Forum B Ceramic Materials

B01(Invited)

Microstructure Evolution Behavior of Metastable SiBCN Ceramics Prepared by Mechanical Alloying

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The fully dense amorphous Si-B-C-N monoliths were fabricated at 1000°-1600 °C under 5 GPa for 30 min where the mechanically alloyed amorphous Si-B-C-N powders were used as raw material. Crystallization and microstructure evolution of the prepared ceramics were investigated by XRD, TEM and HRTEM. Results show that at≤1100°C, the ceramic remains amorphous. With the increasing temperature, the atomic arrangement tends to be well organized, followed by the precipitation and growth of SiC and BN(C) nanocrystals. Above 1400°C, numerous SiC nanocrystals are present in the amorphous ceramic matrix. At 1600°C, the microstructure of Si-B-C-N ceramic is characterized by SiC nanocrystals with average size of 10-30 nm surrounded by BN(C) phase. The further investigation remains to be done for BN(C) microstructure evolution.

B02(Invited)

Relaxor Ferroelectric Crystals for Medical Ultrasound Transducer Application

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Relaxor-based ferroelectric single crystal $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PMN-PT) has drawn much more attention in the ferroelectric field because of its excellent piezoelectric properties near the morphotropic phase boundary (MPB). The piezoelectric constant d_{33} and electromechanical coupling coefficient k_{33} are >1500 pC/N and ~0.9, respectively. The ternary $Pb(In_{1/2}Nb_{1/2})O_3$-$Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PIN-PMN-PT) single crystals also possess good piezoelectric properties comparable with PMN-PT single crystal and have a higher phase transition temperature (rhombohedral to tetragonal T_{rt} and tetragonal to cubic T_c) and larger E_c. Therefore, these relaxor-based PMN-PT and PIN-PMN-PT single crystals have potential applications for ultrasonic transducer applications.

In this talk, recent development of PMN-PT single crystals and their applications in medical ultrasound transducers will be reviewed. Benefited from their extremely large piezoelectric

coefficient and electromechanical coupling factor, medical ultrasound transducers from a few MHz up to 100 MHz have been fabricated in our group and bandwidth and sensitivity have gained significant improvement compared to PZT based transducers. The single crystal based medical ultrasound transducers have been commercialized ten years ago by Philips and are being rapidly adopted by other main ultrasound imaging manufacturing companies.

B03(Invited)

C/SiC Composites with a Self-healing SiBC Matrix Fabricated by Liquid Silicon Infiltration

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Most researched continuous carbon fiber reinforced silicon carbide matrix composites (C/SiC) composites have porous matrix, which are fabricated by chemical vapor infiltration (CVI) or polymer infiltration and pyrolysis (PIP). The porous C/SiC composites exhibit higher fracture toughness, flexural and tensile strength but lower compression and shear strength. Liquid silicon infiltration is a quick and low-cost densification method to fabricate dense C/SiC composites. However, besides the issue of residual silicon, high process temperature results in large thermal residual stress (TRS) in the composites. TRS is released usually in the form of spontaneous matrix microcracks, which is not beneficial to the oxidation resistance of dense C/SiC composites at temperatures ranging from 600 to 1000°C. In order to fabricate dense C/SiC composites with excellent oxidation resistance, it is necessary to design a crack self-healing matrix and relieve TRS in dense C/SiC composites by interphase thickness control. The synthesis mechanism of Si-B-C matrix and the effect of PyC interphase thickness on mechanical properties and oxidation behaviors of C/SiC-SiBC are analyzed in details with an emphasis on the crack self-healing mechanisms. This review might provide a directional guide for the optimization design of dense ceramic matrix composites for long term use in oxidizing atmosphere.

B04

Polycrystalline Lutetium-based Scintillation Ceramics：Fabrication, Microstructure and Scintillation Properties

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Scintillation material is a kind of crucial material for radiation detection in the fields of nuclear medicine diagnosis, high energy physics, security inspection and oil well logging. An excellent scintillation material should possess the merits of high density, high light yield and fast decay time. Polycrystalline scintillation ceramics exhibit the potential to replace scintillation single crystals due to their lower fabrication temperature, easiness of complex chemical composition design, shorter preparation cycle and easier mass production compared to counter part of single crystals. Lutetium is the heaviest element in lanthanide elements. Lutetium-based scintillation material has a high density (usually > 6 g/cm^3), which is beneficial to stop and absorb high energy rays (X-ray or γ ray). We have developed a series of polycrystalline lutetium-based scintillation materials including Lu_2O_3:Eu, $Lu_3Al_5O_{12}$:Ce (LuAG:Ce) and Lu_2SiO_5:Ce (LSO:Ce). Nano-sized Lu_2O_3:Eu and LuAG:Ce powders were synthesized by co-precipitation processing. Lu_2O_3:Eu and LuAG:Ce scintillation ceramics were fabricated by pressureless sintering in H_2 atmosphere and vacuum sintering, respectively. Submicrometer-sized LSO:Ce scintillation ceramics were densified by pressureless sintering coupled by hot isostatic pressing starting from the powder synthesized by sol-gel route, This paper is devoted to introduce fabrications, microstructure and relevant properties of these three kinds of lutetium-based scintillation ceramics.

B05

Fabrication, Microstructure and Properties of Porous Y_2SiO_5 with Low Shrinkage, High Porosity and High Strength

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The emerging porous Y_2SiO_5 ceramic is regarded as a promising candidate of thermal insulator owing to its very low thermal conductivity. However, recent works on porous Y_2SiO_5 are confronted with severe problems such as large linear shrinkage (18.51–20.8%), low porosity (47.74–62%) and low strength (24.45–16.51 MPa) at high sintering temperatures (1450–1500 °C). In this study, porous Y_2SiO_5 ceramic with low sintering shrinkage and high porosity was successfully prepared by in situ foam-gelcasting method using gelatin as the gelformer. The effects of sintering methods, including in situ reaction sintering and direct sintering, and sintering

temperatures on the phase composition, microstructure, and properties of porous Y_2SiO_5 were investigated. The as-prepared sample has unique multiple pore structures, low linear shrinkages of 6.3–4.5%, controllable high porosities of 60.7%–88.4%, high compressive strengths of 38.2–0.90 MPa, and low thermal conductivities of 0.126–0.513 W/(m·K) (porosity: 87.1–60.2%). The effects of relative density on relative strength, as well as porosity on thermal conductivity were quantitatively discussed. The present results indicate that porous Y_2SiO_5 is the potential high-temperature thermal insulation material of light weight, low thermal conductivity, and high strength.

Keywords: porous Y_2SiO_5 ceramic; in situ foam-gelcasting method; low linear shrinkage; high porosity; low thermal conductivity.

B06(Invited)

Why the Permittivity and Permeability Can Be Negative for Some Traditional Materials?

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Double negative materials (DNMs) with negative permittivity and negative permeability have attracted extensive attention worldwide in recent years because of their various potential applications in electronic, microwave and optics. Different from metamaterials which gain their double negative properties not from their composition but from their exactingly-designed structures, random DNMs is proposed from the point of view of materials, i.e. intrinsic properties determined by chemical composition and microstructure. We have prepared a series of conductor-insulator composites for the DNMs. Interestingly, plasmonic negative permittivities are obtained in the percolative composites. And, unique fano-like plasmon resonances that switch the permittivity from negative to positive are also observed in the dielectric spectra. Further investigations indicated that, the fano-like dielectric frequency dispersion can be attributed to the interference between the electromagnetic radiations emitted by the LC resonance of the composites and the external high frequency electromagnetic field. Negative permeability is also obtained in the percolative composite, and the negative permeability is provided by the intrinsic magnetic resonances and the diamagnetism generated by the micro current loops in the composite. The realization of double negative property in percolative

composites will have great significance on some applications at radio frequency (RF).

B07(Invited)

Fabrication and Their Physical Properties of Robust Insulating Bismuth Ferrite Multiferroic Ceramics

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As one high temperature multiferroics, bismuth ferrite is hot researching. However, low resistivity and high dielectric loss are two major problems associated with the fabrications of $BiFeO_3$ multiferroic ceramics and debates their electrical and magnetic properties. In this talk, a series of robust insulating bismuth ferrite ceramics were successfully fabricated using a refined solid state reaction electroceramic processing, using the strategy of ternary solid solution to enhance thermodynamic stability of $BiFeO_3$ perovskite phase. Then their structural phase transition, electrical and magnetic properties were presented and discussed.

B08

Influence of Yb_2O_3 and Lu_2O_3 Doping on Microstructural and Electrical Characteristics of Zno-Bi_2O_3 Based Varistor Films

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ZnO-Bi_2O_3varistorfilms doped with two kinds of rare earth element oxides (Lu_2O_3, Yb_2O_3) were prepared by the sol-gel method. The effects of Lu_2O_3/Yb_2O_3 doping on microstructure and electrical characteristics ofZnO-Bi_2O_3varistor films were investigated. All samples show homogenizedmorphology and improved nonlinear relationship between electric field (E) and current density (I). Both Yb_2O_3 and Lu_2O_3 doping can decrease the grain size ofZnO-Bi_2O_3varistor filmsand improve theelectrical properties, which have positive effect on the development of ZnO varistorceramics. Yb_2O_3 doping significantly increases the dielectric constant in low frequency. 0.2 mol% Yb_2O_3doped ZnO-Bi_2O_3varistor filmsexhibit thehighest nonlinear coefficient (2.5) and lowest leakage current (328μA) among Lu_2O_3/Yb_2O_3 doped ZnO-Bi_2O_3varistor films. Similarly, 0.1 mol% Lu_2O_3 doping increases the nonlinear coefficient to 1.9 and decrease the leakage current to

462μA.

B09

Deuterium Permeation of Alumina Coating on 316L Prepared by Magnetron Sputtering

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Theresearch and development of the structure materials that can resist the permeation of hydrogen and its isotopes is one of the important topics in the fusionreactor blanket. This paper describes the reduction of the effective deuterium permeation rate of 316L stainless steel obtained by the depositionof an alumina coating on the surface.The measurements of thepermeation rate of deuterium were performed by a gas-phasepermeation technique over the temperature range 873K -973 K and for deuterium driving pressures in the rangefrom 40KPa to 100KPa.The maximumdeuterium permeability of the alumina coating is 315times less than that of the bare 316L steel

B10

Blue LD Excitable Glassceramics with 660 Nm Featured Broad Emission

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A 660 nm broad emission glassceramics was prepared by using an inorganic-organic composite slurry mainly containing silica sol and microsized $CaAlSiN_3$: Eu^{2+} phosphor particles by spray atomization and spin coating on the structured patterned glass surface were prepared successfully based remote phosphor coating, examines the structural and optical properties of different curing temperature conditions that influence the properties of fluorescent coating of heat treatment temperature conditions optimization. The components such as TiO_2, ZrO_2 with higher refractive index were added so as to possibly increase the extraction efficiency of the incident blue and the excited emission red light. The structures and refractive indices of these phosphor-in-glass (PIG) in between various interfaces of glass and microsized and nanosized

particles were optimized for the purposes of the remote typed semiconductor lighting technology to construct either warm white or/and photosynthetic active spectrum .

Keywords: interface, refractive index, phosphor in glass (PIG), glassceramics

B11

Monodisperse Mesoporous TiO_2 Microspheres for Dye Sensitized Solar Cells

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To synthesize mesoporous titania microspheres with well-defined pore structure for dye sensitized solar cells. Uniform discrete mesoporous titania microspheres have been synthesized via a facile and controllable interface-directed co-assembly approach by using 3-dimensional macroporous carbon (3DOMC) as the nanoreactor for the confined co-assembly of template molecules and titania source. when hydrophilic 3DOMC is used as the host materials, the macropores of 3DOMC scaffold which act as the uniform compartments can be completely filled with the precursor solution through the “windows” by capillary force, In the course of ethanol evaporation, the Ti species oligomers formed by the hydrolysis and condensation of TIPO can associate with P123 molecules via hydrogen bonding and Vander Waals’ force, then further cooperatively assemble into rod-like composite micelles. The composite micelles can grow on the macropore wall at the solid liquid interface where the concentration is sharply increased due to rapid evaporation of ethanol. Due to the confinement of the macropores, the composite rod-like micelles adapt a curved morphology and assemble into ordered mesostructure in the same direction along the macropore walls. Finally, ordered mesoporous titania microspheres with circularly arranged mesoporous channels can be obtained after the removal of carbon frameworks and P123 via calcination in air. The obtained mesoporous TiO2 microspheres with diameter about 380 nm possess a large pore size (4.7 nm), high accessible surface area (145 m2/g), large pore volume (0.26 cm3/g) and highly crystallized anatase pore walls. From the magnified FESEM and TEM images, the ordered stripe-like mesopores can be clearly noticed in the surface of TiO2 microspheres, and all the mesopores are exclusively circularly arranged in both the surface and inner part of the obtained titania microspher s Wide-angle XRD patterns of the mesoporous titania microspheres show well-resolved and broad diffraction peaks which can be indexed to anatase titania composed of nanocrystals. By adjusting the synthesisparameters, hollow mesoporous microspheres and hemi-microspheres can also be synthesized. The

dye-sensitized solarcell based on the mesoporous TiO2 microspheres exhibits high photoconversion efficiencies up to 8.5 %, which are largely attributed totheir intrinsic high surface area, high porosity and well-connected crystalline framework.Conclusionuniform mesoporous titania microspheres, hemi-microspheres and hollow microspheres with large pore sizes and high crystallized anatase walls have been controlled synthesized via the facile and controllable interface-directed co-assembly approach for the first time by using amphiphilic template molecules P123 as structure directing agent, titanium isopropoxide (TIPO) as titania source and 3-dimensional macroporous carbon as the nanoreactor. The obtained mesoporous TiO2 microspheres have a large pore size of 4.7 nm, high accessible surface area (145 m2/g), large pore volume (0.26 cm3/g) and highly crystallized anatase pore walls. Thanks to their intrinsic high surface area, high porosity and highly crystallized pore walls, the dye-sensitized solar cell based on mesoporous TiO2 microspheres show high photoconversion efficiencies up to 8.5 %. Considering the good shaping effect of confinement synthesis strategy, it is expected that the IDCA method may open up new opportunity for designing mesoporous transition-metal oxide materials with tunable morphologies and high mesoporosity for applications in catalysis, sensors, and optical device.

Keywords: mesoporous materials, titania, confinement, interface assembly, dye-sensitized solar cells.

B12

The Synthesis and Characterization of Sr-Cu-Fe Doped La_2NiO_4

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Doped La_2NiO_4 are promising cathode materials for solid oxide fuel cells (SOFCs) which are environment friendly energy conversion devices.In this work, the synthesis of Sr, Fe and Cu doped La_2NiO_4 and the effects of dopants on phase formation during calcination and on the sinter-ability have been studied. Pure La_2NiO_4 (LNO),$La_2Ni_{0.6}Cu_{0.4}O_{4+\delta}$ (LNCO),$La_2Ni_{0.6}Fe_{0.4}O_{4+\delta}$ (LNFO), $La_{1.8}Sr_{0.2}NiO_{4+\delta}$ (LSNO), $La_{1.8}Sr_{0.2}Ni_{0.6}Cu_{0.4}O_{4+\delta}$ (LSNCO), $La_{1.8}Sr_{0.2}Ni_{0.6}Fe_{0.4}O_{4+\delta}$ (LSNFO) are synthesized via solid state reaction. The mixed precursors are calcined between 800 and 1300 C and the different phase formation temperatures are decided by x-ray diffraction characterization. The sintering behaviors of these doped La_2NiO_4 are characterized by dilatometry. The results show that the phase formation temperatures of pure and doped La_2NiO_4 are varied in the temperature range of 1000-1200 C. The partial substitution of La with Sr has no significant

effect on the phase formation process; the partial substitution of Ni with Cu accelerates the phase formation process and LSNCO can be synthesized at a low temperature of 1000 C; the partial substitution of Ni with Fe, however, retards the phase formation process.

Keywords: Solid oxide fuel cell, cathode, La_2NiO_4, calcination, sintering,

B13

Electromagnetic Wave Absorption Property of SiC NWs/GA-PDMS Composites

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Ultralight graphene foam has triggered a new wave of discoveries. It is expected to be the most promising candidate for lightweight high performance microwave absorption (MA). Aligned-structured SiC nanowires (NWs) / graphene aerogel (GA) polydimethylsilox- ane (PDMS) composites are fabricated through a facile freeze-drying and polymer infiltration method, and the electromagnetic wave absorption properties of the composites are studied at 1350 - 1450 ℃. SEM images indicate that the reduced graphene oxide (RGO) are decorated with numerous SiC NWs with a relatively uniform size of 30 - 50 nm, forming hierarchical nanostructures. Investigations of the electromagnetic properties indicate that the complex permittivity of SiC NWs / GA - PDMS are significantly improved in comparison with that of pure GA - PDMS, leading to enhanced electromagnetic wave absorption properties of the SiC NWs / GA- PDMS. The maximum reflection loss of the SiC NWs / GA - PDMS is up to − 46.58 dB at 12.1 GHz with the matching thickness of 3.8 mm, and the absorption bandwidth with reflection loss values below -10 dB is in the range of 8.2-12.4 GHz when the matching thicknesses are 3.05 ~ 3.15 mm. These results suggest that the aligned-like SiC NWs / GA - PDMS with enhanced electromagnetic wave absorption properties and wide absorption bandwidth are an ideal candidate for electromagnetic wave absorption applications in the future.

B14

Effect of SiO_2 Content on the Mechanical and Dielectric Properties of SiBON Composites

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A novel composite ceramics with excellent mechanical and dielectric properties was fabricated by means of low temperature hot-pressing using mechanically alloyed SiBON powders as raw materials. The influences of SiO_2 content on phase, microstructure, mechanical and dielectric properties of the SiBON ceramics were investigated. The bending strength and fracture toughness were mainly affected by the content of SiO_2 and maximums at the same BN/SiO_2 ratio of 5:1with 247MPa and 3.15 $Mpa \cdot m^{1/2}$, respectively. The ceramics showed both low dielectric constant ($\varepsilon < 4.65$) and loss tangent ($\tan \delta < 0.0036$), with good mechanical properties and excellent thermal shock resistance, indicating the hot pressing sintered SiBON ceramics could be used as promising high temperature wave transparent material.

Keyword: mechanically alloyed, Hot pressing, Mechanical properties, SiBON

B15

Exploration of porous SiC nanostructures as thermal insulator with high thermal stability and low thermal conductivity

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The crucial challenge for current nanoscale thermal insulation materials, such as Al_2O_3 and SiO_2 aerogel composites, is to solve the trade-off between extremely low thermal conductivity and unsatisfied thermal stability. Typical high-temperature ceramic SiC possesses excellent mechanical properties and superior thermal stability. However, this material also has intrinsically high lattice thermal conductivity close to diamond. We herein show that by integrating specific nano-scale phonon scattering mechanisms in porous SiC nanostructures, these outstanding materials could demonstrate promising thermal insulation property. β-SiC nanoparticle (~35nm) packed beds show ultra-low thermal conductivities of 0.068 ~ 0.1 $W\ m^{-1}\ K^{-1}$ and they can retain the excellent thermal stability up to 1500 °C. Also, thermal conductivity and mechanical properties of porous nano-SiC prepared by partial sintering and sacrificial fugitives methods with controllable porosities (50%~76%) are investigated. We find that porous nano-SiC sintered at

1500 °C exhibits a specific balanced mechanical strength and very low thermal conductivity; and sample sintered at 1800 °C shows excellent mechanical strength but also relatively high thermal conductivity. Our results shed light on porous SiC as a promising thermal insulator used in extreme thermal and chemical environments.

B16(Invited)

Synthesis of Well-Dispersed CeO_2–CuO_xcomposite Hollow Spheres with Superior Catalyticactivity for Cooxidation

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Well-dispersed CeO_2–CuO_xcomposite hollow spheres have been successfully synthesized through a facilereflux method using carbon spheres as sacrificial templates. The shells of the hollow spheres, ~40 nm inthickness, consist of self-assembled 10~15 nm sized nanoparticles. Scanning electron microscopy (SEM)and transmission electron microscopy (TEM) were employed to study the structural features of theCeO_2–CuO_xcomposite hollow spheres. X-ray photoelectron spectroscopy (XPS) confirmed that most ofthe copper element is distributed on the surface of the CeO2 shell support. The CeO2–CuOxcompositehollow spheres exhibited enhanced catalytic activity for CO oxidation: complete CO conversion couldbe obtained at 112 °C. The excellent catalytic activity could be ascribed to the hollow structure, highspecific surface area and the strong synergistic interaction between CeO_2 and CuO_x.

Keywords: CeO_2,oxides, hollowsphere, catalytic oxidation

B17(Invited)

Two Dimensional Layered Films for Electronics and Optoelectronics

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Two dimensional layered films such as graphene and layered inorganic materials are promising for future nanoscale electronics and optics. We also performance of dielectric layer and metal contacts on the performces of field effect tranisistors based on InSe. we discover that

carrier scattering from chemical impurities of hydroxyl groups and absorbed water molecules at oxidized dielectric plays a central role in determining the mobilities of 2D layered semiconductors based FETs, and suppression of this carrier scatter can significantly enhance the performance of 2D layered semiconductor devices. Further, we demonstrate high performance multilayer InSe transistors on poly-(methyl methacrylate) (PMMA)/Al_2O_3 bilayer dielectric with a room-temperature mobility > 1000 $cm^2V^{-1}s^{-1}$, comparable to that of strained-silicon thin-film. The first GaS nanosheet-based photodetectors are demonstrated on both mechanically rigid and flexible substrates. Photocurrent measurements of GaS nanosheet photodetectors made on SiO2/Si substrates and flexible polyethylene terephthalate (PET) substrates exhibit a photo-responsivity at 254nm up to 4.2 AW^{-1} and 19.2 $AW^{-1,}$ respectively, which exceeds that of graphene, MoS_2, or other 2D materials-based devices. Additionally, the linear dynamic range of the devices on SiO2/Si and PET substrates are 97.7dB and 78.73 dB, respectively. Both surpass that of currently-exploited InGaAs photodetectors (66 dB). Further, we have also performed work in GaSe based photodetector have for the first time. GaSe based photodetector showing a fast response of 0.02s, high responsivity of 2.8 AW^{-1} and high external quantum efficiency of 1367% at 254 nm, which indicates that the two dimensional nanostructure of GaSe is a new promising material for high performance photodetectors.

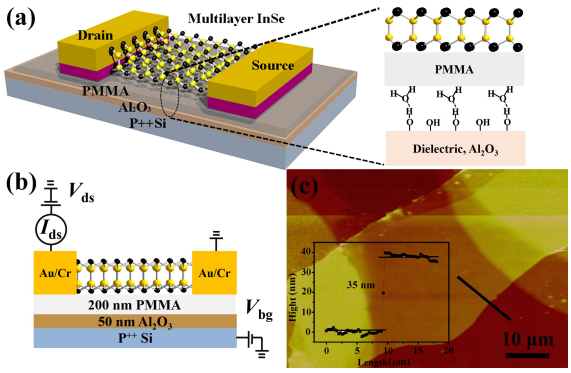

Fig1. (a) Schematic of back-gate multilayer InSe FETs consisting of PMMA/Al_2O_3 back gate insulator,. (b) Cross-sectional view of structure of the two-contact model. (c) Corresponding atomic force microscopy of multilayer InSe FETs. Inset: corresponding height profile of 35 nm.

B18

Better Oxygen Transport Properties and Chemical Stability of La_2NiO_4 Compared with Those of Sr-Fe Doped $Lagao_3$

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Mixed conductors of oxygen ion and electron are important materials. They have been used as oxygen permeation membranes or electrodes of fuel cells. Doped $LaGaO_3$ and La_2NiO_4 are both mixed conductors, but they have different crystal structures which will result in different application potentials. In this work, $La_{0.8}Sr_{0.2}Ga_{0.6}Fe_{0.4}O_{3-\delta}$（LSGFO）and pure La_2NiO_4 (LNO) are synthesized via solid state reaction. Their oxygen transport rates from air to helium between 700°C and 900 C are characterized by gas chromatography. The chemical stabilities are tested by x-ray diffraction, according to the increase of Relative Peak Areas of Impurities (RPAI) before and after annealing in helium atmosphere. LSGFO shows orthorhombic lattice witha = 5.49Å, b = 5.53 Å, c = 7.79 Å. LNO also shows orthorhombic lattice witha=5.458Å，b=5.463Å，c=12.68Å. At 800 C, LSGFO shows oxygen transport rate of $1.03\times10^{-8}mol\cdot cm^{-2}\cdot s^{-1}$ with averageactivation energy of $189kJ\cdot mol^{-1}$; while LNO shows oxygen transport rate of $3.19\times10^{-8}mol\cdot cm^{-2}\cdot s^{-1}$ with averageactivation energy of $69.1kJ\cdot mol^{-1}$. After annealing in helium, the RPAI of LSGFO increases from 8% to 21%, while the RPAI of LNO only increases from 2% to 6%. This work shows LNO exhibits higher oxygen permeation rate and better chemical stability between 700 and 900 C compared with those of LSGFO.

Keywords: Oxygen permeation, mixed conductor, $LaGaO_3$, La_2NiO_4

B19

Crystal Structure,Lattice Vibrational Characteristic, and Dielectric Property of $Nd(Mg_{1/2}Sn_{1/2})O_3$Ceramic

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$Nd(Mg_{1/2}Sn_{1/2})O_3$(NMS)ceramic was synthesized using a conventional solid-state reaction method. Crystal structure and morphology were investigated through X-ray diffraction (XRD) and scanning electron micrograph (SEM) technologies, respectively. Lattice vibrational modes were

obtained through Raman and Fourier transform far-infrared reflection spectroscopy.The main phase is NMS with monoclinic $P2_1/n1$ symmetry certificated by XRD. SEM result shows sample is dense and well-crystallized ceramic. The Raman spectrum with active modes can be fitted with Lorentzian function, then the lattice vibrational modes were assigned and illustrated, respectively. The highest wavenumber mode above 650 cm^{-1} is attributed to A_{1g}-like mode that corresponds to the symmetric breathing of oxygen octahedra. The far-infrared spectrum with seven infrared active modes was fitted by using four-parameter semiquantum modelsto calculate intrinsic properties. Among these modes,$F_{2u}^{(2)}$ yielded the greatest contribution to dielectric constant and loss, which is primarily represented as the inverted translational vibration of Nd-MgO_6 octahedron.

Keywords:$Nd(Mg_{1/2}Sn_{1/2})O_3$ ceramic;Crystal structure; Dielectric properties; Raman spectrum; Far-infrared spectrum;

B20

Prepration and Characterization of Advanced SiC Fibers

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SiC fibers are one of the most promising reinforcements for metal, polymer and ceramic matrix composites, due to the high tensile strength, remarkable oxidation resistance, high thermal stability, which have extensive application as high-temperature structural materials. With great development of the polymer-derived method to prepare ceramic materials of high performance, excellent achievements have been obtained in further improvement of both high temperature stability and oxidation resistance by optimization of composition and microstructure of SiC fibers. SiC fibers are ususally prepared by the melt-spinning, curing, and pyrolysis of an organosilicon polymer, polycarbosilane (PCS). Here newly developed advanced SiC fibers will be reported using PCS as the precursor.

B21

Fabrication of Amorphous SiBN powders by Mechanical Alloying and its Crystallization Process

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Because of the excellent mechanical and dielectric properties, SiBN ceramic was regarded as

one of the best comprehensive performance thermal-insulation and wave-transparent material. We prepared amorphous SiBN powders by mechanical alloying using amorphous nano-Si_3N_4 and h-BN as raw materials and sintered amorphous/nano-crystal SiBN ceramics with great mechanical and dielectric properties by hot pressing. The effects of sintering temperature in phases, microstructure, mechanical properties and dielectric properties of SiBN ceramics have been investigated in this research.

SiBN ceramic by hot pressing is consisted by α-Si_3N_4, β-Si_3N_4, Si_2N_2O and h-BN phases. The SiBN ceramic after hot pressing at 1800°C, 40MPa for 30min owns the best comprehensive performaces of mechanical properties and dielectric properties, of which bulk density, flexural strength, elastic modulus, fracture toughness and Vickers hardness are 2.21g/cm^3, 159±5MPa, 73±1GPa, 2.04±0.07MPa·$m^{1/2}$and 2.9±0.1GPa, respectively.And the mean dielectric constant and dielectric loss tangent value of this ceramic are 4.93 and (3.81~5.24)×10^{-3} in 21~40GHz range at room temperature, respectively.

Keywords: SiBN ceramics, mechanical alloying, microstructures, mechanical properties, dielectric property

B22(Invited)

High Throughput Screening for Rare Earth Silicates as Environmental / Thermal Barrier Coating Materials

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Silicon-based ceramics and composites are enabling high temperature structural materials for a wide range of components in extreme environments. Environmental barrier coating plays a crucial role to protect the silicon-based materials from water vapor and CMAS corrosions attacks at high temperatures. A strategic perspective is to develop integrated environmental/thermal barrier coating (E/TBC) systems in the future protective system. Trial-and-error approaches were typically explored to recognize proper RE-silicate as E/TBC candidates. However, the intrinsic mechanical, thermal and chemical properties of dense materials in extreme environments are still not fully understood. The missing knowledge blocks the breakthroughs on optimal properties which would trigger significant modification of the performances of protective coatings. To promote the high throughput screening for advanced E/TBC candidates, a comprehensive informatics is critically needed on the mechanical and thermal properties, as well as high

temperature water vapor and CMAS corrosion resistance of dense and phase-pure RE-silicates in harsh environments. The lecture clearly describes the dependences of macroscopic performance on crystal chemistry, namely chemical composition and crystal structure. The results would initiate high-efficient materials design and selection of RE-silicates for advanced E/TBC applications.

B23

Preparation, Microstructure and Crystallography of $Al_2O_3/Y_3Al_5O_{12}$ Eutectic Crystal Grown by Floating Zone Method

Luchao Sun*, Xu wang, and Jingyang Wang#

Directionally solidified $Al_2O_3/Y_3Al_5O_{12}$ ceramic has received extensive attention as a new heat-resistant material and been considered as a promising candidate for ultrahigh temperature structural materials due to its excellent performance even close to its melting point. In this work, the $Al_2O_3/Y_3Al_5O_{12}$ eutectic crystal was successfully prepared by an optical floating zone furnace. The microstructure evolution during the directional solidification process was studied by electron backscattered diffraction, and a competitive growth of the Al_2O_3 and $Y_3Al_5O_{12}$ grains was observed. The result show that single crystal Al_2O_3 was obtained in a shorter growth distance compared with $Y_3Al_5O_{12}$. Also, the orientation relationship of the two phases in single crystal was characterized by high resolution electron microscopy. It is found that the crystallographic relations between these two phases are: $(2\bar{1}1)\mathrm{YAG}\,\|\,(0003)\mathrm{Al_2O_3}$ and $[011]\mathrm{YAG}\,\|\,[1\bar{1}00]\mathrm{Al_2O_3}$.

B24

High Emissivity $MoSi_2$-Zro_2-Borosilicate Glass Multiphase Coating with SiB6 Addition for Fibrous ZrO_2 Ceramic

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The reusable thermal protective system consisting of high emissivity coatings used on the surface and a low thermal conductivity substrate used inside must be created to protect the reused space vehicles, which could decrease the surface temperature by radiation and prevent heattransfer via thermal conduction.

To develop a high emissivity coating on the low thermal conductivity ZrO_2 ceramic insulation for reusable thermal protective system, the $MoSi_2$-ZrO_2-borosilicate glass multiphase coatings

with SiB_6 addition were designed and prepared with slurry dipping and subsequent sintering method.

The influence of SiB_6 content on the microstructure, radiative property and thermal shock behavior of the coatings has been investigated. The coating prepared with SiB6 included the top dense glass layer, the surface porous coating layer and the interfacial transition layer, forming a gradient structure and exhibiting superior compatibility and adherence with the substrate. The emissivity of the coating with 3 wt% SiB_6 addition was up to 0.8 in the range of 0.3-2.5μm and 0.85 in the range of 0.8-2.5μm at room temperature, and the "V-shaped grooves" surface roughness morphology had a positive effect on the emissivity. The MZB-3S coating showed excellent thermal shock resistance with only 1.81% weight loss after 10 thermal cycles between 1773 K and room temperature, which was attributed to the synergistic effect of porous gradient structure, self-sealing property of oxidized SiB6 and the match of thermal expansion coefficient between the coating and substrate.

Thus, the high emissivity $MoSi_2$-ZrO_2-borosilicate glass coating with high temperature resistance presented a promising potential for application in thermal insulation materials.

Keywords: SiB_6, high emissivity coating, fibrous ZrO_2 ceramic, thermal shock behavior

B25

The Effects of Substrate Thickness on the Properties of 1-3-2 Multi-element Piezoelectric Composites

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1-3-2 multi-element piezoelectric composites were fabricated by the twice dice-filling technique using epoxy resin as matrix, lead zirconate-titanate piezoelectric ceramic ($Pb(Zr,Ti)O_3$, PZT) as functional material and silicon as decoupling material. The consistency of piezoelectric, dielectric, electromechanical coupling and frequency characteristic was studied and acoustic coupling performance of all elements in the composites were investigated. The results showed that the piezoelectric, dielectric, frequency characteristic of each element in the composite with different substrate thickness exhibited excellent consistency, while the consistency of electromechanical coupling property got worse with the increasing of the PZT substrate thickness, and the acoustic coupling enhanced. With increases of the PZT substrate thickness, d_{33} and ε_r increased, g_{33}, tanδ, f_s and K_t decreased, and the temperature stability of the dielectric constant

got worse.

Keywords: Piezoelectric composite, Multi-element, Consistency, Acoustic coupling performance

B26

In-Situ Synthesis of Polycrystalline Carbon Nanowires with Excellent Microwave Absorption Performance

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To obtain a novel absorber with high absorption, small reflection and wide absorption band, carbon nanowire reinforced Si_3N_4 composite ceramics (CNW/Si_3N_4) have been prepared by catalytic chemical vapor deposition. Results show that as-received carbon nanowires (CNW) have the pitted surface and unique hierarchically (micro-, meso- and macro-) porous construction. Moreover, CNW is polycrystalline and stacked by graphene-like nanosheets with sizes of 1-2 nm. These unique structures make great contribution to the impedance match, and generate strong conductive loss and various dipoles polarization effects which greatly enhance the absorption. A minimum reflection coefficient of CNW/Si_3N_4-1.84 (1.84 wt.% absorber loading) reaches -50.21 dB at 10.8 GHz and the maximum effective absorption bandwidth is 4.2 GHz covering the whole X band (8.2-12.4 GHz). It is believed that porous CNW can not only work as an excellent absorber for the attenuation of electromagnetic wave, but also show great potential to be designed as an electrode material for energy conversion and storage.

B27

Dual-boron-source-modified Polysilazane as a Novel Precursor for SiBCN Ceramics

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Here, we demonstrated a novel synthesis of a polyborosilazane (PBSN) precursor using hydroboration and aminolysis reaction synergies to modify polysilazane (PSN). Specifically, borane tetrahydrofuran and boron trichloride hexane were used as dual boron sources, which not only reacted with Si–Vi and Si–N–H functionality respectively to modify multiple active sites of PSN resulting in boron-rich silicon–boron–carbide–nitride (SiBCN) ceramics, but also improved controllability on composition, molecular structure, as well as final features. The resulting structures were characterized by FTIR, solid-state ^{11}B and ^{29}Si magic-angle-spinning NMR and inductively coupled plasma emission spectral (ICP) analysis. These polymers were found to be structurally complex networks composed of tri-coordinate BC_xN_{3-x} and tetra-coordinate BC_XN4_X bridges. The resulting polyborosilazanes contained ~11 wt% higher boron contents than that in the starting polymer. The structural evolution of the resulting polymers was evaluated by means of XPS, FTIR and XRD, and TGA-DSC-QMS was utilized to detail the precursor-to-ceramic conversion.

Keyword: precursor derived SiBCN ceramics, dual-boron-source, synthesis, structural evolution

B28

A Comprehensive Study of the High Temperature Performance and Microstructure of Different High T_c Piezoelectric Ceramics

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The expanding demand for piezoelectric devices working at elevated temperatures, particularly those for aerospace and automotive industries, has stimulated a great deal of research effort on high Curie Temperature (T_C) piezoelectric ceramics. The fabrication of this type of piezoelectric ceramics is also an important and difficult task in this field.A ferroelectric gradually losses its piezoelectricity upon depolarization around T_C. During this process various electrical properties show aninteresting significant change, which is accompanied by a complicated change in microstructure.However, at present, many details in this process and their structural origin are still unclear. Therefore, to elucidate the details is of importance from both fundamental and scientific points of view. In this study, by combing conventional characterization techniques and *in situ* high temperature characterization techniques, we carried out a comprehensive study of the microstructural change and high temperature performance of a

series of typical piezoelectric ceramics with different T_C range, including the recently developed peroverskite composite $BiMeO_3$-$PbTiO_3$, the tungsten bronze type lead metaniobate ($PbNb_2O_6$,) and the aurivillius type $CaBiNb_2O_9$, and $CaBi_4Ti_4O_{15}$. Structural factors that are important in controlling the high temperature piezoelectric properties are summarized in order to provide some hints on how to improve the high temperature performance of different types of piezoelectric ceramics.

B29

Improving SOFC performance with BCFN-YDC porous layer on cathode surface

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$Ba_{1.0}Co_{0.7}Fe_{0.2}Nb_{0.1}O_{3-\delta}$-$Ce_{0.8}Y_{0.2}O_{2-\delta}$(BCFN-YDC)porous layer were coated on the cathode of Ni-YSZ|YSZ|GDC|BCFN single cell by screen printing.X-ray diffraction characterization showed that the coating materials were chemical stabilityduring the operating temperature range. The effect of BCFN-YDC porous layer on cathode polarization resistance was investigated. Using humidified hydrogen (3% H_2O) as fuel and air as oxidant, power density of single cell were measured. The results showed that with porous layer, the polarization resistance of cathode decreased, and the powder density of single cells was higher than that without porous layer at 650 °C-850 °C. At 650 °C, the power density of single cell with porous layer on cathode could reach to 0.10 W/cm^2, while the value of sample without porous layer was only 0.05 W/cm^2. Thus, it was suggested that BCFN-YDC porous layerenhanced the oxygen exchange on cathode surface, further promoted the redox reaction in cathode, leading to the decrease in cathode polarization resistance and improved the performance of SOFC.

B30

Fabrication and Properties of SiC Nanofiber Paper/Nonwoven Fabric

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SiC nanofibers were synthesized by the sol-gel and carbothermal reduction method. The morphologies, microstructure and composition of the product were characterized by XRD, FESEM,

and TEM. The product was ultralong β-SiC nanofibers with diameter of 100 nanometers. A novel flexible free-standing SiC nanofiber paper was prepared through a facile vacuum filtration approach. SiC nanofiber nonwoven fabric consisting of ultralong SiC nanofibers was also prepared through a facile pushing roller approach. SiC nanofiber paper/nonwoven fabric exhibits high flexibility and thermal stability. The paper exhibits excellent nonflammability in fire. SiC nonwoven fabric also exhibits excellent hot flue gas filtering efficiency and excellent resistances to oxidation.

B31

Multiscaling Effects of Microstructural Domain Morphology and Phase Transition for Relaxor Ferroelectric Single Crystals

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Pt-based relaxor ferroelectric single crystals, such as Pb(Mg1/3Nb2/3)O3-PbTiO3 (PMN-PT) and Pb(Zn1/3Nb2/3)O3-PbTiO3 (PZN-PT), were reported as a novel piezoelectric materials with high properties at 1990's, which have higher piezoelectric coeffiecient d33 (about 2000-3000pC/N), higher electromechanical coupling coefficient K33 (about 90%), and higher electric strain (about 1-2%) than PZT ceramics. Therefore such crystals have been paid more attention to by researcher as well as the origin of its high piezoelectric properties. To understand the mechanism of the high piezoelectric effects of the Pt-based relaxor ferroelctric crystals, the first thing is to analyze the microstructural domain morphology and phase transition of the ferroelectric crystals. in this presentation, we investigated the microstructural domain morphology and phase transition of Pb(In1/2Nb1/2)O3-Pb(Mg1/3Nb2/3)O3-PbTiO3（PIN-PMN-PT）ferroelectric crystals. the results indicated that with the decreasing of the thickness of the samples, the domain characteristics of the crystals with different phase become more clear, the domain size and density showed more diversity, and the temperature gaps of the phase transition were more narrower due to the nonuniformity of the compositon of the samples. we also observe the same phenomenona and rhombohedral to tetragonal phase transition at cryogenic temperature.

B32

Stacked Quantum Dots embedded in Silica Glass by Spark Plasma

Sintering for White Light-Emitting Diodes

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Contributed to the unique size-tunable properties, quantum dots have attracted great interest and been applied in some promising areas involving light emitting diodes, lasers, biomedical imaging and sensors. However, quantum dots have a seriously intrinsic limitation, namely, low stability as photostability and thermalstability. In this work, we firstly report a novel, facile route for the preparation of stable monolithic silica-based CdS nanocomposites, which can be widely used to introduce temperature-sensitive functional nanocrystals into a silica matrix, by spark plasma sintering (SPS). The dependence of the PL properties on the various experimental variables, including Cd/S molar ratio, reaction time, and CdS QDs concentration, are systematically investigated. Owing to the amorphous, transparence nature of the silica matrix, and the fast sintering technology of SPS with relatively low temperature and ultrashort processing time, the size, shape, surface topography, and optical properties of CdS QDs in silica glass are found to remain close to those of untreated counterparts. We further investigate the application of the quantum dots embedded silica glass (QDESG) as color convertor in white LEDs by remote phosphor configuration. Indeed, the LED module utilizing single QDESG, whose concentration of CdS QDs is 1wt% and the ratio of Cd and S is 0.5:1, exhibits a best performance with luminous efficacy of 94 mlm/W, CCT of 4851 K and a high CRI of 86 at operating current of 200 mA.

Keywords: quantum dots, silica glass, SPS, LEDs

B33

The Synthesis and Characterization of Sr-Y Doped $BaCeO_3$

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Doped $BaCeO_3$ is a kind of proton conductor which exhibits high electrical conductivities at relatively low operating temperatures. It has been used as the electrolyte materials for proton ceramic fuel cells, and the effects of dopants on the sinter-ability and electrical performance are critical factors. In this work, the effects of Sr and Y dopants on phase formation during calcination and sinter-ability of pure and doped $BaCeO_3$ have been discussed. Pure $BaCeO_3$ (BCO),

$Ba_{0.5}Sr_{0.5}CeO_{3-\delta}$ (BSCO), $BaCe_{0.8}Y_{0.2}O_{3-\delta}$ (BCYO), and $Ba_{0.5}Sr_{0.5}Ce_{0.8}Y_{0.2}O_{3-\delta}$ (BSCYO) are synthesized via solid state reaction. The mixed precursors are calcined between 800 and 1300 C and the different phase formation temperatures are decided by x-ray diffraction characterization. The sintering behaviors of these doped $BaCeO_3$ are characterized by dilatometry. The results show that the phase formation temperatures of pure and doped $BaCeO_3$are higher than 1000 C. The partial substitution of Ce with Y results in higher temperatures for pure phase formation. The partial substitution of Ba with Sr, furthermore, retards the formation of a pure phase; BaO phase is always tested by XRD characterization.

Keywords: Fuel cell, electrolyte, proton conductor, $BaCeO_3$, calcination, sintering,

B34

Preparation and Research of PSN-PZT Piezoelectric Ceramics with High Piezoelectric Constant

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$Pb_{0.82}Sr_{013}Ba_{0.05}(Sb_{1/3}Nb_{2/3})_{0.02}(Zr_{1/2}Ti_{1/2})_{0.98}O_3$ (abbreviated as PSN-PZT) piezoelectric ceramicswere synthesized by conventional solid-state reaction method. The effect of Bi^{3+} and Ce^{4+} doped on electrical properties were investigated. The ceramics obtains the optimal piezoelectric at 0.25wt% Bi_2O_3 doping, which are listed as follows: d_{33}=980pC/N，k_p=0.83，ε_r=6500，$tan\delta$=0.035，T_c=150 ℃ . Meanwhile, the piezoelectric ceramics actuator were fabricated using PSN-PZT by extruded films method, which has a more than 1.7mm displacement at different temperature.

Keywords: high piezoelectric constant, dielectric constant, piezoelectric ceramics actuator.

B35

The Preparation and Sintering Behavior of $Ce_{0.8}Sm_{0.2}O_{2-\delta}$ Electrolyte and $(NiO\text{-}CuO)/Ce_{0.8}Sm_{0.2}O_{2-\delta}$ Anodes for Solid Oxide Fuel Cells

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The co-pressing and co-firing processes are often used to prepare the anode-electrolyte half cells for solid oxide fuel cells (SOFCs). To get a half cell without cracks, the sintering behavior of electrolyte and anode layers must be controlled carefully. In this work, the sintering behavior of $Ce_{0.8}Sm_{0.2}O_{2-\delta}$ (SDC) electrolyte, NiO/SDC and CuO/SDC anodes are prepared and characterized.

The SDC electrolyte is synthesized via nitrate combustion method; the anodes are prepared via solid state reaction or nitrate combustion method. The sintering dynamics of samples are characterized by dilatometry and the co-pressed half cells are co-sintered at temperatures up to 1300 C. The results show that a special process for binder removal is necessary otherwise it will cause macro cracks in anodes. CuO in anode results in liquid phase sintering at temperatures higher than 1100 C. The as-prepared NiO/SDC anode via nitrate combustion method has a 3.7% expansion at 300 C during sintering, which causes a large mismatch of sintering shrinkage between electrolyte and anode and results in cracks in electrolyte layer.

Keywords: Solid oxide fuel cell, electrolyte, anode, sintering,

B36

Preparation of a Bulk Glass by Spark Plasma Sintering Using Microporous Material

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ZSM-5 molecular sieve is a kind of high silicon microporous crystalline material that possesses three-dimensional frameworks. It has two kinds of ten member ring channels including a set of straight channels and a set of sine channels. These two sets of channels are perpendicular and the orifices are oval. Silica glasses are widely used in optical instrument, optical communication, laser or other areas for their high transparency, low coefficient of thermal expansion and good chemical stability. Silica glasses normally are synthesized by mixing oxide precursors and melting them at high temperature. This traditional process needs high temperature and long time. We have applied spark plasma sintering (SPS) technique to compact ZSM-5 powder in obtain to fully dense glass bodies. A high transparent glass can be obtained at 1300℃with a holding time of 3min.The as-sintered sample was investigated by UV-VIS, photoluminescence spectra, HRTEM and microhardness tester. Visible light transmittance of the as-prepared zeolite-derived glass was higher than 60% and near-infrared light transmittance was close to 90%. It is very interesting that transmittance spectrum of this novel glass showed an absorption peak around 300nm and this specimen exhibited ultraviolet photoluminescence property at about 370nm which is different from the glass prepared by the high temperature melting. It is due to that a few crystalline zeolite fragments were still preserved locally inside the SPS consolidated sample. Vickers microhardness and fracture toughness of the specimen at room temperature reached 7.3±0.2GPa and 2.0±0.3MPa·$m^{1/2}$ respectively. The transparent glass sample was successfully prepared by SPS using microporous material ZSM-5. This method provides a new approach to prepare glasses at low temperature.

Keywords: Spark plasma sintering,ZSM-5,Silica glass,optical property,mechanical property

B37

Microarc Oxidation / Graphene Duplex Coating Formed on Aluminum Alloy Radiator:Preparation, Microstructure and Thermal Dissipation Properties

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The lifetime and luminescenceefficiency of Light emitting diode (LED) tend to drop rapidly with the increasing P-N junction temperature (Tj). To enhancethe heat dissipationofaluminum alloy radiator for LED, a high emissivity and hydrophobic coatingwas fabricated bymicroarc oxidation (MAO) combined withspinning reduced graphene oxide (rGO). The effects of uncoated aluminum,MAOcoated, and MAO/rGO duplexcoated radiator on infrared emissivity, contact angle and heat dissipation propertieswere comparatively investigated. The results show thatthe static water contact angles of aluminumalloy, MAO and rGO/MAO coatings are 72.4°, 22.6° and 114.2°, respectively. MAO coating exhibits a high emissivity up to 0.8 within 8-20 μm wavelength range, while the rGO/MAO duplex coatingfurther promotes the value by about 0.1. Due to the enhanced thermal radiation induced byMAO and rGO/MAO coating, the MAO coated, especially the rGO/MAO coated aluminum radiator enables theTjof LED to drop apparently.

Keywords:aluminum alloy;microarc oxidation;graphene;coating; infrared emissivity; hydrophobic

B38(Invited)

Research and Application of Al_2O_3-ZrO_2 Ceramics

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Al_2O_3 is a very popular ceramic that is used in variousfields.However, applications for the ceramic are limitedowing to its inherent brittleness.In order to improve the toughness and the stability of the Al_2O_3, ZrO_2(3Y) is added as the reinforced phase. The Al_2O_3-ZrO_2 ceramics are prepared using hot-pressing (HP) and hot isostatic pressing (HIP).The effects of sintering method,

grain size, microstructure features and volume fraction of each phase on the mechanical behavior of Al_2O_3-ZrO_2 ceramics are comprehensively studied. The study shows that the Al_2O_3-ZrO_2 ceramicsshow a mixture of inter- and transgranular fracture behavior owing to phase transition. The Al_2O_3-ZrO_2 ceramicsachieve the much higher flexural strength, fracturetoughness and hardness than Al_2O_3.

At present, the graphite oiling roller iscommonly usedduring the manufacture of fiberglass. However, the graphite oiling roller has poor wear resistance, high off-line grinding rate leading to water, power and manpower consumption, and short service life (nearly 1 month), which can also cause environmental pollution and industrial disease. These lead to the high cost, low productivity and poor quality of fiberglass. In our work, the Al_2O_3-ZrO_2 ceramic is used to prepare the oiling roller instead of graphite for the first time. The original oiling roller composite structure is obtained using the Al_2O_3-ZrO_2 ceramic and metallic material. Theoiling roller composite structure solves the existing problems of the commonly used graphite oiling roller. The oiling roller composite structureis applied byChongqing Polycomp International Corp(CPIC). In 2012-2016, the net profit of the Corp is up to RMB 856.344 million owing to the oiling roller composite structure. The application of the oiling roller composite structure also saves 3.336 million tons of water, 1.316 million degrees of power and RMB1.139429 billion of high grade graphite, and eliminates 3.336 million tons ofsewerage. This is highly consists with the national development strategy of energy conservation andenvironmental protection.

Keywords: Al_2O_3-ZrO_2 ceramics; mechanical behavior; oiling roller composite structure; energy conservation andenvironmental protection

B39

Electromagnetic Functional Surface and Its Field-controllable Effect

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Precise and effective control of light has always been pursued. For thousands of years,

people were using the uniform medium to manipulate the propagation of wave, such as lens.The recent emergences of the functional surface and its design method make the controlling methods for electromagnetic waves more convenient and feasible. In this talk, I will show you the theory and design method of the all-dielectric metasurface, which can avoid the ohmic loss, anisotropic electromagnetic responses of the metallic unit-cells. Then an isotropic zero-index medium consisted of the dielectric cubes with subwavelengthdimensions is proposed based on the Mie resonance and the tunable zero-phase delay is experimentally demonstrated, which has potentialapplications in the miniaturization of wave-manipulatingcomponents. Finally, asuperparamagneticmetametamaterial (MMM) metasurface based on Mie resonance is suggested to fulfill the high frequency magnetic effectto gain Casimir repulsion when interacting with the metal plate. And the permeability of such MMM depends on anexternal magnetic field, which makes it possible to adjust the Casimir force, which makes the magneticallycontrollable repulsive Casimir force theoretically feasible.

B40

Fabrication and Research of High Temperature Resistant PNN-PSN-PMN-PZT Piezoelectric Ceramic Buzzer

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$Pb(Ni_{1/3}Nb_{2/3})_{0.10}(Sb_{1/2}Nb_{1/2})_{0.015}(Mg_{1/3}Nb_{2/3})_{0.035}(Zr_xTi_{1-x})_{0.85}O_3$ piezoelectric ceramics (abbreviated as PNN-PSN-PMN-PZT) were synthesized by conventional solid-state reaction method. The effects of R(Zr)/R(Ti) on phase structure, microstructure, dielectric, piezoelectric and ferroelectric properties of the ceramics were investigated in detail. The X-ray resulted that PNN-PSN-PMN-PZT ceramics are a pure perovskite structure without any other second phases, and their crystals structure transform from rhombohedral to tetragonal with increasing Ti content. The piezoelectric ceramics with x=0.49 sintered at 1200℃ exhibited the favorable electrical properties, which were listed as follows: d_{33}=620pC/N，k_p=0.83，ε_r=3010，$tan\delta$=0.017, Qm=65, T_c=304 ℃. Meanwhile, the piezoelectric buzzer were fabricated using temperature stability PNN-PSN-PMN-PZT by extruded films method and assembly technology. The sound pressure level of piezoelectric ceramics buzzer at a high temperature of 150℃ attenuation of less than 5dB, meeting the demands of high temperature components.

Keywords: piezoelectric ceramics, temperature stability, electrical properties, buzzer.