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Amorphous Formation in an Undercooled Binary Ni-Si Alloy under Slow Cooling Rate

Yiping Lu, Gencang Yang, Xiong Li and Yaohe Zhou

High undercooling up to 392 K was achieved in eutectic $\text{Ni}_{70.2}\text{Si}_{29.8}$ alloy melt by using glass fluxing combined with cyclic superheating. A small quantity of amorphous phase was obtained in bulk eutectic Ni70:2Si29:8 alloy when undercooling exceeds 240 K under slow cooling conditions (about 1 K/s). The amorphous phase was confirmed by high-resolution transmission electron microscopy and differential scanning calorimetry. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 370-372)

Hot Deformation Characteristics for a Nickel-base Superalloy GH742y

Fuwei Kang, Jianfei Sun, Guoqing Zhang and Zhou Li

The hot deformation characteristics of as-cast nickel-base superalloy GH742y after hot isostatic pressing (HIP)(hereafter referred to as-cast alloy) have been investigated by hot compression tests in the temperature range of 1050 to 1140°C, strain rate range of 0.01 s⁻¹ to 10 s⁻¹ and strain range of 35% to 50% by means of Gleeble-3500 thermal mechanical simulator. The results show that the as-cast alloy exhibits the poor deformability, and shows wedge-shaped cracking beyond the strain of 35%. At strain rates less than 1.0 s⁻¹, the stress-strain curves exhibit nearly steady-state behavior, while at strain rate of 10 s⁻¹, a yield drop and serrated yielding occur. The activation energy values developed on the basis of the experimental data are divided into three domains. The first domain appears at lower strain rate ($\leq 1.0 \text{ s}^{-1}$) and lower temperature ($\leq 1080^\circ\text{C}$), with the lowest mean value of activation energy about 261.4 kJ/mol. The second domain appears at the same strain rate as the first domain, but higher temperature ($> 1080^\circ\text{C}$), with the intermediate mean value of activation energy about 328.8 kJ/mol. The third domain appears at higher strain rate (10 s⁻¹) and temperature range of 1050 to 1140°C, with the largest mean value of activation energy about 605.05 kJ/mol. Three different constitutive equations are established in corresponding to domains. Microstructural observations in the third domain reveal non-uniform dynamic recrystallization (DRX) of homogeneous γ phase, which leads to the poor deformability and the highest Q value. In contrast, microstructures in the first domain show fully DRX of homogeneous γ phase, leading to the better deformability and the lowest Q value. It is noted that the grain size increases with

the increment of strain rate or temperature. These results suggest that bulk metal working of this material may be carried out in the first domain where fully DRX of γ homogeneous occurred. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 373-378)

Effect of a high magnetic field on the shape of the γ' precipitates in cast nickel-based superalloy K52

X. Ren, G.Q. Chen, W.L. Zhou, C.W. Wu, C. Yuan and J.S. Zhang

The shape change of the γ' precipitates of cast Ni-based superalloy K52 after aging treatment under a high magnetic field was investigated. The results show that duplex γ' precipitates are present in the γ matrix after aging treatment with or without the magnetic field. One is the coarse particles with average size of 500 nm; the other is fine spherical γ' precipitates with average of 100 nm in diameter. The application of a 10T magnetic field only results in the shape of the coarse γ' particles changing from spherical to cuboidal when the alloys subjected to the same heat treatments. This shape change was mainly discussed based on the strain energy increase caused by the difference in magnetostriction between the γ matrix and γ' precipitates. The fine γ' particles still keep spherical. Further TEM observations shows that a number of γ particles in nano-scale precipitate in the coarse γ' particles in the specimens treated without the magnetic field. In addition, it was found that the magnetic field caused the decrease of the hardness in the alloy, and the hardness was associated with the field direction. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 379-382)

A Quantitative Analysis of Mn Segregation at Partitioned Ferrite/Austenite Interface in a Fe-C-Mn-Si Alloy

H. Guo, S.W. Yang, C.J. Shang, X.M. Wang and X.L. He

Mn segregation at austenite/ferrite interface is studied in a Fe-C-Mn-Si alloy held at 656°C. Mn is partitioned during the growth of ferrite and as a result, a Mn pile-up exists in front of interface on the matrix side. An approach to evaluate Mn segregation quantitatively is developed by combining STEM raster window scanning and simulation of the interaction of the electron beam with the sample to subtract the contribution of Mn pile-up and obtain pure Mn segregation value. The evaluated maximum Mn interfacial segregation is in the order of a half-monolayer. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 383-388)

Investigation of Surface Damage in Forming of High Strength and Galvanized Steel Sheets

Zhongqi Yu, Yingke Hou, Haomin Jiang, Xinping Chen and Weigang Zhang

Powdering/exfoliating of coatings and scratching are the main forms of surface damage in the forming of galvanized steels and high strength steels (HSS), which result in increased die maintenance cost and scrap rate. In this study, a special rectangular pan was developed to investigate the behavior and characteristics of surface damage in sheet metal forming (SMF) processes. U-channel forming tests were conducted to study the effect of tool hardness on surface damage in the forming of high strength steels and galvanized steels (hot-dip galvanized and galvanized steels). Experimental results indicate that sheet deformation mode influences the severity of surface damage in SMF and surface damage occurs easily at the regions where sheet specimen deforms under the action of compressive stress. Die corner is the position where surface damage initiates. For HSS sheet, surface damage is of major interest due to high forming pressure. The HSS and hot-dip galvanized steels show improved ability of damage-resistance with increased hardness of the forming tool. However, for galvanized steel it is not the forming tool with the highest hardness value that performs best. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 389-394)

Dynamical Solidification Behaviors and Metal Flow during Continuous Semisolid Extrusion Process of AZ31 Alloy

Renguo Guan, Liqing Chen, Jiangping Li and Fuxing Wang

In this paper, a novel near-net-shape forming process, continuous semisolid extrusion process (CSEP) of AZ31 alloy was proposed, and the dynamical solidification behaviors and metal flow during the process were firstly investigated. During casting AZ31 alloy by this process, non-uniform microstructure distributions and non-equilibrium solidification region near the roll surface were found in the roll-shoe gap. Microstructural evolution from dendrite to rosette and spherical grains was observed during the casting by CSEP. Casting temperature, roll-shoe gap width and cooling ability have great effect on casting process and metal flow, so these factors should be carefully controlled, a proper casting temperature of $710 \times 750^{\circ}\text{C}$ is suggested. The white β phases were strongly stretched during the processing, and the remnant liquids are correspondingly distributes along the solid phase boundaries and also show stripped lines. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 395-400)

β Preparation and Dielectric Properties of Nonstoichiometric β -SiC Powder by Combustion Synthesis

Xiaolei Su, Wancheng Zhou, Zhimin Li, Fa Luo and Dongmei Zhu

The nonstoichiometric β -SiC powders were synthesized via combustion reaction of Si and C system in a 0.1 MPa nitrogen atmosphere, using Teflon as the chemical activator. The prepared powders were investigated by XRD and Raman spectra. The results indicate that the cell parameters of all the prepared β -SiC powder are smaller than the standard value of β -SiC because of generation of CSi defects. The complex permittivity of prepared products was carried out in the frequency range of 8.2–12.4 GHz. It shows that the dielectric property of prepared β -SiC powder decreases with increasing PTFE content. The effect of CSi defects on dielectric property of β -SiC powder has been discussed. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 401-404)

Doping Effects on Electronic Conductivity and Electrochemical Performance of LiFePO₄

Jiezi Hu, Jian Xie, Xinbing Zhao, Hongming Yu, Xin Zhou, Gaoshao Cao and Jiangping Tu

Olivine-structured pure LiFePO₄ and doped Li(M, Fe)PO₄ (M=La, Ce, Nd, Mn, Co, Ni) have been synthesized by a solvothermal method. X-ray diffraction and field emission scanning electron microscopy analyses indicate that the as-prepared LiFePO₄ is well-crystallized nanopowders without any detectable impurity phases. The electronic conductivity of LiFePO₄ is enhanced by around 1-3 orders by doping. It was found that doping alone is not sufficient for the high-rate performance of LiFePO₄ and surface coating with such as carbon should be needed. The best dopant for LiFePO₄ is Nd among those studied in the present work. Accordingly, doping with 1 mol fraction Nd leads to an increase in 70 mAh/g at 0.1 C for the hydrothermally synthesized sample and 50 mAh/g at 1.0 C after carbon-coating in comparison with the undoped samples. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 405-409)

Wetting Behavior and Interfacial Reactions in (Sn-9Zn)-2Cu/Ni Joints during Soldering and Isothermal Aging

Ning Zhao, Haitao Ma, Haiping Xie and Lai Wang

The wetting property of (Sn-9Zn)-2Cu (wt pct) on Ni substrate and the evolution of interfacial microstructure in (Sn-9Zn)-2Cu/Ni joints during soldering as well as

isothermal aging were studied. The wetting ability of eutectic Sn-9Zn solder on Ni substrate was markedly improved by adding 2 wt pct Cu into this solder alloy. Plate-like Cu_5Zn_8 intermetallic compounds (IMCs) were detected in (Sn-9Zn)-2Cu solder matrix. A continuous $\text{Ni}_5\text{Zn}_{21}$ IMC layer was formed at (Sn-9Zn)-2Cu/Ni interface after soldering. This IMC layer kept its type and integrality even after aging at 170°C for up to 1000 h. At the early aging stage (before 500 h), the IMC layer grew fast and its thickness followed a linear relationship with the square root of aging time. Thereafter, however, the thickness increased very slowly with longer aging time. When the joints were aged for 1000 h, a new IMC phase, $(\text{Cu}, \text{Ni})_5\text{Zn}_8$, was found in the matrix near the interface. The formation of $(\text{Cu}, \text{Ni})_5\text{Zn}_8$ phase can be attributed to the diffusion of Ni atoms into the solder matrix from the substrate. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 410-414)

Mechanism of Metal Transfer in DE-GMAW

Kehai Li and Chuansong Wu

Modification of conventional gas metal arc welding (GMAW) process is of great potential to achieve high productivity with low cost and strong usability. Double-Electrode GMAW (DE-GMAW) is such a modified arc welding process which is formed by adding a bypass torch (gas tungsten arc welding torch) to a conventional GMAW system. The mechanism of metal transfer in DE-GMAW was proposed and verified in this paper. Experiments show that the critical current is decreased so that spray transfer can be obtained at a lower current level in DE-GMAW. Analysis of this significant change in metal transfer phenomena is conducted, and explanation is given out. It is found that the bypass arc in DE-GMAW lifts the anode point on the droplets such that the electromagnetic force becomes larger and squeezes the droplets so that spray transfer can take place under welding current lower than that in conventional GMAW. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 415-418)

First-Principle Calculations of Hardness and Melting Point of Mo_2C

X.R. Wang, M.F. Yan and H.T. Chen

This paper has constructed two kinds of atomic and electronic models for hexagonal $\beta\text{-Mo}_2\text{C}$ and orthorhombic $\alpha\text{-Mo}_2\text{C}$. The optimized lattice parameters, elastic constant matrixes and overlap population for Mo_2C crystal cells have been

obtained to realize the characterization of the hardness and melting point of the two structures by the first-principles plane wave pseudo potential method based on the density functional theory. The results reveal that the calculated lattice parameters of the Mo_2C crystal cells agree with the experimental and other calculated data. The calculated melting point/hardness are 2715 K/11.38 GPa for $\beta\text{-Mo}_2\text{C}$ and 2699 K/10.57~12.67 GPa for $\alpha\text{-Mo}_2\text{C}$, respectively. The calculated results from the density of states (DOS) demonstrate that the hybridization effect between Mo-3d and C-2p states in $\alpha\text{-Mo}_2\text{C}$ crystal cell is much stronger than that in $\beta\text{-Mo}_2\text{C}$ one. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 419-422)

Microstructure and Properties of M40 Carbon Fibre Reinforced Mg-Re-Zr Alloy Composites

Gaohui Wu, Meihui Song, Ziyang Xiu, Ning Wang and Wenshu Yang

M40 carbon fibre reinforced rare earth magnesium alloy ZM6 composites with fibre volume fraction about 60% were fabricated by pressure infiltration method. The microstructure, interfacial morphology, and precipitation were studied by scanning electron microscopy, transmission electron microscopy, and energy dispersive X-ray spectrometer. It was shown that the interfaces between Mg alloy and fibres were well bonded and free from cracks. The Mg_{12}Nd phase was preferentially precipitated at the fibre/matrix interfaces, leading to the segregation of Nd at the interfaces and the dramatic decrease of Mg_{12}Nd precipitation in the matrix far from interfaces. Crystal defects such as high-density dislocations and twins were observed in the matrix near the fibre/matrix interface. A high bending strength (1393 MPa) and elastic modulus (190 GPa) were achieved in M40/ZM6 composite. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 423-426)

Growth and Photoluminescence Properties of Tetrapod-Shaped ZnO Microcrystals-Whiskers and Microrods

Xiaojun Liang, Bingfa Liu and Nan Chen

Tetrapod-shaped ZnO microcrystals in forms of whiskers and microrods have been grown in the same crucible by thermal evaporation of Zn/C mixtures at a temperature of 930°C in air without using any catalyst. The tetrapod-shaped ZnO microrods were capped by hexagonal pyramids. It is for the first time observed that the tetrapod-shaped ZnO whiskers and microrods have quite different morphologies, and this is believed to be a result of different growth behaviors

associated with these two forms of ZnO microcrystals. The octa-twin model has been used to discuss their growth behaviors. Photoluminescence properties of these two forms of tetrapod-shaped ZnO microcrystals have been investigated using different excitation wavelengths. Both of the two forms of ZnO microcrystals showed strong green emission and weak ultraviolet emission behaviors. The excitation spectrum of the tetrapod-shaped ZnO whiskers showed a strong excitation peak at 395 nm, which was not observed for the tetrapod-shaped ZnO microrods. (Journal of Materials Sciences and Technology 2009 Vol. 25 (03): 427-432)

Aluminizing Low Carbon Steel at Lower Temperatures

Xiao Si, Bining Lu and Zhenbo Wang

This study reports the significantly enhanced aluminizing behaviors of a low carbon steel at temperatures far below the austenitizing temperature, with a nanostructured surface layer produced by surface mechanical attrition treatment (SMAT). A much thicker iron aluminide compound layer with a much enhanced growth kinetics of ϵ -Fe₂Al₅ in the SMAT sample has been observed relative to the coarse-grained steel sample. Compared to the coarse-grained sample, a weakened texture is formed in the aluminide layer in the SMAT sample. The aluminizing kinetics is analyzed in terms of promoted diffusivity and nucleation frequency in the nanostructured surface layer. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 433-436)

Eutectic Solidification in Al-13.0%Si Alloys with Combined Addition of Strontium and Boron

Hengcheng Liao, Ke Ding, Juanjuan Bi, Min Zhang and Huipin Wang Lei Zhao

The influence of addition of boron (B) on eutectic solidification in a near-eutectic Al-13.0%Si alloy modified with strontium (Sr) was investigated using thermal analysis and macro/microstructure observation. Addition of B in the Sr-modified alloy leads to a considerable increase in nucleation temperature (T_N , the minimum temperature prior to recalescence (T_M) and growth temperature (T_G). In the Sr-modified alloy, nucleation of eutectic might originate at the heterogeneous sites on the mold wall or in the melt near the wall, and eutectic solidification proceeds gradually towards the center, controlled by undercooling of melt. However, with addition of B in the Sr-modified alloy, undercooling required for eutectic nucleation became small, and hence eutectic solidification might occur almost

simultaneously within whole casting, controlled by amount of heterogeneous sites. With excessive addition of B in the Sr-modified alloy, nucleation of eutectic grains was explosive within the whole casting and the power of Sr on eutectic solidification was completely poisoned. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 437-440)

Serrated Flow Behavior during Compression at Elevated Temperatures in Mg-3Al-1Zn-0.1RE Alloy

Wei Qiu, Enhou Han and Lu Liu

The deformation behaviour of an AZE (Mg-3Al-1Zn-0.1RE) alloy at temperature between 393 and 453 K was investigated by uniaxial compression tests carried out at initial strain rate values of 1×10^{-4} , 5×10^{-4} and $1 \times 10^{-3} \text{ s}^{-1}$ in air. The results show that serrated flow occurs at the strain rate of 10^{-4} s^{-1} under all test temperatures and $5 \times 10^{-4} \text{ s}^{-1}$ at 453 K. The mechanism of serrated flow was proposed, which is mainly attributed to the interaction of dislocations to the precipitates. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 441-444)

Microstructures and Morphology Evolution of Icosahedral Phase of As-cast $\text{Mg}_{67.4}\text{Zn}_{28.9}\text{Y}_{3.7}$ Ternary Alloy Subjected to the Pouring Temperature

Man Zhu, Gencang Yang, Diqing Wan, Suling Cheng and Yaohe Zhou

The microstructure, chemical composition and morphology evolution of icosahedral quasicrystalline phase of $\text{Mg}_{67.4}\text{Zn}_{28.9}\text{Y}_{3.7}$ ternary alloy were investigated in detail at different pouring temperatures by X-ray diffraction (XRD), scanning electron microscopy (SEM) and energy-dispersive spectrum (EDS). Low interfacial energy favors the formation of I-phase. The experimental results show that the primary I-phase reveals petal-shaped with five and six branches, where each branch has faceted growth morphology with the size ranging from 50 to 100 μm . As the temperature decreases, the polygon-shaped I-phase forms, attributed to the decomposition of branch of petal-shaped I-phase, and then it grows bigger and some of the fine polygons join together to form large polygons. Besides these, (α -Mg+I-phase) eutectic structures disappear and the relative amount of Mg_7Zn_3 phase increases as the pouring temperature decreases. The chemical composition and morphology evolution of I-phase were also discussed. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 445-448)

Characteristics study on Bi-Pb Based Alloys Quenched from Melt

Rizk Mostafa Shalaby

Three different bismuth-lead systems namely, Wood's alloy ($\text{Bi}_{50}\text{Pb}_{25}\text{Sn}_{12.5}\text{Cd}_{12.5}$), Newton's alloy ($\text{Bi}_{50}\text{Pb}_{31.2}\text{Sn}_{18.8}$) and Rose's alloy ($\text{Bi}_{50}\text{Pb}_{28}\text{Sn}_{22}$), with one used as fusible alloys were quenched from melt by melt spinning technique. Thermal analysis, structure and mechanical properties of all alloys have been studied and analyzed. From X-ray diffraction analysis, an intermetallic compound phase, designated Pb_7Bi_3 is detected. The formation of an intermetallic compound phase causes a pronounced increase in the electrical resistivity. The Wood's alloy containing-cadmium exhibits mechanical properties superior to both the Newton's and Rose's alloys. The presence of cadmium in Wood's alloy decreases its melting point. Wood's alloy has better properties, which make it useful in various applications such as in protection shields for radiotherapy, locking of mechanical devices and welding at low temperature. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 449-453)

A New Aging Treatment Way for Near α High Temperature Titanium Alloys

Na Peng, Qingjiang Wang and Xinan Wang

Two near α titanium alloys Ti-5.6Al-4.8Sn-2.0Zr-1Mo-0.35Si (1#) and Ti-6.0Al-4.8Sn-2.0Zr-1Mo-0.35Si (2#) were solution-treated in the upper $\alpha+\beta$ phase fields and the duplex mixture microstructures consisting of the less volume fraction primary phase (α_p) and the transformed phase (β_t) were obtained. The aging treatments were carried out at 700°C for 1# alloy and 760°C for 2# alloy under varied terms, respectively. It guaranteed 2 ordered phase to precipitate only in β but not in α for the two alloys. The slower precipitation and growth of the α_2 ordered phase and silicide was observed in 1# alloy in comparison with that in 2# alloy. The mechanical properties including tensile strength and ductility, the creep and lasting properties at the temperature of 600°C were investigated. Prolonging aging time did not predominantly change the tensile strength and ductility for the two alloys. The 600°C/100h thermal exposure caused a notable decrease of tensile ductility in 2# alloy though no distinct decrease could be observed in 1# alloy after the thermal exposure. The lasting property of 1# alloy was increased with prolonging aging time and finally equal to or even better than that of 2# alloy. Nevertheless, No evident increase emerged in 2# alloy with prolonging aging time. Similarly, the creep property of 1 # alloy monotonously increased with increasing

aging time and finally equal to or even better than that of 2# alloy. No evident increase could be observed for 2# alloy. It can be deduced that the overgrowth of α_2 ordered phase and silicide is unable to enhance hot strength properties but causes an unacceptable damage to tensile ductility. The optimum equilibrium of the comprehensive properties depending on the proper control of α_2 ordered phase and silicide can be achieved by selecting aging temperature and time. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 454-458)

Al Preparation from Solid Al_2O_3 by Direct Electrochemical Deoxidation in Molten $\text{CaCl}_2\text{-NaCl}$ at 550°C

Hongwei Xie, He Zhang, Yuchun Zhai, Jinxia Wang and Chengde Li

Al was prepared by a new method in molten salt at low temperature. Sintered alumina pellets were used as cathode; graphite rod was employed as anode; and the molten $\text{CaCl}_2\text{-NaCl}$ was the electrolyte. A constant 3.2 V voltage was applied in this experiment, and oxygen in solid alumina cathode was reduced by direct electrochemical deoxidation at 550°C . In this process, the current gradually decreased with increasing time and the alumina pellets became grey and porous. The metallic particles were obtained and characterized by XRD (X-ray diffraction) and SEM (scanning electron microscopy). (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 459-461)

Effect of Sulfur Precursor on Dimensions of One-dimensional CdS Nanocrystals

M. Maleki, Sh. Mirdamadi, R. Ghasemzadeh and M. Sasani Ghamsari

One-dimensional CdS nanocrystals have been prepared by solvothermal method using cadmium acetate as a cadmium precursor, elemental sulfur and Na_2S , as a sulfur precursor, and ethylenediamine as a solvent at 150°C for 5 h. The nanocrystals were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and UV-Vis absorption spectroscopy. XRD patterns indicate that both Na_2S and elemental sulfur as the sulfur precursor result in CdS nanorods with wurtzite phase (hexagonal structure). SEM and TEM images show that diameter of CdS nanorods can be decreased using Na_2S instead of elemental sulfur. For the growth of CdS nanorods, a mechanism has been proposed. UV-Vis absorption of CdS nanorods (sulfur precursor: Na_2S) was shown blue shift to 485 nm due to the quantum size effect. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 462-464)

Synthesis of Nanocrystalline Barium Ferrite in Ethanol/Water Media

M. Montazeri-Pour and A. Ataie

Nanocrystalline particles of barium ferrite magnetic material have been prepared by co-precipitation route using aqueous and non-aqueous solutions of iron and barium chlorides with a Fe/Ba molar ratio of 1:1 and subsequent drying-annealing treatment. Water and ethanol/water mixture with volume ratio of 3:1 were used as solvents in the process. Coprecipitated powders were annealed at various temperatures for 1 h. FTIR (Fourier transform infrared spectroscopy), XRD (X-ray diffraction), DTA/TGA (differential thermal analysis/thermogravimetric analysis) and SEM (scanning electron microscopy) techniques were used to evaluate powder particle characteristics. DTA/TGA results confirmed by those obtained from XRD indicated that the formation of barium ferrite occurs in sample synthesized in ethanol/water solution at a relatively low temperature of 631 °C. Nano-size particles of barium ferrite with mean particle size of almost 75 and 100 nm were observed in the SEM micrographs of the samples synthesized in ethanol/water solution after annealing at 700 and 800 °C for 1 h, respectively. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 465-469)

New Conditions for Intercalation of Organic Compounds into Semiconductor Nanomaterial

A.A. El-Meligi

The intercalation of organic guests, 2-methyl pyridine (2-picoline) and 3-methyl pyridine (3-picoline) into semiconductor layered nanomaterial (MnPS₃) was investigated. New conditions were applied. New phases appeared and lattice expansions were 0.36 nm for 2-picoline intercalation and 0.728 nm for 3-picoline intercalation. The XRD (X-ray diffraction) patterns exhibit sharp hkl reflections confirming that the material is highly crystalline. The interlayer gap (0.64 nm) of the host plays a role for the arrangement of the guest in the interlayer region. The crystal structure of the MnPS₃ was indexed in the monoclinic system before intercalation. After intercalation, the crystal system was indexed in the trigonal unit cell. The lattice parameters were obtained and c-axis value was related to the (001) reflections. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 470-474)

Thermodynamic Properties of Nanograin Boundary and Thermal Stability of Nanograin Structure

Jun Wei, Xiaoyan Song, Qingchao Han and Lingmei Li

The thermal features of the nanograin boundary were described by a developed thermodynamic model. Using the nanocrystalline Cu as an example, the pressure, the bulk modulus, and the volume thermal expansion coefficient were calculated to characterize the thermodynamic properties of the grain boundaries on the nanoscale. Based on the parabola-type relationship between the excess free energy and the excess volume of the nanograin boundary, the thermal stability, as well as its evolution characteristics, was analyzed. The experimental results of the temperature-varying grain growth in the nanocrystalline Cu, which exhibited the discontinuous nanograin growth behavior, verified the thermodynamic predictions. In addition, the quantitative relationships correlating the excess volume and the lattice expansion with the nanograin size were discussed. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 475-478)

Identification of Iron Oxides Qualitatively/Quantitatively Formed during the High Temperature Oxidation of Superalloys in Air and Steam Environments

M. Siddique, N. Hussain and M. Shafi

Mossbauer spectroscopy has been used to study the morphology of iron oxides formed during the oxidation of superalloys, such as SS-304L (1.4306S), Incoloy-800H, Incoloy-825, UBHA-25L, Sanicro-28 and Inconel-690, at 1200°C exposed in air and steam environments for 400 h. The basic aim was to identify and compare the iron oxides qualitatively and quantitatively, formed during the oxidation of these alloys in two environments. The behaviour of alloy UBHA-25L in high temperature oxidation in both environments indicates that it has good oxidation resistance especially in steam, whereas Sanicro-28 has excellent corrosion resistance in steam environment. In air oxidation of Inconel-690 no iron oxide, with established Mössbauer parameters, was detected. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 479-482)

Effects of Vacuum Ultraviolet Radiation on Atomic Oxygen Erosion of Polysiloxane/SiO₂ Hybrid Coatings

Longfei Hu, Meishuan Li and Yanchun Zhou

Polysiloxane/SiO₂ hybrid coatings have been prepared on Kapton films by a sol-gel process. The erosion resistance of polysiloxane/SiO₂(20 wt pct) coating was

evaluated by exposure tests of vacuum ultraviolet radiation (VUV) and atomic oxygen beam (AO) in a ground-based simulation facility. The experimental results indicate that this coating exhibits better AO resistance than pure polysiloxane coating. The erosion yield (Ey) of the polysiloxane/SiO₂ (20 wt pct) hybrid coating is about 10;27 cm³/atom, being one or two orders of magnitude lower than that of polysiloxane. VUV radiation can affect the erosion process greatly. Under simultaneous AO and VUV exposure, the value of Ey of the polysiloxane/SiO₂ (20 wt pct) hybrid coating increases by 39% compared with that under single AO exposure. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 483-488)

Effects of Substrate Temperature on the Growth of Polycrystalline Si Films Deposited with SiH₄+Ar

Hua Cheng, Aimin Wu, Jinquan Xiao, Nanlin Shi and Lishi Wen

Polycrystalline silicon (poly-Si) films were deposited using Ar diluted SiH₄ gaseous mixture by electron cyclotron resonance plasma-enhanced chemical vapor deposition (ECR-PECVD). The effects of the substrate temperature on deposition rate, crystallinity, grain size and the configuration of H existing in poly-Si film were investigated. The results show that, comparing with H₂ dilution, Ar dilution could significantly decrease the concentration of H on the growing surface. When the substrate temperature increased, the deposition rate increased and the concentration of H decreased monotonously, but the crystallinity and the grain size of poly-Si films exhibited sophisticated trends. It is proposed that the crystallinity of the films is determined by a competing balance of the self-diffusion activity of Si atoms and the deposition rate. At substrate temperature of 200 °C, the deposited film exhibits the maximum poly-Si volume fraction of 79%. Based on these results, higher substrate temperature is suggested to prepare the poly-Si films with advanced stability and compromised crystallinity at high deposition rate. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 489-491)

Microstructure of Cu-based Amorphous Composite Coatings on AZ91D Magnesium Alloy by Laser Cladding

Kaijin Huang, Changsheng Xie and T.M. Yue

To improve the sliding wear resistance of AZ91D magnesium alloy, Cu-based amorphous composite coatings made of Cu₄₇Ti₃₄Zr₁₁Ni₈ and Cu₄₇Ti₃₄Zr₁₁Ni₈+20

wt pct SiC powders were fabricated on AZ91D magnesium alloy by laser cladding, respectively. SEM (scanning electron microscopy), EDS (energy dispersive X-ray spectroscopy), XRD (X-ray diffraction) and TEM (transmission electron microscopy) techniques were employed to study the phases of the coatings. The results show that the coatings mainly consist of amorphous phase and different intermetallic compounds. The reason of formation of amorphous phase and the function of SiC particles were explained in details. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 492-498)

Influence of the Thermal Barrier Coatings Design on the Oxidation Behavior

B. Saeedi, A. Sabour, A. Ebadi and A.M. Khoddami

The properties of two different types of thermal barrier coatings (TBCs) were compared to improve the surface characteristics on high temperature components. These TBCs consisted of a duplex TBC and a five-layered functionally graded TBC. NiCrAlY bond coats were deposited on a number of Inconel-738LC specimens using high velocity oxy-fuel spraying (HVOF) technique. For duplex coating, a group of these specimens were coated with yttria stabilized zirconia (YSZ) using plasma spray technique. Functionally graded NiCrAlY/YSZ coatings were fabricated by plasma spray using co-injection of the two different powders in a single plasma torch. The amount of zirconia in functionally graded coatings were gradually increased from 30 to 100 vol. pct. Microstructural changes, thermally grown oxide (TGO) layer growth and damage initiation of the coatings were investigated as a function of isothermal oxidation test at 970°C. As a complementary test, the performance of the fabricated coatings by the optimum processing conditions was evaluated as a function of intense thermal cycling test at 1100°C. Also the strength of the adhesive coatings of the substrate was also measured. Microstructural characterization was analyzed by scanning electron microscopy (SEM) and optical microscopy whereas phase analysis and chemical composition changes of the coatings and oxides formed during the tests were studied by XRD (X-ray diffraction) and EDS (energy dispersive spectrometer). The results showed that microstructure and compositions gradually varied in the functionally graded coatings. By comparison of duplex and functionally graded TBCs oxidation behavior (duplex failure after 1700 h and functionally graded TECs failure after 2000 h), thermal shock test and adhesion strength of the coatings, the functionally graded TBC had better performance and more durability. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 499-507)

Mechanical and Abrasive Wear Properties of Anodic Oxide Layers Formed on Aluminium

W. Bensalah, K. Elleuch, M. Feki, M. Wery and H.F. Ayedi

Aluminium oxide coatings were formed on aluminium substrates in oxalic acid-sulphuric acid bath. Abrasion tests of the obtained anodic layers were carried out on a pin-on-disc machine in accordance with the ISO/DP 825 specifications. The Vickers microhardness, D (HV0.2), and the abrasion weight loss, W_a (mg) were measured. Influence of oxalic acid concentration (C_{ox}), bath temperature (T) and anodic current density (J) on D and W_a has been examined, and the sulphuric acid concentration (C_{sul}) was maintained at $160 \text{ g}\cdot\text{L}^{-1}$. It was found that high microhardness and abrasive wear resistance of oxide layers were produced under low temperatures and high current densities with the addition of oxalic acid. The morphology and the composition of the anodic oxide layer were examined by scanning electron microscopy (SEM), atomic force microscopy (AFM), optical microscopy and glow-discharge optical emission spectroscopy (GDOES). It was found that the chemistry of the anodizing electrolyte, temperature, and current density are the controlling factors of the mechanical properties of the anodic oxide layer. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 508-512)

Improved Fatigue Behavior of Pipeline Steel Welded Joint by Surface Mechanical Attrition Treatment (SMAT)

Yu Wang, Min Huang, Lei Zhou, Zhixin Cong and Huilin Gao

A pipeline steel X80 with welded joint was subjected to surface mechanical attrition treatment (SMAT). After SMAT, a nanostructure surface layer with an average grain size of about 10 nm was formed in the treated sample, and the fatigue limit of the welded joint was elevated by about 13% relative to the untreated joints. In the low and the high amplitude stress regimes, both fatigue strength and fatigue life were enhanced. Formation of the nanostructured surface layer played more important role in the enhanced fatigue behavior than that of residual stress induced by the SMAT. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 513-515)

Cold Cracking of Flux Cored Arc Welded Armour Grade High Strength Steel Weldments

G. Magudeeswaran, V. Balasubramanian and G. Madhusudhan Reddy

In this investigation, an attempt has been made to study the influence of welding consumables on the factors that influence cold cracking of armour grade quenched and tempered (Q&T) steel welds. Flux cored arc welding (FCAW) process were used making welds using austenitic stainless steel (ASS) and low hydrogen ferritic steel (LHF) consumables. The diffusible hydrogen levels in the weld metal of the ASS and LHF consumables were determined by mercury method. Residual stresses were evaluated using X-ray stress analyzer and implant test was carried out to study the cold cracking of the welds. Results indicate that ASS welds offer a greater resistance to cold cracking of armour grade Q&T steel welds. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 516-526)

Interfacial Microstructure of Diffusion Bonded Inconel 738 and Ferritic Stainless Steel Couple

Bulent Kurt and Mustafa Ulutan

In this study, Inconel 738 alloy was diffusion bonded to a ferritic stainless steel. The effect of bonding temperature on the microstructural development across the joint region was investigated. Following the diffusion bonding, conventional characterization techniques such as scanning electron microscopy (SEM), energy dispersive X-ray (EDX) and microhardness were used to examine the interfacial microstructure. It was seen that bonding temperature was effective on the diffusion of Ni from Inconel 738 to ferritic stainless steel that affected the microstructure of the interface. Austenite phase was formed at the interface as a result of Ni diffusion from the Inconel 738 to the interface. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 527-530)

Electron Paramagnetic Resonance and Optical Absorption Studies on Copper Ions in Mixed Alkali Cadmium Phosphate Glasses

G. Giridhar, M. Rangacharyulu, R.V.S.S.N. Ravikumar and P. Sambasiva Rao

Electron paramagnetic resonance (EPR) and optical absorption studies were carried out at room temperature on copper doped mixed alkali cadmium

phosphate (LiNaCdP) glasses to understand the nature and symmetry of dopant. Three samples with varying concentrations of alkali ions have been prepared. The spin Hamiltonian parameters obtained from room temperature EPR spectra are: $g_{\parallel}=2.437$, $g=2.096$, $A_{\parallel}=117\times10^{-4}\text{ cm}^{-1}$, $A=26\times10^{-4}\text{ cm}^{-1}$ for LiNaCdP1, $g_{\parallel}=2.441$, $g=2.088$, $A_{\parallel}=121\times10^{-4}\text{ cm}^{-1}$, $A=25\times10^{-4}\text{ cm}^{-1}$ for LiNaCdP2 and $g_{\parallel}=2.433$, $g=2.096$, $A_{\parallel}=125\times10^{-4}\text{ cm}^{-1}$, $A=32\times10^{-4}\text{ cm}^{-1}$ for LiNaCdP₃. These EPR results indicate that the dopant Cu^{2+} ion enters the glass matrix into a tetragonally elongated octahedral site. The bonding parameters evaluated by correlating optical and EPR data suggest that bonding between the central metal ion and ligands is partially covalent. The mixed alkali effect in cadmium phosphate glasses was reported. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 531-534)

High-temperature Electric Properties of Polycrystalline La-doped CaMnO_3 Ceramics

Jinle Lan, Yuanhua Lin, Ao Mei, Cewen Nan, Yong Liu and Boping Zhang

Polycrystalline La-doped CaMnO_3 ceramics have been prepared by a solid-state sintering method. Analysis of microstructure and phase composition indicates that the addition of La can prohibit the further growth of grain, and no impurity phase appears. The results revealed that the La doping can lead to a large change of the activation energy (from 0.22 to 0.02 eV), and thus result in a marked increase in electric conductivity of 2-4 orders of magnitude. The power factor can reach about $1.5\times10^{-4}\text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-2}$ in a wide temperature range, which potentially make them attractive for n-type high-temperature thermoelectric materials. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 535-538)

Morphology Change of Metastable Regrown Graphite with Boron Additive under HPHT

Chuanyi Zang, Xiaozhou Chen, Qiang Hu, Wei Guo and Guofeng Huang

By temperature gradient method under high pressure and high temperature (HPHT), with NiMnCo alloy as the solvent metal, at diamond-stable region of about 5.4 GPa and 1500 K, metastable regrown graphite crystals of different morphology were synthesized. With B as an additive incorporated into the NiMnCo-C system, metastable regrown graphite crystals of sphere-like shape were firstly obtained under HPHT. If the growth system does not contain B, sheet-like regrown graphite crystals, most with regular hexagonal morphology, are grown

upwards and standing vertically in the metal solvent. When B additive of 1.0 wt pct was added into carbon source (graphite powder), all metastable regrown graphite crystals took on the habit of regular sphere-like morphology, and were grown by a spiral layer growth mechanism. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 539-542)

Damping and Mechanical Properties of Cocured Composite Laminates with Embedded Perforate Viscoelastic Layer

Lijian Pan and Boming Zhang

The composite laminates with embedded acrylonitrile butadiene rubber (NBR) layer were fabricated by cocuring process. The embedded layers were perforated with a series of small holes to allow resin to flow through the damping layer and completely couple the structure to improve bending stiffness and interlaminar shearing strength of these cocured composite laminates. The damping, bending stiffness and shearing strength of these composite laminates with different perforation diameters were investigated. The experimental results show that increasing the perforation diameter leads to significant decreases in damping and significant increase in bending stiffness up to an area ratio of 7.065%. The area ratio here is defined as the ratio of perforation area to the total damping area. Beyond the area ratio of 7.065%, increasing the diameter to an area ratio of 50.24% results in only a slight variation in damping and bending stiffness. Moreover, increasing the perforation diameter does not always increase the shearing strength of the embedded viscoelastic layer. The shearing strength of embedded viscoelastic layer increases only when the area ratio is greater than 19.625%; instead, it will decrease. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 543-546)

Fabrication and Testing of Carbon Fiber Reinforced Truss Core Sandwich Panels

Bing Wang, Linzhi Wu, Li Ma, Qiang Wang and Shanyi Du

Truss core sandwich panels reinforced by carbon fibers were assembled with bonded laminate facesheets and carbon fiber reinforced truss cores. The top and bottom facesheets were interconnected with truss cores. Both ends of the truss cores were embedded into four layers of top and bottom facesheets. The mechanical properties of truss core sandwich panels were then investigated under out-of-plane and in-plane compression loadings to reveal the failure

mechanisms of sandwich panels. Experimental results indicated that the mechanical behavior of sandwich structure under in-plane loading is dominated by the buckling and debonding of facesheets. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 547-550)

Synthesis of Chitosan-Hydroxyapatite Composites and Its Effect on the Properties of Bioglass Bone Cement

Jingxiao Liu, Fei Shi, Ling Yu, Liting Niu and Shanshan Gao

Chitosan-hydroxyapatite (CS-HA) composite powders were synthesized via in situ co-precipitation method, through the reaction of $\text{Ca}(\text{NO}_3)_2$ and H_3PO_4 in the simulated body fluid (SBF) containing appropriate amount of chitosan. The thermal evolution, microstructure and morphology were studied by TG-DTA (thermogravimetry-differential thermal analysis), XRD (X-ray diffraction), FTIR (Fourier transform infrared spectroscopy) and TEM (transmission electron microscopy). The in vitro bioactivity test showed that the obtained CS-HA composites had higher capability of inducing calcium ions deposition. Effects of CS-HA composites on the bioactivity and compressive strength of bioglass bone cement were investigated. The results indicated that the bioactivity of bioglass bone cement could be improved further when CS-HA composite powders were added into the cement, and appropriate amount of CS-HA additive was favorable for compressive strength improvement of bioglass bone cement. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 551-555)

An *in vivo* Evaluation of Ultra-fine Grained Titanium Implants

S. Bindu, K.P. Sanosh, K. Smetana, A. Balakrishnan and T.N. Kim

The present work focuses mainly on an in vivo evaluation of ultra fine grained titanium (UFG-Ti) obtained by severe plastic deformation (SPD). The SPD on commercially produced Grade 2 titanium (Cp-Ti) resulted in the refinement of the grain size by several orders of magnitude. Polished surfaces having similar roughness from both UFG-Ti and Cp-Ti were prepared. *In vitro* test revealed the presence of fibronectin, which was involved in the attachment of the cells to the substrate. Phase contrast micrographs showed the highest signal of fibronectin in UFG-Ti, indicating that it is more cytocompatible than Cp-Ti. In vivo tests, by subcutaneous implantation of the metals in the rats showed the better biocompatibility of UFG-Ti over Cp-Ti. The improved biocompatibility of UFG-Ti

was attributed to the presence of surface discontinuities (in the form of nano-defects), surface energy, higher wettability, surface stress and stable TiO₂ films, which increased the protein adsorption on the surface. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 556-560)

Numerical Simulation of Macrosegregation for an Fe-0.8 wt pct C Alloy

Dongrong Liu, Dianzhong Li and Aoguang Sang

Macrosegregation in Fe-0.8 wt pct C alloy solidifying with equiaxed morphology was numerically simulated. Based on a two-phase volumetric averaging approach, heat transfer, melt convection, composition distribution, nucleation and grain evolution on the system scale were described. A weak-coupling numerical procedure was designed to solve conservation equations. Simulations were conducted to study the effects of cooling rate and nuclei density on the macrosegregation pattern. The relative influence of thermal buoyancy- and solutal buoyancy-induced flows on macrosegregation was identified. Calculated results indicate that a higher cooling rate establishes a more homogeneous composition. More uniform solute distributions are formed with increasing nuclei density. In addition, it is noted that the direction of channel segregates depends on the relative strength of thermal and solutal buoyancy forces. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 561-568)

Initial Oxidation of γ -TiAl(111) Surface: Density-functional Theory Study

Hong Li, Shaoqing Wang and Hengqiang Ye

In this paper, we reported a first-principles investigation on the structural and electronic properties of O adsorption on the γ -TiAl(111) surface, to illustrate the oxidation process. It has been found that: (1) rather than stopping with one full monolayer of coverage, oxygen adsorption continues till two monolayer coverage, rendering an oxide-like structure; (2) full structural relaxation makes the surface oxide layer denser and more stable, which hinders the subsequent O adsorption (oxidation) process. In addition, the transformation from metal to oxide surface was identified by analyzing the local density of states through the oxidation steps, which was in good agreement with experimental results. (Journal of Materials Sciences and Technology 2009 Vol. 25 (04): 569-576)

Effect of Porosity on the Mechanical Properties and Wear Performance of 2% Copper Reinforced Sintered Steel Used in Shock Absorber Piston Production

Bekir Yalcin

Powder metallurgy (P/M) method has mainly been used to produce automobile parts such as self-lubrication beds, shock absorber parts, and gear wheels. In order to investigate the effect of porosity on the mechanical and tribological properties in sintered steel, specimens with 10%, 15%, and 20% porosity were produced in a 10 mm×10 mm×55 mm prismatic shape by pre-alloying powders of the MPlF Fe-C-0.205 alloy used in the production of shock absorber pistons. Sintering was carried out at 900°C for 45 min in an argon atmosphere. Tensile, charpy, and microhardness tests were performed on these specimens. In addition, the wear performance of a 2% Cu reinforced sintered steel alloy under dry sliding conditions was determined. Metallographic studies such as pore formation, worn surface, and fractured surface analyses were performed by scanning electron microscopy and optical microscopy. The results indicate that irregular pore formation tendencies increase with an increase in porosity (%). Furthermore, an increase in porosity was shown to decrease the mechanical properties and increase the wear trace area and the friction coefficient of sintered steel. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 577-582)

Experimental Investigation on the Performance of Armour Grade Q&T Steel Joints Fabricated by Flux Cored Arc Welding with Low Hydrogen Ferritic Consumables

G. Magudeeswaran, V. Balasubramanian, G. Madhusudhan Reddy and G. Gopalakrishnan

Quenched and Tempered (Q&T) steels are widely used in the construction of military vehicles due to its high strength to weight ratio and high hardness. These steels are prone to hydrogen induced cracking (HIC) and softening in the heat affected zone (HAZ) after welding. The use of austenitic stainless steel (ASS) consumables to weld the above steel was the only available remedy to avoid HIC because of higher solubility for hydrogen in austenitic phase. Recent studies revealed that low hydrogen ferritic (LHF) steel consumables can also be used to weld Q&T steels, which can give very low hydrogen levels in the weld deposits and required resistance against cold cracking. Hence, in this investigation an attempt has been made to study the performance of armour grade Q&T steel

joints fabricated by flux cored arc welding with LHF steel consumables. Two different consumables namely (i) austenitic stainless steel and (ii) low hydrogen ferritic steel have been used to fabricate the joints by flux cored arc welding (FCAW) process. The joints fabricated by LHF consumable exhibited superior transverse tensile properties due to the presence of ferrite microstructure in weld metal. The joints fabricated by ASS consumable showed higher impact toughness due to the presence of austenitic phase in weld metal microstructure. The HAZ softening in coarse grain heat affected zone (CGHAZ) is less in the joints fabricated using LHF consumable due to the lower heat input involved during fabrication compared to the joints fabricated using ASS consumables. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 583-591)

Evaluation of the Electroslag Remelting Process in Medical Grade of 316LC Stainless Steel

S. Ahmadi, H. Arabi, A. Shokuhfar and A. Rezaei

This study is focused on the effects of electroslag remelting by prefused slag (CaO , Al_2O_3 , and CaF_2) on macrostructure and reduction of inclusions in the medical grade of 316LC (316LVM) stainless steel. Analysis of the obtained results indicated that for production of a uniform ingot structure during electroslag remelting, shape and depth of the molten pool should be carefully controlled. High melting rates led to deeper pool depth and interior radial solidification characteristics, while decrease in the melting rates caused more reduction of nonmetallic inclusions. Large shrinkage cavities formed during the conventional casting process in the primary ingots were found to be the cause of the fluctuation in the melting rate, pool depth and extension of equiaxed crystals zone. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 592-596)

Effect of Aging Time and Temperature on Mechanical Properties and Microstructural Evolution of 2205 Ferritic-Austenitic Stainless Steel

H. Keshmiri, A. Momeni, K. Dehghani, G.R. Ebrahimi and G. Heidari

Duplex stainless steels (DSS) with ferritic{austenitic microstructures offer good combination of resistance to pitting corrosion and high strength that are not concomitantly attainable using conventional single phase austenitic or ferritic stainless steels. The DSS used in this investigation was 2205 alloy having a stable microstructure consisting of about 45% ferrite and 55% austenite at ambient

temperature. In order to investigate aging behavior of this steel and the influences on mechanical properties, different aging treatments were conducted at temperatures of 350-950°C for various aging time of 15, 30, 60 and 180 min. The aged specimens were subjected to impact testing and hardness measurements. Finally, the changes in microstructure due to aging were studied by optical and scanning electron microscopy. The results showed that aging at temperatures lower than 550°C for different time had negligible effects on mechanical properties. Besides, no considerable changes in term of precipitation of harmful intermetallic particles were observed in microstructure below this temperature. However, a critical temperature range, 550-650 °C, was introduced here. Aging in this range led to a significant decrease in toughness and notable increase in hardness. The formation of intermetallic phases such as σ was recognized as the major reason for the observed changes. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 597-602)

Dynamic Recrystallization Behavior of a Fe-Cr-Ni Super-Austenitic Stainless Steel

Hoseini Asliy and A. Zarei-Hanzaki

The super-austenitic stainless steels are extensively utilized in the seamless tubes production for oil extraction industries. Due to the importance of thermo-mechanical processing in the production of these tubes, the dynamic recrystallization (DRX) characteristics of a Cr-Ni super austenitic stainless steel (1.4563) were investigated in the present study. This was performed using the hot compression testing method in the temperature range of 950-1150°C and the strain rate of 10^{-3} - 10^{-1} s⁻¹. The initiation and evolution of DRX were examined through microstructural analysis. The results indicated that the recrystallized grain formed a necklace type structure at the prior austenite grain boundaries at higher strain rates. In addition, DRX nucleation occurs by bulging and successive strain induced boundary migration (SIBM). (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 603-606)

Effect of Varying Carbon Content and Shot Peening upon Fatigue Performance of Prealloyed Sintered Steels

R. Bidulsky, M. Actis-Grande, M. Kabatova and J. Bidulska

The aim of the work was to find out how the modification of surface treatment and microstructures affect the fatigue characteristics of the considered sintered

materials. Two different systems were prepared: as-sintered and shot peened prealloyed sintered (Astaloy CrL based) steels with addition of 0.5% and 0.7% C. Sintering was carried out in laboratory tube furnace in an atmosphere of pure gases 75%N₂+25%H₂. The sintering temperature was 1180°C and sintering time was 60 min. Heating and cooling rates were 10°C/min. Fatigue tests were carried out in symmetric plane bending at stress ratio R=-1 with frequency of about 24 Hz. The presented experimental results showed that prealloyed water-atomised steels, with surface modification, exhibit positive effects on the fatigue failure resistance, and for that reason are suitable for high-performance applications. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 607-610)

Influence of Surface Treatment on the Corrosion Resistance of Stainless Steel in Simulated Human Body Environment

Esmail Jafariy and Mohammad Jafar Hadianfard

In the present research, the influence of chromium enrichment by surface treatment on corrosion resistance of type 316L stainless steel in body environment was investigated. For this study, weight loss test during 18 months, cyclic and liner polarization tests before and after surface treatment and metallography by electron and light microscopy were used to evaluate the effectiveness of the proposed method. In addition, X-ray photoelectron spectroscopy (XPS) method was used to determine the chromium concentration in the surface layer after surface treatment. Results show that the surface treatment has improved corrosion resistance of the type 316 L stainless steel in body environment. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 611-614)

Isothermal Growth Kinetics of Ultra-fine Austenite Grains in a Nb-V-Ti Microalloyed Steel

Shengjie Yao, Linxiu Du, Xianghua Liu and Guodong Wang

Ultra-fine austenite grains with size of 1~3 µm were prepared in a Nb-V-Ti steel through repetitive treatment of rapid heating and quenching. A model for the growth kinetics of these ultra-fine austenite grains was successfully created through successive 2 processes, and the activation energy Q for growth was estimated to be about 693.2 kJ/mol, which directly shows the inhibition effect of microalloy elements on the growth of ultra-fine austenite grains. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 615-618)

Enhancement of GMI Effect in Silicon Steels by Furnace Annealing

C. Sirisathitkul and P. Jantaratana

The ratio and sensitivity of giant magnetoeimpedance (GMI) in grain oriented silicon steels (Fe-4.5%Si) are improved after furnace annealing in air for 20 min. By annealing at 800°C, the GMI sensitivity rises from 1.29%/Oe to 1.91%/Oe and the ratio increases from 237% to 294% with decreasing characteristic frequency. The results are attributable to an increase in the transverse magnetic permeability during the heat treatment. From simulation by finite element method, the GMI effect can be interpreted as the modification of the current distribution by the applied magnetic field via the transverse permeability. In the case of annealed samples, the larger transverse permeability allows a higher GMI ratio and sensitivity. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 619-621)

Sliding Wear Behavior of a Grey Cast Iron Surface Remelted by TIG

H. Mohamadzadeh, H. Saghafiany and Sh. Kheirandish

The sliding wear behavior of a grey cast iron surface remelted by tungsten inert gas (TIG) was studied and compared with the unremelted one in the current work. To evaluate the wear behavior a Pin-on-Disk wear test machine was used. Pins which were prepared from the samples with the remelted layers of different thicknesses of 1.2, 1.8, 2.5 and 3 mm were worn on an AISI D3 steel counterface having a hardness of 63HRC under the applied loads of 54, 76 and 99 N at a constant sliding velocity of 0.45 m/s. Scanning electron microscopy (SEM) equipped with energy dispersive X-ray analysis (EDS) and X-ray diffraction (XRD) techniques were used to characterize worn surface and subsurface and also wear debris obtained from the wear tests under different test conditions. Results showed that surface remelted grey cast iron have better wear properties for all applied normal loads in comparison with unremelted ones. Microscopic studies on the worn surfaces and subsurfaces of samples revealed that dominant wear mechanism for surface remelted samples was mild oxidative, while it was severe for unremelted samples. Increasing remelted layer thickness and then forming grosser microstructure lead to a decline of wear properties, whereas lower thickness of remelted layer with finer microstructure due to having higher cooling rate through remelting process can withstand better against wear. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 622-628)

Reduction of Sensitivity to Sintering Temperature for Nd-Fe-B Magnets through Zr and Nb Additions

Mi Yan, Xigui Cui, Lianqing Yu and Tianyu Ma

To reduce the sensitivity of grain growth to sintering temperature for improving property consistency of sintered Nd-Fe-B magnets, combined additions of Zr and Nb were investigated. It was found that when Zr content was increased to 0.07 at. pct, abnormal grain growth was effectively hindered even when the sintering temperature reached 1100 °C. With combined additions of 0.07 at. pct Zr and 0.07 at. pct Nb, the sensitivity of grain growth to sintering temperature was greatly reduced. The magnets sintered at 1100 °C showed higher property consistency than the magnets containing no Zr and Nb. In addition, the magnetic properties of magnets were also improved. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 629-632)

Eclipta Alba as Corrosion Pickling Inhibitor on Mild Steel in Hydrochloric Acid

M. Shyamala and A. Arulanantham

Due to ease of application, cost effectiveness and environmentally safe, in this study, the corrosion inhibition effect of aqueous extract of Eclipta alba in 1 N hydrochloric acid has been investigated by weight loss, potentiodynamic polarization and impedance methods and the extracts of Eclipta alba were found to be effective corrosion pickling inhibitor. The effect of immersion time and temperature revealed that the extracts of Eclipta alba with an optimum concentration of 8.0% v/v showed maximum inhibition efficiency of 99.6% at 3 h immersion time and 30 °C. Arrhenius plots for mild steel immersed in 1 N HCl solution in the absence and presence of optimum concentration (8.0% in v/v) of Eclipta alba extract showed the effect of temperature. Polarization studies indicate that this plant extract acts as a mixed type inhibitor. The adsorption of Eclipta alba follows Langmuir adsorption isotherm. The inhibition action may be due to the presence of the Wedelactone and also the alkaloid Ecliptine present in the leaves of Eclipta alba. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 633-636)

Evaluation of Oxidation of Ti-Al and Ti-Al-Cr Coatings Arc-ion Plated on Ti-60 High-temperature Titanium Alloy

Wei Yan, Qingjiang Wang, Jianrong Liu, Shaoqiang Li and Fengjiu Sun

High-temperature titanium alloy for aeroengine compressor applications suffers from high-temperature oxidation and environmental corrosion, which prohibits long-term service of this kind alloy at temperatures above 600°C. In an attempt to tackle this problem, Ti-48Al (at. pct) and Ti-48Al-12Cr (at. pct) protective coatings were plated on the substrate of alloy Ti-60 by arc ion plating (AIP) method. Isothermal and cyclic oxidation tests were performed in static air at elevated temperatures. Phase composition, morphology of the coatings and distribution of elements were investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM) and energy dispersive X-ray analysis (EDX). The results showed that the Ti-48Al coating exhibited good isothermal oxidation resistance during exposure at 800°C, but poorer resistance against oxidation at 900°C. By contrast Ti-48Al-12Cr coating demonstrated excellent isothermal oxidation resistance at both temperatures. Cyclic oxidation tests performed at 800°C indicated that both coatings demonstrated good cyclic oxidation resistance and no spallation of coatings was observed. But at 900°C only Ti-48Al-12Cr coating demonstrated excellent cyclic oxidation resistance. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 637-644)

Effects of Yttria Addition on Microstructure, Mechanical Properties, Wear Resistance and Corrosive Wear Resistance of TiNi Alloy

Hojat Ahmadi, D.Y. Li and Meisam Nouri

TiNi alloy has a high resistance to wear and could be an excellent candidate for various tribological applications. But studies show that oxygen active elements can improve properties of some alloys, markedly. Yttrium is one of the oxygen active elements. In this paper, the effects of yttria addition on properties of TiNi have been studied *via* micro-indentation, hardness, wear and corrosive wear tests. It is demonstrated that by addition of yttria to 5%, TiNi alloy can own improved mechanical properties and resistance to wear and corrosive wear. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 645-648)

Effect of Alloying Elements on Microstructure, Martensitic Transformation and Mechanical Properties of Ni-Mn Based Alloys

K. Alvarez, H.Y. Kim and S. Miyazaki

The microstructural features, shape memory behavior and mechanical properties of Ni-Mn based alloys were investigated by differential scanning calorimetry (DSC), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and thermal cycling test under various stresses. The transformation temperatures shifted toward lower temperatures when adding a third element into the Ni-Mn system. The addition of 10 at. pct Fe increased considerably the mechanical properties exhibiting still high transformation temperatures. However, it was found that in NiMn40Fe10 alloy the martensitic transformation is not thermoelastic in nature. The mechanism of this transformation and the crystallography of Ni-Mn_(50-x)-Fe_x (x=5, 7, 10, 20 at. pct) alloys are presented. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 649-654)

Effect of Process Parameters on Tensile Strength of Friction Stir Welded Cast LM6 Aluminium Alloy Joints

M. Jayaraman, R. Sivasubramanian and V. Balasubramanian

This paper reports the effect of friction stir welding (FSW) process parameters on tensile strength of cast LM6 aluminium alloy. Joints were made by using different combinations of tool rotation speed, welding speed and axial force each at four levels. The quality of weld zone was investigated using macrostructure and microstructure analysis. Tensile strength of the joints were evaluated and correlated with the weld zone hardness and microstructure. The joint fabricated using a rotational speed of 900 r/min, a welding speed of 75 mm/min and an axial force of 3 kN showed superior tensile strength compared with other joints. The tensile strength and microhardness of the welded joints for the optimum conditions were 166 MPa and 64.8 Hv respectively. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 655-664)

Dependence of Amorphous Formation Ability on Intrinsic Parameters in Dy-Gd-Co-Al Alloys

Lin Luo, Rui Tian and Xueshan Xiao

A series of Dy(Gd)-based bulk amorphous alloy rods were prepared by water-cooled copper mold method. Thermal stability and structure of Dy-Gd-Co-Al

alloys were investigated by differential scanning calorimetry and X-ray diffraction, respectively. The results show that the Dy-Gd-Co-Al alloys have good glass-formation ability, and the $\text{Dy}_{31}\text{Gd}_{25}\text{Co}_{20}\text{Al}_{24}$ alloy can be readily cast into full glassy rods up to 5 mm in diameter. The glass-forming ability of multicomponent alloys was greatly dependent on their chemical interaction and the equivalent bond parameters among atoms such as equivalent electronegativity difference, equivalent atomic size parameter. The Dy (Gd)-based bulk amorphous alloys could be expected as potential functional materials. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 665-668)

Morphology Control and Optical Absorption Properties of Ag Nanoparticles by Ion Implantation

G.X. Cai, F. Ren, X.H. Xiao, L.X. Fan, X.D. Zhou and C.Z. Jiang

Ion implantation is a powerful method for fabricating nanoparticles in dielectric. For the actual application of nanoparticle composites, a careful control of nanoparticles has to be achieved. In this letter, the size, distribution and morphology of Ag nanoparticles are controlled by controlling the ion current density, ion implantation sequence and ion irradiation dose. Single layer Ag nanoparticles are formed by Ag^+ ion implantation at current density of $2.5 \mu\text{A}/\text{cm}^2$. By Ag and Cu ions sequential implantation, the size of single layer Ag nanoparticles increases. While, by Cu and Ag ions sequential implantation, uniform Ag nanoparticles with wide distribution are formed. The morphology of Ag nanoparticles changes to hollow and sandwiched nanoparticles by Cu^+ ion irradiation to doses of 3×10^{16} and 5×10^{16} ions/ cm^2 . The optical absorption properties of Ag nanoparticles are also tailored by these ways. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 669-672)

Liquid Phase Behavior during Elevated Temperature Deformation of the Fine-Grained 5083 Al Alloy

Honghua Yan and Kaifeng Zhang

The liquid phase behavior of the fine-grained 5083 Al alloy obtained through thermomechanical process was investigated during the tensile tests in a temperature range of $380\text{-}570^\circ\text{C}$ and strain rate range of 4.17×10^{-4} – $1.0 \times 10^{-2} \text{ s}^{-1}$. The maximum elongation 530% of the fine-grained 5083 Al alloy was obtained at 550°C and $4.17 \times 10^{-4} \text{ s}^{-1}$. Fracture analysis by scanning electron microscopy (SEM) indicated that the formation of filament (formed by liquid phase) was

greatly affected by the tensile temperature and strain rate. The results also showed that the optimum morphology of formed filament was obtained at 550°C and a strain rate of $4.17 \times 10^{-4} \text{ s}^{-1}$. The effect of liquid phase on superplastic deformation of the alloy was further discussed. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 673-676)

Analysis of the Vertical and Lateral Interactions in a Multisheet Array of InAs/GaAs Quantum Dots

Hui She and Biao Wang

The vertical and lateral interactions in a multisheet array of InAs/GaAs quantum dots are analyzed by finite element method (FEM). It is shown that due to the effects of vertical interaction, nucleation prefers to happen above buried quantum dots (QDs). Meanwhile, the effects of lateral interaction adjust the spacing of lateral neighboring QDs. The vertical coupling becomes strong with decreasing GaAs spacer height and increasing number of buried layers, while the lateral coupling becomes strong with increasing InAs wetting layer thickness. The phenomenon that, after successive layers, the spacing and size of QDs islands become progressively more uniform is explained according to the minimum potential energy theory. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 677-680)

Effect of Sample Configuration on Droplet-Particles of TiN Films

Yanhui Zhao, Guoqiang Lin, Jinquan Xiao, Chuang Dong and Lishi Wen

Orthogonal experiments are used to design the pulsed bias related parameters, including bias magnitude, duty cycle and pulse frequency, during arc ion deposition of TiN films on stainless steel substrates in the case of samples placing normal to the plasma flux. The effect of these parameters on the amount and the size distribution of droplet-particles are investigated, and the results have provided sufficient evidence for the physical model, in which particles reduction is due to the case that the particles are negatively charged and repulsed from negative pulse electric field. The effect of sample configuration on amount and size distribution of the particles are analyzed. The results of the amount and size distribution of the particles are compared to those in the case of samples placing parallel to the plasma flux. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 681-686)

Microstructure and Wear Behavior of FeBSiNbCr Metallic Glass Coatings

Jiangbo Cheng, Xiubing Liang, Binshi Xu and Yixiong Wu

In this paper, FeBSiNbCr metallic glass coatings were prepared onto AISI 1045 steel substrate by using wire arc spraying process. The phase and structure of the coating were characterized by transmission electron microscopy (TEM), X-ray diffraction (XRD) and scanning electron microscopy (SEM) equipped with energy dispersive X-ray analysis (EDX). The microstructure of the coating consists of full amorphous phase. The coating has high hardness and low porosity. Full density and little oxides are detected in the coating. The mechanical properties, especially wear resistance, were investigated. The relationship between wear behavior and structure of the coatings were analyzed in detail. The main failure mechanism of the metallic glass coating is brittle breaking and fracture. The results indicate that FeBSiNbCr metallic glass coating has excellent resistance to abrasive wear. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 687-690)

Effects of Homo-buffer Layer on Properties of Sputter-deposited ZnO Films

Jian Huang, Linjun Wang, Run Xu, Weimin Shi and Yiben Xia

Two-step growth regimes were applied to realize a homoepitaxial growth of ZnO films on freestanding diamond substrates by radio-frequency (RF) reactive magnetron sputtering method. ZnO buffer layers were deposited on freestanding diamond substrates at a low sputtering power of 50 W, and then ZnO main layers were prepared on this buffer layer at a high sputtering power of 150 W. For comparison, a sample was also deposited directly on freestanding diamond substrate at a power of 150 W. The effects of ZnO buffer layers on the structural, optical, electrical and morphological properties of the ZnO main layer were studied by X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy, semiconductor characterization system and atomic force microscopy (AFM) respectively. The experimental results suggested that homo-buffer layer was helpful to improve the crystalline quality of ZnO/diamond heteroepitaxial films. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 691-694)

Preparation, Microstructure and Properties of NiO-Cr₂O₃-TiO₂ Infrared Radiation Coating

Wu Chen, Weiping Ye, Xudong Cheng, Wei Duan, Fang Mao and Deliang Li

The spherical agglomerated particles were fabricated by spray drying with the powders of NiO, Cr₂O₃ and TiO₂. Plasma spray power, which has good property of flowability, was acquired by heat treatment from the particles at 1200 °C in the reducing atmosphere. Dark and uniform coating of More than 50 μm thick was deposited on the copper sheet substrate by plasma spraying. It is found that the infrared normal total emissivity of the coating is up to 0.91 at 600 °C by infrared radiation testing. The X-ray diffraction analysis shows that the formation of (Cr_{0.88}Ti_{0.12})₂O₃ and spinel structural NiCr₂O₄ in the coating is the main reason for high efficient infrared radiation, and the phase structure and performance of coating is favorable under the thermal cycle between room temperature and 600±C. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 695-698)

Effects of Interface and Grain Boundary on the Electrical Resistivity of Cu/Ta Multilayers

M. Wang, B. Zhang, G.P. Zhang, Q.Y. Yu and C.S. Liu

The electrical resistivity of Cu/Ta multilayers deposited by radio-frequency magnetron sputtering on a polyimide substrate was investigated as a function of monolayer thickness. It is found that the resistivity of the multilayer increases with decreasing monolayer thickness from 500 nm to 10 nm. Two significant effects of layer interface scattering and grain boundary scattering were identified to dominate electronic transportation behavior in the Cu/Ta multilayers at different length scales. The electrical resistivity of the multilayer with monolayer thickness ranging from nanometer to submicron scales can be well described by a newly-proposed Fuchs-Sandheimair (F-S) and Mayadas-Shatzkes (M-S) combined model. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 699-702)

Optimization of Polishing Parameters with Taguchi Method for LBO Crystal in CMP

Jun Li, Yongwei Zhu, Dunwen Zuo, Yong Zhu and Chuangtian Chen

Chemical mechanical polishing (CMP) was used to polish Lithium triborate (LiB₃O₅ or LBO) crystal. Taguchi method was applied for optimization of the polishing parameters. Material removal rate (MRR) and surface roughness are considered as criteria for the optimization. The polishing pressure, the abrasive

concentration and the table velocity are important parameters which influence MRR and surface roughness in CMP of LBO crystal. Experiment results indicate that for MRR the polishing pressure is the most significant polishing parameter followed by table velocity; while for the surface roughness, the abrasive concentration is the most important one. For high MRR in CMP of LBO crystal the optimal conditions are: pressure 620 g/cm², concentration 5.0 wt pct, and velocity 60 r/min, respectively. For the best surface roughness the optimal conditions are: pressure 416 g/cm², concentration 5.0 wt pct, and velocity 40 r/min, respectively. The contributions of individual parameters for MRR and surface roughness were obtained. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 703-707)

Multi-objective Optimization of Co-cured Composite Laminates with Embedded Viscoelastic Damping Layer

Lijian Pan, Boming Zhang and Fuhong Dai

Presented herein is a methodology for the multi-objective optimization of damping and bending stiffness of co-cured composite laminates with embedded viscoelastic damping layer. The embedded viscoelastic damping layer is perforated with a series of small holes, and the ratio of the perforation area to the total damping area is the design variable of the methodology. The multi-objective optimization is converted into a single-objective problem by an evaluation function which is a liner weigh sum of the two sub-objective functions. The proposed methodology was carried out to determine the optimal perforation area ratios of two viscoelstic layers with different perforation distance embedded in two composite plates. Both the optimal perforation area ratios are approximate to 2.2%. However, the objective value of the plate with greater perforation distance in embedded viscoelatic layer is much greater. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 708-712)

Study of Debond Fracture Toughness of Sandwich Composites with Metal Foam Core

Xinzhu Wang, Linzhi Wu and Shixun Wang

Two types of experiments were designed and performed to evaluate the adhesive bond in metal foam composite sandwich structures. The tensile bond strength of face/core was determined through the flatwise tensile test (FWT). The test results show that the interfacial peel strength is lower than the interlaminar peel strength

in FWT test. The mode I interfacial fracture toughness (GIC) of sandwich structures containing a pre-crack on the upper face/core interface is determined by modified cracked sandwich beam (MCSB) experiment. It is found that the crack propagates unsynchronously on the two side of the specimen and the propagation of interfacial debonding always stays on the face/core interface during the MCSB tests. In order to simulate the failure of metal foam composite sandwich structures, a computational model based on the Tsai-Hill failure criterion and cohesive zone model is used. By comparing with experiment results, it can be concluded that the computational model can validly simulate the interfacial failure of metal foam composite sandwich structures with reasonable accuracy. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 713-716)

Preparation of Al3Sc Intermetallic Compound by FFC Method

Xianjie Liao, Hongwei Xie, Yuchun Zhai and Yi Zhang

The FFC Cambridge process is a direct electrodeoxidation process used to reduce metal oxides for metals or alloys in molten salts. Al-Sc compound oxides are used as a precursor which formed upon blending and sintering Al_2O_3 , Sc_2O_3 and Al powders and are successfully reduced by using the FFC Cambridge process at 973 K with a constant cell voltage of -3.2 V. This method is applied to the preparation of fine Al3Sc particles, which can give another new view for aluminum industry. (Journal of Materials Sciences and Technology 2009 Vol. 25 (05): 717-720)

Tensile and Fatigue Properties of Free-Standing Cu Foils

Caiyun Dai, Xiaofei Zhu and Guangping Zhang

Tensile and fatigue properties of free-standing as-rolled Cu foils were investigated by means of uniaxial tensile and dynamic bending tests. A special testing system was established to evaluate fatigue behavior of a microscale material subjected to dynamic bending load. The experimental results show that the yield strength increases, but the fracture strain and fatigue resistance decrease with decreasing foil thickness. Deformation and fatigue damage behavior was characterized. The size effect on tensile and fatigue properties of the Cu foils are evaluated to get further understanding of the mechanical behavior of the micrometer-scale metallic materials. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 721-726)

Tensile and Fracture Behavior of DZ68 Ni-base Superalloy

Enze Liu, Shuchen Sun, Ganfeng Tu, Zhi Zheng, Xiurong Guan and Lingfeng Zhang

The tensile and fracture behavior of DZ68 directionally solidified Ni-base superalloy was studied in the temperature range of room temperature (RT) to 1000°C. The fracture mode was examined by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The results show the tensile strength and yield strength of DZ68 alloy increase slightly with increasing temperature, so that at 760°C its reach maxima value: 1214 and 1019 MPa, respectively. When the experimental temperature is higher than 760°C, the tensile and yield strengths decrease evidently and the ductility increases remarkably. The fractograph of fracture surface for the tensile specimen at room temperature shows a dimple-ductile fracture mode. The fractograph from 760 to 850°C shows a slide fracture mode. The fractograph from 900 to 1000°C exhibits a creep rupture mode with uneven deformation. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 727-730)

Tensile and Isothermal Fatigue Behaviors of Mg-12Gd-3Y-0.5Zr Alloy at High Temperature

Xiaoming Yang, Huajie Yang, Fan Yang, Shuming Yin, Wei Wang, Shouxin Li and Qudong Wang

Tensile and isothermal fatigue tests were carried out on an as-rolled Mg-12Gd-3Y-0.5Zr alloy and its heat-treated counterpart at different temperatures. The experimental results show that the ultimate tensile strengths of two alloys decrease very slowly with increasing temperature up to 200°C. The ultimate tensile strength of heat-treated Mg-12Gd-3Y-0.5Zr is slight lower than that of as-rolled counterpart; however, the fatigue strength of heat-treated alloy is higher. The mechanism of fatigue failure was nvestigated by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). It shows that cyclic slip combined with environmental effect may be the main crack initiation mechanism. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 731-737)

Preparation and Thermoelectric Properties of $\text{Zr}_{1-x}\text{Ti}_x\text{NiSn}_{0.975}\text{Sb}_{0.025}$ Half-Heusler Alloys

Cui Yu, Yun Zhang, Tiejun Zhu, Guangyu Jiang, Ji Xu, Bo Zhao and Xinabing Zhao

$\text{Zr}_{1-x}\text{Ti}_x\text{NiSn}_{0.975}\text{Sb}_{0.025}$ ($x=0, 0.15, 0.25, 0.5$) half-Heusler thermoelectric materials have been prepared by levitation melt, melt spinning and hot pressing. X-ray diffraction analysis and scanning electron microscopy observation showed that nearly single phase half-Heusler compounds were obtained for the levitation-melted ingots. The effects of Ti substitution and grain refinement by melt spinning have been studied. It is found that both the Ti substitution on the Zr site and the grain refinement can reduce the lattice thermal conductivity and total thermal conductivity. The maximum figure of merit ZT value achieved is about 0.47, which is comparable with the previously reported value of ~ 0.5 for $\text{Zr}_{0.5}\text{Ti}_{0.5}\text{NiSn}$. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 738-741)

Effect of Sintering Temperature on the Texturing Behavior of $\text{NaCo}_2\text{O}_{4.8}$ Synthesized by Urea Auto-Combustion Method

Yue Zhang, Wei Wei, Yong Liu, Benpeng Zhu, Ping Huang, Ziyu Wang, Zhongpo Zhou, Wufeng Tang and Jing Shi

Polycrystalline $\text{NaCo}_2\text{O}_{4.8}$ materials were prepared using the urea auto-combustion method. The reaction process and crystal growth were investigated through X-ray diffraction (XRD), thermogravimetry-differential thermal analysis (TG-DTA), and Fourier transform infrared spectrometry (FTIR). The results indicate that the formation temperature of $\text{NaCo}_2\text{O}_{4.8}$ is about 620°C , which is lower than that for solid-state reaction. XRD results show that the texturing along c -axis occurred as the powders calcined at 700°C were pressed into pellets with subsequently sintering, and the degree of such texturing increases with increasing sintering temperature. Surface morphologies by scanning electron microscopy (SEM) also indicate that the texturing show dependence on sintering temperature. The grains on the surfaces of the pellets sintered at 750 and 850°C have some growth trend along a - b planes, while the grains on the surface of the pellet sintered at 950°C show an obvious growth trend toward c -axis. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 742-744)

Growth, Optical, Mechanical, Dielectric and Theoretical Studies on Potassium Pentaborate Tetrahydrate ($\text{KB}_5\text{O}_8 \cdot 4\text{H}_2\text{O}$) Single Crystal by Modified Sankaranarayanan-Ramasamy Method

C. Justin Raj, S. Krishnan, S. Dinakaran, J. Mary Linet, R. Uthrakumar, R. Robert and S. Jerome Das

A nonlinear optical single crystal of potassium pentaborate tetrahydrate ($\text{KB}_5\text{O}_8 \cdot 4\text{H}_2\text{O}$) has been grown from aqueous solution by using unidirectional crystal growth method of Sankaranarayanan-Ramasamy (SR) with a due modification in the growth assembly. Potassium pentaborate crystal of 60 mm length and 10 mm diameter has been grown along (100) plane with a growth rate of 3 mm per day within a period of 20 days. The grown crystal was subjected to single crystal X-ray diffraction analysis to confirm that the crystal belongs to the orthorhombic system. Some fundamental data such as valance electron plasma energy, Penn gap, Fermi energy and electronic polarizability of the grown crystal were calculated. The presence of borate in the grown crystal was confirmed by Fourier transform infrared (FTIR) spectroscopy. The optical transmission property of the grown crystal was analyzed using ultra violet (UV) visible spectral analysis. Surface morphology of the growth plane was observed using scanning electron microscopy (SEM). The mechanical strength of the crystals was found out using Vickers microhardness test along the growth axis. Frequency dependent dielectric constant of the grown crystal was studied for various temperatures along (100) plane. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 745-748)

Coarsening Behavior of $\text{Al}_3(\text{Sc}, \text{Zr})$ Precipitates and Its Influence on Recrystallization Temperature of Al-Mg-Sc-Zr Alloy

Gang Du, Jingwei Deng, Desheng Yan, Mingjiu Zhao and Lijian Rong

Effects of intermediate annealing temperature and time after hot working on recrystallization temperature (Tr) of Al-Mg-Sc-Zr alloy subjected to further cold working were investigated. It was found that Tr of cold worked alloy dropped with the rise of intermediate annealing temperature or extension of annealing time, due to coarsening of $\text{Al}_3(\text{Sc}, \text{Zr})$ particles during intermediate annealing. After annealed at 550°C for 1 h or 475°C for 50 h, Tr is nearly same as that in a Sc, Zr free 5A06 alloy. Coarsening mechanism was also discussed. After hot rolling, residual dislocations promoted diffusion of Sc and Zr atoms at the elevated temperature of the intermediate annealing. Easier diffusion sped the growth of

the $\text{Al}_3(\text{Sc}, \text{Zr})$ particles, resulting in a coherency loss and quantity reduction of the particles. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 749-752)

Growth of $\text{LaBr}_3:\text{Ce}^{3+}$ Single Crystal by Vertical Bridgman Process in Nonvacuum Atmosphere

Hongbing Chen, Changyong Zhou, Peizhi Yang and Jinhao Wang

The growth of $\text{LaBr}_3:\text{Ce}^{3+}$ crystal by the vertical Bridgman process in a nonvacuum atmosphere was reported. According to the dehydration procedure of $\text{LaBr}_3 \cdot 7\text{H}_2\text{O}$ and $\text{CeBr}_3 \cdot 7\text{H}_2\text{O}$ investigated by differential thermal analysis/thermogravimetry (DTA/TG), anhydrous LaBr_3 and CeBr_3 were prepared by heating $\text{LaBr}_3 \cdot 7\text{H}_2\text{O}$ and $\text{CeBr}_3 \cdot 7\text{H}_2\text{O}$ at 240-260°C for 5-6 h in dried HBr atmosphere. Using the feed materials prepared from the anhydrous lanthanum bromides, a 0.5 mole fraction Ce^{3+} doped LaBr_3 crystal with size of $\varnothing 25 \text{ mm} \times 50 \text{ mm}$ had been grown by vertical Bridgman process successfully. By sealing the feed material in a platinum crucible, the crystal could be grown in a nonvacuum atmosphere as the oxidization and volatilization of the melt could be avoided. The crystal was grown with the optimum conditions such as a growth rate of 0.5-1.0 mm/h and a temperature gradient of around 30°C/cm across solid-liquid interface under a furnace temperature of 850-880°C. The crystal was characterized by DTA/TG, X-ray diffraction (XRD), optical transmission, photoluminescence and X-ray stimulated luminescence measurement. The Bridgman process was confirmed to be promising for growing transparent $\text{LaBr}_3:\text{Ce}^{3+}$ crystal with high optical quality. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 753-757)

Cavitation Erosion Corrosion Behaviour of Manganese-nickel-aluminum Bronze in Comparison with Manganese-brass

Hong Yu, Yugui Zheng and Zhiming Yao

The cavitation erosion corrosion behaviour of ZQMn12-8-3-2 manganese-nickel-aluminum bronze and ZHMn55-3-1 manganese-brass was investigated by mass loss, electrochemical measurements (polarization curves and electrochemical impedance spectroscopy) and the cavitation damaged surfaces were observed by scanning electron microscopy (SEM). The results showed that ZQMn12-8-3-2 had better cavitation erosion resistance than ZHMn55-3-1. After the cavitation erosion for 6 h, the cumulative mass loss of ZQMn12-8-3-2 was about 1/3 that of ZHMn55-3-1. The corrosion current density of ZQMn12-8-3-2 was less than that of ZHMn55-3-1 under both static and cavitation condition. The free-

corrosion potentials of ZQMn12-8-3-2 and ZHMn55-3-1 were all shifted in positive direction under cavitation condition compared to static condition. In the total cumulative mass loss under cavitation condition, the pure erosion played a key role for the two tested materials (74% for ZHMn55-3-1 and 60% for ZQMn12-8-3-2), and the total synergism between corrosion and erosion of ZQMn12-8-3-2 (39%) was larger than that of ZHMn55-3-1 (23%). The high cavitation erosion resistance of ZQMn12-8-3-2 was mainly attributed to its lower stacking fault energy (SFE), the higher microhardness and work-hardening ability as well as the favorable propagation of cavitation cracks for ZQMn12-8-3-2, *i.e.*, parallel to the surface rather than perpendicular to the surface for ZHMn55-3-1. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 758-766)

Direct Reduction of Solid Fe_2O_3 in Molten CaCl_2 by Potentially Green Process

Guoming Li, Dihua Wang and Zhen Chen

Sintered (300 °C) porous pellets of Fe_2O_3 were electrolyzed to Fe in molten CaCl_2 (800-900 °C) under argon at 1.8-3.2 V for 2-20 h. The laboratory scale experiments show that it was a potentially direct green method to produce Fe powder. At lower electrolysis voltage (<2.2 V), higher current efficiency (>90%) and smaller energy consumption (~3.0 kWh/kg) can be obtained. When the electrolysis voltage was above 2.4 V, the deposition of metal Ca from the salt lowered the current efficiency and increased the energy consumption. The electrolysis voltage also had effects on the micrographs of the reduced powder. The cubic particles can be seen in the products at the voltage lower than 2.2 V; when the voltage was higher than 2.2 V, it was nodular. The reduction proceeds at the cathode in two steps, *i.e.*, from Fe_2O_3 to FeO and then to Fe. The oxygen emits at the anode. The process is potentially free of carbon emission and produces two useful products at both cathode and anode, promising a zero-emission technology for the extractive metallurgical industry. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 767-771)

CsCl Effected Ultrafast Third-order Optical Nonlinearities of $\text{GeS}_2\text{-Sb}_2\text{S}_3$ Chalcogenide Glasses

Hua Zhang, Qiuhua Nie, Shixun Dai, Xiang Shen, Xunsi Wang and Xianghua Zhang

A series of alkali halide doped chalcogenide glasses (100- x)(0.9 GeS_2 -0.1 Sb_2S_3)- $x\text{CsCl}$ ($x=5, 10, 15$ and 20 mole fraction) were prepared. The absorption spectra and Raman scattering spectra of these glasses were measured. The optical band

gaps E_{opt} were obtained from ultraviolet absorption edges. Z-scan technique was utilized to investigate the third-order nonlinear optical properties of $\text{GeS}_2\text{-Sb}_2\text{S}_3\text{-CsCl}$ glasses. The value of E_{opt} increases and the third-order optical nonlinearity decreases with increasing CsCl content. Decreasing lone-pair electron and broadening the band-gap will provide less transition paths for nonlinear process, which play a key role in ultrafast third-order nonlinear optical responses of these chalcogenide glasses. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 772-776)

Synthesis and Electrical Properties of Li-modified $\text{Bi}_{0.5}\text{Na}_{0.5}\text{TiO}_3\text{-BaTiO}_3$ Lead-free Piezoelectric Ceramics

Yunwen Liao and Dingquan Xiao

Lead-free piezoelectric ceramics $(1-y)\text{Bi}_{0.5}(\text{Na}_{1-x}\text{Li}_x)_{0.5}\text{TiO}_{3-y}\text{BaTiO}_3$ with $x=0\text{-}0.125$ and $y=0.02\text{-}0.12$ were fabricated by a solid-state reaction process, and their dielectric, piezoelectric and ferroelectric properties were investigated. The results show that the addition of Li^+ significantly improves the sintering performance and piezoelectric properties of the ceramics. X-ray diffraction (XRD) patterns indicate that the ceramics possess pure perovskite structure. At room temperature, the ceramics provide high piezoelectric charge constant d_{33} (up to 210 pC/N), high planar electromechanical coupling factor k_p (34.5%), large remanent polarization P_r (up to $40^\circ\text{C}/\text{cm}^2$), and low coercive field E_c (3.0 kV/mm), which indicates that $(1-y)\text{Bi}_{0.5}(\text{Na}_{1-x}\text{Li}_x)_{0.5}\text{TiO}_{3-y}\text{BaTiO}_3$ is a good lead-free piezoelectric ceramic. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 777-780)

Magnetocaloric Effect in $\text{MnCo}_{1-x}\text{Al}_x\text{Ge}$ Compounds

Weiguang Zhang, O. Tegus, Yongli Wu, Yirgeltu, Huanying Yan and Song Lin

The effects of substitution of Al for Co on magnetic and magnetocaloric properties of $\text{MnCo}_{1-x}\text{Al}_x\text{Ge}$ ($x=0.00, 0.03, 0.05, 0.08, 0.10, 0.13, 0.15$, and 0.20) compounds have been investigated by X-ray diffraction (XRD) and magnetization measurements. XRD exhibits that $\text{MnCo}_{1-x}\text{Al}_x\text{Ge}$ compounds crystallize in the orthorhombic TiNiSi -type structure for $x=0.03$ and in the hexagonal Ni_2In -type crystal structure for $x>0.03$. Magnetic measurements show that the Curie temperature can be tuned between 286 and 347 K by changing the Co/Al ratio. The maximum magnetic entropy change determined from the isothermal

magnetization measurement by Maxwell relation reaches 1.52 J/(kgK) for $x=0.08$ in a field change from 0 to 1.5 T around 310 K. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 781-784)

Effects of Substrate Temperature on the Properties of Mo-doped ZnO Films Prepared by RF Magnetron Sputtering

Xianwu Xiu, Yuping Cao, Zhiyong Pang and Shenghao Han

Transparent conducting molybdenum-doped zinc oxide (MZO) films were successfully prepared by radio frequency (RF) magnetron sputtering method on glass substrates under different substrate temperatures. The nature of MZO film is polycrystalline with hexagonal structure and a preferred orientation along c -axis. With increasing substrate temperature from room temperature to 400 °C, the crystallinity of the films is deteriorated and the resistivity increases sharply due to both the decrease of carrier concentration and Hall mobility. The lowest resistivity achieved is $9.2 \times 10^{-4} \Omega \cdot \text{cm}$ with a high Hall mobility of $30 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ for the film deposited at room temperature. The average transmittance in the visible range exceeds 85% for all the samples. The optical band gap decreases from 3.30 to 3.25 eV with substrate temperature from room temperature to 400 °C. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 785-788)

Correlation of Magnetic Properties of Co/Cr Bilayer Thin Films with Grain Boundary Diffusion

Gaowu Qin, Bo Yang, Wenli Pei and Yuping Ren

The microstructure and magnetic properties of Co/Cr bilayer films were examined before and after post-deposition annealing by using transmission electron microscopy (TEM), X-ray diffraction (XRD) technique and vibrating sample magnetometer (VSM). A model of grain boundary (GB) Cr-rich phase growth involving GB diffusion derived from the Cr underlayer was proposed to elucidate the kinetics of the paramagnetic Cr-rich phase growth along Co GBs within the Co layer. The correlation of the GB Cr-rich phase formation with the magnetic Co grain isolation and accordingly, improvement of magnetic properties was experimentally investigated and discussed in detail. Our analysis results are well consistent with previous micromagnetic simulations on the improvement of magnetic properties by the magnetic grain isolation. The results provide some insights into the processing-structure-property relationships of the Co/Cr bilayer

films, and thus suggest that the magnetic grain isolation be feasible not only in longitudinal recording media, but also be effective in tuning the exchange coupling of magnetic grains in perpendicular recording media via the GB diffusion from underlayer and/or overlayer. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 789-794)

Effects of Ag Layer on the Structure and Magnetic Properties of FePt:AlN Composite Films

Wenfeng Liu, Yuesheng Chai, Gang Sun and Mingang Zhang

[AlN/FePt]₁₀, [AlN/FePt]10/Ag and Ag/[AlN/FePt]₁₀ thin films were deposited by magnetron sputtering onto 7059 glass substrates, then were annealed at 550°C for 30 min. It is found that introducing non-magnetic Ag underlayer can improve the ordering and (001) preferred orientation of FePt grains. Furthermore, the (001) texture of FePt grains increases with increasing Ag underlayer thickness. However, with Ag top layer given, it can only be observed that the ordering of FePt grains was promoted. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 795-798)

Substrate Effects on the High-Temperature Oxidation Behavior of Thermal Barrier Coatings

Limin He, Zhenhua Xu, Jianping Li, Rende Mu, Shimei He and Guanghong Huang

The high-temperature oxidation behaviors of the NiCrAlYSi/P-YSZ thermal barrier coatings (TBCs) produced by electron beam-physical vapor deposition (EB-PVD) on directionally solidified (DS) and single crystalline (SC) Ni-based superalloy substrates were investigated. The cross-sectional microstructure investigation, isothermal and cyclic oxidation tests were conducted for the comparison of oxidation behaviors of TBCs on different substrates. Although TBC on DS substrate has a relatively higher oxidation rate, it has a longer thermal cycling lifetime than that on SC substrate. The primary factor for TBC spallation is the mismatch of thermal expansion coefficient (TEC) of the bond coat and substrate. The morphological feature of thermally grown oxide (TGO) has a strong influence on the TBC performance. By optimizing the elemental interdiffusion between bond coat and substrate, a high quality TGO layer is formed on the DS substrate, and therefore the TBC oxidation behavior is improved. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 799-802)

Synthesis of Cf/TiAl₃ Composite by Infiltration-*In Situ* Reaction

Yanmei Liu, Ziyang Xiu, Yongliang Guo, Longtao Jiang, Wensu Yang and Gaohui Wu

Infiltration-*in situ* reaction synthesis of Cf/TiAl₃ composite was investigated. The as-cast material was obtained by titanium particles, carbon fibers and pure aluminum. Titanium particles and carbon fibers were mixed and pressed to form a preform firstly, and then molten pure aluminum was pressed into the preform, subsequently, cooled rapidly. *In situ* reaction samples were obtained by heating the as-cast material from 600 to 1000°C for 1 h. The microstructural evolution of *in situ* reaction samples was analyzed by scanning electron microscopy and energy dispersive X-ray. In addition, the phase composition of products was inspected by X-ray diffraction. Experimental results showed that the dominant product of TiAl₃ and a small amount of Al₄C₃ were formed at low temperature. While TiAl₃ was not stable at high temperature, along with its decrease, TiC phase became favorable. In the final products, TiAl₃, TiC and Al₄C₃ were detected. Thus, the in situ reaction for Ti-Al-C system composite proceeded a formed-decomposed-precipitated mechanism. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 803-806)

Statistical Analysis of Reinforcement Characterization in SiC Particle Reinforced Al Matrix Composites

Peng Zhang and Fuguo Li

The characterization of reinforcement in 15% SiC particles reinforced Al matrix composites processed by powder metallurgy route was studied by statistical method. During the analysis, a new approach for the estimation of the characterization of reinforcement was presented. The mathematic software MATLAB was used to calculate the area and perimeter of reinforcement, in which the image processing technique was applied. Based on the calculation, the fractal dimension, shape factor, reinforcement size distribution and reinforcement distribution were investigated. The results show that the reinforcement shape is similar to rectangle; the reinforcement size distribution is broad with the range of 1-12 μm ; the topography of reinforcement is smooth; and the reinforcement distribution is inhomogeneous. Furthermore, the cell model based on the statistical characterization was established and tested. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 807-813)

Solidification Features of Ti45Al Alloys with Different Boron Addition

Weidong Wang, Yingche Ma, Bo Chen, Ming Gao, Kui Liu and Yiyi Li

The effects of boron on the solidification behaviors of Ti45Al_xB alloys were studied by high temperature samples. These samples were melted at 1823 K, followed by cooling to the designated temperature, and then quickly water-quenched to preserve the solidification features. Optical microscopy and scanning electron microscopy analysis shows that the solidus temperature of Ti45Al was really reduced by 20 K when adding 0.8 at. pct B, and it was also observed that boride precipitated before the appearance of β phase. Besides, solidification structure confirmed that B addition does not obviously refine β phase. α grain refinement by certain amount of B in alloy probably clarifies the mechanism of B refining lamellar microstructure at room temperature. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 814-818)

Diffusion Bonding of Dissimilar Intermetallic Alloys Based on Ti₂AlNb and TiAl

Jianning Zou, Yuyou Cui and Rui Yang

Direct diffusion bonding of an orthorhombic Ti₂AlNb base alloy to a TiAl base alloy, Ti-22Al-23Nb-2Ta and Ti-46.2Al-2Cr-2Nb-0.15B (at. pct), was carried out and the interface microstructure, formation of new phase at the interface and joint strength were characterized. At low temperature, a new phase with AlNb₂-structure, Al(Nb, Ti)₂, was formed in the interface region adjacent to the O base alloy. The α_2 was found to be the major reaction product and developed in the interface region adjacent to the TiAl alloy as well as in the region adjacent to the O base alloy accompanying the formation of Al(Nb, Ti)₂. The occurrence of Al(Nb, Ti)₂ has been attributed to the different diffusivity of Nb and Al, leading to a eutectoid-like reaction. At relatively high temperature, Al(Nb, Ti)₂ did not form due to enhanced diffusion of Nb but a B2-enriched zone formed on the O alloy side instead after long holding time. Only when an appropriate interface microstructure was achieved by optimizing the bonding parameters, could the shear strength of the joint reach 80% of that of the TiAl base alloy. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 819-824)

Magnetoimpedance of Electroplated Wires with Large Core Diameters

C. Sirisathitkul and P. Jantaratana

Monolayered Co and trilayered Co/Cu/Co were electroplated on 485 μm -diameter Cu wires using the bath pH 2.5. These wires can be functioned as magnetic sensors owing to their magnetoimpedance (MI) effect. By measuring at four different frequencies (100, 250, 500, and 1000 kHz) and Co thicknesses (2.5, 5.0, 10.0, and 25.0 μm), the MI ratio of electroplated Co on Cu wires tended to increase with increasing Co thickness and frequency of the driving current. The Co/Cu/Co on Cu wires exhibited even higher MI ratio. The magnetic layer also regulated the magnetic inductions and anisotropy regardless of the size of nonmagnetic core. Nevertheless, the diameter of the Cu core had a significant effect on the MI ratio. By comparing with the 47.7 μm -diameter Ag cores electroplated by Co and Co/Cu/Co of the same thickness, the Cu cores with a larger diameter gave rise to a larger MI ratio because their lower electrical resistance enhanced the crossing effect. Substantial MI ratio was observed even in a low frequency regime because the skin effect occurred at a low frequency in the case of electroplated wires with large core diameters. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 825-828)

Experimental Analysis of Microscale Laser Shock Processing on Metallic Material Using Excimer Laser

Zhigang Che, Liangcai Xiong, Tielin Shi, Huayang Cheng and Likun Yang

Microscale laser shock processing (μLSP), also known as laser shock processing in microscale, is a technique that uses microscale focused laser beam to induce high pressure plasma and generates plastic deformation and compressive residual stress in target materials, thus improves fatigue or stress corrosion cracking resistance of MEMS (Micro Electromechanical Systems) devices made of such a material. Many works have been reported about the research and experiment for μLSP . But the diameters of 50-200 μm were used at the first time for this field, which was useful for treating micro-device components with larger area and curved surface. The excimer laser was used firstly on μLSP for shorter wavelength than that of used in previous researches. The determination method of laser spot size at micro-level spatial resolution was presented. Under these conditions, plastic deformation, the stress analysis and microhardness with different pulse number, pulse energy and pulse spacing were investigated. Especially the residual stress

distribution with depth treated by μ LSP, was first investigated. Experiment results showed that the material performance was improved remarkably after μ LSP. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 829-834)

Consistent Analytic Embedded Atom Potential for Face-Centered Cubic Metals and Alloys

Iyad A. Hijazi and Young Ho Park

A consistent empirical embedded-atom potential that includes a long range force was developed for fcc (facecentered cubic) metals and alloys. The proposed potential for pure metals does not require modification of the initial function form when being applied to alloy systems. The potential parameters of this model were determined by fitting lattice constant, three elastic constants, cohesive energy, and vacancy formation energies of the pure metals and the heats of solution of the binary alloys via an optimization technique. Parameters for Ag, Al, Au, Cu, Ni, Pd and Pt were obtained. The obtained parameters were used to calculate the bulk modulus, divacancy formation energy, crystal stability, stacking fault energy, vacancy migration energy, and melting point for each pure metal and the heats of formation and lattice constants for binary alloys. The predicted values were in good agreement with experimental results. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 835-846)

Impact Energy of Functionally Graded Steels with Crack Divider Configuration

Ali Nazari and Jamshid Aghazadeh Mohandesi

Functionally graded steels were produced via electroslog remelting process using the primary electrodes of plain carbon and austenitic stainless steels. Charpy impact energy of as-prepared specimens was measured in the form of crack divider. The obtained results show that the impact energy of the specimens depends on the type and the volume fraction of the present phases. Based on the rule of mixtures, a mathematical model, which correlates the impact energy of functionally graded steels to the impact energy of the individual layers through Vickers microhardness of the layers, was presented. A good compatibility between the experimental results and those obtained from the model was observed. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 847-852)

Friction Stir Welding of Zr₅₅Al₁₀Ni₅Cu₃₀ Bulk Metallic Glass to Crystalline Aluminum

Zuoxiang Qin, Cuihong Li, Haifeng Zhang, Zhongguang Wang, Zhuangqi Hu and Zhiqiang Liu

The Zr₅₅Al₁₀Ni₅Cu₃₀ bulk metallic glass plate were successfully welded to crystalline aluminum plates by using a friction stir welding (FSW) method. The welded zone was examined. No defects, cracks or pores were observed and no other crystalline phases except for aluminum were found in the welded joint. The strength of the joint is higher than that of aluminum. The glassy phase in the stir zone keeps the amorphous state, showing a successful welding. The storage modulus softens over the glass transition. And the weldability was discussed according to this phenomena. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 853-856)

Microstructure Characterization of High-heat-input Welding Joint of HSLA Steel Plate for Oil Storage Construction

Weihua Sun, Guodong Wang, Jiming Zhang, Dianxiu Xia and Hao Sun

In this paper, microstructure and mechanical properties of welding metals in 610 MPa high strength low alloy (HSLA) were studied after high-heat-input welding. Both the base material and the weld joint proved excellent strength and toughness by vibratory electrogas arc (VEGA) welding under 90 to 100 kJ/cm heat-input. The heat-affected zone (HAZ) was comprised of fine-grain zone (FGZ) and coarse-grain zone (CGZ), which characterizes fine granular structure and lathing-bainite substructure. It has found that large quantity of dispersed TiN and M₂₃C₆ precipitates restrain structure growing in HAZ and strengthen the weldment together with dislocations in the welded joint. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 857-860)

Prediction of Large Structure Welding Residual Stress by Similitude Principles

Shude Ji, Liguang Zhang, Xuesong Liu and Jianguo Yang

On basis of the similitude principles, the conception of virtual simulative component and the auxiliary value of welding residual stress which is deduced by the welding conduction theory, the relation of the welding residual stress between the

simulative component and the practical component is attained. In order to verify the correctness of the relation, the research work is done from the view of the welding experiment and the numerical simulation about the simulative component and the practical component. Moreover, for the welding experiment and the simulation, the proportionality coefficient of dimensions between the simulative component and practical component is 1:1.5. The results show that the distribution of welding residual stress of the simulative component is the same as that of the practical component. The ratio of welding residual stress attained by the experiment or the simulation method between the practical runner and the simulative component is compared with the ratio got from the similitude principles. Moreover, the error is less than 10%. This provides a new idea to predict the welding stress distribution of large practical structure by the contractible physical model, which owns important theory meaning and practical engineering significance for the welding experiment or the numerical simulation of large welding structures. (Journal of Materials Sciences and Technology 2009 Vol. 25 (06): 861-864)

Synthesis of GaPO₄-GaN Coaxial Nanowires

Lutang Fu Zhigang Chen Hongtao Cong

GaPO₄-GaN coaxial nanowires were synthesized by two-step chemical vapor deposition method using H₂ and NH₃ as reactant gas in turn at 950°C. The morphology and microstructures of the GaPO₄-GaN coaxial nanowires were studied by scanning electron microscopy (SEM), X-ray diffraction (XRD) and transmission electron microscopy (TEM). The nanowires have an average diameter of ~15 nm and length of hundreds of nanometers. The core is GaPO₄ crystal and the outer shell is GaN crystal. The formation mechanism was discussed and the key factors controlling the growth are temperature and the concentration of reactant gases. These coaxial nanowires may have potential application for piezoluminescence nano-devices, and the two-step synthetic technique could be used to grow rationally other 1D GaN-based nanowire heterostructures. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 15-19)

Preparation of Large Area Double-walled Carbon Nanotube Macro-films with Self-cleaning Properties

Ziping Wu Qianfeng Xu Jiannong Wang Jie Ma

Double-walled carbon nanotube (DWCNT) macro-films with large areas, excellent flexibility and superhydrophobicity are reported. The area of the macro-

film is larger than 30 cm×15 cm, and this large film can be bended, or folded without any damage, and even can be tailored freely. After a simple modification of perfluoroalkylsilane, the surface of the macro-film shows excellent superhydrophobicity with a water contact angle of 165.7 ± 2 deg. and sliding angle lower than 3 deg., the prepared superhydrophobic films showing excellent antifouling, self-cleaning and water-repellent functions. The topographic roughness and perfluoroalkylsilane modification are found to contribute to the observed superhydrophobicity. Considering the outstanding electronic, chemical and mechanical properties of DWCNTs, it is expected that this multifunctional DWCNT macro-film has potential applications in many fields. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 20-26)

Effect of Titanium, Antimony, Cerium and Carbon Nanotubes on the Morphology and Microhardness of Mg-based Icosahedral Quasicrystal Phase

Zhifeng Wang Weimin Zhao Haipeng Li Jian Ding Yongyan Li Chunyong Liang

For the first time, petal-like and spherical Mg-based icosahedral quasicrystal phase (I-phase) were obtained by introducing Ti, Sb, Ce and C nanotubes into Mg-Zn-Y alloy under normal casting conditions. The formation mechanism and stability criterion of spherical I-phase were discussed. The morphology and microhardness of I-phase and their determinants were studied in this paper. The results show that the different value of microhardness of I-phase could be attributed to the different kinds of the fourth component and its content, and its different innate characters. The final morphology of icosahedral quasicrystalline (IQC) is decided by the size of critical stable radius R_r , the content of the fourth component and degree of undercooling. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 27-32)

Formation and Annealing of BaTiO₃ and SrTiO₃ Nanoparticles in KOH Solution

Tomoki Tsumura Keiichi Matsuoka Masahiro Toyoda

Barium titanate (BaTiO₃) and strontium titanate (SrTiO₃) nanoparticles were synthesized separately through hydrothermal reaction of crystalline TiO₂ particles and corresponding alkaline earth hydroxides, Ba(OH)₂ and Sr(OH)₂ respectively, in 50 mol·dm⁻³ KOH solution at 150 °C. Each structural evolution of BaTiO₃ and SrTiO₃ during the hydrothermal treatment was investigated by X-ray diffraction

(XRD), field emission scanning electron microscopy (FE-SEM), field emission transmission electron microscopy (FE-TEM) and thermogravimetry- differential analysis (TG-DTA). In the BaTiO₃ system, round particles with cubic perovskite-type structure were obtained within 1 h. However, these particles were gradually dissolved and then were re-precipitated in the form of cube-shape BaTiO₃ particles with a smaller lattice constant a_c than that of the former phase. After the BaTiO₃ particles formed firstly have disappeared completely, or the two phases coexistence stage with different lattice constant a_c passed, lattice constant a_c of BaTiO₃ phase re-precipitated continuously decreased with annealing time. In contrast, once SrTiO₃ particles are formed, the lattice constant a_c decreased continuously throughout the reaction. The result indicates that SrTiO₃ particles were annealed without dissolution and precipitation process under the present condition. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 33-38)

Sea Cucumber-like Polyaniline Nanofibers Synthesized by Aqueous Solution Method

Baoyun Liu Li Liu Nanlin Shi Jun Gong Chao Sun

The preparation of polyaniline nanofibers in aqueous solution was studied as functions of the concentrations and ratios of reactants. The morphology and microstructure of polyaniline nanofibers are affected by the concentrations and proportions of the reactants. A special kind of sea cucumber-like polyaniline nanofibers can be prepared under control of reaction conditions. Secondary growth is the formation mechanism. In addition, the bulk electrical conductivity of these sea cucumber-like polyaniline nanofibers was higher than that of other common polyaniline nanofibers. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 39-44)

A Facile Synthesis of Cerium Phosphate Nanofiber by Solution-solid Method

Mingyun Guan Jianhua Sun Tongming Shang Quanfa Zhou Jianting Han Aiqin

A solution-solid method is developed to construct cerium phosphate (CePO₄) nanofibers. Tetraphosphoric acid formed the condensed linear polyphosphate (PnO_{3n+1})⁽ⁿ⁺²⁾⁻ before reacting with cerium carbonate (Ce₂(CO₃)₃) powder, which was favourable for one dimensional CePO₄ nanofibers forming. The growth mechanism was proposed based on solution-solid process. CePO₄ nanofibers

display strong UV luminescence emission and weak blue emission. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 45-48)

Interface Structure of Ag/SnO₂ Nanocomposite Fabricated by Reactive Synthesis

Jingchao Chen, Jing Feng, B. Xiao, K.H. Zhang, Y.P. Du and Z.J. Hong

The electric contact material of Ag/SnO₂ composite was achieved by reactive synthesis method. The compositions and microstructure of Ag/SnO₂ composite were analyzed and characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and high-resolution electron microscopy (HRTEM). The structural feature was typical of the particle reinforced composites. The HRTEM images revealed that the observed Ag/SnO₂ interface was absence of the precipitated phase and the lattice contrast across the interface was clear and sharp. The average particle size of SnO₂ in composite was near 50 nm and it was well dispersed in spherical shape. The thermodynamic mechanism of reactive synthesis method was also discussed. The electronic density distribution analysis of the interface showed the charges of Ag atoms transmitted to O atoms and the conductivity of the material was also affected. No extra compounds expected such as Ag_xO_y formed at interface. The distribution of electrons was of inequality near the interface which explained why the mechanical property of the metal/ceramic materials was improved but the machining property declined. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 49-55)

An Examination on Atomic-level Stress Calculations by Nanoindentation Simulation *via* the Quasicontinuum Method

Yufei Shao Shaoqing Wang

Nanoindentation simulations on single crystals Al and Cu via the quasicontinuum method have been performed. Two kinds of atomic-level local stress calculation methods, *i.e.* the coarse-grained local stress and the virial local stress, are employed to calculate the stress state of the contact area. Various comparisons between the coarse-grained local stress and the virial local stress have been made. Firstly, the averaged normal stress beneath the contact surface calculated by coarse-grained method agrees well with continuum mechanical pressure measurement, while the virial method gives unphysical results sometimes. Secondly, the coarsegrained results reflect the indenter size effect on the critical shear stress quite accurately, while the virial calculations fail. Thirdly, the

distribution of maximum shear stress of the coarse-grained method predicts the defects nucleation locations reliably, while the distribution of virial local stress gives an incorrect prediction sometimes. Thus it is concluded that the coarse-grained method can offer a more reliable description of the local stress states of atoms in spatially inhomogeneous solids. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 56-64)

Mechanical Properties of the TaSi₂ Fibers by Nanoindentation

Chunjuan Cui Jun Zhang Lin Liu Hengzhi Fu

The Si-TaSi₂ eutectic in situ composite, which has highly-aligned and uniformly-distributed TaSi₂ fibers in the Si matrix, can be obtained when the solidification rate changes from 0.3 to 9.0 mm/min. It is very interesting that one or two TaSi₂ fibers are curved when the solidification rate reaches 6.0 mm/min, although it is very brittle in general. The formation mechanism of the curved fiber is discussed and mechanical properties of the TaSi₂ fibers are examined by nanoindentation. It is found that the hardness and the elastic modulus of the bended TaSi₂ fiber are much higher than that of the straight TaSi₂ fiber. Moreover, the reasons why the mechanical properties of the straight TaSi₂ fiber are different from that of the curved TaSi₂ fiber are discussed. This can be ascribed to internal stress which results from mismatch of the thermal expansion coefficients of the two phases and different crystallographic orientations. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 65-68)

Nanocrystal Model for Liquid Metals and Amorphous Metals

X.L. Tian, C.W. Zhan, J.X. Hou, X.C. Chen and J.J. Sun

A nanocrystal model for liquid metals and amorphous metals has been developed. With the nanocrystal model, the broadening peak profiles (BPPs) of Cu, Al, Al₆₅Cu₂₀Fe₁₅ alloy, Cu₇₀Ni₃₀ alloy and Fe₅₀Si₅₀ alloy were gained by broadening the X-ray diffraction (XRD) peaks of a crystal lattice. By comparing the BPPs with the XRD intensity curves measured on the liquid metals, it is found that the BPPs are closely in agreement with the XRD intensity curves, respectively, except the Fe₅₀Si₅₀ alloy. Therefore, the nanocrystal model can be used to determine if the atomic cluster structure of the liquid metal is similar to the structure of its crystal lattice. (Journal of Materials Sciences and Technology 2010 Vol. 26 (01): 69-74)