

MAIN TOPICS, ABSTRACTS & KEY WORDS

Research on microstructure and crack of EBW of cemented carbide and 40CR steel

CHEN Guoqing, LIU Junpeng, ZHANG Binggang, FENG Jikai (State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China) . pp 1 – 5

Abstract: The microstructures of the WC-Co/40Cr joint were formed by martensite and η phase. Due to the different spread intensity of the interface elements, the center of the joint got different morphology and the η phase distributed differently in the weld when the welding beam was changed. Two kinds of typical cracks generated under the force of the microstructures and the tensile stress, one was crystalline crack and the other was quenching embrittlement crack. Carbon depleted environment was formed at the interface due to the C element diffusion and η phase will be formed under the appropriate temperature gradient. Mechanical properties of the joints were carried out that average shear strength exceeded 506 MPa. Fracture occurred through the carbide heat affected zone, interface, and weld, which present the characteristics of intergranular fracture, quasi cleavage fracture and cleavage fracture features.

Key words: cemented carbide; EBW; η phase; cracks

Arc behavior of fluoride effects in the A-TIG welding of Ti6Al4V

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Abstract: Three types of compounds, fluorides with MF type (including LiF, NaF, KF) and MF₂ type (including MgF₂, CaF₂, BaF₂) and potassium with KN type (including KF, KCl, KBr), were chosen as activated fluxes to evaluate the effect of arc behavior in A-TIG welding of Ti6Al4V. The results showed that LiF and KBr fluxes could not impact arc behavior. KF and CaF₂ fluxes could contract the arc and increase the arc temperature, but showed no effects on the arc force. MgF₂ flux could contract the arc, increase the arc temperature and arc force. BaF₂ flux could increase the arc temperature and reduce the arc force, but showed no effects on the arc shape. NaF and KCl could contract the arc in different levels, and increase the arc temperature, but showed no effects on the arc force. In addition, further research suggested that fluoride fluxes should be the first choice in A-TIG welding of Ti6Al4V. In MF type fluorides, KF should be selected as activated flux, and in MF₂ type, MgF₂ should be selected.

Key words: A-TIG welding; Ti6Al4V alloy; arc behavior

Numerical simulation on interfacial creep failure of dissimilar welded joint between HR3C and T91 heat-resistant steels

ZHANG Jianqiang, ZHANG Guodong, GUO Jialin (Key Laboratory of Hubei Province of Water Jet Theory and New Technology, Wuhan University, Wuhan 430072, China) . pp 11 – 15

Abstract: The maximum principal stress, von Mises e-

quivalent stress, stress triaxiality in dissimilar welded joints between austenitic (HR3C) and martensitic heat-resistant steel (T91) are simulated by FEM under the conditions of 600 °C and inner pressure of 42.26 MPa. The results show that the maximum principal stress and von Mises equivalent stress are quite high in the vicinity of weld/T91 interface, creep cavities are easy to form and expand in the weld/T91 interface. Weld/T91 interface is the weakest part of welded joint. The stress triaxiality peak is located exactly at the weld/T91 interface, and quite high. Therefore, using stress triaxiality to describe creep cavity nucleation and expansion and crack development is reasonable for the dissimilar welded joint between austenitic and martensitic steel.

Key words: dissimilar metal welded joint; FEM; maximum principal stress; equivalent stress; stress triaxiality

High energy space density measurement system of active zone for electron beam

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Abstract: The method of beam detection and parameters measurement was researched on the basis of the characteristic of high energy and high speed for electron beam welding machine. The small angle of the electron beam magnetic deflection scanning acquisition scheme was put forward. The sensor was designed on the refractory tungsten plate with 25 μ m diameter aperture. The establishment of a set of signal detection device and a control signal process was built. The scanning and sampling process were synchronized by sharing 60 MHz clock. Electronic intensity which passed through the aperture was collected and converted into voltage signal which was high-speed transferred to memory after frequency A/D sampling and quantization. After visual reconstruction of single section signal, the energy region was divided by the energy level and then the energy density distribution was calculated. Activity zone volume was reconstructed by the acquisition of different height of the multilayer electronic beam. Sequence curved surface was generated by segmentation space energy contour surface. Regional spatial energy peak value of 90% was labeled as the focal spot of active zone. The hardware and software system for calculating energy density of electron beam active zone and measurement of focal spot can be effectively used in the quality evaluation for electron beam.

Key words: deflecting scan for electron beam; high frequency data acquisition; energy density distribution; focal spot of action zone; 3D volume reconstruction

Research on deposited layer scanning trace skanning based on rapid-prototyping using CMT technology

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cial Key Laboratory of Special Welding Technology, Harbin Institute of Technology at Weihai, Weihai 264209, China; 3. Kuka Robotics (Shanghai) Co., Ltd, Shanghai 201612, China) . pp 21 – 24, 65

Abstract: In additive manufacturing process using CMT welding process, research on the influence of specimen deformation in different welding path was made. And by using Dimensional Least-Squared Methods, a quantitative measure method of specimen deformation, called S-Judging law, was modeled. Compared the value of S in different welding path with the summarized characteristic that large deformation accompanied with a bigger value of S, the suitable welding trace planning principle was acquired and had succeeded in acquiring well-formed and dense-organized specimen during the real arc welding additive manufacturing process, which founded an experimental base in deposited layer scanning traces planning.

Key words: additive manufacturing; cold metal transfer; scanning trace Planning

Mechanical and fatigue property of stationary shoulder friction stir welding AA6005 ZHANG Kun¹, FANG Yuanfang¹, LUAN Guohong¹, ZHANG Jingyu², HU Feng² (1. Beijing Aeronautical Manufacturing Technology Research Institute, Aviation Industry Corporation of China, Beijing 100024, China; 2. CRRC Zhuzhou Locomotive Corporation, Zhuzhou 412000, China) . pp 25 – 28

Abstract: The 4.5 mm 6005 aluminum alloys was friction stir welded via a stationary shoulder invented by authors. The traveling speed was 1 000 mm/min for industrial production efficiency. The results showed that tensile strength of joint increased firstly and then decreased when rotation speed changed from 1 700 r/min to 2 300 r/min. The maximum tensile strength of 232 MPa, account for 80% of parent metal, as rotation speed set as 2 100 r/min. There was no fracture in face bend and root bend sample when bending angle reached 180°. The fatigue strength and S-N curves of samples was investigated at cycle frequency of 70 Hz, $R = 0.1$, sine wave. The limit inferior strength was 105 MPa, at condition of (1-a) confidence coefficient 90%, failure probability $P = 5\%$. The fractography showed that there were three characteristic regions including initiation region, expand region and fracture region in failed fatigue sample.

Key words: stationary shoulder friction stir welding; AA6005; mechanical property; fatigue strength

Analysis on metal transfer in underwater wet welding based on X-ray high-speed photography DU Yongpeng^{1,2,3}, GUO Ning^{1,2}, FENG Jicai^{1,2} (1. State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China; 2. Shandong Provincial Key Laboratory of Special Welding Technology, Harbin Institute of Technology at Weihai, Weihai 264209, China; 3. Institute of Oceanographic Instrumentation, Shandong Academy of Science, Qingdao 266001, China) . pp 29 – 32

Abstract: Underwater wet welding is a widely used technology. To study the process of the transfer process of underwater wet welding can be helpful for the further analysis of the welding process and then improve the welding quality. In order to overcome this disadvantage, the experimental system was built by using X-ray which is not easy to reflect and refract. The image of

metal transfer process and the synchronal electrical signal, which was collected from the underwater wet welding process was analyzed. The research results showed that the globular repelled transfer, short-circuit metal transfer and surface tension transfer were the main metal transfer modes during underwater welding. To obtain a stable welding process, the proportion of excessive repelled metal transfer and short-circuit transfer should be restricted.

Key words: underwater wet welding; high-speed photography; metal transfer

Kinematic and dynamic analysis of wheeled mobile robot for right-angle weld tracking ZHOU Yilin, ZHANG Hua, WANG Shuai (Key Laboratory of Robot & Welding Automation of Jiangxi, Nanchang University, Nanchang 330031, China) . pp 33 – 38

Abstract: In order to study the effect of different turning center in robot path planning on right-angle weld tracking, the kinematic model of wheeled mobile robot is established based on the analysis of weld tracking process. Through analyzing the forces which act on contact surface between wheel and ground, a dynamic model considering the wheel deformation is established. At last the simulations of robot and experimental study of welding are performed. The results indicate that the selection of turning center have a significant impact on both of the angular velocity of driving wheels and telescopic speed of horizontal slider. The influence of turning center on driving force can be ignored and the value of driving force is nearly constant when the robot turning. The turning of robot can be considered a stable process. The velocity of inflection point changes with the welding speed which required rather than the selection of turning center.

Key words: wheeled mobile robot; right-angle weld tracking; turning center; kinematics; dynamics

Interfacial behavior of SiO₂ ceramic/TC4 brazed joint

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Abstract: SiO₂/TC4 brazed joint was obtained by adopting AgCu/Ni composite interlayer filler, and thus a fine joint was formed. A home-made AgCuTiNi active filler which began to melt at 909.1 °C was used to brazing SiO₂ ceramics, and a good connection was formed. The effect of the Ti activities on interfacial behavior of the ceramic side in SiO₂/TC4 brazed joint was discussed by using SEM, XRD and other methods to analyze the interfacial microstructure of the two brazed joints mentioned above. It turned out that, the typical interfacial microstructure of TC4/AgCu/Ni/SiO₂ brazed joint was: TC4/Ti(s,s) + Ti₂(Ni, Cu) + Ti₂(Cu, Ni)/Ti₄O₇ + TiSi₂/SiO₂; the typical interfacial microstructure of AgCuTiNi/SiO₂ sample was: Ti₂(Cu, Ni)/Ti(s,s) + Ti₂(Ni, Cu) + Ti₂(Cu, Ni)/Ti₄O₇ + TiSi₂/SiO₂. The thickness of reaction layer at the SiO₂ ceramic side was increased obviously with the Ti activities enhanced when the joints were brazed at 970 °C and held for same time. The thickness of reaction layer at SiO₂ ceramic side increased with the holding time prolonged at 970 °C.

Key words: SiO₂ ceramic; TC4 alloy; active filler metal; brazing; interfacial microstructure

Detection and analysis of weld pool oscillation frequency for continuous P-GTAW

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Abstract: There exists a direct relationship between the weld pool oscillation frequency and volume of weld pool. But the detection of oscillation frequency in continuous condition is difficult. A new laser-vision method was proposed for detecting the weld pool oscillation frequency under the condition of stationary and continuous welding. In order to study the rule of weld pool oscillation frequency from partial penetration to full penetration, several experiments with stationary and continuous condition were conducted and the change mode of frequency was analyzed. The results showed that from partial penetration to full penetration, there was a mutation mode in stationary condition. In continuous condition, the weld pool was elongated and the arc had an asymmetrical position with respect to weld pool center, which resulted in two change mode, mutation mode and continuous mode. This characteristic of frequency can be used in sense and control of weld pool penetration of GTAW.

Key words: laser-vision; weld pool oscillation; change mode of oscillation frequency; continuous welding

Single welding torch coupled arc AA-TIG welding

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Abstract: By using the improved welding torch, coupled arc AA-TIG welding experiments were carried out with SUS304 plate as the base metal. The differences of arc morphology and weld shape between AA-TIG welding and traditional TIG was compared. Meanwhile the effects of major parameters to AA-TIG weld bead as well as the weld mechanical properties were investigated. The results showed that the welding parameters including oxygen flowrate, electrode spacing and arc length had significant influences on the weld penetration of coupled arc AA-TIG welding. Under the same total current, the welding bead of coupling AA-TIG was narrower and deeper when comparing with conventional TIG welding. The weld presented better mechanical properties. For 12 mm thickness SUS304 stainless steel plate, the weld penetration of one pass exceeded 11mm, the weld depth/width ratio reached 1.3. The welding productivity was improved dramatically.

Key words: AA-TIG welding; coupled arc; welding torch; weld shape; weld property

Laser-TIG arc hybrid welding technology of 6005A aluminum alloy with filler wire

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dao Sifang Co., LTD, Qingdao 266111, China) . pp 51–54

Abstract: 6005A aluminum alloy which is used for high-speed vehicle was welded by a new technology of laser-TIG arc hybrid welding with filler wire. According to the research of hybrid welding process, microstructure of the joints, mechanical properties, fracture morphology and welding hot cracking, welding process was relatively stable and welding appearance were perfect when laser power was in the range of 2 000 W to 3 000 W, TIG current was 150–195 A, welding speed was 0.4 ~ 0.8 m/min. Welding zone was composed of columnar grains in the edge of welding seam and equiaxed grains in the center of welding seam. The average tensile strength of joint was about 193.39 MPa and joint tensile strength increased with the increase of penetration ratio. In addition, the maximum tensile strength was about 205 MPa—70% of the strength of base metal when penetration ratio was 0.7.

Key words: 6005A aluminum alloy; laser-TIG hybrid welding; microstructure; mechanical properties

Numerical analysis model of temperature field in swing-arc narrow gap GMAW

XU Guoxiang, PAN Haichao, WANG Jiayou (Key Laboratory of Advanced Welding Technology of Jiangsu Province, Jiangsu University of Science and Technology, Zhenjiang 212003, China) . pp 55–60

Abstract: Based on macro thermal transfer theory and geometric feature of weld cross section, the heat source model for swing-arc narrow gap GMAW is developed after considering the influence of arc swing, geometric feature of welded joint and weld surface shape on arc heat flux distribution. By using ANSYS software, the transient temperature profile and thermal cycle curve in swing arc narrow gap GMAW are calculated and their distribution features are analyzed. The results show that the established heat source model can reflect the moving path of swing arc and its thermal action feature and the calculated geometry and size of weld cross section agree well with the experimental data, validating the accuracy of the developed model. At 300A welding current and 2 Hz swing frequency, the weld pool changes limitedly.

Key words: swing arc narrow gap welding; heat source model; temperature field; numerical simulation

Numerical simulation of shunting in resistance spot welding for dissimilar unequal-thickness aluminum alloys

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Abstract: The model of shunting in resistance spot welding for dissimilar unequal-thickness aluminum alloys 2219/5052 is established by using ANSYS software in the paper. The effect of different weld spacing between two welds on shunting and nugget diameter is researched. The mechanism of shunting in resistance spot welding is analyzed, and a processing method for improving shunting is proposed. The calculated results show that the smaller the weld spacing is, the larger the shunting is. The nugget is not formed when the weld spacing is 12 mm. Shunting can be diminished and improved by increasing current. Experiments verify that the nugget diameter of numerical calculation a-

greets with that measured experimentally very well. Hence, the correctness of the model is verified, and theoretical basis is provided for studying shunting in resistance spot welding.

Key words: dissimilar welding of 2219 and 5052; unequal-thickness aluminum alloys; shunting in resistance spot welding; numerical simulation

The metal transfer and weld formation of twin-arc integrated cold wire hybrid welding XIANG Ting¹, LI Huan¹, WEI Huiliang¹, GAO Ying² (1. School of Materials Science and Engineering, Tianjin University, Tianjin 300072, China; 2. Tianjin Key Laboratory of High Speed Cutting and Precision Machining, Tianjin University of Technology and Education, Tianjin 300222, China) . pp 66 – 70

Abstract: Twin-arc integrated cold wire hybrid welding system has been established in the test, and the whole welding process at different preset voltages and currents was studied. The experimental results showed that when direct currents were supplied to two consumable electrodes, the metal transfer modes were divided into three types: short-circuiting transfer, short-circuiting transfer mixed globular transfer and globular transfer. When the arc voltage was relatively lower, the metal transfer mode was short-circuiting transfer. With continual increase of arc voltage, the transfer mode transformed from short-circuiting transfer to short-circuiting transfer mixed globular transfer, and changed into complete globular transfer eventually. Besides, among the three transfer modes, the short-circuiting transfer was characterized by most stable welding process, least welding spatters and best weld formation. The globular transfer mode came second. However, the mixed transfer mode possessed poorest welding stability and weld formation. Moreover, the metal transfer frequency decreased to a minimum value and then increased with the increase of arc voltage.

Key words: twin-arc integrated cold wire hybrid welding; metal transfer; weld formation; metal transfer frequency

Analysis on interfacial reaction of Ni/Sn/Cu solder joint under temperature gradient QI Lin, WEI Guoqiang, LIU Henglin (School of Mechanical and Automotive Engineering, South China University of Technology, Guangzhou 510640, China) . pp 71 – 74

Abstract: The growth behaviors of the interfacial intermetallic compounds (IMCs) in Ni/Sn/Cu solder joints with Ni as hot end and Cu as cold end were systematically investigated under a temperature gradient of 1 046 °C/cm without any electromigration. The result showed that the thicknesses of IMC at both cold and hot end increased with loading time under thermomigration, and the growth rate of IMC at cold end was larger than hot end. It was also indicated that the IMC was the (Cu,Ni)₆Sn₅ phase, and the Ni content at hot end was higher than cold end by EDS analysis. In addition, a large number of voids were observed in the interfacial (Cu,Ni)₆Sn₅ phase at cold end, and no Cu₃Sn phase was observed between the interfacial (Cu,Ni)₆Sn₅ and Cu substrate.

Key words: thermomigration; Ni/Sn/Cu solder joint; interfacial reaction; interfacial IMC

Effect of flux-cored ingredients and welding parameters on arc stability of ENiCrMo3T0-4 wire WANG Heng¹, LI Zhuoxin¹, LI Guodong¹, Wolfgang Tillmann², Hee Jin Kim³ (1.

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Abstract: The effect of flux-cored ingredients and welding parameters on arc stability of ENiCrMo3T0-4 flux-cored wires were investigated by Hanover Analyzer. It was found that with the ratio of CaO/(SiO₂ + TiO₂) decreased in flux-cored ingredients, the lower the basicity of melt slag were, the better the welding arc stability were. Compared with standard deviation of voltage and current, coefficient of voltage, current and burning time variability, standard deviation of short-circuiting and burning time, coefficient of short-circuiting time variability can reflect welding arc stability more accurately. In the range of normal welding process parameters, the arc stability became more stable with the welding parameters increase.

Key words: nickel-based flux-cored wire; flux-cored ingredients; welding parameters; arc stability

Cu/Ag system low-temperature transient liquid phase bonding with Sn-Ag mixed powders SHAO Huakai¹, WU Aiping^{1,2,3}, BAO Yudian¹ (1. Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China; 2. State Key Laboratory of Tribology, Tsinghua University, Beijing 100084, China; 3. Key Laboratory of Advanced Materials Processing, Ministry of Education, Beijing 100084, China) . pp 80 – 84

Abstract: In this study, low-temperature TLP bonding with Sn-Ag mixed powders was investigated, and the effect of Ag content on the microstructures and mechanical properties were discussed. Experimental results showed that the microstructures could be divided into three areas, interfacial diffusion reaction zone and powers' in-situ reaction zone. With the increase of the Ag content, the number of Ag₃Sn grains distributing in the in-situ reaction zone increased but their grain sizes decreased, and the thickness of the IMC layers on both the interfacial diffusion reaction zone reduced. When Ag content exceeded 70%, a great amount of Ag particles remained and a few pores formed in the bonded layer. Both shear strength and microhardness of the joints increased firstly but declined at last with the increase of the Ag content, reaching to the maximum of about 35 MPa and 70 HV, respectively. The rupture behaviors were also discussed according to the fracture surfaces.

Key words: Sn-Ag mixed powders; TLP bonding; intermetallic compounds; mechanical properties; fracture

Analysis of the micro-structure and properties of 316L stainless steel and copper magnetic pulse welding WANG Weidong¹, QIN Ganglin², XING Shuqing¹, MA Yonglin¹ (1. School of Material and Metallurgy, Inner Mongolia University of Science and Technology, Baotou 430000, China; 2. Essen Wuhan Automation Engineering Co. Ltd, Wuhan 430000, China) . pp 85 – 88

Abstract: In order to get the interface combination micro-structure and properties of 316L stainless steel and copper magnetic pulse welding joint, the micro-structure observation and mechanical properties of the magnetic pulse welding joint were respectively measured at room temperature and cryogenic treatment. The results showed that the interface of magnetic pulse

welding joint had destabilizing effects of Helmholtz caused by stress wave. The interface was wave and the combination method was metallurgical combination. The micro-structure and mechanical properties of welding joint after cryogenic treatment were basically same as the untreated. Cryogenic treatment didn't make changes at the interface of organization and combination. During the process of magnetic pulse welding, the deformation of copper tube was mainly in the radial and circumferential deformation, and the interface was deformed twins structure, and the stainless steel was deformed at radial direction, the interface was deformed austere structure.

Key words: dissimilar metal welding; magnetic pulse welding; organization; low temperature mechanical properties

Effect of second phases on oxidation resistance of Ti_3SiC_2 based composites

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Abstract: Ti_3SiC_2 based composites were prepared by argon tungsten arc welding on the titanium alloy substrate. The oxidation resistance of matrix and the effect of the second phases on it were investigated. The results of high temperature oxidation experiments showed that the oxidation resistance of the sample was good below 1 100 °C. However, as the temperature rose up to 1 200 °C, the oxidation behavior became very rapid and the oxidation kinetics of the sample fitted the parabolic-linear law. The results of XRD, SEM and EDS analyses showed that the main phase of composites was Ti_3SiC_2 and the second phases were TiB_2 , SiC and TiSi_2 . Furthermore, these second phases distributed uniformly in the matrix. Thermodynamic analysis showed that TiB_2 and SiC as the second phases could improve the oxidation resistance of Ti_3SiC_2 , but the role of TiSi_2 was on the contrary.

Key words: Ti_3SiC_2 based composites; argon tungsten arc depositing method; second phases; oxidation resistance

Life prediction of CBGA soldered joints under extreme temperature thermal shock

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Abstract: Deep space exploration requires operations under extreme cold temperature and wide temperature range condition. Thus, it is significant to investigate the reliability of electronic device under such condition. In this study, multilinear isotropic hardening (MISO) model was used to describe the mechanical behavior of Sn63Pb37 and Sn96.5Ag3.0Cu0.5 solders, the stress and strain distribution of soldered joints under extreme temperature thermal shock were obtained. In the end, the thermal fatigue life of CBGA was predicted by Darveaux energy model. The results showed that the maximum stress caused by a local stress condition was located in the interface of pad on the package side and solder. Fatigue life of soldered joints under extreme temperature thermal shock was much lower than that of soldered joints under thermal cycling with standard temperature range.

Key words: CBGA; extreme temperature; thermal

shock; fatigue life; finite element method

Soldering between active solder Sn3.5Ag4Ti(Ce, Ga) and GaAs substrate at low temperature

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Abstract: The microstructure and the soldering mechanism of GaAs/Sn3.5Ag4Ti(Ce, Ga)/GaAs have been investigated by using scanning electron microscopy (SEM), transmission electron microscope (TEM) and energy-dispersive spectroscopy (EDS). The mechanical properties of joints have been evaluated through the shear testing. The experiment results show that active solder Sn3.5Ag4Ti(Ce, Ga) can wet the GaAs substrate well at 250 °C in air, and Ga_4Ti_5 phase is formed at the interface. The mechanism of active soldering has been analyzed based on the active adsorption and reaction thermodynamics theories. Results indicate that there is a larger chemical adsorption between GaAs substrate and Ti atoms which may be the main reason for wetting. The interfacial reaction between Ti and GaAs to generate reactants is the main soldering mechanism. The shear strength of the joints is measured to be 15.25 MPa, 17.43 MPa, 23.32 MPa with soldering time of 1 min, 30 min, 60 min respectively, which meet the requirements of the MIL-883G-2006 standard for the shear strength of die attachment well.

Key words: low temperature; active soldering; interface reaction; shear strength

Microstructure evolution of Cu/Sn-15Bi/Cu solder joint under the effect of current

GUO Qinhan, ZHAO Zhenjiang, SHEN Chunlong (School of Shipping and Mechatronic Engineering, Taizhou University, Taizhou 225300, China) . pp 103 – 106

Abstract: The microstructure evolution of Cu/Sn-15Bi/Cu solder joint electro-migrated at 150 °C was investigated. The results showed that the eutectic phase layer segregated on the anode side of solder joint. The thickness of eutectic phase layer increased as the extending of electro-migration time. The Cu_6Sn_5 IMCs migrated towards the anode side as the effect of electron wind. The volume fraction of Cu_6Sn_5 IMCs of solder alloy increased as the falling of Cu_6Sn_5 IMCs layer of cathode side. The thickness of interfacial IMCs layer on cathode side increased as the extending of electro-migration time. The thickness of interfacial IMCs layer on anode side increased at first and decreased then as the extending of electro-migration time when the time shorted than 5 h. Then the thickness of interfacial IMCs layer on anode side increased rapidly as the extending of electro-migration time.

Key words: Sn-15Bi; electro-migration time; eutectic phase layer; segregation; intermetallic compounds

Impact of rare earth LaNd on corrosion property of Zn9.3Al7Cu solder

ZHANG Shaoqi, YAN Yanfu, LI Tao (Materials Science & Engineering College, Henan University of Science & Technology, Luoyang 471023, China) . pp 107 – 111

Abstract: By using alloying principle, rare earth LaNd was added in the matrix Zn9.3Al7Cu solder to study the effects of LaNd on the corrosion resistance of Zn9.3Al7Cu lead-free solder. The results showed that if the RE content was less than

0.3%, with the increase of RE content, the ε (CuZn₅) phase which has strong corrosion resistance increased and dispersedly distributed, Zn9.3Al7Cu_xLaNd solder alloy corrosion potential increased, and then the corrosion resistance of solder increased. If the RE content was more than 0.3%, with the increase of RE content, some corrosion pits began to appear, the O content in corrosion products increased, Zn9.3Al7Cu_xLaNd solder alloy corrosion potential reduced, and then the corrosion rate of solder increased. 0.3% is the best addition of LaNd standing on the point of corrosion resistance.

Key words: Zn9.3Al7Cu_xLaNd solder; corrosion potential; corrosion rate

Effect of residual stress on mechanical properties of sheet laser overlap welding joints LIANG Hang^{1,2}, JIANG Yunlu¹, CHEN Huaining¹, KAN Ying¹ (1. Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China; 2. School of Materials Science and Engineering, University of Science and Technology of China, Hefei 230026, China) . pp 112 – 116

Abstract: Aimed at the penetrating and non-penetrating laser overlap welding of stainless steel sheet, 80mm and 10mm were recognized as the widths with or without considering the effect of residual stress respectively. Then, a series of tensile-shear and fatigue tests of specimens with two widths were carried out. Finally, the effect of welding residual stress on the mechanical properties of the welded joint was obtained, and the analysis of this effect was taken. The results showed that there were larger longitudinal tensile stress and smaller transverse residual compressive stress on the front and back of the overlap joints; the existence of residual stress not only reduced the tensile-shear strength of the joint, but also reduced the fatigue strength. The degree of reduction changed with the irradiation angle and overlap gap changed. When the irradiation angle increased to 20°, for penetrating welding, the degree of reduction of tensile-shear strength, which was caused by residual stress, was up to 7 times the original, and for non-penetrating welding it was up to 10 times. Moreover, when the overlap gap increased within a certain range, the degree of reduction of tensile-shear strength caused by residual stress increased.

Key words: laser overlap welding; residual stress; tensile-shear strength; fatigue strength

Visual sensing based image processing of auto tube-sheet welding JIN Zeshi¹, ZHANG Chenghao¹, LI Haichao¹, WANG Ziyang² (1. State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China; 2. Harbin Intelligence Robot Technology Limited Company, Harbin 150001, China) . pp 117 – 120

Abstract: In order to solve the problem of low automation and inefficiency in the tube-sheet welding of industrial components such as heat exchanger, condenser, high-pressure heater and so on, a set of passive vision based automatic tube-sheet welding system was established. And on this basis, the detection and extraction of welding trajectory were studied in tube-sheet welding by the visual sensing. The direct extraction method of welding trajectory was replaced by the method of combining with the tube thickness and the dimensions of the inside tube circle, through the study of the characteristics of the binary image to non-uniform polished tube-sheet weldment. A multiple iteration

least squares method was also proposed in this paper to remove the background noise. And the edge of the inside tube circle was accurately extracted by using the method. The error analysis of extraction accuracy to the method of this paper was done by comparing with manual measuring result. The result showed that the deviation of the inside circle center position was -3 pixel and -3 pixel in x and y directions, and relative error of the radius was about 1.49%.

Key words: visual sensing; tube-sheet welding; image processing

Corrosion mechanism analysis of copper and aluminum brazed joints YIN Zuozhu, SUN Fenglian (School of Material Science and Engineering, Harbin University of Science and Technology, Harbin 150040, China) . pp 121 – 124

Abstract: Three distinctive brazing joints (Zn-2Al, Zn-2Al-1.2Cu, Zn-13Al-1.5Ag) were studied by frequency induction. Through electrochemical test, mechanical property and filler metals behavior of the brazing joints were studied. In 3.5% NaCl solution, the resistance of three filler metals was Zn-13Al-1.5Ag filler metal > Zn-2Al-1.2Cu filler metal > Zn-2Al filler metal. The shear strength decrease ratio was 29.4%, 24.5%, 23.7% respectively. This is due to the intermetallic compounds that were formed at the copper side interface of these brazing joints became high potential cathode phase, combining with α -Al to form high potential difference. In Zn-13Al-1.5Ag solder brazing joint seam, Ag₂Zn₃ reinforce phase was not to occur anodic dissolution, and small α -Al phase anodic dissolution formed passivation film on the surface, which made reaction uneasy to happen, therefore its' corrosion resistance was best.

Key words: induction brazing; brazing joint; mechanical properties; electrochemical corrosion

Microstructures and properties of joints formed by Ni-Cu TLP bonding process at low temperature DONG Hongjie¹, ZHAO Hongyun², SONG Xiaoguo¹, FENG Jicai², LI Zhuolin¹ (1. Shandong Provincial Key Laboratory of Special Welding Technology, Harbin Institute of Technology at Weihai Weihai 264209, China; 2. State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China) . pp 125 – 128

Abstract: In this study, pure Sn foil with a thickness of 40 μ m was used as a solder interlayer in the low-temperature transient liquid phase (TLP) bonding process between Ni and Cu substrates, and joints completely composed of (Cu, Ni)₆Sn₅ and Cu₃Sn intermetallic compounds (IMCs) phases were achieved by prolonging the isothermal reaction time. During the soldering process, the interfacial (Cu, Ni)₆Sn₅ formed on the Ni side and Cu side. However, the grain morphology of the (Cu, Ni)₆Sn₅ compounds subsequently exhibited fine rounded, needlelike and coarse rounded shapes from the Ni side to the Cu side. On the other hand, the growth of the Cu₃Sn compounds was suppressed. The IMCs joint had a remelting temperature of 418.4°C and an average shear strength of 49.8MPa, which can fulfill the requirement for thermal stable joints in high-temperature power electronics packaging and promote the reliabilities of devices operated in harsh environment.

Key words: Ni-Cu dissimilar metallic materials; low-temperature TLP bonding; interfacial microstructure; remelting temperature; shear strength