AA-01
All Dielectric Antennas from Transformation Optics
Yang Hao
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Antenna research is more than 150 years old and fundamental limits still exist in terms of its bandwidth, gain and electrical size. There have been many attempts to overcome this limit by using metamaterials, transformation optics as well as nanomaterials. In this talk, I will present an overview of antenna research conducted at Queen Mary University of London. Recent work has been done based on the metamaterials, especially non-foster’s active devices and 3D rapid free-forming process. Transformation Optics, the concept behind the design of invisibility cloaks has been applied to the design of various novel lenses and reflector antennas. Both measurement and simulation results will be presented.

AA-02
A Feasible Method to Make Germanium from room temperature Ionic Liquids
Yao Li
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We report for the first time on the synthesis of 3DOM germanium by directelectro deposition at room temperature within polystyrene colloidal crystal templates from the ionic liquids ([HMIm]FAP) and ([EMIm]Tf2N) containing GeCl4as precursor. Our method is quite promising, because these types of ionic liquids are chemically and electrochemically stable enough to deposit germanium, they are aprotic, and they can be dried quite easily. Moreover, there is no need to add supporting electrolytes that are needed when organic solvents are used. The PS template has the advantage of being easily removed by simple dissolution in THF without damage to the Ge macroporous structure. The only restriction to this method is that the experiments must be performed under inert gas owing to the water-sensitive nature of GeCl4. We report our new results on the photoluminescence (PL) properties 3D ordered macroporous Ge exhibits a reversible capacity of 1024 mA h g-1 and retains a capacity of 844 mA h g-1 after 50 cycles at a rate of 0.2 C. 3D germanium–acetylene black–Ni foam nanocomposite electrodes for lithium-ion batteries, exhibits a high capacity of up to 924 mA h g-1 after 100 cycles at 0.1 C and a high rate capability at 1 C and 5 C rates of 1210 and 524 mA h g-1, respectively. Ge nanostructures on freestanding Ni-nanocone arrays for Li-ion battery are prepared show remarkable cycling ability at 0.2 C, with a very high initial discharge capacity of 1641 mA h g-1 and a charge capacity of 1260 mA h g-1. After 250 cycles the capacity retention is 98% relative to that at the 50th cycle. 3DOM Ge/Al and Ge/Si bilayer films also have been made. Periodical macroporous SixGe1-x was made by a multilayer polystyrene (PS) template assembled as face-centered cubic lattice. Two-dimensional (2-D) S SixGe1-x bowl-like and fishing-net structures can be obtained.

AA-03
Tuning the electromagnetic propery of core@shell microwave absorber based on atomic microstructural design
Renchao Che
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Broadband microwave absorbing materials have been attracting hot attentions. Core-shell composite absorbing material is the hot topic, however, there are still a series of urgent scientific problems. Fe3O4 as core is easy to be synthesized, but the saturation magnetization is low. Graphene has certain dielectric loss and relaxation polarization,
but the conductivity depends sensitively on the oxidation degree. The systematic regulation and preparation of high efficient microwave absorbing materials strategy is still lack. This report reviews our research results of nearly 20 years about microwave absorbing materials, reflecting the design principles of the "impedance matching", "core-shell", "electromagnetic compatibility" and "control at atomic and electronic scale".

(1) The carbon nanotubes with magnetic nanowires contributed significant magnetic crystal anisotropy field, and the intersecting angle between the arrayed carbon nanotube can change polarized electron cloud shape, facilitating to realize the strong absorbing, these results were published on Adv. Mater. 16, 401 (2004) and Adv. Mater. 26, 8120 (2014). The total cited times are over 500 times.

(2) High-temperature structural stability of core shell structure has been studied using in situ TEM heating technique, which confirm the microwave absorption property under 400℃. These results are published on Adv. Mater., Small, JMC and other journals (more than 30 papers) as corresponding author.

AA-04
Reconfigurable Metasurfaces at Microwave Frequency: Opportunities and Challenges
Lie Liu
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Metamaterials are engineered structures normally designed with metallic patterns and dielectric substrates, which may exhibit unusual dielectric or magnetic properties typically not observed in natural materials. Microwave frequency is used by most cellular phone, wireless or satellite communication devices, surveillance and fire-control radar as well as remote sensing systems. Hence, Metamaterials and their devices initially were designed for applications within microwave band. Although THz and optical Metamaterials have attracted great attention in the last few years, their importance and market value are far behind those working in microwave band.

Being an artificial three-dimensional electromagnetic media, Metamaterials are made of periodic or non-periodic microstructures of subwavelength scale. Metamaterials initially was proposed as a media with negative refraction index, which could be of interest for applications like superlens with high resolutions, perfect radar absorber and cloaking etc. Metasurfaces, the two dimensional equivalence of metamaterials, could be applied in certain traditional fields as well, for example, reflectarray, beam deflection surface or high impedance surface. Due to their unusual EM properties are the result of the resonance phenomena of microstructures, Metasurfaces are usually intrinsic narrowband with relative bandwidth of merely a couple of percents, also extremely lossy. One of the most promising solutions to broaden bandwidth and compensate the Omega loss is to integrate microstructures with components with controllable circuit parameters, or smart materials with tunable EM properties.

In this review, the recent progress of reconfigurable Metasurfaces, realized through PIN diode, varactors or Micro-electro-mechanical systems (MEMS) are discussed first. Some smart materials, like liquid-crystal, ferroelectric or ferromagnetic materials may have better power handling capability and tunability at microwave frequency. Hence, they can be the potential candidates of the controllable devices of reconfigurable Metasurfaces. As a leading research institute in China, Kuang-chi institute of advanced technologies devote its effort into the cutting-edge Meta-RF technologies with applications for frequency-selective radome, wave-deflection surface as well as beam-steering reflectarray. The main achievement and works of Kuang-chi institute will be briefly introduced in this talk.

Metamaterials, absorber, reflectarray

AA-05
Radio-frequency dielectric properties of metal-ceramic 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
(such as dielectric constant, electric and thermal conductivity, etc) of the composite will undergo significant changes, leading to various fascinating properties. As we know, there exist obvious different physical properties (conductivity and dielectric) between metal and ceramic. Therefore, it is interesting to explore the properties of metal-ceramic composites near percolation. In this paper, the radio-frequency (300 kHz - 30 GHz) dielectric properties of metal-ceramic composites are investigated in detail. Metal-ceramic composites with high permittivity and low loss were prepared, but the dielectric strength should be further improved. Moreover, a plasma-like negative permittivity behavior is observed in the composites with metal contents above but still near percolation. And the influences of the metal-ceramic composites' compositions and microstructures on the negative permittivity behaviors were further investigated. The high permittivity composites with low loss and high dielectric strength have great potential for application in high-density energy storage field. And the composites with tailored negative permittivity can be used as metamaterials, microwave attenuation and absorbing materials, etc.

Percolation, Cermet, Dielectric property, Negative permittivity, Metamaterial

**AA-06**

**Tunable metamaterial bandpass filter based on ferromagnetic resonance**

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Tunable microwave devices are essential in wideband communication and radar systems. Bandpass filters are among the essential devices used in detecting and controlling the spectrums of radio frequency signals in communication and radar systems. However, most of these filters do not possess tunable properties. Metamaterials are a class of artificial materials with subwavelength functional electromagnetic microstructures. Ferrite-based metamaterials with magnetically tunable properties have been widely discussed in theory, and various structures have been proposed. By interacting with electromagnetic wave, ferrite-based metamaterials provide negative permeability when the ferromagnetic resonance takes place.  
In this work, we demonstrate a magnetically tunable metamaterial bandpass filter composed of transmission line and ferrite rods. Several pairs of ferrite rods are symmetrically placed on both sides of the transmission line with a distance 3 mm to prepare the tunable metamaterial bandpass filter.  
According to the simulated and experimental results, two transmission pass-bands influenced by ferromagnetic resonance appear in the range of 5-20 GHz. When a magnetic field $H=2700$ Oe is applied, the measured transmission characteristics of a passband at the center frequency of 15.5 GHz shows a -0.1 dB bandwidth as large as 0.8 GHz, an out–of–band rejection of -20 dB and transmission characteristics of the second passband at the center frequency of 7.5 GHz shows a 0 dB, an out-of-band rejection of -25 dB. When $H$ increases from 2500 Oe to 3000 Oe, two transmission passbands move to higher frequency region, which exhibits a magnetically tunable behavior. The ferrite rods will be magnetized when $H > 0$, by interacting with the electromagnetic wave, the ferromagnetic resonance takes place in the ferrite rods. The pass-bands induced by transmission line are influenced by the ferromagnetic resonance. Hence, two transmission pass-bands can be tuned by adjusting the applied magnetic field.  
In conclusion, we experimentally and numerically demonstrated a tunable metamaterial bandpass filter based on ferromagnetic resonance by placing several pairs of ferrite rods symmetrically on both sides of a transmission line. The tunable property is attributable to the ferromagnetic resonance of the ferrite rods. When a certain magnetic field is applied, two transmission pass-bands appear in the range of 5-20 GHz. The frequency of the passbands increases as $H$ increases.

Metamaterial; Bandpass filter; Tunable property

**AA-07**

**Negative permittivity spectra in copper/alumina composites prepared by chemical impregnation process**

Kai Sun, Zidong Zhang, Runhua Fan, Chuanbing Cheng, Min Chen, Qing Hou, Guifang Liu, Peitao Xie, Chu anxin Hou, Zhongyang Wang  
山东大学材料液固结构演变与加工教育部重点实验室
More extensive attentions have been paid to the high frequency electromagnetic properties of ceramic matrix composites due to their wide potential applications. Copper/alumina composites with tailored microstructures were prepared via a facile chemical impregnation process, and the electromagnetic properties including impedance, conductivity and complex permittivity were investigated in the radio frequency regime. The results show that there appears obvious percolation phenomenon with the increase of copper content and the conduction mechanism changes from hopping conduction to metal-like conduction. Beyond the threshold, the negative permittivity was observed. It is indicated that the plasma oscillation of conduction electrons is attributed to the negative permittivity. Hopefully, the copper/alumina composites with tunable negative permittivity could be used for electromagnetic wave shielding or attenuation.

AA-08
To be updated
Huaxin Peng;
Zhejiang University

AA-09
A dual-band double negative-index material using elliptical nanohole arrays
Tun Cao
大连理工大学
In this work, we numerically study the angle dependence of the displacement current in a structure composed of two dimensional aligned elliptical nanohole arrays (ENAs) in the Au- Al2O3-Au material system. According to Faraday’s law, the magnetic dipolar mode will be excited at the frequencies in which the formation of enclosed current loops can be observed. Thus, by using this approach, we can predict the effects of the incident angle on the double negative index for the ENA structure. The geometry was chosen because it constitutes the most promising variant of a negative refractive index material with relatively low losses at optical frequencies since the thinner metallic strip width along the short axis of the elliptical aperture can be used to improve the impedance matching between the air and MMs [1]. Since the use of parameter retrieval for the study of negative index at different incident angles is not ideal, here for what we believe is the first time, we turn to the representation of the loop of the displacement current to study the negative index in an ENA at any incident angle. This method enables us to easily calculate the optical properties of the negative index of an ENA at off-normal-incidence. We first show that the ENA gives rise to a wide-angle double negative index because the displacement current of the ENA can maintain its loop over a broad angle range so the permeability is negative. In addition, we have designed the structure to possess a dual-band negative index [2].

AA-10
Multifunctional Field-Induced Nonlinear Electrical Properties of Perovskite Relaxor Ferroelectrics
Huiqing Fan
Northwestern Polytechnical University

(111)-oriented and random oriented Pb0.8Ba0.2ZrO3 (PBZ) perovskite relaxor ferroelectric thin films were fabricated on Pt(111)/TiOx/SiO2/Si substrate by sol-gel method. Nano-scaled antiferroelectric (AFE) and ferroelectric (FE) two-phase coexisted in both (111)-oriented and random oriented PBZ thin film. High dielectric tunability (η = 75%, E = 560 kV/cm ) and figure-of-merit (FOM ~ 236) at room temperature was obtained in (111)-oriented thin film. A large recoverable energy storage density of 40.18 J/cm3 along with an efficiency of 64.1% was also achieved at room temperature. Over a wide temperature range of 250 K (from room temperature to 523 K), the variation of energy density is within 5%, indicating a high thermal stability. Meanwhile, giant electrocaloric effect (ECE) (ΔT = 45.3 K and ΔS = 46.9 JK−1kg−1 at 598 kVcm−1) at room temperature (290 K) rather than at its Curie temperature (408 K) was observed in random oriented Pb0.8Ba0.2ZrO3 (PBZ) thin film, which makes it a promising material for the
application in cooling systems near room temperature. The high performance was endowed by a large dielectric breakdown strength, great relaxor dispersion, highly textured orientation and the coexistence of the FE/AFE phases. The PBZ thin film is believed to be an attractive multifunctional material for applications in energy storage systems as well as dielectric phase shifter over a wide temperature range, and a solid-cooling systems near room temperature.

**Keywords:** relaxor ferroelectrics, dielectric tunability, energy storage, electrocaloric effect, field-induced nonlinear electrical properties, two-phase coexistence, sol-gel

**AA-11**

**Absorption properties of twinned SiC nanowires reinforced Si3N4 composites fabricated by 3D-printing**

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1. Northwestern Polytechnical University
2. University of Erlangen-Nuernberg

Near net- and complex shaped porous silicon nitride (Si₃N₄) composites reinforced with in-situ formed twinned silicon carbide (SiC) nanowires (NWs) were successfully fabricated by 3D-printing (3DP) followed by polymer precursor infiltration and pyrolisis (PIP) up to 1400°C. An increase of the PIP cycle number of the printed bodies resulted in a homogeneous distribution of SiC NWs in the fabricated composites. An increase of SiC NW content in the fabricated composites led to the growth of both the real and the imaginary parts of permittivity. The formation of twinned SiC NWs which had high electrical conductivity led to a minimal electromagnetic wave reflection coefficient of -57 dB, demonstrating that Si₃N₄-SiC ceramics with the in-situ formed SiC NWs had a superior microwave absorbing ability.

**Si3N4-SiC, 3D-printing, PIP, Absorption properties**

**AA-12**

**A new kind of meta-composite and its tunable electromagnetic property**

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**Purpose:** To obtain tunable metacomposite.

**Method:** In this paper, we demonstrate a new way to achieve tunable EM properties in a new kind of C/SiO₂ bulk composites, which we called ‘Meta-composite’. The composite is prepared based on SiO₂ microspheres’ self-assembly under the centrifugal force field.

**Results:** In the composite, amorphous carbon fills in the gaps between SiO₂ micro-spheres periodic matrix to form a 3-D periodic carbon network. Compared with the conventional C/SiO₂ composite in which carbon particles random distributed in SiO₂ matrix, the formation of 3-D periodic carbon network will introduce a new structure-based EM property into meta-composite. The EM property can be tuned by control of the diameter of the SiO₂ micro-spheres. After high-temperature treatment, a tunable negative permittivity has been obtained.

**Conclusion:** The meta-composite not only reduce the cost of metamaterial’s fabrication, but also gives a feasible way for the realization of tunable double negative property in metamaterials.

**Metacomposite, Self-assembly, electromagnetic property**

**AA-13**

**Hierarchical reduced graphene oxide/SiOC ceramics for efficient electromagnetic wave absorption**

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Northwestern Polytechnical University

A high-performance electromagnetic wave absorbing composite based graphene and polysiloxane-derived SiOC ceramic is realized via the polymer pyrolysis process. Hierarchical architecture of two-dimensional graphene and one-dimensional SiC nanowires in ceramic matrix is formed when the sintering temperature is 1400 °C. The
multi-dimensional hierarchical structure exhibits excellent electromagnetic wave absorbing capability at 293-673 K, in which the heterogeneous interfaces, defects and electronic conductivity play the important roles in dielectric loss. When graphene oxide loading is 3 wt.%, the composite reaches a minimum reflection loss value of -69.3 dB at 10.55 GHz with a sample thickness of 2.35 mm, and the effective absorption bandwidth reaches 3.4 GHz. With the elevated temperature, the composite exhibits better absorbing performance, its effective absorption bandwidth reaches 3.9 GHz at 673 K. Graphene/SiOC ceramics provide a convenient process to incorporate graphene into ceramic matrix, and display the great potential in ceramic-based electromagnetic absorbing materials at high temperature.

graphene; SiOC; electromagnetic wave absorption; polymer-derived ceramic

**AA-14**

**Design of wideband microwave absorberes based on resistive square-loop arrays**

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Microwave absorbers can be widely used in both military and civil field. The Salisbury Screen is the simplest model for microwave absorbing, which consists of a resistant sheet and a grounded dielectric spacer. However, the Salisbury Screen owns an inevitable drawback that it has a relatively narrow absorption bandwidth. By multiple resistant sheets and dielectric spaces, Jaumann absorber has been proved to increase the bandwidth effectively. As a consequence the total thickness would increase meanwhile. Replacement of the resistive sheets by patterned resistant arrays would offer extra capacitance and inductance, which would have great significance in impedance match so as to better absorbing. In our paper, square-loop arrays have been utilized as the patterned resistive sheets to obtain a wideband absorber. The 3D simulation software high frequency structure simulator (HFSS) has been used to simulate and analysis the absorbing (reflection) performance of the designed structure. S-parameter could be extracted from HFSS to characterize reflection properties. According to the simulation results, reflection of the structure composed by square-loop arrays and dielectric substrates could be affected by many parameters about both the patterned arrays and dielectric substrates. For the structure composed by a single square-loop on substrate, an increase of thickness, permittivity and permeability would decrease the resonant frequency and absorption bandwidth. Furthermore the gap between arrays and the width of the square-loop would affect absorption properties to a certain extent. An optimal absorption could be achieved with 100 ohm/sq resistance, owning a 90% bandwidth from 7.4 to 11.5 GHz. However the absorption performance of single square-loop structure is limited, an additional loop that double square-loop arrays would improve the absorption bandwidth. The current distribution on square-loops would illustrate the mechanism of absorption difference. For the single loop, current distribute mainly along the E vector on the loops, while for the double square-loop current would distribute on the four corners of the outer loop. By tuning the resistance of the double square-loop and other parameters such as the width of each loop, and the distance between the two loops, would finally obtain a 90% bandwidth covering the entire X-band, from 7.7 to 12.1 GHz. Moreover, the absorption bandwidth can be improved by covering the resistively patterned arrays by substrate on its top. First of all, the upper substrate would provide protection assurance for patterned arrays from physical and chemical damage. Secondly, the top substrates would improve the absorption bandwidth due to better impedance match. An ultimate bandwidth absorbing 90% the incident microwave could be achieved from 4.7 to 15.4 GHz, including the whole C and X bands. In conclusion, for the structure composed by resistively single square-loops arrays, tuning the pattern parameters and resistance would improve absorption bandwidth in a limited extent. The double square-loop arrays would offer a batter absorbing properties than the single square-loop. After all, a top substrate on the upmost resistive arrays would improve the absorption bandwidth significantly. An optimal design of the wideband microwave absorbers could be acquired, which composed by double resistively square-loop arrays located at the interface between two substrates.
microwave absorbers, wideband; square-loop

AA-15
Electromagnetic properties Si-C-N based composites containing carbon nanotubes
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Ceramics containing carbon nanotubes (CNTs) are attractive not only for structural applications but also for electromagnetic wave (EM) shielding and absorption applications. Especially, Si₃N₄ and SiC ceramics possess not only excellent mechanical properties but also attractive EM response characteristics, which make them promising materials in various applications relating to EM radiations. For the above reasons, high temperature structural ceramics such as porous Si₃N₄, SiC, Si-C-N, Si-B-C-N ceramics containing CNTs are attracting extensive interest in recent years. The key developments and future challenges in this field are summarized. The main issues regarding permittivity of high-temperature structural ceramics are discussed, with an emphasis on the EM shielding and absorption mechanisms that are responsible for EM properties. Compared with other methods, Chemical vapor infiltration and polymer derived ceramics methods are demonstrated to be attractive for structural functional ceramics matrix composites.

Electromagnetic properties, CNTs, CVI, PDC

AA-16
Wave absorbing properties of Fe-doped SiCN polymer-derived ceramics
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This paper concerns low-temperature pyrolysed SiCN magnetic ceramics with Fe ions using poly(vinyl)silazane and nanocrystalline iron oxide as raw materials, dicumyl peroxide as a cross-linking agent. The geometric structures and bonds between atoms were analysed by Fourier-transform infrared (FTIR) spectroscopy. The influences of nanocrystalline iron oxide adding amount (6 wt%, 12 wt%, 15 wt%, 18 wt%) on the sintered phase compositions and microstructures are discussed. Several phases of ceramics were detected and alpha-Fe and graphite were main crystal phases. The relationships of nanocrystalline iron oxide contents with electromagnetic properties and wave absorbing ability of the pyrolysed composites were mainly discussed. When 15 wt% nanocrystalline iron oxide was doped, the reflectance of SiCN magnetic ceramics with Fe ions reached -10.7 dB at the frequency of 10GHz, meeting the requirements of radar absorbing.

AA-17
Enhanced Microwave Absorption Properties of Fe₃O₄/Graphene Nanocomposites with Controllable Microstructure
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Using an easy solvothermal method, Fe₃O₄ nanoparticles were in-situ formed on the reduced oxide graphene (RGO) in the system of EG/Urea. By controlling the mass ratio of oxide graphite (GO) and Fe₃⁺, Fe₃O₄/RGO composites with different loading amounts were synthesized, and the structure of nanoparticles changed from ring-like spheres, flower-like spheres to solid spheres. The SEM and TEM images showed that the nanoparticles with relatively uniform size are well-distributed on the surface of graphitic layers. In addition, the loading amounts and structures for the nanocomposites have huge influences on the microwave absorption properties. The value of reflective loss (RL) changes with the increase of mass ratio, which shows the maximum of -53.2 dB at the ratio of 5:1 with the
thickness of 2 mm and the microwave absorption values less than -5 dB is in the range of 8.1-18 GHz, while less than -10 dB is in the range of 9.15-15.6 GHz. Therefore, Fe3O4/RGO composites with different structure of the nanoparticles can be considered as a good candidate of microwave absorption materials with lightweight and strong absorbing properties.

AA-18
Effect of Doping Concentrations on Ga-Ti Co-doped ZnO Ceramic Targets
Haitao Yang;
Shenzhen University

AA-19
The Realization of Double Negative Property in Metal/Ceramic Composite
Zidong Zhang;
Shandong University

AA-20
Sb掺杂量对BaZn2Fe16O27/ATO复合吸收剂电磁吸波性能的影响
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以固相法制备的W型BaZn2Fe16O27铁氧体为原料,采用共沉淀法制备BaZn2Fe16O27/氧化锡锑(ATO)复合吸收剂,并研究不同Sb掺杂量对BaZn2Fe16O27/ATO复合吸收剂的物相、形貌及电磁吸波性能的影响。通过X射线衍射(XRD)、场发射电子显微镜(FESEM)、能谱仪(EDS)等测试表征手段,研究了产物的物相组成、显微结构。研究结果表明:产物物相包含SnO2和W型BaZn2Fe16O27两相,并且无其他杂相生成,ATO为SnO2四方相金红石结构;Sb掺杂量发生变化,对产物的物相并没有影响;产物的电磁性能为纳米级的ATO颗粒包覆在六角片状铁氧体表面;随着Sb含量的增加,ATO颗粒粒径变小,当Sb/Sn摩尔配比达到3/10及以上时,ATO纳米颗粒在铁氧体表面发生团聚现象。通过网络分析仪对2~18 GHz频段内,产物的电磁性能进行测试分析,并且使用兵器五三所的软件对产物的反射损耗进行模拟计算。研究结果表明:产物的介电损耗主要来源于ATO,随着Sb掺杂量的增加,Sb部分取代Sn,体系中载流子浓度增大,而当Sb掺杂量达到一定值时,体系中载流子浓度发生降低,因此产物的介电常数实部与虚部呈现出增大后减小的趋势;产物的磁损耗主要来源于铁氧体,但是由于铁氧体与ATO之间产生大量的异质界面,对电磁波具有损耗作用,因此随着Sb掺杂量的增大,磁导率和磁损耗呈先增大后减小的趋势;当Sb/Sn摩尔配比达到2/10时,厚度为2.8 mm的吸波涂层的反射损耗在10.64 GHz频率位置处达到最大值-43.07 dB,并且小于-10 dB的有效带宽(即反射率达到99%以上)达到8.32 GHz,涵盖7.12 GHz到15.44 GHz频率段,BaZn2Fe16O27/ATO复合吸波剂表现出优异的吸波性能。

AA-21
Experimental Realization of Tunable Permittivity and Permeability in CNTs/YIG composites
Min Chen

Negative parameters materials have attracted intensive attentions for their further enhancement of the materials applications, especially in electromagnetism. Permittivity and permeability which are the two constitutive parameters can be adjusted respectively in the near field at low frequency. In this paper, the CNTs/YIG composites with different CNTs content were prepared via hot pressing molding. The dielectric and magnetic properties of the composites have been investigated in the radio frequency (< 1 GHz). The results indicated that negative permittivity was obtained in the composites with CNTs content of 8 wt%, 10 wt% and 14 wt%. This can be explained by the Lorenz resonance. With increasing CNTs content, the Lorenz resonance frequency shifts to lower frequency. Meanwhile, the value of permeability decreases with the increasing frequency, which can be attributed to the
domain wall resonance and gyromagnetic spin resonance. Hopefully, tunable double negative parameters could be realized by adjusting the content of CNTs in the CNTs/YIG composites.

double negative material, metamaterial, CNTs/YIG, negative permittivity

AA-22
Direct bonding of copper to ceramics - A review
Wei-Hsing Tuan
Taiwan University
Metallic copper, which has low electrical resistivity and high thermal conductivity, is widely used as an interconnector or substrate within microelectronic packages. If a small amount of oxygen is introduced to the surface of the copper, a eutectic liquid forms above 1065°C. The eutectic liquid wets many ceramics well; it is thus possible to bond slightly oxidized copper to many ceramics directly. The present report summarizes previous results on the ceramic/copper systems prepared by the direct bonding process. The reported data demonstrate that ceramic/copper interfaces prepared with this technique are strong. The experimental data suggest that the thermal conductivity of the laminates is high; the potential for using the laminates for thermal dissipation is thus high. In the present report, the current status for the technique is summarized; critical topics for further improvement are also proposed.
Direct bonding, Copper, Ceramics, Review

AA-23
Double-negative microwire metacomposites
Faxiang Qin
Zhejiang University
Unlike any of the natural materials, metamaterials are artificially constructed media that possesses peculiar electromagnetic (EM) properties such as negative refractive index1 and double negative medium. Metamaterials have attracted tremendous research interests during recent years, adding strong impetus towards fascinating application areas of, for example, superlens, electromagnetic cloaks and perfect absorber. However, some important issues remain to be resolved. In fact, conventional metamaterials derive their properties through the interaction between EM waves and structures, rendering themselves practically ‘meta-structures’. Besides, the prerequisite that the size of their building blocks must be identical or smaller than the wave length requires rather delicate fabrication techniques at micro-/nano-scales. This is not economic from mass production viewpoint.

AA-24
Synthesis of hollow magnetic materials and their electromagnetic wave absorption performances
Jiurong Liu
Shandong University
We present a template-free approach to prepare hollow magnetic materials by combining a facile solvent-thermal route with a 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 the 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 hollow ferromagnetic materials as efficient and lightweight electromagnetic wave absorber.

**AA-25**

**Electromagnetic properties of FeSi particles: the effect of microstructure, morphology and SiO\textsubscript{2} cladding**

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The Particle of ferromagnetic metal or alloy is a catalog of candidates that presents high electromagnetic wave absorbing (EMA) performance in L-S band. To tailor the electromagnetic properties is the basic mission for achieving high EMA efficiency in target bands. High complex permeability and appropriate permittivity is the most desired considering the rare of high permeability in microwave band combined with the requirement from the electromagnetic matching. The current study was thus motivated to investigate the influence of microstructure, size/shape and SiO\textsubscript{2} cladding on the EM properties of FeSi alloy particels and EMA performance of the coating in L-S band.

Particles with different diameter/thickness ratio (DTR) were obtained by sieving the ball milled FeSi powder. VNA measurement shows that the complex permittivity increases as particles’ DTR increases, while the complex permeability remains unchanged. The calculation of EMA indicates that the matching frequency (f\textsubscript{m}) shift to lower frequency and the matching thickness (t\textsubscript{m}) decreases as DTR increases, the effective absorption bandwidth (EABD) however is found narrowed. The hydrogen-thermal treatment is found eliminate the oxidation and the defects of the as-milled particles, leading to a decrease in complex permittivity and the imaginary part of permeability. Meanwhile, the natural resonance frequency (f\textsubscript{r}) as well as the absorption shifts towards the higher frequency. The EMA performances in L-S band was then decreases. The electric resistivity of the composite particles increases sharply after the SiO\textsubscript{2} cladding, which lead to a severely decreased complex permittivity. The impedance matching is thereby improved, keading to a high EMA efficiency but f\textsubscript{r} shifts towards higher frequency.

The high EM properties of flakes is believed contribute to shift of the f\textsubscript{m} and the t\textsubscript{m} which is favoable for obtaining high EMA performances in L-S band with thin coating. Coating using FeSi flaky particles as filler exhibit excellent EMA performances in L-S band. Specifically, A EABD of 1GHz together with a peak reflection loss of 7.6 dB (at 1.87 GHz) was obtained in a thin coating (1mm).

**AA-26**

**Mechanical and electromagnetic interference shielding properties of carbon fiber reinforced multilayered (PyC-SiC)\textsubscript{n} matrix composites**

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Carbon fiber reinforced multilayered (PyC-SiC)\textsubscript{n} matrix (C/(PyC-SiC)\textsubscript{n}) composites were fabricated by alternately infiltrating PyC and SiC into preforms via isothermal chemical vapor infiltration. The phase compositions, microstructure, mechanical and electromagnetic interference shielding properties of the composites were investigated. The results show that a four-layer structure consisting of alternate layers of PyC and beta-SiC deposits compactly on carbon fibers. The flexural strength and toughness of C/(PyC-SiC)\textsubscript{n} composites with a density of 1.43 g/cm\textsuperscript{3} are 200 MPa and 2936 kJ/m\textsuperscript{3} respectively, which are comparable to those of carbon/carbon composites with a higher density. The enhanced mechanical properties of C/(PyC-SiC)\textsubscript{n} composites are attributed to the presence of multilayered (PyC-SiC)\textsubscript{n} matrix. Cracks deflect and propagate at both fiber/matrix and PyC-SiC interfaces resulting in a step-like fracture mode, which is conducive to fracture energy dissipation. Moreover, due to the repeated reflection and dissipation of electromagnetic wave at fiber/matrix and PyC-SiC interfaces, the composites show an
about 40 dB shielding effectiveness in the frequency range of 8.2-12.4 GHz. These results demonstrate that C/(PyC-SiC)n composites exhibit great potential as structural and functional materials.

Composite materials; Multilayer structure; Mechanical property; Electromagnetic interference shielding.

AA-27
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.

negative permittivity, negative permeability, metamaterial, cermet

AA-28
Multishell Particles with Hollow Core and Tunable Property
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AA-29
DIRECT CHEMICAL SYNTHESIS OF L10-FePtAu NANOPARTICLES WITH HIGH COERCIVITY
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Recently, solution synthesis allows the preparation of monodispersed FePt nanoparticles (NPs) with a narrow size distribution, composition control and well defined shapes.[1-3] However, the as-synthesized FePt NPs typically adopt a face-centered cubic (fcc) structure, which is unsuitable for data storage and permanent magnetic applications, because of the superparamagnetic property of fcc-FePt phase at room temperature. The ordering phase transformation requires high temperature (>550 °C) annealing. However, high temperature annealing leads to complete decomposition of the surfactant on the surface of each NP and consequently produces an undesirable aggregation and sintering. [4, 5] To make disperable L10-FePt NPs, one can coat the as-synthesized FePt NPs with SiO2[6] or MgO[7, 8] layer before annealing, which serves as a protective layer that prevents FePt sintering during annealing. Then the protective layers can be removed after the fct FePt NPs are formed. Although these methods can reduce sintering and result in hard magnetic FePt NPs at room temperature, high-temperature annealing is still required.

Here, we report a new method to directly prepare L10-FePtAu NPs from solution synthesis. The unique feature of this synthesis is that oleylamine (OAm) in the synthesis serves as surfactant, solvent and reducing agent at the same time and no other strong reducing agent was used in the synthesis. By simply heating the solution of Fe(acac)3, Pt(acac)2 (acac = acetylacetonate) and gold acetate with OAm to 350 °C, L10-FePtAu NPs could be directly obtained without further annealing. In the current reaction condition, NP sizes were controlled to be 5.5 to 11.0 nm by changing the amount of Au doping. The composition of NPs could be simply controlled by the amounts of the precursors used in the synthesis. The highest coercivity of 12.15 kOe at room temperature could be achieved for the
NPs with 32% Au doping, which is much higher than the coercivities reported by the previous studies on solution-synthesized FePt NPs.

To understand the formation mechanism of L1₀-FePt phase in the NPs, the synthesis temperature was changed. The results suggest that Au composition in the NPs increase with increasing the synthesis temperature. For 230 °C synthesis, only fcc FePt (111) and (200) peaks can be seen. No Au peaks appear in the XRD curve, which means that Au atoms entered into the fcc FePt lattice. With increasing the synthesis temperature to 260 °C, Au peak appeared at the left side of fcc FePt peak, suggesting that Au atoms segregated from fcc FePt lattice. When the synthesis temperature was increased to 290 °C, L1₀-FePt peaks can be observed and Au and L1₀-FePt peaks were completely divided, which means that ordered FePt phase was formed. The NPs synthesized at 230 °C show the typical soft magnetic properties. Increasing the synthesis temperature to 260 °C, the coercivity of the NPs is about 0.90 kOe, which means that the FePt phase in the NPs started to order. Further increasing the synthesis temperature to 290 °C, the NPs have 5.53 kOe coercivity. Base on these results, it can be concluded that at low temperature synthesis, Fe, Pt and Au atoms nucleated together and alloy FePtAu NPs with fcc structure can be formed. With an increase of the synthesis temperature, Au atoms would diffuse out of the fcc FePt lattice, creating lattice vacancies that increase the mobility of Fe and Pt atoms to rearrange to fct phase.

The work provides a facile general approach to directly synthesize L1₀-FePt based NPs may help to build high performance magnets for magnet applications or produce high quality NPs for various catalytic applications.

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FePt; nanoparticles; coercivity; monodisperse

**AA-30**

**Fabrication and Properties of HNTs/Silica Aerogel Composites Via Ambient Pressure Drying**  
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The halloysite nanotubes/silica aerogel composites were fabricated by a sol-gel method using TEOS and aminopropyltriethoxysilane (APTES) modified halloysite nanotubes (HNTs) as the main materials, followed by an environmentally friendly ambient pressure drying (APD). The influences of the HNTs content on the mechanical, microstructural, and thermal properties were studied. In the samples investigated, the compressive strength was found to vary from 400 kPa to 5.6 MPa, average pore sizes from 32 nm to 86 nm, and thermal conductivity from 0.025 W/m K to 0.034 W/m K. The HNTs were uniformly dispersed in the silica aerogel, which resulted in composites with unique interpenetrating network microstructure that could offer excellent mechanical properties to aerogels. The composites with outstanding mechanical properties prepared by APD are potential for building applications.

halloysite nanotubes; silica aerogel; sol-gel; ambient pressure drying; network

**AA-31**

**Synthesis and characterization of nanosized oxide ceramic powders with eutectic compositions by heating of alcohol-aqueous salt solutions**  
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Generally, unagglomerated spherical ceramic powder with a narrow size distribution is the most desirable state for sintering and densification of ceramics. In the present work, a facile and novel method has been performed to fabricate nanosized oxide powders of Al₂O₃-ZrO₂(Y₂O₃) and Al₂O₃-LnAlO₃ (Ln = Gd, Sm) with eutectic compositions by heating of aqueous salt solutions with an alcohol-water mixture as the solvent. The kind and concentration of aqueous salt solutions have a significant influence on precipitation and morphologies of the resulting particles. When zirconyl chloride and yttrium- or aluminum-nitrate solutions are used as the reactant solutions, the resulting nanoscale particulates have a narrow size distribution. These amorphous powders are
crystallized to a mixture of t-ZrO2 phase and α-Al2O3 phase at 1250oC. However, when aluminum-nitrate, and gadolinium- or samarium-nitrate solutions are employed as the reaction species, the resulting precipitates are crystallized to a mixture of α-Al2O3 and orthorhombic LnAlO3 (Ln = Gd, Sm) at 1300oC. After calcination, these ceramic powders have a particle size of 100 to 200 nm. Finally, the densification process of these synthesized ceramic powders has been performed by hot pressing to further evaluate their microstructure and mechanical properties.

Synthesis of Heterostructured VO2@ZnO Dandelions Initiated by Heteroseed Assembly with Enhanced Thermochromic Performance and Photocatalytic Activity

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Vanadium dioxide (VO2) is a well-known thermochromic material that undergoes an abrupt reversible semiconductor-metal transition (SMT) at around 68 °C which is accompanied by a structural phase transition from monoclinic to rutile phase with an abrupt change in optical properties from transmitting to highly reflecting particularly in the infrared spectral region. The compound can be applied as a thermochromics smart material for energy saving and comfort. While the low visible transmission (Tvis), bad solar modulating ability (ΔTsol) and weak chemical stability the major drawbacks for preventing the practical application. However, zinc oxide (ZnO) has good chemical stability and high transparency, which is often used as a buffer layer in some functional coatings. Besides, ZnO is a well-known photocatalyst for self-cleaning coatings. If we combine the two kind of functional materials, the composite material should simultaneously have thermochromic property and photocatalytic Activity.

In this paper, we have successfully fabricated heterostructured VO2(M)@ZnO dandelions structure, in which the VO2(M) nanoparticles were prepared by TiO2 seed-assistant hydrothermal method and the quasi-spherical shape of VO2(M) NPs were with a size of around 50-100 nm. The dandelion-like ZnO shell was synthesized by three steps: firstly, the VO2(M) NPs were modified by sodium citrate for surface preparation; then, ZnO seeds were introduced into the system; finally, the VO2(M)@ZnO heteroseeds served as non-planar substrates for the growth of ZnO nanorod arrays and eventually formation of VO2(M)@ZnO dandelions. The dandelion-like spherical assemblies were with about 400 nm in size and each “dandelion” was comprised of radially arrayed nanorods with 20-50 nm in diameter and about 200 nm in length growing around a core.

The existence of ZnO could widen the optical band gap from 2.27 eV in a pristine VO2 to 2.67 eV in the heterostructured VO2(M)@ZnO composite. The widening of the optical gap could lead to a blue shift in the absorption edge from 498 nm to 475 nm, which, in turn, resulted in a significant increase in the visible transmittance. According to the Optical calculations performed by Granqvist et al., VO2 nanoparticles dispersed in a dielectric matrix should have relatively higher optical properties than pure VO2 films. The VO2(M)@ZnO composite film exhibited perfect optical properties. It reached a sufficiently high visible transmission (Tvis =52.2%) and still kept excellent Solar modulating ability (ΔTsol =9.3%), which were really well than the pure VO2(M) film (Tvis-l =35.0% and ΔTsol =8.5%). Besides, the ZnO shell could improve the oxidation resistance at the same time. The pure VO2(M) was readily oxidized into V2O5 at temperature higher than 320 °C, while the VO2(M)@ZnO could still remained chemically stable until 430 °C. It might due to the incorporation of Zn and the interfacial stress induced a distortion of the VO2 material, the phase transition temperature of the heterostructured VO2(M)@ZnO dandelions was decreased to 62.6 °C, which was obviously lower than that of the VO2(M) (67.8 °C).

Furthermore, the heterostructured dandelion-like VO2(M)@ZnO product had relatively large specific surface area of about 69.5 m2/g, which was nearly twice than that of the pure ZnO nanorods (34.5 m2/g). The hierarchical VO2(M)@ZnO dandelion structure could keep the catalyst NPS from aggregation and prevent the loss of active sites and photogenerated carriers. The narrowed band gap, higher specific surface area and special hierarchical structure were all beneficial to enhance the photocatalytic performance. The existence of the VO2(M) core could efficiently separate the photogenerated electrons and holes, which could also increase the photocatalytic ability of the ZnO.
This is the first report of such a single VO$_2$(M)@ZnO dandelions structure with both thermochromic and photocatalytic properties that offer significant potential for creating a multifunctional smart coating.

**AA-33**  
*Magnetoresistive Nanocomposites for Electrochemical Energy Storage*  
John Zhanhu Guo;  
University of Tennessee, USA  
Electrochemical capacitors (ECs) have been in urgent demand for utilizing sustainable and renewable energy sources due to the concerns over both the depletion of fossil fuels and climate changes. However, the current ECs have some challenges, for example, high power but low energy densities for electric double layer capacitors or high energy but low power densities for pseudocapacitors. Main efforts have been focused on developing new electrode materials (for example, highly conductive composites with high capacitance), or designing hierarchical nanomaterials (for example, microstructures with shortened low-resistive pathways for electron transport and ion diffusion). Recently, a small magnetic field of about 0.072 T was reported to significantly enhance the capacitance by 155% in a novel magnetic graphene nanocomposite electrode. However, the measured positive giant magnetoresistance (GMR, a large resistance change upon applying a magnetic field) of the electrode materials failed to interpret the capacitance enhancement. Therefore, how the magnetic field affects the electrochemical energy storage remains unclear. In this talk, the lab-made conductive polymer based nanocomposites have been designed and synthesized to disclose this puzzle.

**AA-34**  
*Formation Mechanism of Snowflake-shaped α–Fe$_2$O$_3$ via Hydrolysis of [Fe(CN)$_6$]$_{3–}$*  
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University of St Andrews, UK  
Snowflake-like α–Fe$_2$O$_3$ microcrystals can be produced in a hydrothermal treatment of an aqueous solution of K$_3$[Fe(CN)$_6$], due to highly selective growth orientations along the <11-20> zone axes. This phenomenon cannot be explained by classical theory such as the Bravais-Friedel-Donnay-Harker (BFDH) law and the Curie-Wulff theorem. Both of these theories only consider the lattice energy of the crystals without thinking out any effects from the environment. When the crystal growth of snowflake-like α–Fe$_2$O$_3$ was investigated step-by-step, we revealed a new crystal growth mechanism: surface hydrolysis of [Fe(CN)$_6$]$_{3–}$ guides the crystal growth. At very beginning, [Fe(CN)$_6$]$_{3–}$ anions polymerised into disordered clusters and the nucleation of α–Fe$_2$O$_3$ took place in these clusters. Spherical crystals grew up to about 100 nm in diameter before six branches appeared. Because the [Fe(CN)$_6$]$_{3–}$ anions were only adsorbed on the surfaces containing positive charged hydroxide sites, followed by surface hydrolysis into iron oxide, the growth orientations became highly selective. During the formation of ‘snowflake’ microcrystals, the <11-20> growth directions dominated the process. On the other hand, the {10-10} and {0001} surfaces containing no positively charged hydroxide groups were not active. However, this situation can be changed when the concentration of K$_3$[Fe(CN)$_6$] or the pH value of the synthetic solution is changed. This work will demonstrate how we can control the evolution of crystal morphology by changing the synthetic conditions. This newly established mechanism is complementary to the classical theories of crystal growth, and may be applied in synthesis of other materials with novel morphologies.

Vanadium dioxide, zinc oxide, thermochromic property, photocatalytic Activity

**AA-35**  
*Pt/Carbon Aerogel Catalytic Counter Electrodes for Dye Sensitized Solar Cells*  
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Pt/Carbon Aerogel Catalytic Counter Electrodes for Dye Sensitized Solar Cells
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The dye-sensitized solar cell (DSSC) using a carbon aerogel (CA) counter electrode (CE) with higher surface area and porosity exhibits enhanced overall power conversion efficiency (η) (8.24%) compared with that of the conventional Pt CE based DSSCs (6.69%), under 100 mWcm\(^{-2}\), AM 1.5 G sunlight illumination. Furthermore, Pt nanoparticles loaded onto CA (CA-Pt) are fabricated using a thermal decomposition process in the presence of a Pt precursor (H\(_2\)PtCl\(_6\)), and CA as supporting materials in an ethanol solvent. When CA-Pt was used as a CE in DSSCs, higher η can be obtained due to smaller charge-transfer resistance (R\(_{ct}\)) compared to CA counter electrode, indicating higher electrocatalytic activity. The highest η could reach up to 9.13% by optimizing Pt to CA ratio, which has a major impact on short current density (J\(_{sc}\)) but little on open-circuit voltage (V\(_{oc}\)) and fill factor (FF). CA-Pt use is expected to not only reduce the dependence on the Pt but also further enhance the device performance in DSSCs by hampering Pt nanoparticle aggregation. This work provides substantial support for developing low-cost Pt-load composite counter electrodes for DSSCs.

Carbon aerogel, counter electrode, solar cell, dye sensitized

AA-36
Subwavelength structure-induced ultralow diffuse reflectivity of carbon aerogels
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Carbon aerogels, consisting of hierarchical amorphous carbon skeleton and high porosity, has nanoscale and highly porous interface[1], network structure and optical isotropy which may trap light efficiently. In this paper, we studied the diffuse back-reflectivity of the carbon aerogels which were prepared by carbonizing the resorcinol-formaldehyde (RF) aerogels with different nanostructure. The carbon aerogels all showed ultralow reflectivity in the UV-Vis-NIR spectra. By changing the concentrations (W%) and catalyst ratios (R/C) of the RF colloid, it was found that there was a roughly positive correlation between the reflectivity and the density (42~328 mg/cm\(^3\)). Moreover, R/C parameter which determined the microstructure of the carbon aerogels affected the reflectivity greatly. By tuning the nanostructure of carbon aerogels, we got the minimum at about 0.19 % which approached the measuring limit of our equipment. The value was just 1/10 of inverse V-type structured film[2] and 1/40 of that of glassy carbon which is conventionally used as a black standard. Meanwhile, carbon aerogels were activated using CO2 at 1000 oC in order to induce the micropore (< 2 nm). The reflectivity of carbon aerogels decreased sharply after activated 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 surface electromagnetic coupling similar to disordered photonic crystal structure on the butterfly wing.

AA-37
Luminescent properties promoted by oxide ions trapped in nano-cages of Yb-doped mayenite glasses
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Rare earth (RE) elements with abundant f-orbital configurations are attractive candidates and have been widely employed as luminescent ions, activators and sensitizers in phosphor materials for applications in fluorescent lamps, X-ray intensifying screens, cathode ray tubes etc. Upconversion phosphors are also widely studied as emitting species that can exhibit sharp fluorescent emissions via intra-4f or 4f5d transitions. However, direct excitation of lanthanide ion (Ln\(^{3+}\)) is relatively inefficient for upconversion because of the forbidden character of 4f electrons tran
sitions. Therefore, Ytterbium usually acts more like a sensitizer (or electron donor) other than a luminescence center among currently investigated upconversion matrix, such as NaYF4, CaF2, and TeO2 etc.

Recently, the insulator 12CaO7Al2O3 (mayenite, C12A7) has being extensively investigated as transparent conductor, catalyst, ionic conductor, radiotio n resistant material, electron emitter, and superconductor. It is composed of densely packed, sub-nanometer-sized cages (~0.4 nm inner diameter) with positive charge. There are two formula units and 12 cages per unit cell, and thus its structure can be represented as [Ca24Al28O64]4+2O2 -. The diameter of each cage is approximately 5 O2- ions with other anions such as O2-, O- and even e- trapped in sub-nanometer-sized cages, resulting in the revision of its energy band structure, unique photo-induced conductivity and several other properties. Further more, this feature caused by nano-cages in C12A7 can still be maintained in glass state, which would greatly reduce the possibility of photo-induced electron scattering by grain boundaries, improving upconversion efficiency of C12A7 glass matrix. Massive progress on the luminescence of RE-doped C12A7 ceramics was mainly made by solid state reaction method in recent years, focusing on doping of RE ions into systems like Ho/Yb, Er/Yb, Eu/Yb etc, where Yb ions behave like a common sensitizer. The role of Yb ions as a luminescence center might come front with the promotion of oxide ions in C12A7 glass phosphors.

Aerodynamic levitation (ADL) is one of containerless processing methods that levitates melts during sample solidification, enabling effectively exploring amorphous materials with a low glass forming ability because it prevents heterogeneous nucleation from the container walls in a state of deep undercooling. Some binary systems, such as Al2O3-based, TiO2-based, and Nb2O5-based glasses, have been successfully vitrified in bulk form even without network-former oxides by utilizing ADL processing. In this study, we investigate the luminescent properties promoted by oxide ions trapped in nano-cages of Yb-doped mayenite glasses. Oxygen gas was employed as levitation force and additional oxide ions source to synthesize Y b-doped C12A7 glass spheres with diameter up to 8 mm. XRD, SEM, EDS results proves the glass state of as-prepared Yb-doped and Yb-free C12A7 samples. Transmittance spectra certified the absorption energy of photons around 980 nm of Yb-doped C12A7 glasses. XPS and Raman shift results co-illuminated the existence of Yb3+ cations in Yb-doped C12A7 glasses. The luminescent properties were evaluated by emission spectra in the visible light range on excitation with 980 nm radiation by comparison with Yb-free C12A7 glasses. It was found that Yb-doped C12A7 glass emitted strong green emission with peak wavelength at 510 nm due to the 4f5d→4f transition. Emission power spectra results clarified that two photons was involved in the emission process. The relative luminescent intensity finally vanished with Yb ion concentrations up to 40 mol% due to concentration quenching. Investigations about upconversion mechanism of Yb doped C12A7 glass revealed that the transitions of all emissions were two-photon cooperative processes with the absorption of Yb3+ ions and oxide ions promoted excitation in nano-sized cages. The excited Yb3+ ions in 2F7/2 and 2F5/2 levels lead to the luminous transition which could only happen when the top of energy band was decreased by oxide ions captured in nano-sized cages dispersed in C12A7 glasses. This can be illustrated why Yb ions commonly play the role of sensitizer among recently studied phosphor systems.

Conclusively, Yb-doped mayenite glasses has been successfully fabricated by ADL technique. Upconversion luminescence was observed at 510 nm green light by excitation of 980 nm. We proposed a new idea for exploring potential phosphors whose energy band could be modified by oxide ions encaged in nano-sized cage structure. Our further study was going on with other RE ions such as Er3+ ions, and other mayenite glasses such as Sr12Al14O33 (S12A7) to certify this theory. Furthermore, a new kind of conductive oxide glass phosphors would be proposed considering the latest exciting findings on the conductivity of C12A7 crystals reported on science magazine.

mayenite, glass, nano-cages, Yb-doped

AA-38
One-pot synthesis of Pt-Pd bimetallic nanoparticles as highly active electrocatalysts for the methanol oxidation reaction

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Direct methanol fuel cells (DMFCs) have aroused considerable interests as substitutes for conventional combustion engines in future mobile applications due to their high efficiency, low operation temperature, and environmentally benign products.1, 2 However, the commercialization of this technology has been hindered because of the sky-rocketing price of Pt, which has been widely used as the promising catalyst in fuel cells.3 As a result, Pt-based alloy nanostructures have emerged as ideal candidates as low-cost catalysts that can reduce the cost and still maintain high activity.4, 5 Many different methods have been developed to prepare porous Pt-Pd nanostructures, including galvanic replacement, seeded growth, and chemical etch. Nevertheless, the above methods have several disadvantages, including relatively high cost and complex reaction steps. Thus, more economic, facile, and environmentally friendly approaches are desirable to be explored in the synthesis of Pt–Pd nanostructures to achieve superior properties.

In this presentation, we developed a facile one-pot solution-phase method to fabricate Pt–Pd bimetallic nanoparticles by a modified polyol process using ethylene glycol (EG) as the reductant, and poly(vinylpyrrolidone) (PVP) and hydrochloric acid (HCl) as the stabilizing and structure-directing agents without using any toxic organic solvent, seed, or template.

The Pt-Pd NPs with different compositions have been prepared through tuning the ration of procurers. Besides, the as-prepared Pt-Pd NPs possess plentiful steps and thus more active site for good electrocatalytic property. The electrocatalytic activity of the Pt–Pd NPs for the oxidation of methanol was investigated in detail, and Pt-Pd NPs show higher activity in comparison with that of commercial Pt black.

Our work successfully provides a one-pot and efficient route for the synthesis of Pt-Pd bimetallic nanoparticles with different compositions and excellent catalytic performance. And it is also expected to be used to prepare other alloy nanostructures.

AA-39
Synthesis and densification of nano-hafnium carbide powder and HfC-SiC nano composites

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Objective: We wanted to synthesize ultra-fine hafnium carbide powder by the carbothermal reduction of HfO2 and wanted to fabricate HfC-SiC nano composites using the powder.

Methods: The powder was synthesized at 1600°C using a modified spark plasma sintering (SPS) apparatus. HfC-SiC composites were prepared by high-energy ball-milling and reactive spark plasma sintering (R-SPS) at 1700°C under 40MPa pressure using HfSi2 and C as the starting materials.

Results: The synthesized powder had a fine particle size of about 125nm and a low oxygen content of below 0.5wt%. The purity of the powder was >99.9% excluding Zr, and 99.6% when including Zr impurity. The intermediate reactions and particle growth were minimized due to the low synthesis temperature, fast heating/cooling rate and the effect of current during the modified SPS process. Ultra-fine (200-300nm) and homogeneously distributed HfC and SiC grains were obtained in the dense composites due to the molecular-level homogeneity of Si and Hf in HfSi2, the high-energy ball-milling of raw powders and low sintering temperature by R-SPS.

Conclusion: We could synthesize fine HfC powder and nano-HfC-SiC composites by using modified SPS and reactive SPS process.
Progress on porous ceramics for heat-insulation
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With the development of aerospace industry, higher requirements, e.g. lightweight, high temperature resistance, high strength and low thermal conductivity, have been put forward for heat insulation materials for high temperature parts. The properties of porous ceramics depend on the characteristics of the composition and structure including porosity, pore configuration, pore size and distribution.

In this presentation, some progress on porous ceramics for heat-insulation in my group will be reported. Some novel processing techniques, including modified gelcasting, freeze-casting, fiber reinforcing, aerogel impregnation, hollow-grained processing and so on, have been developed to design and control the specific porous structure, therefore, some specific properties including ultra-high porosity, ultra-lightweight, high strength, and low thermal conductivity have be achieved for some potential heat-insulation applications. The matching relationship between strength and thermal conductivity will also be discussed.

porous ceramics, heat-insulation, processing

Highly transparent cryogel- filmed-glass with enhanced thermal insulting property
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Aerogel is a highly porous material with pore diameters in the range of 10–100 nm. The porosity is above 90%, which combined with the nanometre pore size makes the aerogel a highly insulating material with a thermal conductivity lower than of still air [1]. High-performance thermal insulating materials currently constitute one of the main areas of materials research for environmental-friendly energy-saving technologies driven by the need to develop low CO₂ emissions technology. Traditionally, oxide aerogels with low thermal conductivity are prepared by supercritical drying, however, the process run in autoclaves is expensive and hazardous. In order to overcome these disadvantages, a cheaper and safer process, drying at ambient pressure has been developed for decades, but tedious repetitive gel washing and solvent exchange steps are involved. Therefore, in the present studies, a novel vacuum freeze drying was utilized to prepare the super thermal insulating SiO₂, ZnO, TiO₂ cryogels. In the case of SiO₂ cryogels, the wet gels were synthesized via acid-base catalysis using tetraethoxysilane (TEOS) as a silica precursor, the different solvents containing ethanol (EtOH), methanol (MeOH) and tert-butanol (TBA) during synthesis reaction and drying processes were tested for work simplification. After vacuum freeze drying, nanoporous SiO₂ cryogels with low-density in the range of 0.08–0.15 g/cm³, and large specific surface area value over 1000 m²/g were obtained. Super low thermal conductivities measured by NETZSCH GHP 456 were achieved in 0.0021–0.0277 W/mK corresponding to vacuum in the range of 2–100000 Pa.

Nano-silica cryogels and ATO composite dispersion was coated on PET film, and the filmed glass was then prepared by using this PET film to paste on the glass. The optical and thermal insulation properties were investigated. The results showed that the filmed glass with the dispersion of 10%SiO₂ + 10%ATO had the better spectral selectivity. Its visible light transmittance was 77.2%, the near-infrared shielding wavelength (the transmittance less than 10%) was 1500 nm, and the shading coefficient was 0.69. It also had a good heat-insulating performance. The air temperature inside the test box was 8 °C lower than that using blank glass.

Nano-silica cryogels ;filmed glass;cryogels dispersion;visible light transmittance ;thermal insulting
原位自生 SiAlON 对氮化硼基透波复合材料抗热震性的影响
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本文通过在 BN-SiO₂陶瓷基体中引入 AlN 作为增强相, 采用热压烧结工艺制备出 BN-SiO₂-SiAlON 透波复合材料, 研究了 AlN 添加量对复合材料物相组成及不同气氛条件下抗热震性的影响。XRD 分析结果表明:烧结后材料的主相为 BN 相, 并且当材料中未加入 AlN 或者加入的量小于 5vol% 时, 依旧能够发现非晶的 SiO₂相, 而当加入的 AlN 量进一步增加后, 不再显示有非晶的 SiO₂相, 同时随着 AlN 的加入, 发现有新相 SiAlON 生成。抗热震性测试表明: 在保护性气氛条件下, 对于未添加 AlN 的试样, 随着热震温差的增加, 热震后残余强度在热震温差为 900 ℃时达到最大值为 208.2MPa, 而后随着温度的升高而降低, 但依旧高于室温时的弯曲强度。而对于添加 AlN 的复合材料, 其热震后残余强度均呈现降低的趋势。实验环境为氧化性气氛时, 对于未添加 AlN 的复合材料, 经过热震后, 复合材料的残余强度随着热震温差的升高而增加, 经过 1200℃热震后, 复合材料的残余强度为 216.8MPa, 与热震前的强度相比提高了 38.3%。随着 AlN 的引入, 在热震温差范围内, 复合材料经热震后其残余强度均呈现下降的趋势。其中, 当添加 15vol%AlN 后, 复合材料经 1200℃热震后其残余强度为 158.4MPa, 与热震前的强度相比下降了 41%。
BN-SiO₂-SiAlON 复合材料、显微组织、抗热震性

AA-43
The influence of extrusion ratio on W-40wt.% Cu alloy produced by powder canning hot extrusion
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In this paper, W-40wt.% Cu alloys with different extrusion ratio have been obtained by powder canning hot extrusion. The experimental results show that, the relative density, specific conductance and hardness of the billets are increased with increasing extrusion ratio. Because of the high content of Cu phase (40wt.%), there is no shape change of W phase after powder canning hot extrusion even if the extrusion ratio is up to 25. The deformation mainly occurred in Cu phase. The total extrusion ratio (λ) is divided into three kind of actual extrusion ratio: the extrusion ratio of billet (α) --- which do not considering the volumetric deformation, the plastic extrusion ratio (β) --- which have excluded the influence of volumetric deformation and the extrusion ratio of can (γ). The influence of these three kind of actual extrusion ratio on the densification of W-40wt.% Cu alloy by powder canning hot extrusion has been studied.
Keywords: W-40wt.% Cu alloy, Extrusion ratio, Powder canning hot extrusion, Powder densification

AA-44
Energy harvesting in a piezoceramic under hybrid stimulations
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Shandong University
Energy harvesting from ambient environment vibration is a potential method to supplying the low-power consumption devices. This paper demonstrates a method to proceed energy harvesting using a piezoceramic (PZT). Both the mechanical and electrical excitations (hybrid stimulation) have been exerted on a piezoceramic. Current is measured through a current amplifier to calculate the induced polarization. By comparing the hybrid stimulation and the pure mechanical stimulation, it is found that the hybrid stimulation method enables to enhance the harvested amount, which is promising to be used in energy harvesting and sensor field.

AA-45
创新绿色建材产品技术
李宗津
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本报告主要介绍香港科技大学近年来研发的创新绿色建材产品技术，包括功能建筑材料；可持续发展材料，混凝土碗型浮力发电系统，以及新型材料测试技术。

在本报告中介绍的功能建筑材料包括无机反射型隔热材料，相变保温隔热板材，薄壁低频隔音材料，及水泥基压电机敏材料。无机反射型隔热材料是利用折射原理开发的绿色环保隔热涂料，可有效降低夏季空调耗电量。相变保温隔热材料是将低融点的化学工业副产品经一定的封装工艺后均匀地掺入水泥基材料，利用其由固相转变为液相或由液相转变为固相所积存或释放的潜热，来达到建筑物保温隔热或控制热吸收或热释放的效果。薄壁低频隔音材料是一种复合材料，利用其可调节的弹性系数有效隔离500赫兹以下低频噪音。水泥基压电机敏材料与用量最大的混凝土有着良好的相容性，适用于土木结构工程的健康监测及振动控制。

混凝土碗型浮力发电系统是香港科大最新研发的垂直轴风力发电系统，突破了超大型风力发电机尺寸设计瓶颈，具有风场利用率高，高效长时间运行，及可利用高性能混凝土制作的优点。

新型材料测试技术主要介绍香港科大发明的非接触式电阻抗测试方法。

AA-46

Fine Structured Piezoceramic/Polymer Composites for Smart Applications
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Central South University

Fine structured piezoceramic/polymer composites, which compromise micro-sized ceramic elements arrays embedded in polymer matrix, have shown superior properties over their bulk counterparts owning to improved strength, excellent flexibility and optimized sensing and/or actuating capability. Till now, dice-and-fill remains the most frequently used technique for fabricating fine scaled piezoceramic/polymer composites; however, it suffers the limitation of saw-blade thickness of around 20 μm and generally high cost. Recently, we have made much progress on developing micro-scaled structures for the fabrication of piezocomposites, involving tape casting, gelcasting, and viscous plastic processing (VPP). High quality PZT (lead zirconate titanate) arrays with fine scaled elements (10-20 μm) and capability of complex designs were successfully obtained. Fine structured 2-2 and 1-3 PZT/polymer composites were evaluated for high frequency ultrasonic transducer applications. Alongside, piezoelectric fiber composites (PFCs) with interdigitated electrodes (IDEs) were fabricated and characterized for actuating applications. This talk will present the structural optimizations, key processing issues and characterizations of these fine structured piezocomposites for smart applications.

AA-47

多壁碳纳米管-磷酸（亚）铁铵纳米复合材料的阻燃与力学性能研究
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AA-48

ROTATING MAGNETIC FIELD ANNEALING EVOKE REMARKABLE IMPROVEMENT OF GMI PROPERTY OF MICROWIRES
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Optimization of giant magnetoimpedance (GMI) property relies on the tailoring techniques¹–³. One of the more effectively used techniques is magnetic field annealing⁴. There are some diverse types of field annealing such as longitudinal or transverse magnetic field annealing, multi-angle magnetic field annealing⁵. Accordingly, magnetic field annealing both can release the internal residual stress, modulate structural relaxation, and thoroughly evoke the induced anisotropy of wires in favor of GMI property. We therefore proposed here a series of novel tailoring technique integrated conventional vacuum annealing (CVA) and rotating or uni-directional magnetic field annealing (RMFA or UMFA). Experimental results indicated that RMFA treatment composed of two-step CVA annealing (350°C for 1200s and 450°C for 600s, rotating magnetic field of 0.4T, furnace cooling) can remarkably enhance GMI property in comparing with as-prepared, CVA-treated and UMFA-ed wires. Moreover, GMI ratio increases firstly then tends to stable state with increasing frequency at different selected externally magnetic fields, and both permeability including GMI ratio decrease with the increase of dc magnetic field. At 13MHz, the maximum GMI ratio \([\Delta Z/Z_{\text{max}}]_{\text{max}}\) and field response sensitivity \(\xi_{\text{max}}\) of RMFA-ed wires increased to 398.39% and 21.83%/Oe, which is 2.41 times and 3.17 times of 165.18% and 6.88%/Oe for the as-prepared wire, which is also referred to 334.61% and 33.50%/Oe of UNFA-ed wire, respectively. And the induced anisotropy field of was effectively enlarged during RMFA annealing process, which is advantageous in the stable and uniform formation of circumferential anisotropy and magnetic domain combined atomic order orientation by the co-action of rotative variation magnetic field energy and thermal activation energy. While GMI behavior evolved from single peak (SP) to double peaks (DPs) at lowly magnetic field under the action of uni-directional magnetic field, which is attributed to the typically magnetic moment rotation of UMFA-ed wire for overcoming eddy-current damping or nail-sticked action at relatively high frequency. Therefore, It can be concluded that RMFA would be used to explore microwires with enhanced GMI property for high-performance sensor applications.

Rotating magnetic field annealing (RMFA); Uni-directional magnetic field annealing (UMFA); Co-based microwires; GMI property

AA-49

Mechanical and electromagnetic shielding properties of carbon fiber reinforced silicon carbide matrix composites
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Carbon fiber reinforced SiC matrix composites (C/SiC) were fabricated through chemical vapor infiltration. Effects of SiC content on the mechanical and electromagnetic properties of the as-prepared materials were studied systematically. Since high volume fraction of SiC matrix is beneficial to the transfer of load to carbon fiber, the flexural strength and the fracture toughness of C/SiC increase from 38 to 375 MPa and from 6.2 to 21 MPa-m⁰.⁵ with the increase of SiC content from 21.5 to 42 vol.%. The electromagnetic interference shielding effectiveness of the as-prepared C/SiC decreases from 43 to 31 dB over the frequency range of 8.2-12.4 GHz with the increase of SiC content, which is mainly attributed to the decline of absorption loss. With the increase of SiC content, the electrical conductivity of C/SiC diminishes, leading to the conspicuous drop of conductive loss, which plays the key role in lowering absorption loss of electromagnetic waves.
Keywords: A. Carbon fiber reinforced SiC matrix composites; B. Chemical vapor infiltration; C. Mechanical properties; D. Electromagnetic interference shielding effectiveness.

AA-50
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AA-P01
The preparation of nanosheets NiO by hydrothermal method and its electrochemical capacitive properties
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NiO is considered to be an excellent electrode material of pseudocapacitance supercapacitor for its lower cost, lower toxicity and good electrochemical performance. However, NiO electrode material still exists many problems to be solved. Such as high electrical resistivity, poor loop performance and the low energy density. In this paper, the precursor Ni(OH)2 was synthesized by a simple hydrothermal method with NiSO4 and (CH2)6N4 as reactants. Both concentrations of reactants are same. Concentrations of reactants are 0.02 M, 0.04 M, 0.06 M, 0.08 M for experiment contrast, and then NiO was gained after calcination at 400℃. Through the phase and morphology analysis to explore the forming process of nanosheets NiO. Electrochemical test and analysis to explore its structure formation process and mechanism. The result shows that with the increase of concentrations of reactants, nanosheets stack together and turn into thick slices, specific capacity gradually increased. CV curves have obvious redox peak, the GCD curves are nonlinear, EIS curves of high frequency area are curves, all these points to the same conclusion the capacitance type is pseudocapacitance.

AA-P02
Synthesis of single VO2 nanoparticles by using a biphasic liquid-liquid system
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One of the enormous challenges in the development of smart windows by using vanadium dioxide (VO2) is to obtain pure single phase vanadium dioxide nanoparticles. The solution of monodispersed vanadium dioxide nanoparticles was proposed using a biphasic inorganic-organic liquid-liquid system in one autoclave. The most exciting thing was that we achieved well-distribute vanadium dioxide nanoparticles thin film just by dripping solution on silicon slice directly with a pipette. The structure and optical properties of the film was characterized by scanning electron microscope (SEM), x-ray Diffraction(XRD), ultraviolet-visible(UV-vis) spectrophotometry and Fourier transform infrared (FT-IR) spectroscopy. The results exhibited that the film owns an excellent thermochromics property, and has good energy-saving effect due to its phase transition at 68℃; meanwhile this method of forming film is inexpensive, easy to preparation and highly effective, offering a great route for smart windows to be mass-produced.

AA-P03
Effects of Amino Groups in Carbon Nanotubes on Glass Transition Temperature of Epoxy Resin Composites
Cai Jiang, Jianwei Zhang, Shaofeng Lin, Su Ju, Dazhi Jiang
Molecular dynamics (MD) simulations and dynamic mechanical analysis (DMA) on amino groups grafted carbon nanotubes (NH₂-CNTs) reinforced epoxy resin composites were conducted to study the effect of amino groups (-NH₂) on the glass transition temperature (T_g) of the composites. The composite matrix is cross-linked epoxy resin based on the epoxy monomers bisphenol A diglycidyl ether (DGEBA) cured by diaminodiphenylmethane (DDM). MD simulations of NPT (constant number of particles, constant pressure and constant temperature) dynamics were carried out to obtain density as a function of temperature for each system. The T_g was determined as the temperature corresponding to the discontinuity of plot slopes of the density vs. the temperature.

The results indicated that T_g of the composites increased ~30 K when the NH₂-CNTs were bonded to the epoxy matrix via two N-C bonds on one N atom, compared with the composites lack of covalent bonds between the NH₂-CNTs and the epoxy matrix, namely the NH₂-CNTs were free in the epoxy matrix. The DMA tests verified that the T_g would be raised effectively when the NH₂-CNTs embedded into the epoxy matrix.

**AA-P04**

Structure and Magnetic Properties of Self-assembly L10 FePd-SiN Thin Films

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FePd alloys with fct-FePd structure for future high-density perpendicular magnetic recording media have been extensively investigated due to its high uniaxial magnetocrystalline anisotropy constant (Ku) [1]. The grain size of FePd thin films to serve as high magnetic recording media must less than 10 nm. Hence, several researchers have controlled the FePd grain size by adding ceramic materials [2], such as SiO₂, Al₂O₃, B₂O₃, in the films to fabricate a nanocomposite structure, which is helpful to realize the high magnetic recording density.

In this paper, we report on our recent efforts to fabricate FePd nanoparticles embedded in an amorphous nonmagnetic Si-N matrix by direct current (dc) reactive magnetron sputtering and then followed by vacuum annealing. The effects of Si-N additions and annealing temperature on the structure and magnetic properties were investigated. The as-deposited films had face-centered cubic (fcc) structure, which transforms into the face centered tetragonal (fct) structure after thermal annealing at 700°C. The grain size of FePd increased with the annealing temperature but decreased with increasing Si-N content. Increasing Si content led to the formation of SiN-rich amorphous phase distributed between the FePd nanograins, which reduced the lattice distortion and increased the coercivity. The fct-FePd films annealed at 700°C exhibited moderate coercivity, up to 3010 Oe at room temperature. These FePd-SiN films have shown promise for high-density magnetic recording medium.

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**AA-P05**

Preparation and properties of Polylactic acid/sericite nanocomposites modified by Gemini surfactants

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Due to its extensive sources, low price, excellent physico-chemical properties and good biological compatibility, polylactic acid (PLA) as a kind of green environmental protection material have been expected to replace the traditional plastic. But the preparation of layered silicate mineral/PLA composite has become an important issue because of its poor thermal stability and gas barrier property.

This paper selected three different 1, 2-alkyl amine bromides whose chain length is 8, 12 and 16 for substitution to synthesize three series of Gemini surfactants with different hydrophobic chain lengths by the multi-step recrystallization purification. Finally, we used these Gemini surfactants to modify sericite, and successfully prepared PLA/organic sericite nanocomposites via solution intercalation method. As result, we found that layer spacing of sericite modified by different Gemini surfactant increases obviously, confirming its layered structure has been destroyed. For PLA/organic sericite nanocomposites, the layer spacing also increases. The structure of sericite was damaged, and its nanosheets were scattered uniformly. At the same time, as the hydrophobic chain of Gemini surfactant added long, the nanocomposites’ thermal stability increased at first and then decreased, when thermal stability of Gemini surfactant with hydrophobic chain length of 12 is the highest.

Above all, we successfully prepared of PLA/sericite nanocomposites by Gemini surfactants modified with good thermal stability, and promoted the application of PLA replacing traditional plastic products.

Polylactic acid, sericite, Gemini surfactants, nanocomposites

AA-P06
Dual-band linear polarization transformer with diode-like asymmetric transmission based on composite metamaterial
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Huazhong University of Science and Technology

Objective: For dual-band linear polarization conversion with diode-like asymmetric transmission, a three-layer composite metamaterial was proposed and investigated numerically.

Method: By introducing the sub-wavelength cross structure into the asymmetric chiral metamaterial, which form an electromagnetic wave tunneling effect for the incident waves. The proposed composite metamaterial comprise two layers of asymmetric split-ring resonators (SRRs) and a sub-wavelength cross structures sandwiched symmetrically between these layers. Thus, the transmissions in the composite structures can be strongly modified, one of the two off-diagonal cross-polarized transmission ($t_{xy}$) of the Jones matrix is enhanced while all the others ($t_{xx}$, $t_{yy}$, and $t_{yx}$) are suppressed extremely. The numerical simulations were performed based on the standard finite difference time domain using the frequency domain solver of the CST microwave studio. In simulation, the metallic SRRs layers were modeled as a 0.036 mm copper film with an electric conductivity $\sigma = 5.8 \times 10^7$ S/m. Each dielectric layer is selected as Rogers RO4003 with a permittivity of 3.5 and a loss tangent of 0.0027. For practices, we define $t_{xx} = |E_{x1}/E_{x1}|$, $t_{yx} = |E_{y1}/E_{x1}|$, $t_{yy} = |E_{y1}/E_{y1}|$, and $t_{xy} = |E_{x1}/E_{y1}|$ as the transmission coefficients for different polarization conversion (x- to x-, x- to y-, and y- to y-).

Results: From the simulated transmission coefficients spectra, the cross-polarization transmission coefficient $t_{xy}$ reaches maximum of 0.94 and 0.96 at 8.76 GHz and 9.68 GHz for the designed composite structure, while the co-polarization transmission coefficients ($t_{xx}$ and $t_{yy}$) reduce to minimum of about 0.058 and 0.053 at the same frequency, and $t_{yx}$ is around small values of and 0.0031 and 0.0037. We also find that the two co-polarization transmission coefficients are exactly equivalent ($t_{xx} = t_{yy}$), which could ensure zero asymmetric transmission of circular polarization waves for this particular composite structure. In addition, when the propagation direction is reversed, the cross-polarization transmission coefficients ($t_{xy}$ and $t_{yx}$) interchange with each other while the co-polarization transmission coefficients ($t_{xx}$ and $t_{yy}$) keep the same in a dual-band frequency range. Thus, we can conjecture that when a y-polarized (x-polarized) wave normally incidents into the designed structures along the z (+z) direction, the wave is well coupled to the structures and converted mostly to x-polarized (y-polarized) wave due to the cross coupling between metallic layers when passing through the structures, while along the opposite
direction, the y-polarized (x-polarized) wave can hardly be coupled to the structure, resulting in a very weak transmission.

**Conclusion:** The numerical simulation results demonstrate that the design exhibits a dual-band linear polarization conversion as well as diode-like asymmetric transmission only for forward and backward propagating linearly polarized waves in a dual-band range. This present design for enhancing polarization conversion via asymmetric transmission can be used as many novel EM components, such as EM isolators, asymmetric wave splitters, and circulators.

polarization transformer, diode-like asymmetric transmission, composite metamaterial

**AA-P07**

**Multi-walled Carbon Nanotubes-Ferrum Ammonium Phosphate Nanocomposites: Flame Retardancy and Mechanical Properties**

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To recycle the nitrogen (N) and phosphorus (P) from waste water, the Multi-walled carbon nanotube-ferrum ammonium phosphate (MWCNT-FAP) was synthesized using simulated waste water containing N, P and Fe pollutants as raw materials. The adsorption-chemical precipitation method was employed to synthesize target products in situ and the optimal conditions for synthesis of MWCNT-FAP were obtained. The FT-Infrared (FTIR) spectroscopy, Energy Dispersive Spectrometer (EDS), Scanning Electron Microscope (SEM), Transmission Electron Microscopy (TEM) and Thermal Gravity Analysis (TGA) were conducted to characterize the samples. The FAP particle size was ~20-30 nm. The FTIR spectra demonstrated that a small amount of water in MWCNT-FAP promoted the curing reaction. The MWCNT-FAPs and Exolit AP 750 (AP) were introduced into epoxy (EP) to prepare the polymer nanocomposites. The Heat Release Rate (HRR) and flammability of epoxy composites were tested by Micro-scale Combustion Calorimetry (MCC) and UL-94 instruments. The mechanical properties of EP composites also were tested by tension testing system. Results indicated that the flame retardancy and mechanical properties of epoxy composites were improved by MWCNT-FAP. The addition of MWCNT-FAP and AP gave rise to an evident reduction of HRR and prolonged burning time for epoxy. The EP/MWCNT-FAP/AP passed the UL 94 V-0 rating. The analysis of the char revealed the synergy of MWCNT-FAP and AP in reducing the flammability of polymers. Conclusions of this work show a potential application in the wastewater treatment, N/P recycling and flame resistant material.

ammonium-nitrogen and phosphate removal; ferrum ammonium phosphate; multi-walled carbon nanotubes; flame retardant; epoxy.

**AA-P08**

**Electromagnetic Simulation of Influences of Metamaterial for Magnetic Resonance Imaging at 3T**

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This paper presents an approach to investigate the influences of metamaterial to radio-frequency (RF) magnetic field in magnetic resonance imaging (MRI) at 3T. The variety of magnetic fields of RF receiving coil was calculated using the commercial finite element method (FEM) software. The simulation results demonstrate that the receiving
magnetic field $B_{1}$ can be enhanced when the metamaterial is inserted into the RF coil, suggesting that the metamaterial has potential in MRI applications at 3T MRI.

Introduction

Metamaterials with the negative permeability have been proposed in magnetic resonance imaging (MRI) applications due to the superlens’ unique capability of imaging an object in deep subwavelength by recovering the evanescent wave. Wiltshire had designed a Swiss roll cell in 2001, which proved that the magnetic metamaterial can enhance the strength of magnetic field at 0.5T. Marques’ group had proposed a super lens with permeability -1 at 1.5T by adopting the split resonance ring (SRR), which improved that the signal to noise ratio (SNR) of RF coil. In MRI, the intensity of the receiving magnetic field of radio-frequency (RF) coils is a determinative factor for SNR or detection sensitivity. In this paper, we investigate the influence of metamaterial board insert into receiving magnetic fields ($B_{1}$) generated by a surface RF coil for 3T MRI using electromagnetic (EM) simulation.

Method

The main simulation model consisted of a square loop RF coil, a square metamaterial board and a cuboid phantom. The direction of main magnetic field $B_{0}$ in MRI is generally along axis z. The square loop RF coil was arranged in the x-y plane. The length and width of the square loop RF coil were $a = 40 \text{ mm}$ and $d = 5 \text{ mm}$, respectively. The thickness, conductivity and relative permittivity of RF coil were set to $t = 1 \text{ mm}$, $5.8 \times 10^{7} \text{ siemens/m}$ and $\varepsilon_{r} = 1$. The loop RF coil was tuned to 123.2 MHz by capacitors with 105 pF, which corresponds to the proton Larmor frequency at 3T. The metamaterial board with length $b = 100 \text{ mm}$ and thickness $t = 2 \text{ mm}$ was arranged at distance $D = 20 \text{ mm}$ away from the top of the RF coil. The relative permittivity and permeability of metamaterial were set to $\varepsilon_{r} = -1$ and $\mu_{r} = -1$. The cuboid phantom with $70 \times 57 \times 70 \text{ mm}^{3}$ was 2 mm distance from the top of the metamaterial board and was filled with water with permittivity $\varepsilon_{r} = 74$ and permeability $\mu_{r} = 0.99$.

The finite element method (FEM) software as was used to calculate the electromagnetic field distribution of the simulation model. The simulation model was surrounded by cuboid air space with $4000 \times 2000 \times 4000 \text{ mm}^{3}$. The total mesh number of the simulation model was 454298 with adaptive mesh discretization. The absorb boundary condition was used to mimic the infinite free space.

The magnetic field $B_{1}$ generated by the square loop RF coil was linearly polarized. Because magnetization vectors can be excited only by the transverse component of magnetic field $B_{1}$ in MRI. According to the EM field theory, the magnetic field $B_{1}$ can be decomposed into two circularly polarized field, one a left-handed rotating field $B_{1}^{-}$ and the other a right-handed rotating field $B_{1}^{+}$. The right-handed rotating field $B_{1}^{+}$ was called receiving magnetic field in MRI. In this paper, the distribution of receiving magnetic field $B_{1}$ for single loop RF coil and the Specific Absorption Ratio (SAR) in the cuboid phantom were investigated for the influences of metamaterial board insert.

Furthermore, in order to design the corresponding metamaterial with the negative relative permittivity and permeability, we have proposed that dual-layer metamaterial square spirals design has 4 turns approximately, a line width $W = 1 \text{ mm}$, line spacing $S = 0.5 \text{ mm}$, and unit cell size of 18 mm. The material of square spirals is copper with a conductivity of $5.8 \times 10^{7} \text{ S/m}$ and the dielectric slab between two spirals is 0.5 mm thick. The resonance frequency is not sensitive with the varying of line width but decreases with the number of turns, and converges to fixed value. Therefore, the resonance frequency of one unit cell can be adjust to the proton Larmor frequency at 3T by changing the number of turns of spirals. In addition, one unit cell has a flexible design to allow adjustment to human body. Finally, the negative relative permittivity and permeability of metamaterial will be verified in the metamaterial simulation design of one unit cell by numerical simulation.

Results

In order to investigate the influence of metamaterial board inserted, the metamaterial board was placed on the top of RF coil with distance $D = 20 \text{ mm}$. The receiving magnetic fields $B_{1}$ of different orientations in the cuboid phantom were selected. Firstly, the plane paralleled to x-z plane was 13 mm deep along axis y in the cuboid phantom. It was used to investigate the variation of pattern of field $B_{1}$. The distributions of field $B_{1}$ with various distances can be seen that the receiving magnetic field $B_{1}$ was enhanced with the meta-material board insert.

Secondly, the plane perpendicular to the x = 0 plane was considered in order to investigate the penetration depth of field $B_{1}$. The patterns of field $B_{1}$ with distance $D = 20 \text{ mm}$ were shown. The variation of receiving field $B_{1}$ along
the middle line of axis x was presented. The magnitude of receiving field $B_1$ with various depths along the axis +y was also displayed. It can be seen that the magnitude of receiving field $B_1$ with the metamaterial board insert was enhanced with improvement about 15.6% at 50 mm away from the bottom of phantom, which means that the metamaterial board maybe have potential in MRI applications at 3T MRI.

Conclusions and Discussion
A method of simulation to investigate the influences of metamaterial for MRI at 3T is presented. The variation of receiving magnetic field was studied numerically. The simulation results indicate that the receiving magnetic field can be enhanced in depth of 50 mm by metamaterial insert. Furthermore, the design of one unit cell of metamaterial is in good progress. It can be designed by structural simulation with using FEM software. The proposed metamaterial will be fabricated and the negative relative permittivity and permeability of designed metamaterial will be verified by measurement in future investigation.

Electromagnetic field, metamaterial, magnetic resonance imaging, simulation

AA-P09
Preparation and characterizations of ZrC-SiC composite ceramic fibers
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A kind of novel ZrC-SiC composite ceramic fibers were prepared via melt-spinning and pyrolysis of polymeric precursor polyzircononcenecarbossilanes(PZCS). The green fibers were cross-linked by surface oxidation in air and pyrolyzed at 1600°C under argon atmosphere. The cross-linkage and pyrolysis process of the precursor were characterized by FT-IR and TG analysis. The solid phases and microstructures of the obtained ZrC-SiC fibers were investigated by XRD, SEM and elementary analysis, which shown formation of composite ceramics with uniform distribution of nano sized ZrC in continuous SiC. By using HR-TEM, the crystallization of the derived ceramics in the fibers was investigated. The results shows that the formation of nanocrystallites ZrC, 10–20 nm in size. ZrC-SiC, polymeric pre-ceramic precursors, composite ceramic fibers.

AA-P10
Magnetically tunable extraordinary transmission based on dielectric and ferrite composite structure
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Extraordinary optical transmission through a single small aperture at a certain frequency has greater potential for the tunable filters. Metamaterials are a class of artificial materials with subwavelength functional electromagnetic microstructures. By placing artificial metamaterials near the single small aperture, the enhanced transmission has been achieved. Because of the coupling between the metamaterial resonators, a remarkable transmission appears at a certain frequency. However, most of the enhanced transmission can not be tuned due to the fixed structures.

Here, we report an approach to obtain magnetically tunable transmission by placing one pair of dielectric cube and ferrite cuboid on one side of a single aperture. According to the simulated and experimental results, under a magnetic field $H=1000$ Oe, a transmission peak at 10.7GHz induced by Mie resonance of the dielectric particles and the other transmission peak at 11.3GHz induced by ferromagnetic resonance of the ferrite particles appear. The measured transmission characteristics of the first transmission peak shows a -9 dB and the transmission characteristics of the second transmission peak shows a -11 dB. When $H$ increases from 1000 Oe to 2000 Oe, the first transmission peak barely changes, but the second transmission peak obviously increase as the $H$ increases.

In conclusion, we have obtained magnetically tunable transmission by placing one pair of dielectric cube and ferrite cuboid on one side of a single aperture. Two transmission peaks appear at 8 – 12 GHz. By adjusting the applied magnetic field, the transmission peak controlled by ferromagnetic resonance can be tuned.

Extraordinary optical transmission; Ferrite
AA-P11
Synthesis and evaluation of an all-new oxygen-free precursor for SiC/ZrC composite ceramics
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A novel polymeric precursor for SiC-ZrC composite ceramics was synthesized by dimethyldichlorosilane, Zirconocene dichloride and sodium in one-pot. The pyrolysis behavior and structural evolution of the precursor, the microstructure and composition of the synthesized SiC and ZrC particle were fully investigated. The results showed that the precursor could be completely transformed into SiC and ZrC after heat treatment in argon at temperatures above 1100 °C. Since there was no oxygen element in this precursor, carbothermic reduction reactions would not happen. Therefore, pure SiC and ZrC particle can be obtained from the precursor at relatively low temperatures, with ceramic yields more than 67%. The obtained ceramic consisted of amorphous matrix phase with amounts of SiC and ZrC nanocrystallites, which was 10-20 nm in size. This new precursor is suitable for production of ultra-high temperature ceramic fiber and composite matrix.

Pre-ceramic precursor; Zirconium carbide; Silicon carbide; Ceramics; Microstructure

AA-P12
Low density polyurethane/hollow glass particles composites with tunable mechanical and heat insulation property
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Although polymer materials have been widely used for their lightweight, low cost and easy-manufacturing nature compared to metal or wood materials, the shortages in function, stability and mechanical strength always lead to inferior performance and greatly hampered the expansion of their application. Therefore, combination of polymer matrix with functional fillers has been widely employed to overcome the inferior performance of polymer materials, and to endow special shape to the fillers for better handling and application. Among others, the combination of hollow structures with polymer matrices can significantly improve the physical properties without sacrificing the lightweight. Herein, polyurethane (PU) and hollow glass particles (HGP) were used as model materials to study the effect of the composition and fabricating condition on the physical properties of the polyurethane/hollow glass particles composites thus obtained. It is found that the presence of HGP contributes to the decrease of the density and increase of mechanical strength. The surface group and wettability of HGP exhibit certain influence on the interface match and the mechanical strength. Moreover, with properly controlled surface modification and weight ratio of HGP, the heat insulation property can be remarkably enhanced without reducing the adhesive strength of PU to certain surfaces such as steel. This work provides a better understanding of the surface and physical performance control of functional filler, composition, and processing parameters on the physical properties of polymer composites.

Composites; hollow glass particles; heat insulating property, mechanical property

AA-P13
Multi-pass compression of 3003/4004 clad alloy
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Multi-pass compression tests of 3003/4004 clad alloy were conducted on a Gleeble3500 thermo-mechanical simulator at deformation temperatures ranging from 280°C to 420°C and interval times ranging from 30s to 240s, with a constant strain rate of 0.5s⁻¹. The influence of deformation temperatures and interval times on fractional softening and microstructure were investigated. The results indicate that yield stress of the second pass was lower than the stress at the interrupted strain, which means static softening behavior happened during the interval time between two passes. The fractional softening, which describes the degree of static softening behavior, increases with the increasing of deformation temperature and interval time. It can be found that static recovery is the main mechanism of static softening.

3003/4004 clad alloy, multi-pass compression, static softening.

AA-P15
磁各向异性可控的柔性磁性薄膜的连续制备方法研究
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磁各向异性是磁性材料的重要内秉参量之一，不仅决定着磁性材料的磁矩取向和矫顽力，也会影响到磁性器件的工作频率乃至功耗。磁性材料针对不同应用领域对于磁各向异性大小有着不同的要求。研究磁各向异性可控的磁性材料的调控方法和机理一直是个磁性材料和磁性物理中的核心问题之一。另一方面，如何获得磁各向异性可控的磁性薄膜的连续制备方法也是降低磁性材料与器件应用成本的有效途径。这里我们报道一种在柔性衬底弯曲状态下生长薄膜的方法，制备后的薄膜由于受到压应力作用从而产生磁弹各向异性。磁性材料选用被广泛应用在自旋电子学器件的非晶 CoFeB 合金材料。在制备过程中通过改变柔性衬底的曲率半径，达到对制备后的磁性薄膜施加不同压应力的目的，进而实现对其磁各向异性有效调控。此外，对薄膜的厚度、缓存层的种类、柔性衬底的种类和厚度等因素进行了系统的研究。实验结果表明，通过设计不同曲率半径的装置，可以在不同的柔性衬底上实现实对不同厚度的磁性薄膜的磁各向异性有效调控。另外，基于这一调控磁各向异性的方法，我们设计了一种薄膜制备装置有望实现磁各向异性可控的柔性磁性薄膜的连续制备。磁各向异性 柔性磁性薄膜

AA-P16
基于磁致伸缩材料的柔性自旋阀结构的制备与应力调控研究
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基于巨磁电阻效应（GMR），以铁磁金属（自由层）/非磁金属/铁磁金属（钉扎层）/反铁磁为基本结构的磁性自旋阀具有很高的磁场灵敏度，在磁场探测等领域具有重要的应用。为提高磁场灵敏度，磁性自由层通常使用低矫顽力、低磁致伸缩的磁性材料。把大磁致伸缩材料 FeGa 引入到磁性自由层，有望获得应力敏感的磁性自旋阀，同时由于自旋相关散射的减弱，基于磁致伸缩材料的自旋阀结构的巨磁电阻率较低。我们利用磁控溅射在柔性 PET 衬底上制备了具备“磁致伸缩材料/高自旋极化率材料”复合自由层的磁性自旋阀结构：Ta/FeGa/FeCo/Cu/FeCo/IrMn。利用应力施加装置在垂直交换偏置方向施加不同的拉应力，研究了自旋层的 GMR 对应力的响应规律。在未施加应力时，此结构的 GMR 可达 5.8%，并且随着应变逐渐增大到 1.8%，零场附近的 GMR 值降低到 4.9%（相对变化率 15.2%），磁场为 120 Oe 处的 GMR 值随应力基本保持不变（相对变化率 2.8%）。钉扎层 FeCo 受到 IrMn 的交换偏置作用，使得钉扎层磁化方向在应力作用下改变不如自由层显著，从而 GMR 随着应变的增大而降低。在应力的作用下，自由层 FeGa 的磁化方向偏离磁场方向从而转向应力方向，但是在外磁场作用下，矫顽力较小的 FeCo 磁化方向转回到磁场方向，从而在 FeGa 与 FeCo 界面处形成了交换弹簧（Exchange Spring），使得 120 Oe 处的磁电阻率随应变基本不发生改变。
通过制备具有复合自由层的自旋阀结构，在保持高的巨磁电阻率的同时具有高的应力敏感度，对磁性应力传感器的发展具有重要的意义。

巨磁电阻 应力 复合自由层 传感器

AA-P17
CNTs 导电聚合物的研究进展
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碳纳米管(CNTs)因其优异的力学性能、热学性能和电学性能而作为导电填料广泛用作聚合物的无机填料。但是 CNTs 容易团聚,因而需要用合适的处理方法来减少碳纳米管在聚合物中的使用。当前减少碳纳米管使用量的办法有化学强氧化处理 CNTs、其他无机物与 CNTs 协同填充聚合物,利用其他加工技术如超临界 CO2 发泡技术等,以及新的加工工艺如使用干燥的翻筋斗(dry state tumble mixing) 制备材料等。
研究发现，上述方法能在满足电性能或者力学性能的基础上，减少碳纳米管的使用量，降低表面电阻率或者体积电导率。
本文研究了碳纳米管填充型导电聚合物的研究现状并对今后的发展趋势进行了展望。

CNTs; 导电聚合物; 分散; 协同

AA-P18
对载体进行预涂层处理来制备 MFI 取向沸石分子篩膜
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研究目的
MFI 型沸石膜(Silicalite-1 和 ZSM-5 两类)具有与分子尺寸相近的孔道体系,能耐高温、化学及生物侵蚀,可在分子级别上进行物质分离,实现催化反应分离一体化,在环保、石油、生物化工等领域具有广泛的应用。但是不容易得到均匀、连续、无裂痕的 b 轴取向分子筛膜。

研究方法
本实验采用玻璃片为载体在其表面进行壳聚糖复合溶液进行涂层,其优点是在低成本条件下得到均匀、连续、无裂痕的 b 轴取向分子筛膜。本实验主要采用玻璃片为载体,在载体上旋涂一层壳聚糖-氧化硅复合涂层后进行 b 轴取向分子筛膜的合成,我们调节壳聚糖的含量使其均匀分布在玻璃片表面,有利于 b 轴取向分子筛膜在玻璃表面生长。

结果与讨论
通过 SEM、XRD 表征发现调节分子筛膜合成液的比例、晶化时间、载体放置方式等得到了均匀、连续、无裂痕的 b 轴取向分子筛膜。通过固定床的反应对催化性能进行测试,证实其具有良好的催化性能。

壳聚糖-氧化硅复合溶液: b 轴取向: MFI 分子筛膜

AA-P19
毛细冷凝 APTES 增强 SiO2 纳米减反涂层耐磨性
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目的:
基于二氧化硅(SiO2)纳米颗粒的减反涂层在平板显示器、太阳能电池、发光器件等都有着广泛应用。然而, SiO2 纳米颗粒涂层往往存在耐候性能差的缺点,利用高温烧结来增强其机械性能的方法不能用于有机透明基底。

方法:
本文采用毛细冷凝方法,在较低温度下,将 APTES 沉积于 SiO2 纳米颗粒涂层的间隙中,使颗粒之间、颗粒与基底之间形成桥连结构,但同时保证涂层本身的孔隙结构不被破坏,使涂层减反性能不受影响。
AA-P20
Effects of Pouring Temperature on Interfacial Reaction between Ti-47.5Al-2.5V-1Cr alloy and Mold during Centrifugal Casting
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In this paper, we studied the centrifugal casting of Ti-47.5Al-2.5V-1Cr alloy, and explored the effects of pouring temperature on the interfacial reaction. Castings at 1600, 1650 and 1700 ℃ were obtained by controlling the other parameters constant in the experiments. The thickness of the reaction layer was measured by hardness test. The microstructure, elemental distribution and phase composition of the castings at the interface were detected by scanning electron microscopy (SEM), energy dispersive spectrometry (XRD) and X-ray Diffraction (EDS) respectively. The results show that the thickness at the interfacial reaction layer is increased by raising the pouring temperature. The elements in the mold and the matrix were double-diffused and reacted at the interface during the casting process, and formed solid solutions with the precipitation of many new phases such as Al2O3 and TiO2.

AA-P21
The development of the aluminized copper molybdenum molybdenum alloy frame
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Harbin University of Science and Technology
In this work, different content of bismuth oxide doped in 3YSZ material and formed mixed powder. After press forming, the samples were sintered at 850℃, 900℃, 1000℃ and 1100℃ respectively, then the electrical properties, thermal shock resistance, the phase components and the microstructure morphology were analyzed to study the solid solution mechanism of Bi2O3-Y2O3-ZrO2 three-phase system. It was found that the Bi2O3 can effectively reduce sintering temperature as a flux; Sintered at 1000 ℃, t-ZrO2 can be induced into m-ZrO2 by Bi2O3 doped; With the increasing of Bi2O3 content, system shock resistance decreases, approaching a value ; The 2-3mol% Bi2O3-YSZ system of the thermal shock resistance is the best; In the different content of Bi2O3 system, 3 mol% doped materials has the highest conductivity.
Bi2O3; YSZ; structure; electrical conductivity

The development of Molybdenum skeleton of Molybdenum copper composites melt infiltration
Jing-ze Wang, Jian-nan Cai, Wei Zhang
Harbin University of Science and Technology
The pure Mo skeleton melt infiltration of Mo-Cu composites prepared by Mo skeleton of the production process were studied. We can make its density controlled between 60%-70%.
By fine powder according to certain proportion with the coarse powder mixing, and design the corresponding mold suppression. The results show that we can choose the particle size of 48μm-106μm thick powder and grain size of 11μm-13μm fine powder, in and mixing ratio of 7:3, then ball mill for 5h, add 4% of stearic acid after 40min ball mill in the designed die with four different pressure value, such as 120MPa, 150MPa, 200MPa and 240MPa. We can get four round billet.

Density can be obtained by \( \rho(\%) \) was 63.59%, 65.36%, 64.83%, and 68.27% pure Mo skeleton. Density generally increases with the pressing force, to meet the first thing we need to between 60% and 70%, resilient rate at the same time also can maintain at around 1%. Because of its porous, so resilient rate is not a linear growth.

1) By using the method of grading of thick Mo powder and Mo powder according to the ratio of 7:3, after ball mill and repression, a certain density of pure Mo skeleton can be obtained.

2) Pure Mo powder, coarse powder particle size in 48μm - 106μm, powder particle size is about 11μm - 13μm, after ball mill 5 h joined 40 min 4% stearic acid to ball mill, thick powder can be mixed evenly.

3) Increases as the pressure value, the density of general parts will also increase, resilient rate can be controlled at about 1%. Parts of the volume rate of springback and its change is very small. Parts in 240MPa density was 68.27%, close to the general density.

density, Mo skeleton, Mo-Cu composites, density, Melt infiltration

Moisture absorption and mechanical degradation studies of PMI foam cored fiber/epoxy resin sandwich composites
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The present paper explores the result of hydrothermic aging of polymethacrylimide (PMI) foam core sandwich composites immersed in different temperature deionized (DI) and sea waters. The prepared specimens were tested for moisture up-take behavior and the resulting property degradation in terms of flexural and flatwise compressive strength. The results indicate that the saturated hygroscopic time of specimens immersed in low temperature water and high temperature water is about 480h and 720h, respectively. Due to the presence of ionic in sea water, the specimens immersed in sea water have higher compressive and flexural strength than specimens immersed in DI water.
Sandwich structure, PMI foam, Moisture absorption, Mechanical degradation

Comparative study on synthesis of MgAl2O4 by microwave sintering and conventional sintering
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This article mainly aims at the comparison of the Magnesia alumina spinel(MgAl2O4) phase synthesized by microwave sintering and conventional sintering respectively. Experiments were to measure and mix MgO powder and Al2O3 powder with mole ratio 1:1, then to sinter the mixture powder by microwave sintering and conventional sintering respectively, and MgAl2O4 phase was got. X-ray Diffraction(XRD) analysis, scanning electron microscopy (SEM) analysis and the statistics & calculation software of particle size distribution were investigated, and the results revealed tha:
1) High-purity MgAl2O4 phase could be synthesized by microwave sintering and conventional sintering of MgO powder and Al2O3 powder with mole ratio 1:1.
2) Microwave sintering could influence the MgAl2O4 phase microstructure because of the more excellent crystallinity, more fine and homogeneous crystal grains.
3) Microwave sintering could save the time and energy, and it can avoid such micro defects as coarse grains, molten grains and ablative grains.
Comparative study; MgAl2O4; Microwave; Sintering
Law of heat and mass transfer in montmorillonite during vacuum freeze-drying

Kui Yang, Lei Huang, Huarong Liu

In the process of vacuum freeze-drying, mathematical model of the heat and mass transfer was established in the montmorillonite colloidal suspension frozen body, and distribution of the temperature and concentration fields in the montmorillonite porous material drying process was analyzed. The calculation results show that the temperature and concentration fields follow parabolic distribution in the freeze-dried montmorillonite, and the temperature of the sample center gradually decreases from the top to the bottom, however the water vapor concentration gradually increases. At the same level of the sample, the temperature gradually increases from the inside out, and the water vapor concentration decreases. When the ambient temperature is 308K, the theoretical drying time is about 39.0 h for the frozen sample, consistent with the observed drying time (40.0h).

2D Meso-Scale Finite Element Modeling and Simulation of Polymer-Mineral Composite Material

Peiyao Sheng, Zhong Ji, Shizhao Wang

Polymer-mineral composite material uses modified epoxy resin as binder and mineral particles as aggregates. Its excellent damping characteristic and low thermal expansion make it ideal in manufacturing machine tool beds. However, the properties of this material depend on its formula and structure, so it is very important to develop an efficient method to numerically model the materials and then to optimize their properties. In this paper, 2D meso-scale finite element modeling is presented for numerical analysis and optimization of the mechanical and thermal properties of polymer-mineral composite material. First, the material is treated as a 2-phase composite composed of aggregates and binder which is epoxy resin mixed with fillers. Based on grading curve, the weights of aggregates are converted into the corresponding areas, and then aggregate particles are randomly generated and assembled with binder to produce the model. Second, the aggregates and binder’s mechanical and thermal properties are regarded as variables, and their effects on the composite are simulated by finite element method. Last, with controlling variable method, the compressive strength, elastic modulus, as well as minimum thermal expansion and heat-conduct rate of the composite material have been optimized. The results show that: (1) The simulated compressive properties are consistent with experimental results, which validate the fidelity of the generated finite element model and numerical analysis method. (2) By comparing the materials’ properties under four different gradations, we can find that materials with SAC gradation have best mechanical property, but poor thermal characteristics, and materials with n=0.45 fuller gradation have best thermal property. (3) The model’s compressive strength is proportional to the aggregate yield strength, but has an inverse relationship with binder yield strength. (4) For compressive elastic modulus, the model has a direct ratio relation with both aggregate and binder. (5) The increase of binder and aggregates’ thermal expansion coefficient and heat-conduct coefficient, the drop of their specific heat capacity, the growth of binder elasticity modulus and the reduction of aggregates’ elastic modulus all lead to enhancement of the model’s thermal expansion rate. (6) The heat-conduct rate of the composite material decreases with increasing the aggregate and binder’s heat capacity, and with decreasing heat-conduct coefficient.

Thermal expansion, magnetic and electrical properties of ternary compound DyCo0.67Ga1.33

Liuting Liang

The ternary compound DyCo0.67Ga1.33 was synthesized and the thermal expansion of DyCo0.67Ga1.33 was studied in the temperature range of 309–608 K by high temperature powder X-ray diffraction technique. The volumetric coefficient of thermal expansion, αv, can be represented by αv(T)=4.28786 ×10-6+6.97374×10-8T. The Debye temperature of DyCo0.67Ga1.33 is calculated to be ΘD= 328.4 K. Its magnetic properties was measured between 30 and 300 K, and the magnetic susceptibility of DyCo0.67Ga1.33 was found to follow the Curie–Weiss law.
law in the 40-300 K temperature range. The effective magnetic moment $\mu_{\text{eff}}$ and paramagnetic Curie temperature were estimated to be 9.86 $\mu_B$ and 40.4 K, respectively. Electrical resistivity of the compound DyCo0.67Ga1.33 was also measured between 5 and 300 K. Temperature variation of the electrical resistivity suggests the metallic character of the compound DyCo0.67Ga1.33 with an anomaly detected at 45 K. The residual resistivity ratio RRR of the compound is about 1.2.

Crystal structure; DyCo0.67Ga1.33; thermal expansion; Magnetic properties; electrical properties

One dimensional phase change in the process of pre-freezing with montmorillonite colloid suspension
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In the process of pre-freezing, the heat balance equation was established in the solid and liquid phase region of the montmorillonite colloid suspension, and the heat transfer law of montmorillonite colloid suspensions at phase transition was analyzed. According to the exact solution based on the error function by Franz Neumann, the temperature distribution feature and the velocity equation for the movement of the phase region were procured from the inner side of the liquid and the solid body in the pre-freezing process. The calculation results show that the internal temperature line of the montmorillonite colloid suspension is a distribution curve, the temperature curve of the freezing montmorillonite solid is linear distribution, and the moving rate of the freezing phase interface is function of its freezing time. Through the calculation, the freezing time is 12 hours for the 3.0% concentration, Ф40×40 simple, which is the same as the experimental data.

montmorillonite; pre-freezing; heat balance equation; heat transfer law

Synthesis and characterization of SiO2-Al2O3 composite aerogel using inexpensive inorganic salt of aluminum as raw material
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Monolithic SiO2-Al2O3 composite aerogel using inexpensive inorganic salt of aluminum as raw material was first prepared by sol-gel method, followed by C2H5OH supercritical fluid drying. The changes of phase structures during thermal treatment were characterized by Fourier Transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD) technique. The micro-morphology and structures were investigated by scanning electron microscope (SEM) and transmission electron microscope (TEM). Nitrogen adsorption-desorption isotherm was used to investigate the changes of pore structures during the heat treatment process. Results showed that SiO2 existed as unobvious amorphous state and Al2O3 mainly existed as polycrystalline boehmite which consisted of fibrous particles and weblike microstructures. As the heat treatment temperature rises, the Al2O3 aerogel part within the as-dried composite aerogel follows the sequence boehmite→ $\gamma$-Al2O3→ $\delta$-Al2O3, and mullite phase began to appear when the heat treatment temperature reached to 1300 °C, whereas the SiO2 aerogel part began to crystallize at temperature as high as 1100 °C. The specific surface area decreased with the increase of heat treatment temperature, however it remained 120 m²/g until 1200 °C. Heat treatment process improved quality of the three-dimensional network within aerogel, and the pore distribution became uniformity after heat treatment.
sol-gel; C2H5OH supercritical fluid drying; SiO2-Al2O3 composite aerogel; boehmite; mullite; pore structures

Fabrication of Co/Aluminum oxide composite nanofibers with tunable magnetic properties via electrospinning
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One-dimensional (1D) nanomaterial, including nanotubes, nanofibers, nanowires and nanobelts, has gained significant attention due to their potential applications in many areas, such as electronics, optics, sensing, etc. In this paper, the Co/Al2O3 composite nanofibers with controllable diameters have been fabricated via electrospinning. The X-ray diffraction (XRD) analysis, scanning electron microscope (SEM) and vibrating sample magnetometer (VSM) are used to investigate the surface morphology and the magnetic properties of the Co/Al2O3 composite nanofibers. The results show that the morphology and magnetic properties of the nano composites can be easily adjusted by control the parameters during the fabrication process. Due to the quantum size effect, the Co/Al2O3 composite nanofibers have revealed tunable and admirable magnetic properties, which show great potential in high-density information storage application.

electrospinning, nanofiber, composite, magnetic property

Effects of Pore-forming Agent on Characterization of Ni/YSZ Porous Anode for SOFC
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A comparative study has been carried out on the effects of pore-forming agents on the microstructural characteristics and properties including porosity, microstructures, linear sintering shrinkage and mechanical strength of Ni/YSZ anode. Different pore-forming agents (soluble starch, graphite and activated carbon) were incorporated into NiO/YSZ at various mass mixing ratios (5%, 10% and 15%). Under the condition of same content, sintered samples using activated carbon as pore-forming agent has a higher porosity than that with identical content of the other two kinds of pore-forming agents. Sintered samples with 10.0 wt% activated carbon have a porosity of 35%. Section morphologies show that pores distribute uniformly and connect very well in the anode with activated carbon as pore-forming agent. The mechanical strength of these sintered samples with carbon as pore-forming agent is also better in contrast with the other two kinds of pore-forming agents. With the activated carbon particle size decreasing (from 100 mesh to 320 mesh), the open porosity of porous NiO/YSZ is reduced (from 31.7% to 30.9%). Activated carbon is the best choice as pore-forming agent for Ni/YSZ anode.

SOFC, Ni/YSZ anode, Pore-forming agents, particle sizes

Preparation of anode-supported SOFC electrolyte membrane and porous anode material
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The graphite is used as pore-forming agent to prepare porous NiO - YSZ anode material. It explores the influence of the content of pore-forming agent on the anode material, and the change of the anode material before and after the reduction of NiO, etc. It’s found that the porosity and shrinkage rate of the anode are increased with the addition of the pore-forming agent, and the thermal shock resistance is also improved. The porosity rate of the anode with 10 wt% Graphite is 19%, and can increase to 36% after reduction, which will meet the basic requirement of the SOFC. Choose Y(NO3)3·6H2O and ZrOCl2·8H2O as raw materials, ethylene glycol monomethyl ether as solvents to make collosol. Using the spin coating method to succeed in preparing electrolyte membrane on the Si piece. The concentration of the sol should be smaller and the electrolyte membrane will be thinner if it spins faster and longer. Then choose the anode material with 10wt% graphite and 6wt% Bi2O3 as support to prepare electrolyte membrane by spin-coating. The collosol of large concentration should be spun first to plug the hole, then spin the smaller concentration to ensure its density. The thickness of the electrolyte membrane will increase with the increase of the layer number. If layer number is too less, porosity can not completely blocked. If layer number is too more, the electrolyte membrane will be prone to crack. The most appropriate layer number is two layers.
**Research on the Preparation and Oil-Absorbing Ability of Graphene Aerogels**

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Graphene has been closely studied due to its excellent physical and chemical properties since it was found in 2004. With its stable chemical properties, large specific surface area, high mechanical strength, strong surface chemical activity and wide distribution range of pore structure, it can be used as adsorption sites. However, graphene also can be reused which attributed to its application as adsorbent materials. The research work of this paper is: Porous graphene oxide with different concentrations has been prepared via freeze-drying, then graphene was produced through H2 reduction method. 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 (SEM), X-ray photoelectron spectroscopy (XPS), laser Raman spectroscopy (RS), 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 7mg/ml on methanol is the largest, up to 179.2 mg; the adsorption capacity of graphene with 7mg/ml and 2.5% PVA on acetone is the largest, up to 93.4 mg, and graphene can be reused after evaporation, and maintain a high adsorption rate.

**Microstructure, phase transformation and mechanical property of magnetic shape memory alloy particles/Mg composites**

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The magnetic shape memory alloys (MSMAs), such as NiMnGa, NiCoMnIn, exhibiting a high response frequency and large magnetic field induced strain, have been widely investigated in the past few years. However, these alloys belong to intermetallics and have a severe brittleness, which hinders their practical applications. To overcome this problem, making composites consisting of MSMA particles and a ductile matrix have been proposed and developed. In the present study, the MSMA particles/Mg composites are prepared by powder metallurgical method, that is, the MSMA powders are mixed with Mg powders and then sintered at 500~600 °C in vacuum. The microstructure observation results show that the interfacial reactions happened between the MSMA particles and Mg matrix in the composites. The reduction of MSMA particle size is in favor of the interfacial reactions. The interfacial reactions are helpful to enhance the mechanical properties but deteriorate the phase transformation of the composites.

**Percolation phenomenon in FeSiCr–epoxy composites Prepared by cryomilling**

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Purpose: To study the percolation phenomenon in metal-polymer composites.

Method: In this paper, FeSiCr-epoxy composites consisting of different content FeSiCr particles were prepared through pressure molding after mixing by cryomilling at liquid nitrogen temperature.

Results and Conclusion: The electromagnetic properties including ac conductivity, permittivity, and permeability were investigated in detail. The result showed that the frequency dispersions of ac conductivity follow the power law, indicating the hoping conduction behavior. The real permittivity of composites increases with higher FeSiCr
objective: In this paper, a broadband metamaterial absorber (MMA) based on magnetic rubber plate (MRP) and cross-shaped structure (CSS) resonator is presented numerically and experimentally which exhibit a -10dB absorption bandwidth from 2.35GHz to 4.67GHz with the total thickness of 2.3mm.

methods: The designed MMA is consisted of the MRP, cross-shaped structure, FR-4 dielectric substrate and metallic background plane. The MRP in our experiments is composite of epoxy resin and FeCo alloy powders, which is a homogeneous absorbing material as the permeability and permittivity are isotropic due to that the powders are randomly dispersed. Numerical simulations are performed using the frequency domain solver based on Finite-Difference Time-Domain (FDTD) in CST Microwave Studio. In the simulation, we set the boundary condition as unit cell, the material types of the metallic pattern and the grounded plane are lossy metal with electric conductivity of $5.8 \times 10^{7}$ S/m. The absorbance properties were measured by the Naval Research Laboratory arc testing system equipped with Agilent N5244A PNA-X network analyzer.

results: Experimental results show that the MMA designed achieves above 90% absorbance from 2.35GHz to 4.67GHz compared with 2.3GHz to 4.56GHz in the simulation when the thickness of the MRP and CSS is 1.7mm and 0.6mm respectively. According to the reflectivity spectrum, the proposed MMA excites two resonant absorption peaks to expend the bandwidth. With the increase of the thickness of the FR-4 dielectric substrate, the first resonant absorption peak shifts to the lower frequency while the second resonant absorption peak almost remains the same, with the increase of the MRP thickness from 1.5mm to 1.9mm, both resonant absorption peaks gradually shift toward the lower frequency together.

conclusion: The ultra-broadband absorption is attributed to the combination of two resonant absorption peaks, which originates from MRP and CSS resonator, respectively. By tuning the geometric parameter of the CSS and the thickness of MPR, the operating frequency band can be easily adjusted. Further, the MA is polarization-insensitive for both the transverse electric (TE) and transverse magnetic (TM) radiation. The MA has applications in the area of eliminating microwave energy and electromagnetic stealth.

Magnetic and microwave absorption Properties of Barium Ferrite fibers and Sr substituted barium ferrite fibers via Electrospinning

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Barium ferrite fibers and Sr substituted barium ferrite fibers were successfully prepared via Electrospinning method by using Fe(NO$_3$)$_3$·9H$_2$O, Ba(NO$_3$)$_2$ as the main raw materials. X-ray diffraction (XRD) and field emission scanning electron microscope (FSEM) were used to study the phase composition and microstructure of barium ferrite fibers. The results showed that barium ferrite fibers consist of a mix of barium ferrite particles of less than 100 nm in size stacking along the fibers. Magnetic properties were investigated by vibrating sample magnetometer (VSM), and the
magnetization measurements revealed that Sr substituted barium ferrite fibers have higher saturation magnetization (Ms) and lower levels of coercive force (Hc) which is more suitable for absorbing materials in theory, but in fact, the Sr substituted barium ferrite fibers have lower dielectric permittivity and permeability according to the test results. Barium ferrite; Magnetic properties; microwave absorption properties; Electrostatic spinning; Fibers

The isothermal section of the Ni-Mn-Sb ternary system at 773K

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The isothermal section of the Ni-Mn-Sb ternary system at 773K was investigated and constructed by using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersion spectroscopy (EDS), and electron probe microanalysis (EPMA) techniques. The existence of 7 binary compounds named MnNi, Mn\textsubscript{2}Sb, MnSb, NiSb\textsubscript{2}, NiSb, Ni\textsubscript{2}Sb\textsubscript{2}, Ni\textsubscript{3}Sb and 2 ternary compounds named Ni\textsubscript{2}MnSb and NiMnSb was confirmed in the isothermal section. The four binary compounds Ni\textsubscript{3}Sb (Cu\textsubscript{3}Ti-type structure, space group Pmnm), Ni\textsubscript{2}Sb\textsubscript{2} (Ni\textsubscript{2}Sb\textsubscript{2}-type structure, space group I\textsubscript{2}), NiSb\textsubscript{3} (FeS\textsubscript{2}-type structure, space group Pnnm) and Mn\textsubscript{2}Sb (Cu\textsubscript{2}Sb-type structure, space group P4/nmm) in the sub-binary systems Ni-Sb and Mn-Sb are stoichiometric compounds, the homogeneity ranges of which are negligible. While the five single phase regions in the Ni-Mn binary system and the binary compounds MnSb and NiSb show a more or less homogeneity ranges formed by replacement of Mn and Sb for Ni. The Huesler compound $\mu$ (Ni\textsubscript{2}MnSb) has L\textsubscript{2}-type ordered structure with space group Fm-3m, $a = 0.6017$ nm. And the crystal structure for the half-Huesler compound $\kappa$ (NiMnSb) is C\textsubscript{1b}-type (F-43m) with $a = 0.5961$ nm. The homogeneity ranges of the two ternary compounds $\mu$ and $\kappa$ at 773K were determined.

Ni-Mn-Sb, Ternary system, Phase diagram, Metals and alloys

Influence of Applied Load on Wear Behavior of C/C-Cu Composites under Electric Current

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Using carbon fiber needled fabrics with Cu-mesh and graphite powder as the preform, Cu mesh modified carbon/carbon(C/C-Cu) composites were prepared by chemical vapor deposition (CVD) with C\textsubscript{3}H\textsubscript{4} and impregnation-carbonization (I/C) with furan resin. Wear behavior of C/C-Cu composites under different applied loads was investigated on a pin-on-disc wear tester. Their microstructures and wear morphologies were observed by optical microscopy (OM) and scanning electron microscope (SEM), respectively. The results show that Cu meshes are well dispersed and pyrolytic carbon is in rough laminar structure. The current-carrying capacity of C/C-Cu composites increases and the arc discharge is hindered as the applied load increases from 40N to 80N. The mass wear rate of C/C-Cu composites under 80N was only 4.2\% of that under 60N. In addition, C/C-Cu composites represent different wear behaviors because wear mechanisms of arc erosion, abrasive wear, adhesive wear, and oxidative wear are changing under different applied loads.

C/C-Cu Composite, Microstructure, Applied Load, Wear, Electric Current

A two-dimensional gradient metasurface for excitation of spoof surface plasmon polariton and backward radar cross section reduction

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Objective:
A two-dimensional gradient metasurface (GM) for excitation of spoof surface plasmon polaritons (SPP) and backward radar cross section reduction (RCS) is proposed and investigated theoretically and experimentally at X-band.

**Method:**
According to generalized Snell’s law, on the GM, the tangential wave vector of the incidence is not conserved, thus, the transmission direction of electromagnetic (EM) waves can be controlled. Great excitation of spoof SPP can be realized when the composite surface wave vector consisting of the pre-defined wave vector provided by GM and the tangential component of the incident EM wave vector is greater than the wave vector of incident EM wave in free space. Therefore, reduction of backward RCS can be realized. The designed GM is consisted of a dielectric substrate sandwiched with continuous metallic film and metallic improved split cross structure (SCS). Finite element method (FEM) simulations are used to simulate the reflection phases of the improved SCS. The corresponding different reflection phases can be generated by changing geometry parameter of improved SCS. Finally, a super cell, as basic element of GM, comprising 3×3 unit cells with equivalent phase gradients along x-axis and y-axis, are obtained. In the simulation, the incident plane EM wave with different linear polarization is along the z-axis, and an infinite GM composed of the super cells was studied numerically. A 429 mm × 429 mm square GM composed of the super cell is fabricated and its reflection and backward RCS are measured.

**Results:**
The results of simulation show that the high degree of consistency exists in the reflectance of all incident waves with different linear polarization. The reflectance of the GM is severely reduced more than 10 dB around the designed frequency 10.0 GHz. Especially at 10.1 GHz, reduction of the reflection is more than 24 dB, that is, the efficiency of transformation from EM waves to spoof SPPs as high as 99.6%. The experimental results agree well with the numerical results around the designed frequency point. They convincingly verify that the designed GM as excitation of spoof SPP is polarization-independence and highly effective. The experiment results of RCS show that compared with those of bare metallic plate with the same size, backward RCS reduction of the designed GM reaches a highest value of 15 dB to the normal direction of the GM and 7 dB on average at angular region between -30° to +30° in the frequency range of 9.5 GHz to 11 GHz.

**Conclusion:**
On the designed GM, propagating EM waves follow the generalized Snell’s law, which allow one to control the reflection direction of EM waves. Excitation of spoof SPP can be obtained under normal incidence when the pre-defined wave vector provided by GM is greater than the wave vector of incident EM wave, thus, RCS reduction can be realized.

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**Design and characterization of planar magnetic metamaterials with double-sided windings/ceramic substrate for MRI application**

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There are three types of the MRI (magnetic resonance imaging) enhancement devices based on metamaterials so far. One is composed of metallic wires, the another one has the Swiss roll structure, and the last one has the microstructure of a capacitively loaded split-ring with a high precision (~1%) capacitor. However, those metamaterial devices yet have long way to go for practical MRI applications. The one with wires has a significant thickness and an inconspicuous image enhancement, the one with the Swiss roll structure also has considerable thickness and in fact its intrinsic resolution is limited by the diameter size of element rolls except for its high loss. The one with split-rings is much less thick than the others but not thin enough for application yet, moreover the addition of high precision capacitors increases cost dramatically and not friendly for fabrication. Presently the last type has been more attractive than the other two. While examining the structures of the last type carefully, one can find that the only reason to use capacitors is to reduce the resonance frequency of the split-rings. Hence it is not necessary to utilize capacitors if the resonance frequency of the microstructure is low enough. To lower the resonance frequency of a unit cell, two approaches were investigated separately, one was using double-sided metallic windings by normal PCB, the other one was utilizing high dielectric constant substrate. The metamaterials were simulated and fabricated based on those two methods. The final thickness including package were both less than 5mm, much thinner than previous metamaterials for MRI. The resonance frequency was characterized by vector analyzer and was in good agreement with aimed frequency about 63.7MHz for 1.5T MRI system. The gain of the one with ceramic substrate was about 12.83dB, while the one with only double-sided windings 7.19dB. More over the signal enhancement of both metamaterials were confirmed by a water phantom test. The latter one showed a promising image enhancement in both gray level value and signal to noise ratio. However, the one with ceramic substrate demonstrated severe nonuniformity or artifact. This could be resulted from the strong coupling between metamaterials and receiving coils and the relatively high loss tangent of ceramic substrate. Our results show that by the structure of double-sided windings or high permittivity ceramic substrate could dramatically diminish the size of the unit cell and lower the resonance frequency in the meanwhile, especially with a thickness under 5mm, much thinner than any previous reported metamaterials for MRI.

**Effects of contents and organic groups of carbon nanotube on creep properties of epoxy resin composites**

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Carbon nanotubes (CNTs) reinforced epoxy resin composites were prepared and examined to determine the effects of contents and organic groups of CNTs on creep property of the CNTs/epoxy composites. The CNTs/epoxy composites with different CNTs content and variously functionalized CNTs, namely, pristine, carboxylated, aminated, hydroxylated, were fabricated. Tip sonication and high speed shearing method were used to disperse CNTs in the epoxy resin, followed by a casting process. While the CNTs loading had little influence on the tensile property of the epoxy, it significantly reduced the creep compliance of the composites. Moreover, aminated CNTs reinforced epoxy composite had the least creep strain in given conditions. DMA study showed that there was a decrease on the mobility of the epoxy resin polymer chains, indicated by their increasing activation energy.