is one of ring closing reaction and the -C=O- appeared at the period of late stage of polymerization. It can be inferred reasonably that the heat
treatment process can promote the completing of the ring reaction, the molecular chain structure tended to be perfect. Therefore, the strength and the modulus would be increased substantially.

Fifthly, according to the mechanical property test results, it can be found that after 400°C treatment, the PBO-HM fibers obtained showed lower strength and modulus. When compared to the 450°C, resident time was 53s, the fibers we got showed much more better mechanical properties. It can be concluded that the higher the temperature is, the higher the modulus would get but the strength would drop under the air atmosphere. But if the resident time extended to 160s or more, the surface structure of PBO fibers would be damage by the high temperature and the air atmosphere. So at that time the strength would definitely decrease. Consequently, it is necessary to choose appropriate heat treatment temperature and resident time. In this article, the most preferred heat-treatment condition was that N₂ atmosphere, at the temperature of 500°C and the resident time was 32s.

In general, the higher the temperature is, the shorter the heat treatment time required for the same heat treatment effect. The superiority of this method is that the PBO-AS fibers are treated at a relatively low temperature but the speed of treatment is relatively rapid. Besides, it is a method of big treatment capacity and nice treatment effect.

Preparation of Graphene by High Speed Shearing-Assisted Exfoliation and Its Application in Thermal Conductive Silicone

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The superior properties of graphene in applications ranging from electronic devices to composites has attracted significant attention. Herein, we investigate an efficient method to produce little-defect few-layer graphene by exfoliating the graphite with a high speed shearing machine. The morphology, structure, and thickness of exfoliated-graphene were characterized by transmission electron microscopy (TEM), atomic force microscopy (AFM), and Raman spectroscopy. Exfoliation in aqueous solutions produced graphene in high yield (> 80%, ≤3 layers), with a large lateral size (3-4μm) and high quality ($I_D/I_G$ ratio≈0.1). In this work, we investigated the thermal properties of the composites with the novel hybrid graphene-silver particle fillers, which can be used as efficient thermal interface materials (TIMs). It was found that the thermal conductivity (K) of silver-silicone TIMs can be dramatically improved from 4.9 w/m·k to 12.367 w/m·k at a small graphene loading fraction of 3 vol%. The high K value was explained by the unique physics of phonon transport in graphene and specifics of thermal properties of the hybrid fillers. This work suggests that little-defect graphene prepared by our method can significantly enhance the thermal conductivity of silver-silicone thermal interface materials. The obtained results are important for the high-efficiency TIMs for thermal management in advanced electronics.

The High Frequency Electromagnetic Property and Mechanisms of Barium Titanate/Nickel Ferroelectric–Ferromagnetic Composites

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Metal-ceramic composites are widely used in a broad range of applications, especially in the design of multifunctional devices such as capacitors, dielectrics or electroactive materials due to their exceptional
mechanical, electrical, or nonlinear optical properties. BaTiO$_3$-Ni composites obtained by solid state sintered technology with CO atmosphere. The Ni loading was varied from zero to 20 wt %. With the increasing of Ni content, the relative density is decreased, suggesting that Ni hampers the consolidation process. With the increase of Ni content, Curie temperature deviation is very small. BaTiO$_3$ with 5wt% Ni has the high permittivity and low dielectric loss. All the samples exhibit dielectric resonance about 1G Hz, with the difference of Ni content, the dielectric loss peak move to low frequency.

Research on electromagnetic shielding effectiveness of nickel fiber-reinforced cement composites

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The nickel fiber as shielding medium added into the cement made of cement-based composite materials. In the experiments, influences of the three different types and amount of dispersants and weight fraction of nickel fibers on the electrical conductivity and the electromagnetic shielding effectiveness(SE) of nickel fiber cement-matrix composite were discussed. The conductivity of cement-based composite materials and the uniformity distribution of shielding medium were characterized by four-point probe meter and scanning electron microscopy and the electromagnetic interference shielding effectiveness in the frequency range of 1MHz to 1.5GHz was characterized by coaxial cable method. The results indicated that the improved dispersion of nickel by incorporation of dispersants might yield the enhancement of the electrical properties of nickel fiber-reinforced cement composites. When the dosage of methyl cellulose reaches 0.4% pre-dispersing nickel fiber enhances electrical conductivity of cement-based composite materials significantly. By this method, with the increase of fiber volume fraction, the SE and trend of frequency change of corresponding fiber reinforced concrete were enhanced. When the content of nickel fiber powder was 9.0%, the conductivity was reaches $2.65 \times 10^{-3} \, \text{s} \cdot \text{cm}^{-1}$, the shielding property of specimen was best in 1MHz-1.5GHz frequency range, the average shielding effectiveness was about 21.78dB, the maximum shielding effectiveness was 24.48 dB and the minimum shielding effectiveness was 19.85 dB.

Influence of SiC fiber type on the electromagnetic microwave absorbing properties of SiCf/epoxy composites

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A comparative investigation of microstructure, mechanical properties, complex permittivity and microwave absorbing properties of KD-1SiC$_f$ and SLF-SiC$_f$/epoxy composites was investigated. The electrical conductivity of KD-1SiC$_f$ was higher than that of SLF-SiC$_f$ due to the rich carbon layer on the KD-1SiC$_f$ surface, which can be proved by the SEM, XPS and Ramen techniques. The different microstructure of SiC$_f$ types led to different complex permittivity of the composites. The complex permittivity of KD-1SiC$_f$/epoxy composite was larger than their counterparts of SLF-SiC$_f$/epoxy composite while the flexural strength of both composites was almost same. The strong interfacial polarization and high electrical conductivity are attributed to the higher complex permittivity of KD-1SiC$_f$/epoxy composite. Though the complex permittivity of KD-1SiC$_f$ and SLF-SiC$_f$ composites have big difference, the absorbing properties in the X band (8.2-12.4GHz) were not effective due to
the impedance degree and attenuation characteristics cannot meet the requirement at the same time.

Synthesis and Application of a Novel P-N Flame-retardant in Fabrics
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Cotton textiles with high air permeability, good hygroscopicity and good soft-feeling due to be natural cellulose fabrics, but their high flammability greatly limit its applications; fire-retardant finishing of cotton fabrics can impart good flame retardant properties. In this research, a novel phosphorous-nitrogen flame retardant (FR), poly-(imino-4-amino-1,3,5-triazin-2,6-imino-(3-oxopropyl)-N-phenylphosphinamido) (PCEPAM) was synthesized with 2-carboxyethyl(phenyl)phosphinic acid (CEPPA) and melamine (MA). Its structure was characterized by FTIR, ¹H-NMR, and the thermal performance was analyzed by TGA-DSC. Cotton fabrics were treated via pad-dry-cure process with PCEPAM. The surfaces of treated fabrics and the combustion residue were characterized by SEM. The fire behavior was performed by limited oxygen index (LOI) and vertical burning test. The LOI of FR fabric is more than 28.5% after washing once. The thermal stability and surfaces of the combustion residue of the fabrics were investigated by TG and SEM, respectively. The results show that PCEPAM is not only an effective FR but also a good char-forming agent for the cotton fabric.

Fabrication of SU8/Au multilayer far-infrared perfect absorber
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Far-infrared imaging has garnered recent interest for applications in biomedicine, environmental remote sensing, explosives detection, materials characterization, and astronomy. Bolometric detection, in which the heat generated by far-infrared absorption is sensed, is usual in this wavelength range. However, there are few prior reports of periodic square (or rectangular patterns) designed for far-IR absorption beyond 10 micron wavelengths. Then, we designed, modeled, fabricated and characterized, thin-film resonant absorbers for the far-IR spectral range about 21.5μm. The 2μm-thick structure comprises two periodic surface array of metal squares(width 6μm, period 10μm, height 60nm), two dielectric spacer(SU-8 1040, 1μm) and a metallic ground plane(Au 150nm). Up to 99% absorption for the fundamental band at 21.5μm wavelength is achieved in COMSOL MULTIPHYSICS simulation. Absorption bands are dependent of the width of metal squares and only weakly dependent on polarization and incident angle. The ground plane gold and gold squares were deposited using a multi-pocket electron beam evaporator without breaking vacuum. SU-8 dielectric was spin use mycroWS-650. Square patterns of gold were fabricated by standard photolithography, DC sputtering, and lift-off. Square dimensions and array period were determined by scanning electron microscopy (SEM). Their nominal values were 5.8 and 9.7μm, respectively. The thickness of the gold squares, gold ground plane and SU8 dielectric lays were 63nm, 163nm and 1088μm respectively as determined from SEM of a cleaved and polished cross-section. This thickness of gold squares and gold ground plane are much greater than the estimated electromagnetic penetration depth of 2μm in our wavelength range. The results are well explained in terms of LC model. The structure has application as a wavelength selective coating for far-IR bolometers.

Preparation of Fe-SBA-15 by evaporation-induced self-assembly (EISA) and its catalytic activity
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In this paper, Fe-SBA-15 materials with different Fe content have been prepared by using tetraethyl orthosilicate (TEOS) and iron nitrate (Fe(NO₃)₃·H₂O as precursors, Pluronic P123 as structure directing agent through evaporation-induced self-assembly (EISA) method. The prepared materials were characterized by nitrogen sorption, powder X-ray diffraction and TEM. The results showed all the Fe-SBA-15 samples exit an ordered 2D hexagonal mesostructure. The BET surface area and pore diameter were about 500 m²/g and 4 nm respectively. In the reaction of phenol hydroxylation to dihydroxybenzenes, the Fe-SBA-15 materials show a good catalytic activity, giving 20.2% of phenol conversion, 58.2% of selectivity for o-dihydroxy benzene and 41.8% of selectivity for p-dihydroxy benzene. After five cycles, the product yield was 25.2%, while selectivities of o-dihydroxy benzene and p-dihydroxy benzene were 58.2% and 41.8%, respectively. All these findings suggest the potential of Fe-SBA-15-10 as a cost-effective, environment-friendly catalyst.

**Ambient-pressure drying synthesis of large methyltrimethoxysilane based silica aerogel with low density, superhydrophobicity**

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Silica aerogels are nanostructured porous solids with low bulk density, high porosity, low thermal conductivity and so on. Their unique properties are of great interest to researchers in the field of science and technology. However, silica aerogels are generally prepared via supercritical fluid (SCF) drying which involve high-pressure process, cost and safety issues and limit the large-scale production and application. Ambient pressure drying (APD) is considered an alternative and more practical approach. However, the tedious surface modification and solvent exchange steps involved in conventional APD for the synthesis of large silica aerogels are still challenges.

In this study, a facile, rapid sol-gel route and APD process were developed to fabricate a large (>200 cm⁻³) silica aerogel monolith using methyltrimethoxysilane (MTMS) as precursor, distilled water as solvent, and ammonia as alkali catalyst. The resulting aerogels were characterised by scanning electron microscopy (SEM), transmission electron microscopy (TEM), Brunauer-Emmett-Teller (BET) method, contact angle and thermal conductivity measurements, and the aerogel mechanical properties were evaluated by a unidirectional compression test. The ambient pressure dried aerogel has macropore structure and low density (as low as 0.075 g·cm⁻³). The Young's modulus of compression of the aerogels was observed to increase from 0.053 to 1.073 MPa with an increase in the density of the aerogels from 0.075 to 0.165 g·cm⁻³. Simultaneously, the aerogels were observed to be superhydrophobic, with a contact angle as high as 152°, and exhibited low thermal conductivity (0.036 W·m⁻¹·K⁻¹), kept thermal stability until 400 °C in air atmosphere, which are critical characteristics for the practical application of aerogels, especially in energy-saving practice.