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Vol. 53

2024

JOINING AND WELDING RESEARCH INSTITUTE

OSAKA UNIVERSITY

JAPAN

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Assistant Professor *	Dr. YAMASHITA Shotaro

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Guest Researcher	Mr. KOBAYASHI Haruhiko

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Specially Appointed Associate Professor *	Dr. AOKI Yasuhiro
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Assistant Professor *	Dr. MIURA Takuya
Specially Appointed Assistant Professor *	Dr. SHARMA Abhishek
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guest Professor	Dr. ABE Nobuyuki
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Specially Appointed Assistant Professor	Mr. MIZUTANI Masami
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Visiting Researcher	Mr. TATSUMI Yoshihiro

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Guest Professor	Dr. LI ChangJiu
Guest Professor	Dr. NAKAO Kazunari
Guest Professor	Dr. FUJIKUBO Masahiko
Guest Associate Professor	Dr. SHIBAHARA Masakazu
Guest Associate Professor	Dr. MIYAMOTO Kenji

14. Joining Technology Hub

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Professor *	Dr. ITO Kazuhiro
Professor *	Dr. SERIZAWA Hisashi
Professor *	Dr. IKEDA Rinsei
Professor *	Dr. MA Ninshu
Professor *	Dr. TSUKAMOTO Masahiro
Professor *	Dr. MIKAMI Yoshiki
Associate Professor *	Dr. SATO Yuji
Assistant Professor *	Dr. YAMASHITA Takayuki
Assistant Professor*	Dr. MIURA Takuya
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Specially Appointed Associate Professor *	Dr. MORISADA Yoshiaki
Specially Appointed Associate Professor *	Dr. AOKI Yasuhiro
Specially Appointed Associate Professor *	Dr. SHARMA Abhishek
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Graduate School of Engineering, Professor *	Dr. OHATA Mitsuru
Graduate School of Engineering, Professor *	Dr. SANO Tomokazu
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Graduate School of Engineering, Associate Professor *	Dr. OGINO Yosuke
Graduate School of Engineering, Associate Professor *	Dr. NOMURA Kazufumi
Graduate School of Engineering, Assistant Professor *	Dr. MATSUDA Tomoki
Graduate School of Engineering, Assistant Professor *	Dr. SHOJI Hiroto

15. Co-Creation Consortium for Joining and Welding with Blue Diode Laser

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Associate Professor *	Dr. SATO Yuji
Guest Professor	Dr. ABE Nobuyuki
Assistant Professor *	Dr. TAKENAKA Keisuke
Specially Appointed Researcher	Ms. HIGASHINO Ritsuko
Specially Appointed Researcher	Mr. YOSHIDA Norio
Specially Appointed Researcher	Dr. MIZUGUCHI Yuta

16. Industry Cooperation Office

Professor *	Dr. ITO Kazuhiro
Guest Professor	Dr. SUGA Tetsuo

***** Supplementary Assignment

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Research Division of Materials Joining Process, Dep. of Energy Control of Processing

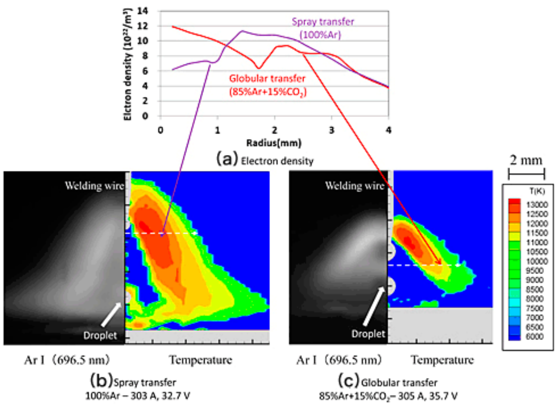
Research summary

The main research subject is the development of the high density energy source for processing advanced materials having special functions and properties. We undertake fundamental investigations of the properties of the high energy source interacting with materials, and we study advanced control techniques for optimizing the energy transport.

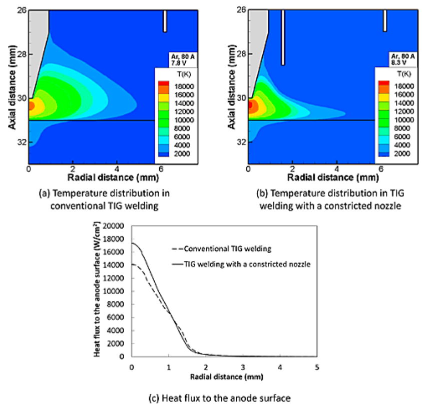
Major emphasis is placed on the generation, control and energy transport in arc plasmas, which are a high density energy source which have been applied to a variety of materials processing techniques such as welding, cutting, heating, high temperature processing, surface modification and the creation of powders.

Research subjects

(1) Generation and control of thermal plasmas, and their application to welding and joining processes
(2) Arc physics, molten pool behavior, and transport theory in fusion welding
(3) Development of new arc electrodes based on the analysis of electrode-plasma interaction
(4) Development of advanced high quality clean welding processes
(5) Development of new generation welding and joining processes employing atmospheric pressure plasma
(6) Control of arc discharge in lighting and electrical devices



Optical measurement of electron density and plasma temperature during spray transfer and globular transfer in gas metal arc welding process ((a) Electron density, (b) Spray transfer, (c) Globular transfer). An addition of CO_2 into shielding gas causes constriction of arc current toward the arc axis, which leads to globular transfer due to increase in arc pressure.



Numerical simulation on effects of constricted nozzle on arc phenomena in TIG welding process ((a) Temperature distribution in conventional TIG welding, (b) Temperature distribution in TIG welding with a constricted nozzle, (c) Heat flux to the anode surface). In TIG welding with a constricted nozzle, arc temperature increases due to constriction of arc. Consequently, larger heat flux to the anode surface is obtained compared with that of conventional TIG welding.

Major Papers

X. Xiao, C. Zhang, D. Wu, H. Komen, J. Gou, Y. Zhang, K. Zhang, S. Uchida, M. Tanaka, "Stabilising mechanism of cathode jet and droplet transfer in hybrid-laser–GMAW-based directed energy deposition of titanium alloy", Virtual Phys. Prototyping, 19 1(2024), 104029. doi

D. Wu, H. Komen, Y. Asai, M. Tanaka, A. Murata, "Arc micro-joining of Al and Cu foils", Int. Commun. Heat Mass Transfer, 156 (2024), 107681. doi

S. Tashiro, N.Q. Trish, K.D. Le, T. Suga, T. Kakizaki, K. Yamazaki, A.B. Murphy, A. Lersvanichkool, H.V. Bui, M. Tanaka, "Elucidation of droplet detachment mechanism in metal-cored arc welding", J. Manuf. Process., 124(2024), 1583–1605. doi

S. Tashiro, "Interaction Mechanism of Arc, Keyhole, and Weld Pool in Keyhole Plasma Arc Welding: A Review", materials, 17(2024), 1348. doi

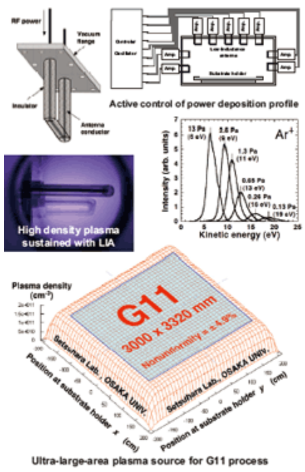
Research Division of Materials Joining Process, Dep. of Energy Transfer Dynamics

Research summary

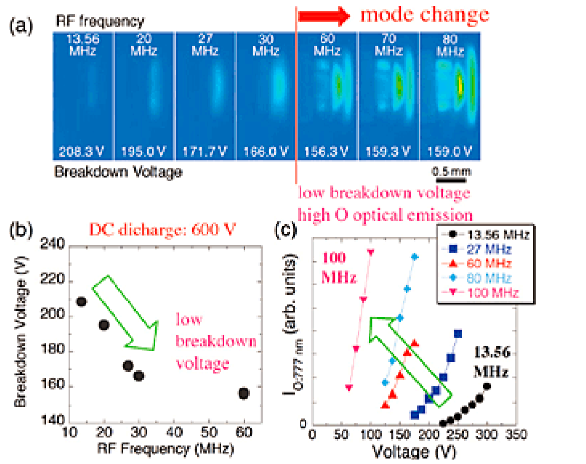
Our research activities encompass works on development of process control technologies of surface and interface for advancement of materials joining science and processing technologies through creation of novel process-energy sources (plasmas and particle beams), and span the range of applications from to functionalization of materials to their process control. These research activities are based on fundamental studies on energy transfer dynamics involved in a variety of materials processing with process-energy sources.

Research subjects

(1) Development of novel plasma sources and particle beams for advanced process technologies (CVD, PVD)
(2) Development of novel large-area, low-damage and high-density plasma sources for advanced process control of functional materials
(3) Development of novel large-area, low-damage and high-density plasma sources for advanced process control of functional materials
(4) Creation of softmaterial processing science for development of advanced green nanotechnologies with inorganic/organic flexible hybrid structures
(5) Studies on temporal and spatial control of discharge for development of innovative plasma sources for plasma medicine



Low-damage and ultra-large-area plasma source with multiple low inductance antenna modules



Development of innovative plasma source for plasma medicine
(a) ICCD images of atmospheric RF plasmas
(b) Frequency dependence of discharge breakdown voltage
(c) Frequency dependence of O optical emission intensity

Major Papers

K. Takenaka, A. Jinda, S. Nakamoto, R. Koyari, S. Toko, G. Uchida, Y. Setsuhara, "Improving bonding strength by non-thermal atmospheric pressure plasma-assisted technology for A5052/PEEK direct joining", Int. J. Adv. Manuf. Tech. 130 (2024) 903–913. doi

K. Takenaka, A. Jinda, S. Nakamoto, R. Koyari, S. Toko, G. Uchida, Y. Setsuhara, "Influence of pre-treatment using non-thermal atmospheric pressure plasma jet on aluminum alloy A1050 to PEEK direct joining with hot-pressing process", Int. J. Adv. Manuf. Tech. 130 (2024) 1925–1933. doi

K. Takenaka, S. Nunomura, Y. Hayashi, H. Komatsu, S. Toko, H. Tampo, Y. Setsuhara "Stability and gap states of amorphous In-Ga-Zn-Ox thin film transistors: Impact of sputtering configuration and post-annealing on device performance", Thin Solid Films, 790 (2023) 140203. doi

K. Takenaka, H. Komatsu, T. Sagano, K. Ide, S. Toko, T. Katase, T. Kamiya, Y. Setsuhara, "Hydrogen-included Plasma-assisted Reactive Sputtering for Conductivity Control of Ultra-Wide Bandgap Amorphous Gallium Oxide" Jpn. J. Appl. Phys., 63 (2024) 04SP65. doi

K. Takenaka, S. Nakamoto, R. Koyari, A. Jinda, S. Toko, G. Uchida, Y. Setsuhara, "Influence of pre-treatment with non-thermal atmospheric pressure plasma on bond strength of TP340 titanium-PEEK direct bonding" Int. J. Adv. Manuf. Tech. 134 (2024) 1637-1644. doi

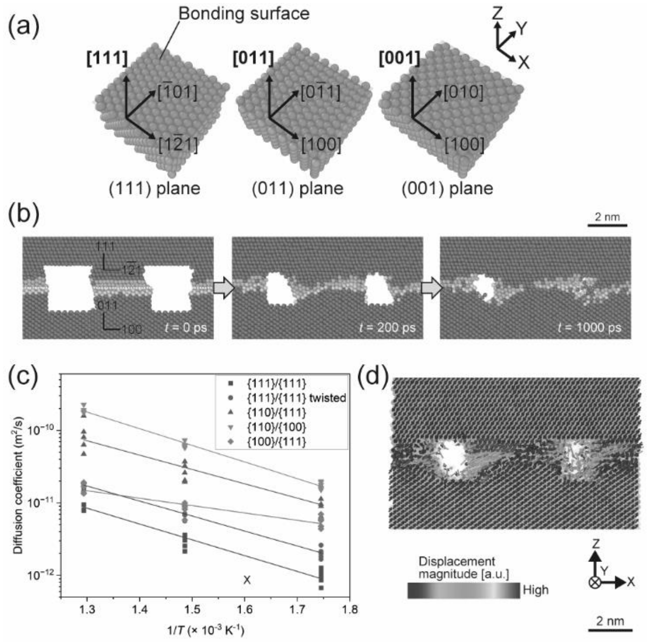
Research Division of Materials Joining Process, Dep. of Micro Joining

Research summary

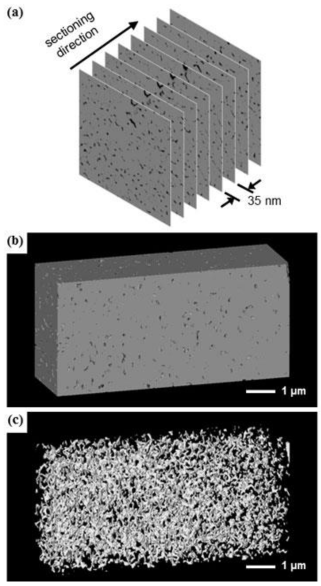
The main research objectives are for electronics packaging to develop advanced joint materials, to establish advanced micro joining processes, and to elucidate the mechanisms of the micro joining processes. Especially, the creation of the functional joint materials, the development of novel advanced micro processes by various energy sources, the understanding of interfacial behaviors in nano-/micro-scale, and the enhancement of the highly reliable joints based on the control of interfacial structure and performance are performed.

Research subjects

(1) Development and evaluation of advanced micro joining process
(2) Elucidation of micro joining phenomena and defect suppression
(3) Control and analysis of microstructure at soldered interface
(4) Development of low-temperature solder alloys contributing to the reduction of CO_2 emissions
(5) Formation of high heat-resistance joint using three-dimensional nanostructure
(6) Elucidation of interfacial bonding mechanisms through atomistic simulation
(7) Macro-micro simulation for joint-property prediction



Molecular Dynamics (MD) simulation results on Cu-Cu bonding behavior: (a) Bonding interfaces replicating various crystal orientations, (b) Void closure behavior at the interface, (c) Diffusion coefficients on the bonding interface with various orientations, (d) Atomic displacement vectors analysis.



Microstructure of sintered joint using Ag nanoparticle paste
(a)Serial sectioning of Ag sintered layer by FIB/SEM system
(b)Reconstructed 3D image of Ag sintered layer
(c)Reconstructed 3D pore distribution into Ag sintered layer

Major Papers

X. Liu, H. Tatsumi,J. Wang, Z. Jin, Z. Chen, H. Nishikawa, "Analysis of microstructures and fractures in Ag–In transient liquid phase bonded joints", Mater. Sci. Eng. A-Struct. Mater., 892, (2024), 146045. doi

X. Liu. F. Huo, J. Wang, H. Tatsumi, Z. Jin, Z. Chen, H. Nishikawa, "Interfacial reactions between In and Ag during solid liquid interdiffusion process", Surf. Interfaces, 45, (2024), 103844. doi

Hiroaki Tatsumi, S. Moon, M. Takahashi, T. Kozawa, E. Tsushima, H. Nishikawa, "Quasi-direct Cu–Si3N4 bonding using multi-layered active metal deposition for power-module substrate", Mater. Des., 238, (2024), 112637. doi

C. Wang, H. Tatsumi, L. Xu, T. Zhao, P. Zhu, R. Sun, H. Nishikawa, "Transparent Liquid Ag-Based Complex for the Facile Preparation of Robust Sintered Ag Joints in Power Devices", ACS Appl. Electron. Mater.,6, (2024), 1718. doi

W. Chuncheng, H. Tatsumi & H. Nishikawa, "Thermal decomposition temperature-dependent bonding performance of Ag nanostructures derived from metal–organic decomposition", J. Mater. doi

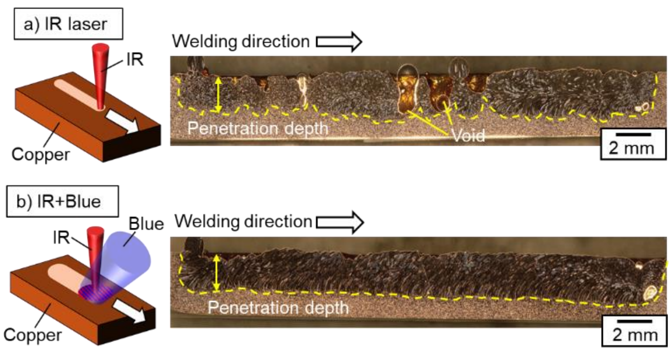
Research Division of Materials Joining Process, Dep. of Laser Materials Processing

Research summary

Fundamental studies are performed concerning welding, joining, cutting, surface modification and removal processing with laser beams, aimed at advanced fusion between laser science and production engineering. We focus on clarification of welding or joining mechanisms on the basis of the visualization of material processing phenomena with high-speed optical observation or X-ray transmission imaging techniques. Moreover, laser should be utilized with not only high thermal efficiency but also physicochemical effects induced by interaction between light and material. Thus we create innovative processes including laser direct joining of metal and plastic, put these processes to practical use and disseminate achievements of our research to the world.

Research subjects

(1) Development and evaluation of joining and welding processes for the advanced functional materials
(2) Development of additive manufacturing technologies with blue diode laser
(3) Creation of new function by surface modification with laser
(4) Fundamental studies on laser interaction with materials and fundamental studies of materials processing utilizing laser



Longitudinal section of welding bead with a) IR fiber laser and b) blue and IR hybrid laser

Clarification of laser welding phenomena with 16 kW disk laser

Major Papers

K. Takenaka, P. Chen, Y. Sato and M. Tsukmaoto, "Formation of Periodic Nanostructures on Medical Polymer with Femtosecond Laser for Control of Cell Spreading", J. Laser Micro Nanoeng., 19 3(2024). doi

T. Pasang, S. Fujio,P,-C. Lin,Y. Tao, M. Sudo,T. Kuendig,T. Kuendig, Y. Sato and M. Tsukamoto, "Weldability and Mechanical Properties of Pure Copper Foils Welded by Blue Diode Laser". Materials, 17 9(2024), 2140. doi

Fujio, Y. Sato, M. Sudo, K. Takenaka, K., T. Pasang, M. Tsukamoto, "Spatter reduction in deep penetration welding of pure copper using blue-IR hybrid laser", Weld. World, 68 (2024) 1515-1524. doi

10.2320/matertrans.MT-D2024002 K. Takenaka, M. Sudo, S. Fujio, M. Mizutani, Y. Sato, M. Tsukamoto, "Spectroscopic Analysis of Blue Diode Laser Induced Plume Generated by Welding of Pure Copper", Mater. Trans., 66 (2024), 113-116. doi

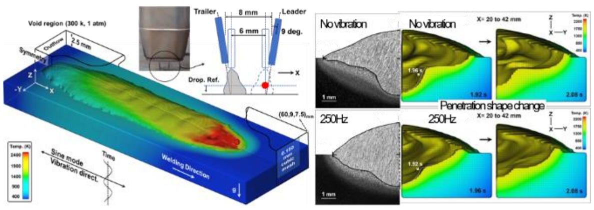
Research Division of Materials Joining Mechanism, Dep. of Welding Mechanism

Research summary

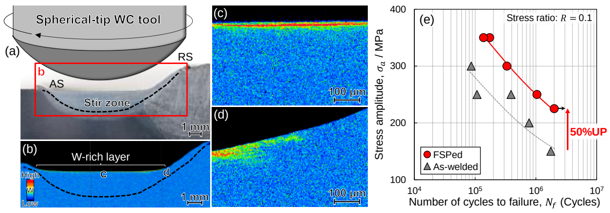
Mechanisms controlling the joint performance of structural and functional materials, which obtained by fusion welding, liquid-state/solid-state bonding, and solid-state bonding, are metallographically characterized to establish a scientific basis to produce joint materials featuring superior performance. The microstructures of the weld-deposited metal, the heat-affected zone of fusion-welded joints, and the interfacial region of solid-state bounded joint are thoroughly investigated utilizing various methods such as X-ray diffraction, electron-microscopy observation, elementary analysis, EBSP analysis, and numerical modeling and simulation. Formation processes of the microstructures and their relation to joint performance are discussed from the material scientific viewpoint.

Research subjects

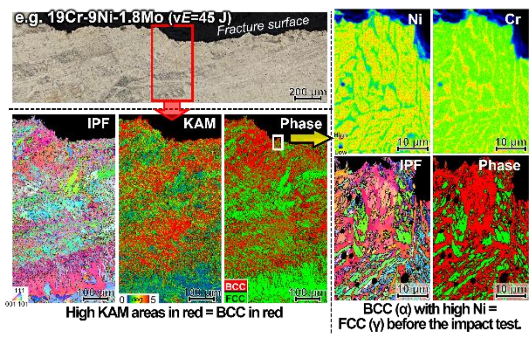
(1) Weld microstructure analyses of structural material such as steel
(2) Bonding mechanism of solid-state joining of metals and ceramics, and its application to microstructural control
(3) Application of welding and joining phenomena to development of advanced materials
(4) Synthesis of new functional materials at welding and joining interface
(5) Evaluation of the effect of microstructure on mechanical behavior of structural materials joints



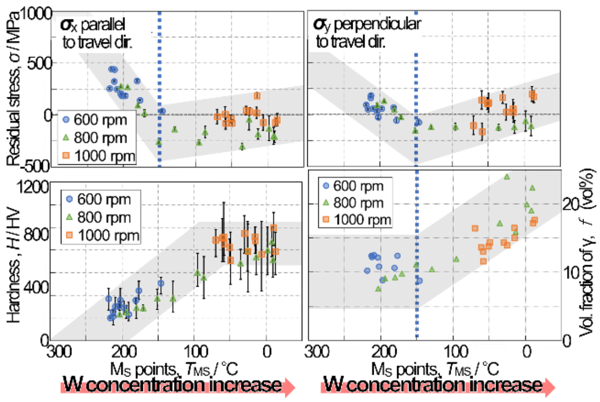
Welding-time variation of penetration shape change in the simulated vibration assisted tandem-pulsed GMAW using the Flow-3D commercial software in the presence of sine-vibration parallel to the welding direction (250 Hz) and the surface tension active elements.



Geometry modification and W-rich layer formation for weld toe of high-strength low-alloy steel joints using friction stir processing (FSP) with spherical-tip WC tool, resulting in fatigue strength improvement.



Deformation induced phase transformation from FCC to BCC occurred in an impact test of δ-ferrite-containing γ stainless steel deposited metal at liquid N2 temp., resulting in increasing ultralow-temp. toughening.



Dependence of residual stress on Ms in parallel and perpendicular directions to the FSP direction, hardness, and the volume fraction of the retained γ, in the stir zone surface FSPed at tool rotational speeds of 600, 800, and 1000 rpm.

Major Papers

H. Yamamoto, Y. Yamamoto, K. Ito, Y. Mikami, "Compressive residual stress applied to a low-carbon steel surface alloyed with WC tool constituent elements according to friction stir processing", Mater. Des., 244, (2024), 113225.
doi

M. Malekinia, H. Hamed Zargari, K. Ito, S. Hossein Nedjad, "Flux Enhancement with Titanium or Vanadium Oxides Addition for Superior Submerged Arc Welding of HSLA Steel Plates", J. Adv. Join. Process., 10, (2024), 100238.
doi

A. Siyahtiri, S. H. Nedjad, H. H. Zargari, K. Ito, "Medium-carbon dual-phase steels with spheroidized ferrite matrix", J. Mater. Res. Technol, 30, (2024), 4692-4701.
doi

Research Division of Materials Joining Mechanism, Dep. of Joint Interface Structure and Formation Mechanism

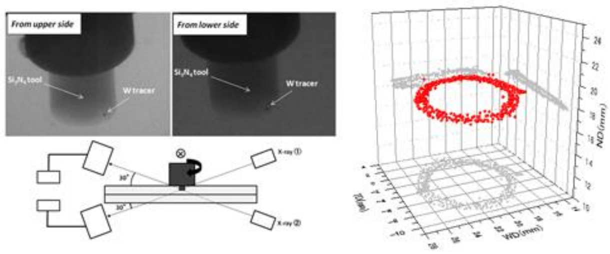
Research summary

In this department, based on the elucidation of the various phenomena at the joint interfaces of ferrous, nonferrous, non-metal materials at both macroscopic and microscopic levels, the interface formation mechanisms during various joining processes are clarified to create new interface control methods.

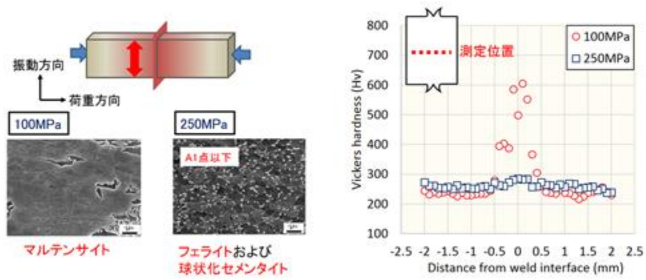
In addition, novel welding and modification processes are developed, mainly based on fusion welding methods and friction welding methods such as the friction stir welding, rotary friction welding and linear friction welding methods, which is the core of the fundamental technologies having a great potential to produce new values. These developments are going to be used and focused simultaneously in our society in order to create a new research field and elevate the continuous growth of industrial competitiveness of our country.

Research subjects

(1) Control of interface and elucidation of formation mechanism during friction welding (FSW, Friction welding, Linear friction welding)
(2) Development of novel joining and modification processes
(3) Elucidation of formation mechanism of weld interface and molten pool
(4) Analysis of joint interface structure
(5) Control of solid-liquid interface formation



Three-dimensional visualization of the material flow using a W tracer during the FSW.



SEM microstructures and Vickers hardness along the central axis of LFWed joints.

Major Papers

F. Khan, T. Miura, T. Ito, Y. Morisada, K. Ushioda, and H. Fujii, "Sound dissimilar linear friction welding of A7075-T6 Al and mild steel by simultaneous interfacial deformation using higher forging speed", J. Manuf. Process., 109(2024), 512-523.
doi

D. Ambrosio, Y. Morisada, K. Ushioda, and H. Fujii, "Asymmetry in microstructure and mechanical properties of FSWed joints using a hemispherical tool tilted towards the retreating side", J. Manuf. Process., 119(2024), 32-45.
doi

R. Shotri, T. Miura, P. Geng, Y. Morisada, K. Ushioda, and H. Fujii, "Probing joining mechanism of Ti6Al4V - SS316L steel rods in pressure-controlled joule-heat forge welding", J. Manuf. Process. Technol., 326(2024), 118315.
doi

T. Aibara, M. Kamai, Y. Morisada, K. Ushioda, T. Miyauchi, S. Hasegawa, and H. Fujii, "Cold spot joining of high-strength steel sheets", J. Adv. Join. Process., 9(2024), 100179.
doi

H. Miao, T. Yamashita, K. Ushioda, S. Tsutsumi, Y. Morisada, and H. Fujii, "Linear friction welding of T-Joints in low carbon steel: Effect of welding parameters on joint quality", J. Adv. Join. Process., 10(2024), 100267.
doi

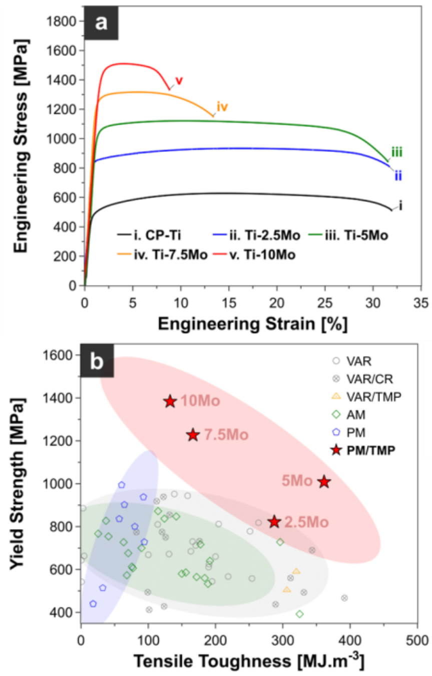
Research Division of Materials Joining Mechanism, Dep. of Composite Materials Processing

Research summary

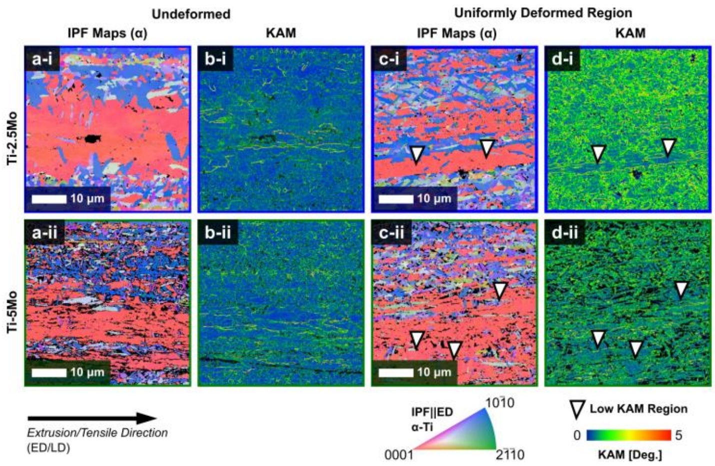
From a viewpoint of the energy saving and environmental problem solutions, the research fields of this department focus on both of the effective reuse of resources and energy including renewable ones and reduction of life hazardous materials and air pollutions. In particular, by controlling the interfacial mechanics and high-performance of materials, atomic/nano-scale composite materials and processing designs for the environmentally benign are established, and applied to innovative industrial development.

Research subjects

(1) Powder based titanium materials with static and dynamic high-strength & ductility
(2) Core-shell structured Ti-N composite powders via solid-gas reaction
(3) Laser powder bed fusion titanium alloys strengthened by solid-solution and nano-dispersoids
(4) Nano-carbon materials reinforced metal matrix composites via local interface mechanics
(5) Direct bonding of plastic materials to metals by molecular structure and fine bubbles control



(a) Tensile curves of as-extruded (i) CP-Ti, (ii) Ti-2.5Mo, (iii) Ti-5Mo, (iv) Ti-7.5Mo, and (v) Ti-10Mo samples.
(b) Yield strengths and tensile toughness in the present binary Ti-Mo alloys compared to reported properties in previous literatures by using various processes.



Microstructures of (a,b) undeformed and (c,d) deformed microstructures of (-i) Ti-2.5Mo, and (-ii) Ti-5Mo, as shown in (a,c) orientation maps of the α phase and (b,d) kernel-average-misorientation maps. The deformed microstructures are captured from the uniformly deformed region of the tensile specimen (i.e., outside of the necked region).

Major Papers

H. Yao, H. Wen, G. Li, N. Chen, K. Chen, K. Kondoh, X. Dong, H. Zhu, M. Wang, "Evolution of interfacial phases between Al alloy and high entropy alloy during annealing", Mater. Charact., 211 (2024) 113890. doi

S. Kariya, A. Issariyapat, A. Bahador, J. Umeda, J. Shen, K. Yamanaka, A. Chiba, K. Kondoh, "Novel tensile deformation mode in laser powder bed fusion prepared Ti–O alloy", Mater. Sci. Eng. A-Struct. Mater., 892 (2024) 146057. doi

L. Liu, S. Li, X. Zhang, S. Li, S. Wang, B. Li, L. Gao, H. Liu, D. Hui, D. Pan, S. Kariya, J. Umeda, K. Kondoh, "Synthesis mechanism of pelleted heterostructure Ti64–TiB composites via an interdiffusion and self-organization strategy based on powder metallurgy", Compos. Pt. B-Eng., 276 (2024) 111366. doi

X. Ye, Z. Heng, B. Chen, Q. Wei, J. Umeda, K. Kondoh, J. Shen, "An in-situ study of static recrystallization in Mg using high temperature EBSD", J. Magnes. Alloy., 12 (2024) 1419-1430. doi

Research Division of Materials Joining Assessment, Dep. of Joining Mechanics and Analyses

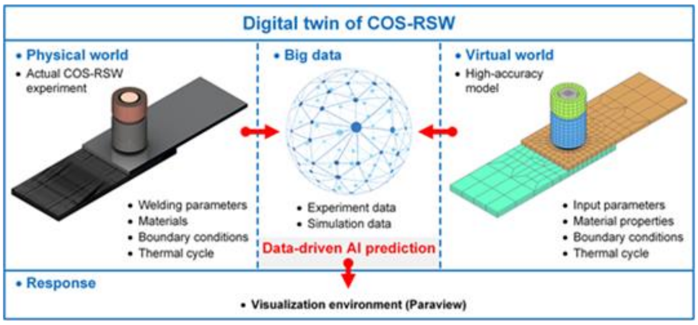
Research summary

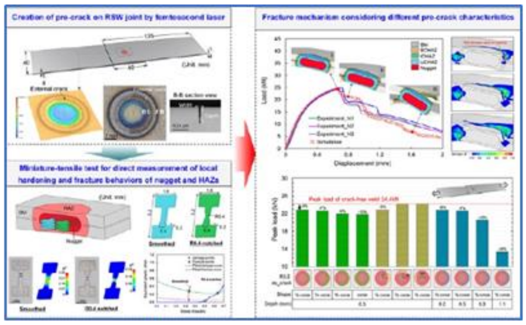
Extended FEM and IGA for numerical modelling is a basis of the Artificial Intelligent (AI) and one of the most efficient approaches to look into various detail phenomena involved in joining & welding & additive manufacturing processes & structure sensing. In addition, assessment to residual stress/strain and strength of various types of joints between dissimilar materials is being studied through both the advanced measuring technology and numerical computational approaches.

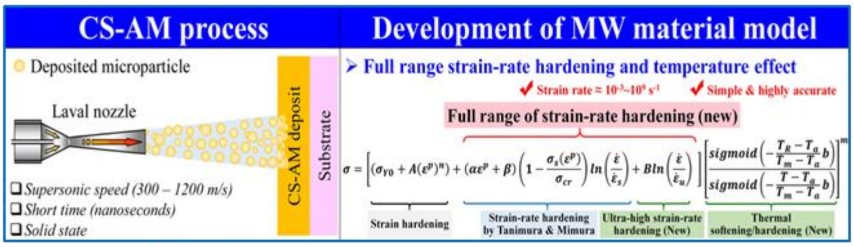
Research subjects

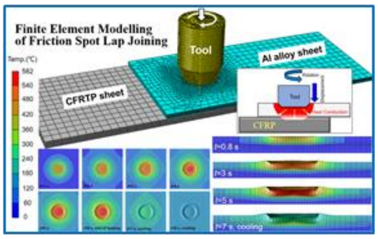
(1) Finite element analysis of nonlinear thermo-mechanical-metallurgical phenomena in multi-materials additive manufacturing, fusion welding and solid-state joining.

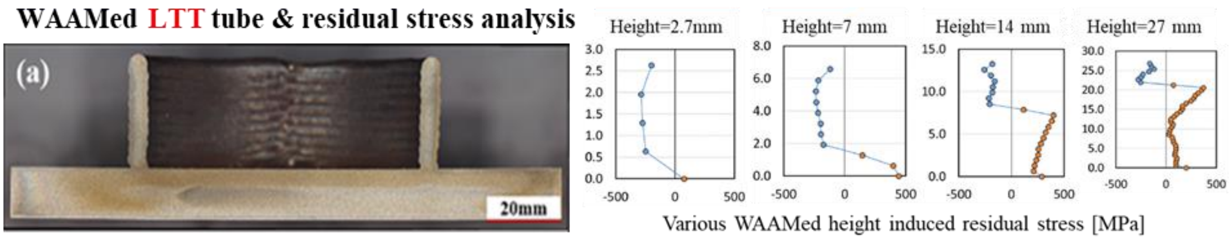
(2) Artificial Intelligent (AI) and digital twin for full manufacturing processes including metal forming, joining, welding and assembling of structures.











Major Papers

N. Ma, Z. Feng, K. Hiraoka, T. Matsuzaki, "Compressive residual stresses in LTT elongated bead welded in all positions for fatigue crack prevention of boxing fillet joints", J. Manuf. Process., 117, (2024), 82-94. doi

W. Huang, N. Ma, Q. Wang, K. Hiraoka, H. Komen, C. Shao, F. Lu, S. Kano, "Interpass temperature strategies for compressive residual stresses in cladding low-transformation-temperature material 16Cr8Ni via wire arc additive manufacturing", Int. Commun. Heat Mass Transf., 157, (2024), 107777,1-15. doi

M. Tsutsumi, S. Yamagami, K. Narasaki, D. Watanuki, Y. Miyamoto and N. MA, "Measurement of Internal Residual Stress of Three-Directional Components and Estimation of Inherent Strain in Carburized Steel for Large Rolling Bearings by Combining the Contour Method and XRD Method", Mater. Trans., 65, (2024) 9, 1099-1107. doi

Z. Yu, N. Ma, H. Lu, H. Yang, W. Liu, Y. Li, "Narrow gap GTAW defect detection and classification based on transfer learning of generative adversarial networks", J. Manuf. Process., 131, (2024), 2350–2364. doi

P. Chaimano, N. Ma, K. Narasaki, T. Suga, S. Ren, H. Kato, "Electric-thermal-mechanics modeling for in-process phenomena during micro resistance spot welding spark plug of Pt and Inconel600", J. Mater. Res. Technol-JMRT, 30, (2024), 2630-2641. doi

Research Division of Materials Joining Assessment, Dep. of Joining Design and Structuring

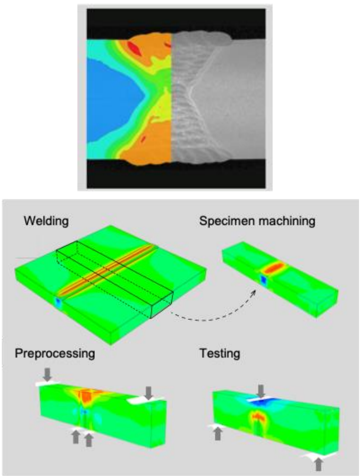
Research summary

In this research division, the structural design and fabrication processes are considered in the following two aspects: the "through-process" and "trans-scale." The concept of "through-process" considers the time axis throughout the life cycle, from the design and construction process, such as welding and joining, to testing, service, repair, reinforcement, and maintenance. The concept of "trans-scale" considers spatial axes ranging from micro to macro, such as the microstructure of materials of welds, welding and joining components, and structures.

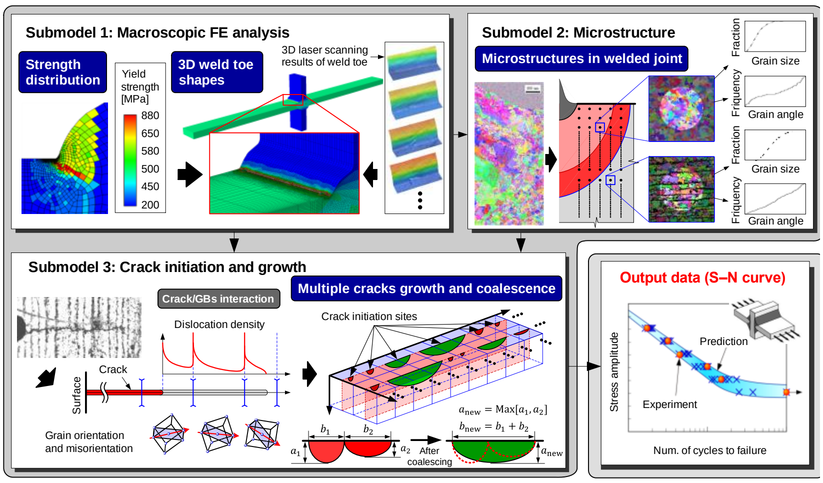
We research the evaluation of the performance and reliability of various structures at each of these stages and scales. In particular, the effects of thermal processing, represented by residual stresses and deformations, on the performance of welded and joined components and structures will be clarified from microscopic and macroscopic perspectives. Based on these findings, we will also develop a detailed and intelligent evaluation method. We aim to establish design engineering that contributes to advancing structuring processes such as welding and joining.

Research subjects

(1) Development of evaluation methods for strength properties and reliability of structural members, welds and joints
(2) Development of performance evaluation technique for welded structures in consideration of residual stress
(3) Development of manufacturing process simulation technology for design applications
(4) Development of damage evaluation method considering microscopic plastic deformation behavior of materials and welds
(5) Evaluation of cracking characteristics considering the heterogeneity of structural materials and weld



Through-process simulation of specimen machining, residual stress modification, and fracture toughness testing.



Evaluation of Fatigue Properties of Structural Materials and Weldments by Multiscale Modeling

Major Papers

H. Zhou, M. Kinefuchi, Y. Takashima, K. Shibanuma,"Multiscale modelling strategy for predicting fatigue performance of welded joints", 284 (2024), 109751.
doi

W. Jo, I. Woo, Y. Mikami, G. An, "Residual Stress Characteristics in Spot Weld Joints of High-Strength Steel: Influence of Welding Parameters", 14(2024), 11971.
doi

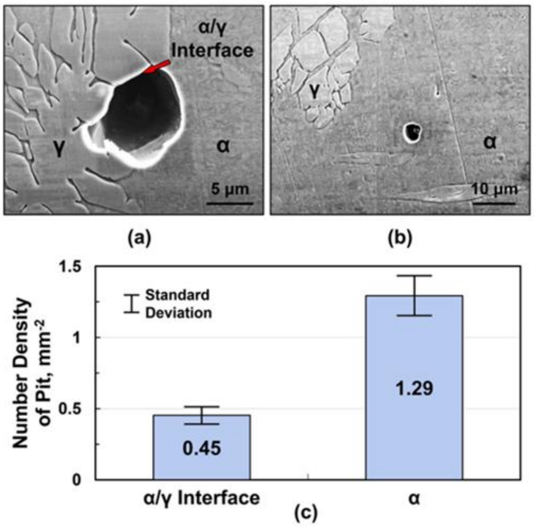
Research Division of Materials Joining Assessment, Dep. of Joining Metallurgical Evaluation

Research summary

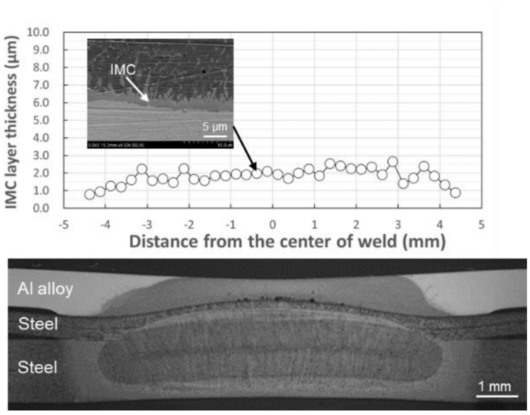
Development of innovative manufacturing technology is required to manufacture high-performance machine products and structures for the next generation. Department of Joining Metallurgical Evaluation conducts research and education for elucidation and control of the factors on weldment properties to create innovative and attractive techniques of welding & joining as a final aim. Specifically, our department is working on clarification of the characteristics of spot welds of dissimilar materials and spot welds using resistance heat generation. We are also working on elucidation of metallurgical phenomena such as solidification and transformation during welding and additive manufacturing, and on developing the control method for the microstructures and the properties of weldments.

Research subjects

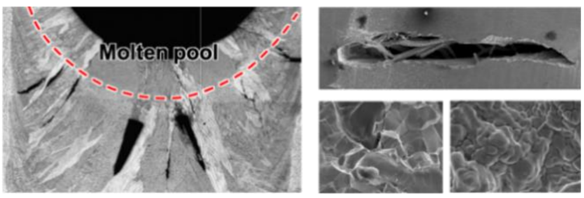
(1) Development of improvement technology of joint properties of various spot welds.
(2) Reliability assessment of resistance spot welds.
(3) Microstructural evolution during solidification and solid state in welds.
(4) Hot cracking during welding and additive manufacturing process and the prediction technology.
(5) Improvement of mechanical and corrosion properties of welds of stainless steels and Ni-based alloy by microstructure control.



Observation of pitting initiation in heat-affected zone by FESEM
(a) α / γ Interface and (b) α -ferrite, (c)Location of pitting initiation



Cross-sectional photo and IMC thickness distribution of weld interface of resistance spot weld of aluminum alloy sheet to high-strength steel sheet



Evaluation and analysis of hot cracking susceptibility test

Major Papers

K. Kadoi, M. Kogure, H. Inoue, "Formation condition of lacy ferrite during solidification and subsequent transformation in austenitic stainless steels solidified with primary ferrite", Materials & Design 241 (2024), 112984. doi

K. Kadoi, Y. Matsumoto, H. Chiba, H. Inoue, "Solidification cracking susceptibility of alloy 718 during additive manufacturing and evaluating method", Journal of Materials Research and Technology 33 (2024), 6389-6396. doi

Y. Hou, K. Kadoi, "Effect of Ti, Al, and Mg addition on microstructure evolution in weld metal of stainless steel solidified with F and FA modes and the tensile property", Materials Science and Engineering: A (2024), 147190. doi

K. Kadoi, Y. Kanno, S. Aoki, H. Inoue, "Influence of MC Carbides on Pitting Corrosion Resistance of Weld Metal in Austenitic Stainless Steels", ISIJ INTERNATIONAL 64(9) (2024), 1450-1456. doi

T. Yamamoto, Y. Ogawa, M. Hayashi, K. Kadoi, D. Shiozawa, T. Sakagami, "Fatigue Limit Estimation Based on Dissipated Energy of Butt Laser-Welded Joints", Engineering Proceedings 51 (2024), 47. doi

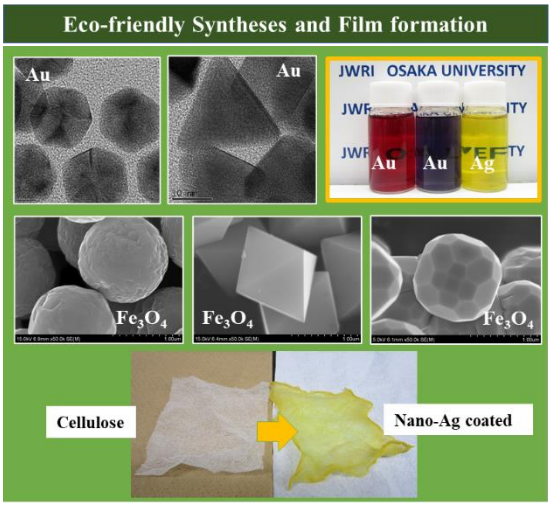
Research Center for Additive Joining Application, Dep. of Green Additive Manufacturing

Research summary

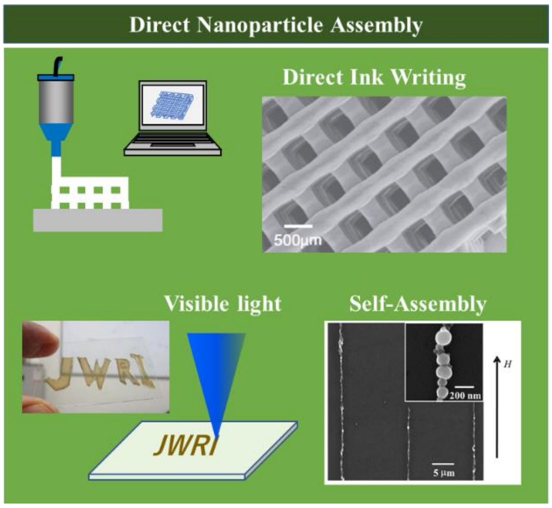
As environmental and energy problems become more serious on a global scale, we are working on research and development of material process technologies and environment-friendly materials that will greatly reduce the environmental load. We recently focus on inorganic nano- and micro-particles as building blocks for functional materials and devices, and we develop low-environmental load methodologies for their syntheses, film formation, bonding, integration, and 3D printing. Furthermore, we are proceeding with research and development of environment and energy related materials and devices using our new process technology.

Research subjects

(1) Eco-friendly solution-based syntheses of nano- and micro-particles
(2) Eco-friendly assemblies of nano- and micro-particles
(3) Development of Environment friendly materials
(4) Development of environmental monitoring devices



(Top) Reductant free synthesis of noble metal nanoparticles (NPs)
(Middle) Shape-controlled synthesis without any additives
(Bottom) Reductant-free coating of noble metal NPs



(Top) Direct Ink Writing of Nanoparticle-Ink
(Left-bottom) Visible-light induced patterning of metal NPs
(Right-bottom) Self-assembly of magnetic NPs under magnetic field

Major Papers

N. Kannari, Y. Yokota, K. Onoduka, A. Shimizu, K. Sato, H. Okazaki, S. Yamamoto and H. Abe “Effect of the Ca/P ratio of Ni-loaded hydroxyapatite on the catalytic decomposition of biomass tar at low temperatures”, Sustain. Energ. Fuels, 8 (2024), 2850-2859. doi

Y. YAGI, K. YOSHIDA, T. KOZAWA, M. OSADA, H. ABE, “Defective multi-element hydroxides nanosheets for rapid removal of anionic organic dyes from water and oxygen evolution reaction”, J. Smart Process., 13(4), (2024), 200-204 doi

T. Kozawa, T. Hashiba, K. Fukuyama, H. Abe, S. Morita, M. Osada, M. Naito, “Beyond Fertilizers: NH4ZnPO4 for the Reversible Chemical Storage of Ammonia”, Adv. Mater. Interfaces, 2400729 (2024). doi

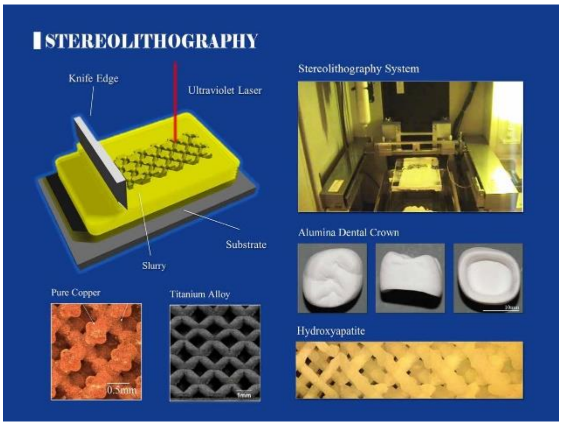
Research Center for Additive Joining Application, Dep. of Lithographic Additive Manufacturing

Research summary

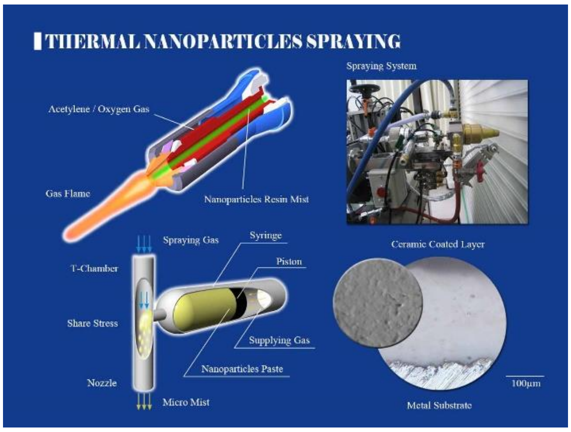
Additive Manufacturing (AM) was newly developed as novel process to create three dimensional (3D) structures through two dimensional (2D) layer laminations. Metal and ceramic nanoparticles were dispersed into resin paste to use for our original process. In lithography techniques, a high power laser beam was scanned on the spread paste for 2D layer drawing and 3D structure forming. In deposition techniques, the paste was introduced into high temperature plasma or gas flame for 2D cladding and 3D patterning. Created electric devices, biological implants and energy modules will contribute to sustainable development.

Research subjects

(1) Stereolithographic Additive Manufacturing of Metal and Ceramic Parts Using Nanoparticles Pastes
(2) Structural Fabrication of Photonic Crystals with Diamond Structures for Terahertz Wave Control
(3) Modulation of Micro Porous Structures in Biological Ceramic Implants for Artificial Metabolism
(4) Manufacturing of Micro Metal Lattices for Effective Controls of Heat Flow and Stress Distributions
(5) Advance Development of Thermal Nanoparticles Spraying for Additive Manufacturing Technique
(6) Fine Separator Formation in Solid Oxide Fuel Cells by Using Thermal Nanoparticles Spraying
(7) Fine Ceramic Coating with Thermal Conductivity and Corrosion Resistance for Heat Exchanger Tubes
(8) Layer Laminations by Fine Particles Spraying and Sintering to Create Functionally Graded Structures



Laser Scanning Stereolithography of Additive Manufacturing to Fabricate Bulky Metal and Ceramic Components with Micro Geometric Patterns



Thermal Spraying Using Fine Particle Pastes to Laminate Metal and Ceramic Coated Layers with Functional Nano/Micro Structures

Major Papers

F. Spirrett, A. Oi, S. Kirihara, "Ceramic Stereolithography of $Li_7La_3Zr_2O_{12}$ Micro-Embossed Sheets for Solid Electrolyte Applications" Ceramics, 7(3), (2024), 1218-1226. doi

F. Spirrett, S. Kirihara, "Fabrication of Complex Lattices and Fractal Patterns by Additive Manufacturing" J. Smart Process.,1 , 3(4) , (2024), 195-199.

K. Yoshihara, F. Spirrett, S. Kirihara, "Applications of Three-Dimensional Modeling Technology in Dentistry" J. Smart Process., 13(4), (2024), 189-194.

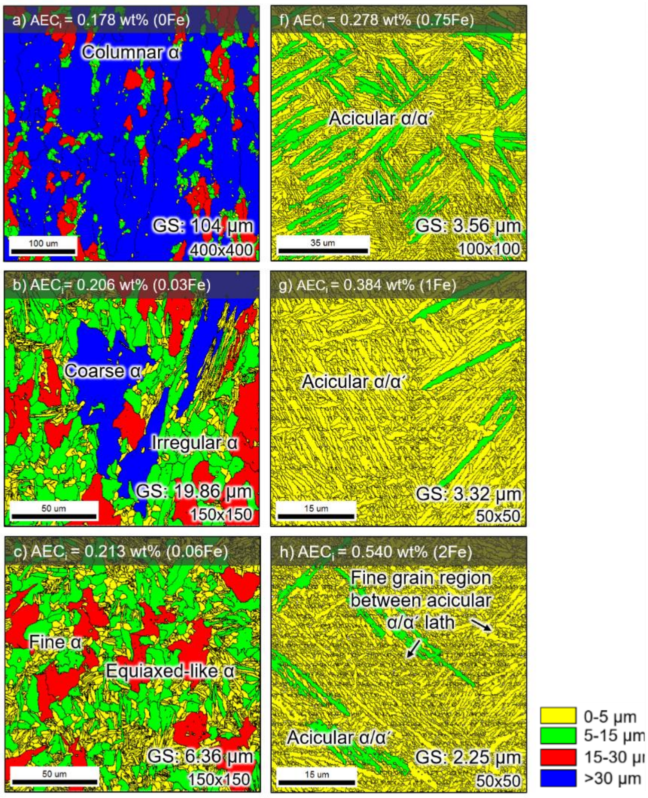
Research Center for Additive Joining Application, Dep. of Additive Manufacturing Mechanism

Research summary

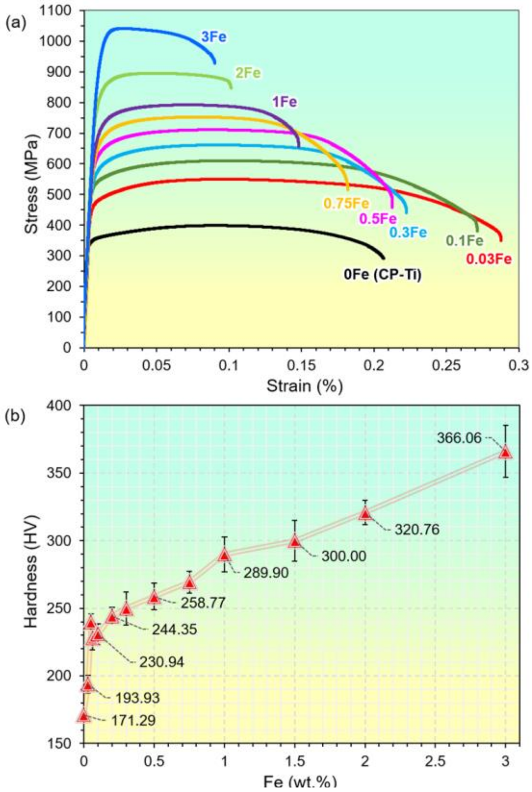
Laser powder bed fusion (L-PBF), one of additive manufacturing technologies, is based on a rapid solidification process, and enables to form ultra-fine microstructures and supersaturated solution of metal materials, which are effective to improve mechanical properties. This department focuses on clarification of both unique microstructures formation mechanism and their effect on the strength and ductility balance of L-PBF titanium alloys.

Research subjects

(1) Formation mechanism of unique fine microstructures and orientations of L-PBF Ti alloys
(2) High-strengthen metal matrix composites fabricated by L-PBF process
(3) Strengthening mechanism of L-PBF Ti alloys – grain refining, solid solution and dispersions
(4) Deformation behavior of Gyroid scaffolds L-PBF Ti-Zr alloy and its medical applications



Grain size map obtained by EBSD analysis for LPBF fabricated Ti-*x*Fe alloys (*x*= 0, 0.03, 0.06, 0.1, 0.2, 0.75, 1, 2, and 3 wt%). The numbers in bottom-right corner represent analysis scan area (in μm).



Variation in mechanical properties of LPBF fabricated Ti-*x*Fe alloys: (a) depicts the tensile stress-strain curves, while (b) presents a plot of Vickers hardness versus Fe addition.

Major Papers

A. Issariyapat, J. Huang, S. Kariya, B. Chen, S. Li, J. Umeda, K. Yamanaka, A. Chiba, K. Kondoh, "Sustainable alloy design: Fe-enhanced Ti alloys for superior mechanical performance in additive manufacturing", J. Alloy. Compd., 1010 (2024) 177767. doi

Y. Shigeta, N. Nomura, K. Kondoh, K. Uesugi, M. Hoshino, M. Aramaki, Y. Ozaki, "Use of X-ray CT Imaging to Quantitatively Analyze the Effects of the Pore Morphology on the Tensile Properties of CP-Ti L-PBF Materials", ISIJ International, 64 7 (2024) 1162–1171. doi

J. Wan, B. Chen, J. Shen, K. Kondoh, S. Liu, J. Li, "Improving the mechanical properties of laser powder bed fused AlSi10Mg alloys by eliminating the inevitable micro-voids via hot forging", Rapid Prototyping J., 30 4 (2024) 621-632. doi

Research Center for Additive Joining Application, Dep. of Laser Additive Manufacturing

Research summary

In this department, fundamental studies on laser additive manufacturing (LAM) are performed and apparatuses for LAM are developed.

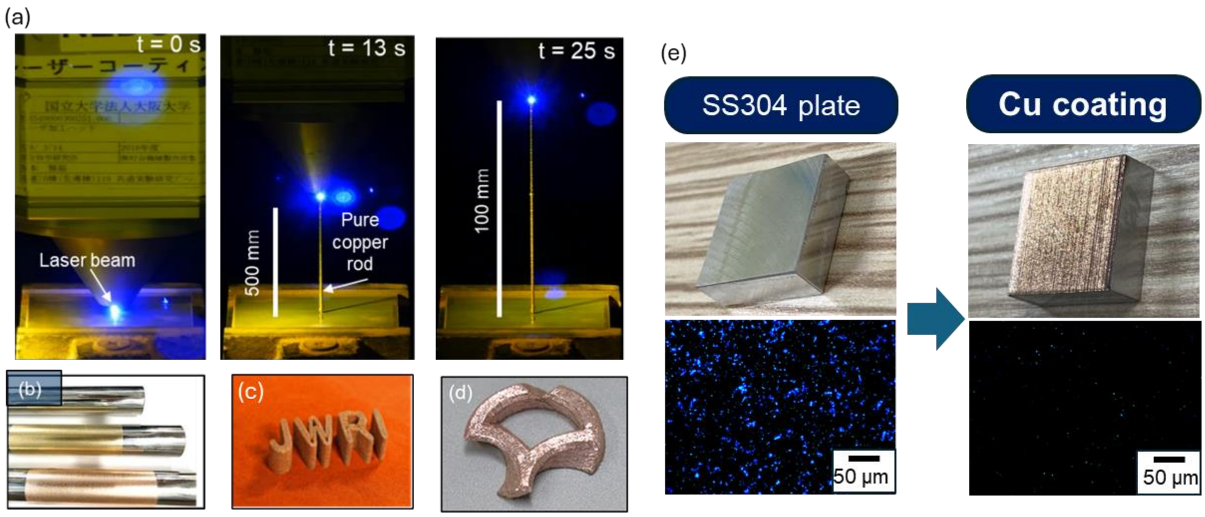
In particular, the apparatuses installed with high power blue diode lasers are also developed since those lasers enable stable and high efficient melting of metal materials such as copper.

Furthermore, in order to realize high-quality and high-speed LAM, we will experimentally and theoretically proceed with the analysis of the melting and solidification process of the material by laser irradiation.

Utilizing the obtained knowledge, we will work on the creation of innovative LAM processes and the development of equipment and promote their social implementation.

Research subjects

(1) Development of additive manufacturing technologies with blue diode laser
(2) Elucidation of laser interaction with metal powders for LAM
(3) Creation of new function by laser metal deposition
(4) Elucidation of melting and solidification phenomena in LAM process



Additive manufacturing of copper using blue diode laser (a)3D rod formation (b) Micro-coating of copper alloy (c) JWRI logo by L-PBF (d) Osaka University's school emblem by L-PBF (e) Antimicrobial effect of the pure copper coating by DED against S.aureus.

Major Papers

T. Yoshida, Y. Sato, K. Takenaka, P. Chen, H. Kanetaka, T. Mokudai, M. Tsukamoto, "Pure copper coating by multibeam directed energy deposition with blue lasers for antimicrobial effect", J. Laser Appl., 36 4, (2024) 042035.
doi

R. Matsuda, Y. Sato, K. Takenaka, M. Kusaba, M. Tsukamoto, "Improvement of layer fabrication efficiency and dilution rate for nickel based super alloy by multibeam directed-energy-deposition with blue diode lasers", J. Laser Appl.36 4 (2024) 042046.
doi

R. Ueda, Y. Sato, S. Srisawadi, D. Tanprayoon, B. Chayasombat, P. Promoppatum, M. Yoshida, M. Tsukamoto, "3D fabrication of nickel based alloys by powder bed fusion with blue diode laser", J. Laser Appl., 36(2024) 042077.
doi

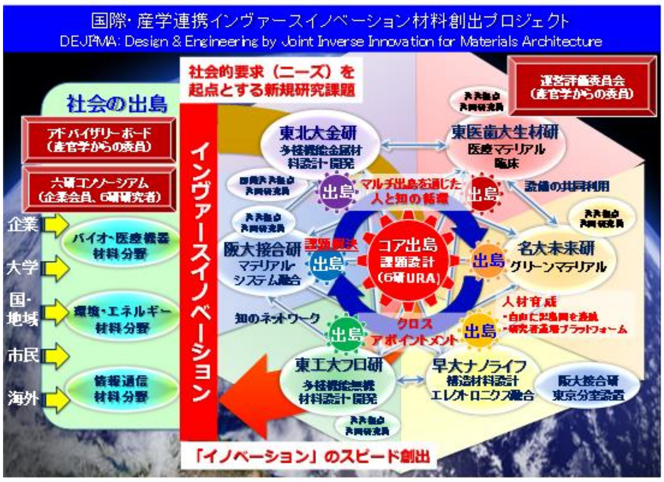
A. Kapil, O.-C. Ozaner, Y. Sato, Y. Hayashi, K. Ikeda, T. Suga, M. Tsukamoto, S. Karabulut, M. Bilgin, A. Sharm, "Overcoming machining challenges in hybrid laser metal deposition of IN718 with heat-assisted minimum quantity lubrication", Int. J. Adv. Manuf. Technol., 132 (2024), 5407-5424.
doi

K. Yamamoto, R. Matsuda, K. Takenaka, Y. Sato, Y. Yamashita, A. Saikai, T. Yachi, M. Kusaba, M. Tsukamoto, "Experimental evaluation of a WC-Co alloy layer formation process by multibeam-type laser metal deposition with blue diode lasers", J. Laser Appl. 36, (2024), 012010.
doi

Strategy Office for Promotion of Inter-Institute Collaborations

Research summary

"Strategy Office for Promotion of Inter-Institute Collaborations" has been established in JWRI as the headquarter to carry out the Project "Development of Inter-Institute Collaborations of 6 Research Institutes from 5 Universities for Strengthening Material Innovation Force", which has been supported by the Ministry of Education, Culture, Sports, Science and Technology since 2022. Through promotion of the inter-institute collaborations of the 6 research institutes from the 5 Universities (Joining and Welding Research Institute, Osaka University, Institute for Materials Research, Tohoku University, Institute of Integrated Research/Materials and Structures Laboratory, Institute of Science Tokyo, Institute of Materials and Systems for Sustainability, Nagoya University, Institute of Integrated Research/Laboratory of Biomaterials and Bioengineering, Institute of Science Tokyo, Research Organization for Nano & Life Innovation, Waseda University), the project has been carried out for acceleration of the problem-solving and the creation of innovations, which are based on social demands, and thus for strengthening material innovation force. The related research project "Design & Engineering by Joint Inverse Innovation for Materials Architecture (DEJ^{2}MA Project)" has been carried out through the inter-institute cooperative research activities.



Research subjects

(1) Environmental and Energy Materials
(2) Biomedical and Healthcare Materials
(3) Information and Communication Material

Major Papers

T. Mokudai, M. Kawada, D. Tadaki, A. Hirano-Iwata, H. Kanetaka, H. Fujimori, E. Takemoto, M. Niwano, "Radical generation and bactericidal activity of nanobubbles produced by ultrasonic irradiation of carbonated water," Ultrason. Sonochem., 103 (2024) 106809.
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A. Issariyapat, J. Huang, S. Kariya, B. Chen, S. Li d, J. Umeda, K. Yamanaka, A. Chiba, K. Kondoh, "Sustainable alloy design: Fe-enhanced Ti alloys for superior mechanical performance in additive manufacturing", J. Alloy. Compd., 1010 (2024) 177767.
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F. Li, K. Yoshida, N.-V Chuc, M. Osada, H. Abe, "Synthesis of High-Entropy Rare Earth (Y0.2 La0.2 Nd0.2 Sm0.2 Gd0.2) BO4 (B = Cr, Mo, W) Oxide Powders", J. Smart Process., 13 (2024) 205-209.
doi

Joint Interface Microstructure Characterization Room

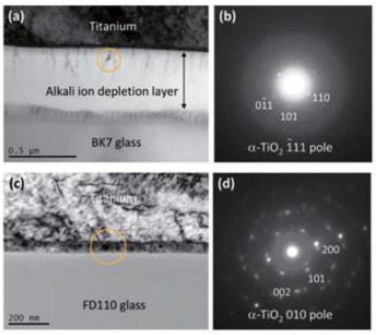
Research summary

In order to clarify the effect of material structure on the properties of joints joined by various methods and new materials made by applying joining technology, their microstructures are examined using a transmission electron microscope (TEM). TEM observation provides various information such as the crystal structure, chemical composition, properties and distribution of lattice defects in minute areas. We also support the preparation of specimens for TEM observation from difficult-to-process joint structures, etc., using various means such as focused ion beam (FIB) processing. In addition to TEM sample preparation, we develop methods for micromechanical testing of materials using FIB processing and apply them to strength evaluation of joint structures.

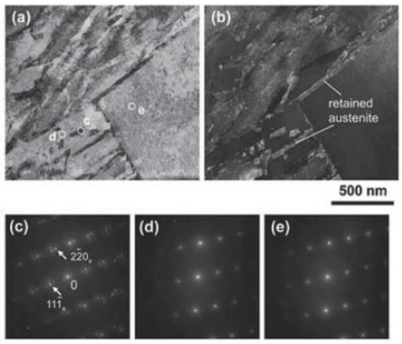
As a unique activity of the analysis room, we perform basic study on the bonding mechanism of anodic bonding, which is a method of bonding glass to conductors at relatively low temperatures, and develop new bonding methods and high-function bonding interfaces by applying that knowledges.

Research subjects

(1) Microstructural analysis of various bonding interfaces and material structures
(2) Fundamental research on the anodic bonding process of glass to various conductors
(3) High functionalize of glass-to-glass anodic bonding interfaces
(4) Development of new bonding methods that applies the principle of anodic bonding



Reaction products that grew at joint interfaces between titanium and optical glasses. The bright-fi eld image of BK7 crown glass/titanium joint interface by transmission electron microscopy (a), Selected Area electron Diff raction (SAD) pattern taken from the area indicated by a circle in the image a (b), bright-field image of FD110 dense flint glass/titanium joint interface (c), and SAD pattern taken from the area indicated by a circle in the image c (d). These reaction products were found to consist of α-TiO2 . However, those forms are strongly aff ected by types of glass.



Distribution of retained austenite in 980 MPa high-tensile steel. (a) Bright-field image, (b) dark-field image taken by 111 reflection from austenite indicated in the diff raction pattern in (c), and (c)-(e) selected-area electron diff raction patterns taken from positions indicated in the bright -fi eld image in (a). Austenite appears bright between ferrite laths in the dark-fi eld image.

Major Papers

M. Takahashi, "Multilayer Anodic Bonding", 30th Symposium on Microjoining and Assembly Technology in Electronics, held on 23-24 January in Yokohama, Japan,(2024).

Global Diversity and Inclusion Promotion Office

Summary

Global D&I (Diversity & Inclusion) Promotion Office promotes the development of an environment that maximizes the strengths of Joining and Welding Research Institute (JWRI) and all members by truly embracing diversity and respecting the individuality of each person, regardless of gender, nationality, age, cultural background, etc., in order to achieve the SDGs, which aim to realize a society where "no one is left behind". In response to the trend toward internationalization in academic research, JWRI will develop international joint industry-academia research based on the international network we have established to date. JWRI aims to develop competent human resources to face global challenges, to strive to stimulate innovation in joining science as the world-leading research in the field of welding and joining, and to realize the institute where diverse human resources can play an active role.

In FY 2024, major activity that Global D&I Promotion Office has worked on was for the actual commencement of the operation of the "Joining and Welding Research Institute HUST-UOsaka" which was established in January 2023 in Hanoi, Vietnam under collaboration with Hanoi University of Science and Technology. Also, by receiving the funding support from Japan International Cooperation Agency (JICA), the first Seminar and Exam for Welding Coordinator which is certified by Japan Welding Engineering Society was held in Hanoi. These activities, centered by HUST-UOsaka, are expected to contribute to further expanding and diversifying collaboration between the Southeast Asian region and JWRI.

Another activity was focused on diversifying human resources with regards to gender and global perspective in order to enhance outcomes for further diversity and inclusion within JWRI.

Activities

(1) Increase Global Diversification: Strengthen International Collaboration Research; Operation of "Joining and Welding Research Institute HUST-OU"; Create and activate foundation of International Industry-Academia Collaboration; Increase number and quality of Welding Engineers in Vietnam and in Southeast Asia; Strengthening research collaborations with oversea institutes through various schemes; Foster friendly work environment at JWRI.

(2) Increase Gender Diversification: Bring together students, faculty and staff from different roles and positions; Lecture at a science course for junior high school girls.

Table.1. List of activities and projects for Global Diversification (Extracted)

Name	Contents
Opening Ceremony of "Joining and Welding Research Institute HUST-UOsaka" (HUST-UOsaka)	Building re-construction completed and opening of the building and commencement of the operation of HUST-UOsaka was celebrated as the Opening Ceremony on 29th November, 2024.
Vietnam Welding Research Club	Three Seminars were held: 1) April 26th, 2024 in Hanoi, Hoa Lac High Tech Park 2) July 24th , 2024 in Hanoi 3) November 29th, 2024 in Hanoi
Welding Coordinator Training & Exam (Fund partially supported by JICA)	First Training and Exam in Vietnam held November 19-23, 2024. (Certification Approved by Japan Welding Engineering Society)
JST Sakura Science Exchange Program	Invited 8 students and researchers during Nov.14-Dec.4, 2024: 2 from Ghana, 1 from Egypt, 1 from Thailand, 2 from China, 2 from Vietnam.
JWRI D&I Café	"Enjoy Learning Japanese" for non-Japanese and "Easy Japanese" for Japanese were held on July 3rd, 2024.


Welding Club: Seminar

Opening Ceremony


JWRI D&I cafe


Lecture junior high school girls

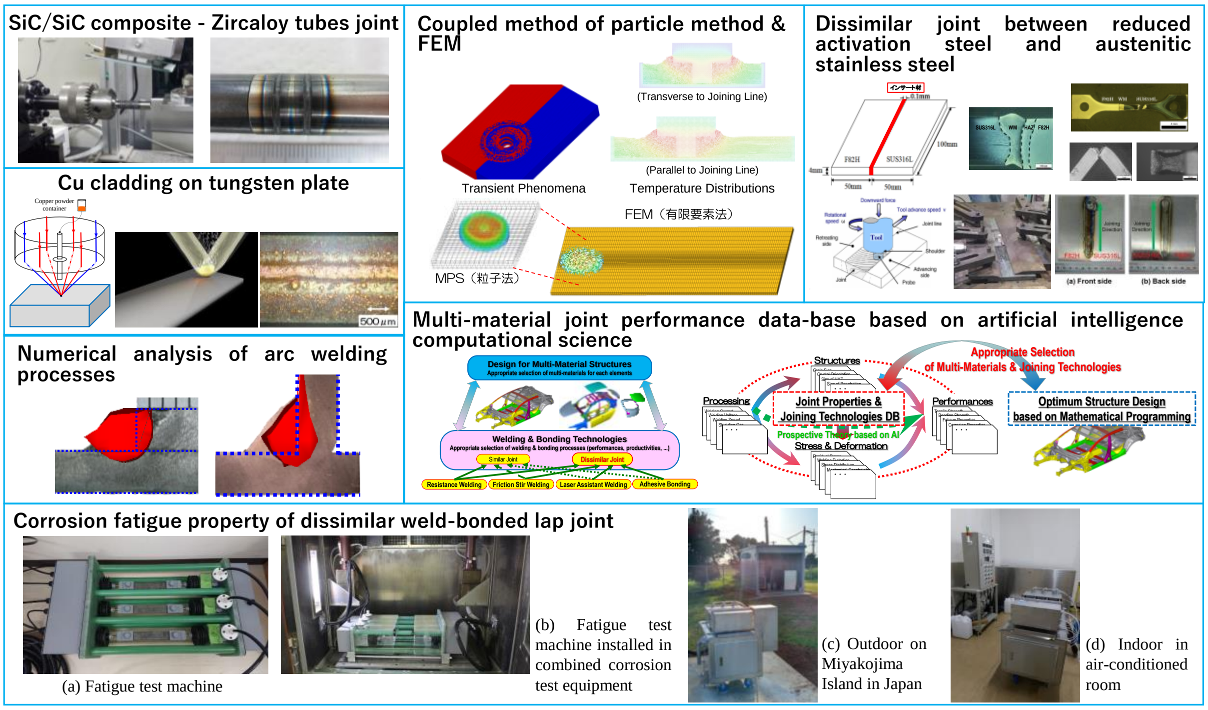
New Normal Manufacturing Consortium Office

Research summary

New Normal Manufacturing Consortium Office deals with not only basic researches for generating advanced materials but also developments & educations of their applied technologies in order to establish Material Innovation Strategy. As for the creation of advanced materials, new high-functional (environmentally) adaptive materials is developed by using the advanced processing technologies. In addition, in order to achieve "Carbon Neural 2050", optimum structural design is studied through the appropriate selection of multi-materials and joining technologies with the aid of Artificial Intelligence computational science.

Research subjects

(1) Development of advanced dissimilar materials joint technology by using high brightness laser beams
(2) Computational analysis of friction stir processes by using coupled method between particle method and finite element method
(3) Numerical analysis of arc welding processes by using three-dimensional, non-stationary thermal model
(4) Creation of advanced joining technologies for innovative fusion reactor power generation system
(5) Development of dissimilar materials joint performance data-base based on artificial intelligence computational science



Major Papers

H. Serizawa, "'Research on Corrosion Fatigue Property of Steel/Aluminum Alloy Weld-Bonded Lap Joint in High Temperature and High Humidity", 77th Annual Assembly of Int. Inst. Welding (IIW), (2024), IIW Doc. III-2244-2024.

Osaka Fuji "Advanced Functional Processing" Joint Research Chairs

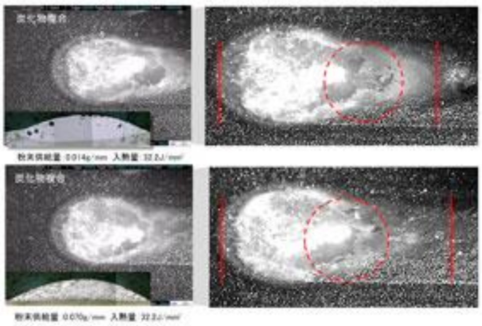
Research summary

This research chair aims to develop advanced functional processing technics by combining laser processing technology and materials knowledge in JWRI and advanced functional manufacturing technologies of Osaka Fuji Corporation.

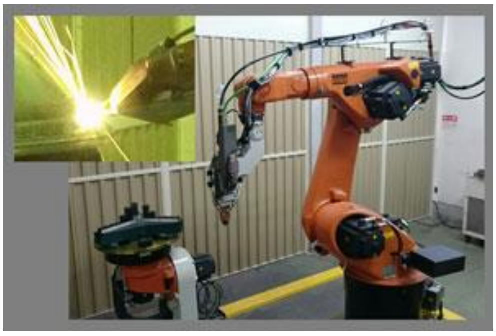
The main purpose is to develop the surface functioning of various materials by laser cladding method, low weldability materials. Finally, these fruits are applied to the next generation of manufacturing technology for various industrial fields.

Research subjects

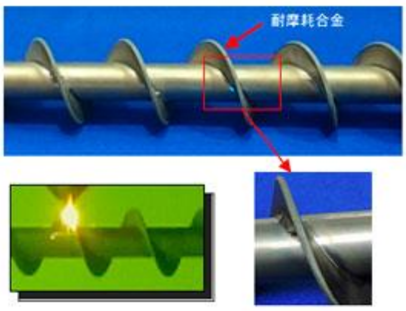
(1) Development of highly functional surface by laser cladding
(2) Development of functional surfaces of small or thin parts
(3) Development of hybrid technology of laser and conventional surfacing technologies
(4) Fundamental research of laser additive manufacturing technology



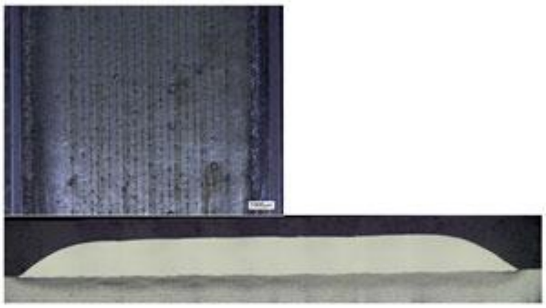
Dynamic observation of molten pool behavior for analysis of blow halls formation using high-speed camera



Experimental apparatus for laser cladding



Example of laser cladding on edge of screw



Wide, flat cladding layer which was provided by beam control

Major Papers

M. Wahba, M. Mizutani, S. Katayama, “Multi-pass laser welding with cut-wire particles of 50 mm thick steel plates”, J. Alloy Metall. Syst., 8 (2024) 100125.
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Influencing Mechanisms of Melt Behavior on Metal Vapor Characteristic and Columnar Grain Formation in Wire-Arc Directed Energy Deposition of Titanium Alloy
Addit. Manuf., 82 (2024), 104029.

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Int. Commun. Heat Mass Transf., 156 (2024), 107681.

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Eligible CO_2 Content in Ar-CO_2 Mixture Shielding Gas for Improving Metal Transfer in Metal-Cored Arc Welding
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IIW Annual Assembly, 2024 (USB), (2024), Doc. XII-2701-2024.

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Thin Solid Films, 790 (2024), 140203/1-140203/8.

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