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JOINING AND WELDING RESEARCH INSTITUTE
OSAKA UNVERSITY
JAPAN

Organization and Staff (December 2023)

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Assistant Professor	Dr. HOU Yuyang

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Assistant Professor	Dr. KARIYA Shota

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Assistant Professor *	Dr. GENG Peihao
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Guest Researcher	Mr. TATSUMI Yoshihiro

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Guest Researcher	Mr. MURASE Keisuke
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13. Strategy Office for Promotion of Inter-Institute Collaborations

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Assistant Professor	Dr. KOZAWA Takahiro
Specially Appointed Researcher	Dr. LI Fei

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Guest Associate Professor	Dr. SHIBAHARA Masakazu

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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
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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

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

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Associate Professor *	Dr. SATO Yuji
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Assistant Professor *	Dr. TAKENAKA Keisuke
Specially Appointed Researcher	Ms. HIGASHINO Ritsuko
Specially Appointed Researcher	Mr. YOSHIDA Norio

17. Industry Cooperation Office

Professor *	Dr. SETSUHARA Yuichi
Guest Professor	Dr. SUGA Tetsuo

***** Supplementary Assignment

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CONTENTS

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

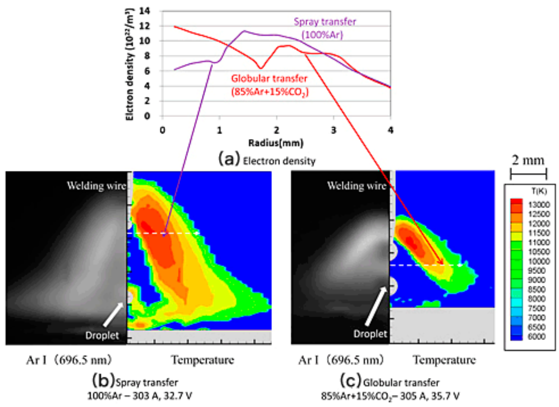
Research summary

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.

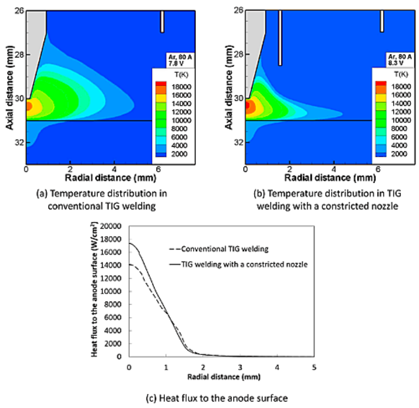
Major emphasis is placed on the generation, control and energy transport in arc plasmas, which are a high density energy source which have been applied to a variety of materials processing techniques such as welding, cutting, heating, high temperature processing, surface modification and the creation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

K. Iida, H. Komen, M. Shigeta, M. Tanaka, “Splashing of tungsten-based anode during arc discharge”, Scientific Reports, (2023), 13, 12210.
doi

Y. Asai, H. Komen, M. Tanaka, M. Nomoto, K. Watanabe, T. Kamo, “Investigation for Oxygen Transfer Mechanism During Gas Tungsten Arc Welding with Carbon Dioxide Gas”, Q. J. Jpn. Weld. Soc., (2023), 41-2, 49s-52s.
doi

W. Zhao, S. Tashiro, A. B. Murphy, M. Tanaka, X. Liu, Y. Wei, "Deepening the understanding of arc characteristics and metal properties in GMAW-based WAAM with wire retraction via a multi-physics model", J. Manuf. Process., (2023), 97, 260-274.
doi

X. Wang, S. Tashiro, M. Tanaka, A. B. Murphy, "Numerical Investigation of the Iron and Oxygen Transport in Arc Plasma During an Activated Tungsten Inert Gas Welding Process", Plasma Chemistry and Plasma Processing, (2023), DOI:10.1007/s11090-023-10359-2.
doi

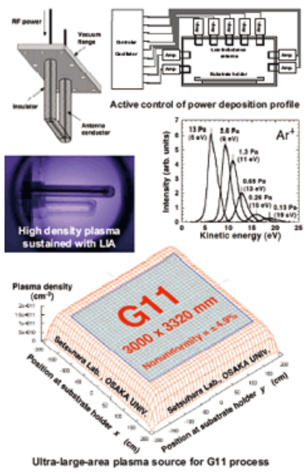
Research Division of Materials Joining Process, Dep. of Energy Transfer Dynamics

Research summary

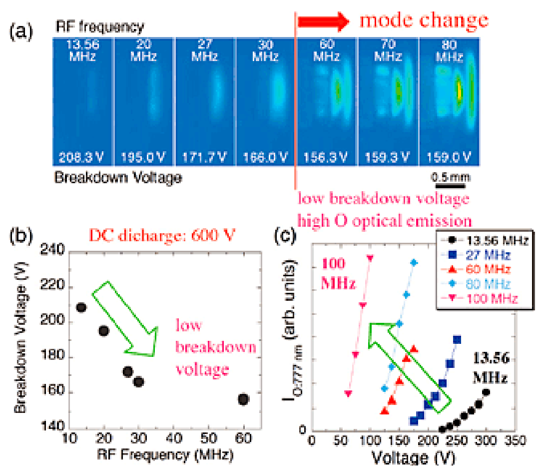
Our research activities encompass works on development of process control technologies of surface and interface for advancement of materials joining science and processing technologies through creation of novel process-energy sources (plasmas and particle beams), and span the range of applications from 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, S Toko, G Uchida, Y Setsuhara, "Direct bonding of stainless steel and PEEK using non-thermal atmospheric pressure plasma-assisted joining technology", J. Manuf. Process., 105 (2023), 276-281.
doi

K Takenaka, M Endo, H Hirayama, S Toko, G Uchida, A Ebe, Y Setsuhara, "Analysis of residual oxygen during a-IGZO thin film formation by plasma-assisted reactive sputtering using a stable isotope", Vacuum, 215 (2023), 112227.
doi

K Takenaka, H Hirayama, M Endo, S Toko, G Uchida, A Ebe, Y Setsuhara "Analysis of oxygen-based species introduced during plasma assisted reactive processing of a-IGZO films", Jpn. J. Appl. Phys., 62 (2023), SL1018.
doi

K Takenaka, T. Yoshitani, M Endo, H Hirayama, S Toko, G Uchida, A Ebe, Y Setsuhara "Plasma processing technique by combination of plasma-assisted reactive sputtering and plasma annealing for uniform electrical characteristics of InGaZnO thin film transistors formed on large-area substrates" Jpn. J. Appl. Phys., 62 (2023), SI1005.
doi

S. Toko, T. Hasegawa, T. Okumura, K. KAMATAKI, K. TAKENAKA, K. Koga, M. SHIRATANI, Y. Setsuhara, "Contribution of active species generated in plasma to CO_2 methanation" Jpn. J. Appl. Phys., 62 (2023), SL1023.
doi

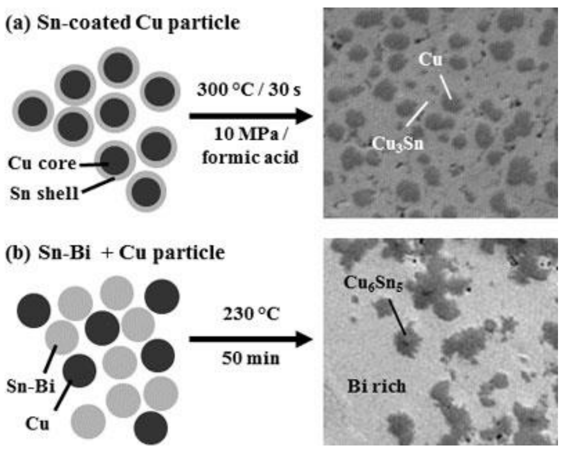
Research Division of Materials Joining Process, Dep. of Micro Joining

Research summary

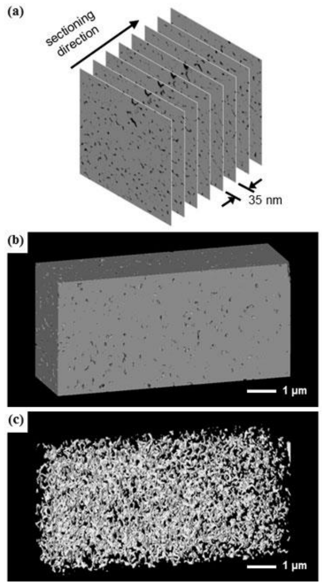
The main research objectives are for electronics packaging to develop advanced joint materials, to establish advanced micro joining processes, and to elucidate the mechanisms of the micro joining processes. Especially, the creation of the functional joint materials, the development of novel advanced 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 eco-friendly fluxless soldering process using a reducing atmosphere
(5) Formation of high heat-resistance joint using three-dimensional nanostructure
(6) Simulation-based evaluation of micro joints nanostructure



Micro joining process using a transient liquid phase bonding (TLPB) method
(a)TLPB process and microstructure of joint using Sn-coated Cu particles
(b)TLPB process and microstructure of joint using Sn-Bi solder particles + Cu particles



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

H. Tatsumi, C. R. Kao and H. Nishikawa, "Impact of crystalline orientation on Cu–Cu solid-state bonding behavior by molecular dynamics simulations", Sci. Rep., 13 (2023), 23030. doi

J. Wang, S. Yodo, H. Tatsumi, C. R. Kao and H. Nishikawa, "Thermal conductivity and reliability reinforcement for sintered microscale Ag particle with AlN nanoparticles additive", Mater. Charact., 203 (2023), 113150. doi

X. Liu, H. Tatsumi, Z. Jin, Z. Zhen, H. Nishikawa, "Fabrication and thermo-mechanical properties of Ag9In4 intermetallic compound", Sci. Rep., 162 (2023), 108028. doi

S. Nitta, H. Tatsumi, H. Nishikawa, "Strength-enhanced Sn–In low-temperature alloy with surface-modified ZrO2 nanoparticle addition," J. Mater. Sci.-Mater. Electron., 34 (2023), 2066. doi

J. Wang, S. Yodo, H. Tatsumi, H. Nishikawa, "Reliability-enhanced microscale Ag sintered joint doped with AlN nanoparticles," Mater. Lett., 349 (2023), 134845. doi

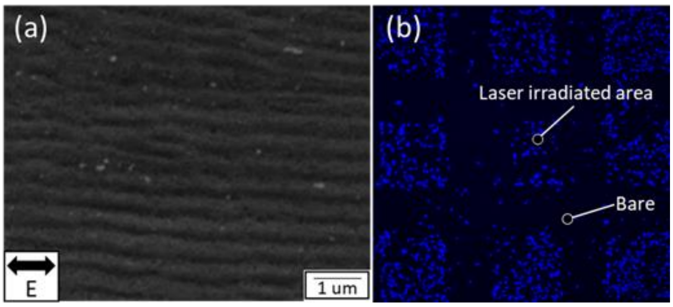
Research Division of Materials Joining Process, Dep. of Laser Materials Processing

Research summary

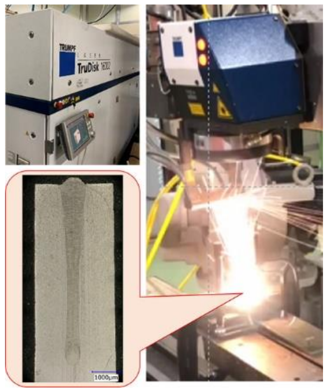
Fundamental studies are performed concerning welding, joining, cutting, surface modification and removal processing with laser beams, aimed at advanced fusion between laser science and production engineering. We focus on clarification of welding or joining mechanisms on the basis of the visualization 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



PMMA film surface after femtosecond laser irradiation.
(a) SEM image with periodic nanostructures oriented to the direction perpendicular to the laser polarization vector (The period of the periodic nanostructure is about 230nm) on PMMA film surface.
(b) Fluorescence microscope image of cell cultivation test. Cells adhered to the periodic nanostructures surface rather than bare surface.



Clarification of laser welding phenomena with 16 kW disk laser

Major Papers

Takenaka, K., Sato, Y., Fujio, S., & Tsukamoto, M., "Comparison of melting efficiency between blue, green, and IR lasers in pure copper welding", J. Laser Appl., 35(4) (2023). doi

Kurita, Y., Sato, Y., Fujio, S., Mizutani, M., & Tsukamoto, M., "Influence of the laser-induced plume on welding behavior in keyhole welding for stainless steel using a 16 kW disk laser, J. Laser Appl., 35(4) (2023). doi

Maeda, K., Sato, Y., Suzuki, R., Suga, T., & Tsukamoto, M., "Influences of cold-sprayed steel interlayer on mechanical properties of laser welded steel/Al lap joints", J. Mater. Process. Technol., 320 (2023), 118103. doi

Kato, S., Ono, S., Sunahara, A., Sato, Y., & Tsukamoto, M., "Optical properties of liquid pure copper by density functional theory", J. Phys. Condensed Matt., 35(32) (2023), 324004. doi

Kato, S., Ono, S., Sunahara, A., Sato, Y., & Tsukamoto, M., "Optical properties of liquid pure copper by density functional theory", Journal of Physics: Condensed Matter, 35(32) (2023), 324004. doi

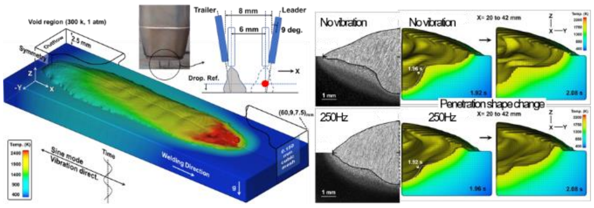
Research Division of Materials Joining Mechanism, Dep. of Welding Mechanism

Research summary

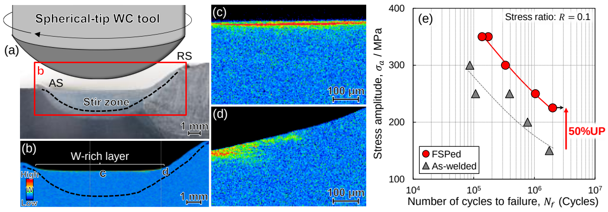
Mechanisms controlling the joint performance of structural and functional materials, which obtained by fusion welding, liquid-state/solid-state bonding, and solid-state bonding, are metallographically characterized to establish a scientific basis to produce joint materials featuring superior performance. 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

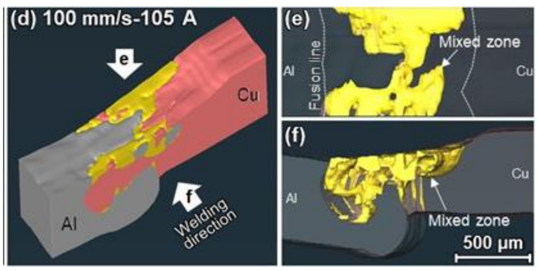
(1) Weld microstructure analyses of structural material such as steel
(2) Bonding mechanism of solid-state joining of metals and ceramics, and its application to microstructural control
(3) Application of welding and joining phenomena to development of advanced materials
(4) Synthesis of new functional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



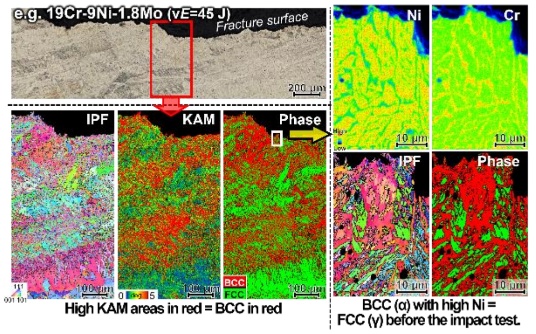
Welding-time variation of penetration shape change in the simulated vibration assisted tandem-pulsed GMAW using the Flow-3D commercial software in the presence of sine-vibration parallel to the welding direction (250 Hz) and the surface tension active elements.



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.



(d) 3D image of the 100 mm/s-105 A, Al/Cu joints, reconstructed by the serial sectioning technique. The volumes of Al, Cu, and Al/Cu-mixed zone are colored gray, orange, and yellow, respectively. Their (e) top-view and (f) cross-sectional 2D images with the mixed zone highlighted.



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.

Major Papers

Habib H. Zargai, K. Ito, A. Sharma, “Effect of workpiece vibration frequency on heat distribution and material flow in the molten pool in tandem-pulsed gas metal arc welding”, Int. J. Adv. Manuf. Technol., 129 (2023), 2507-2522.
doi

M. Liu, L. Zhang, B. Zhao, F. Chen, X. Xia, Y. Yu, H. Yamamoto, K. Ito, “Orientation dependence of plastic deformation of sintered Nd-Fe-B magnets at high temperature”, Acta Mater., 244 (2023) 118559.
doi

H. Yamamoto, Y. Yanagi, K. Ito, H. Komen, M. Tanaka, Akihisa Murata, “Strengthening of Al/Cu dissimilar joint due to complicated interface produced by pulsed TIG welding with a constricted nozzle”, QJ-JWS, 41 (2023) 168-177.
doi

Y. Kitagawa, H. Maniwa, M. Abe, M. Suzuki, Y. Hohino, R. Oda, H. Yamamoto, S.M. Hong, K. Ito, “Low-temp. Toughness Increase for Austenitie Stainless Steel Weld Mwtal for Cryogenic Use”, IIW Annual Assembly 2023, held on July in Singpore.

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

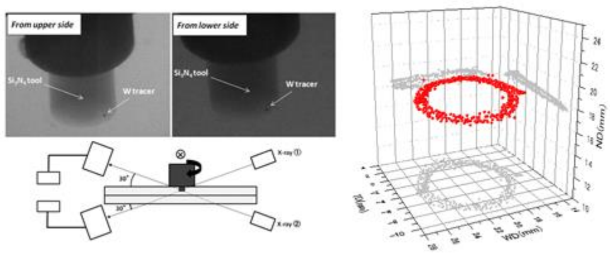
Research summary

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.

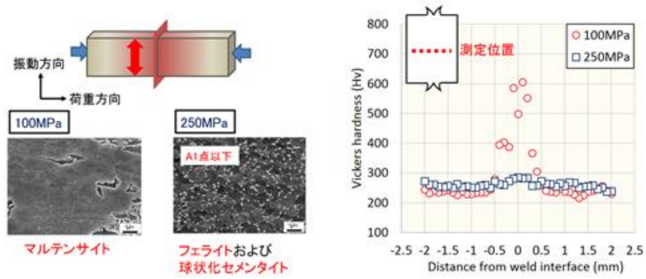
In addition, novel welding and modification processes are developed, mainly based on fusion welding methods and friction welding methods such as the friction stir welding, rotary friction welding and linear friction welding methods, which is the core of the fundamental technologies having a great potential 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

R. Shotri, T. Ogura, P. Geng, Y. Morisada, K. Ushioda, and H. Fujii, "Numerical and experimental investigation of pressure-controlled joule-heat forge welding of steel tubes", J. Manuf. Process., 106(2023), 240-253. doi

A. Sharma, Y. Morisada, K. Ushioda, and H. Fujii, "Elucidation on the correlation between thermal stability of Al13Fe4 intermetallic phase and mechanical properties of the Al-Fe alloy fabricated via friction stir alloying", J. Alloys Compd., 967(2023), 171732. doi

T. Aibara, Y. Morisada, and H. Fujii, "Development of a cold spot joining method that enables sound joining of carbon steel below the A1 temperature", Sci. Technol. Weld. Join., 28(2023), 964-973. doi

T. Ito, M. Kamai, T. Miura, Y. Morisada, and H. Fujii, "Dissimilar joining of carbon steel, pure nickel and aluminum alloys by center-driven double-sided linear friction welding", J. Adv. Join. Process., 8(2023), 100165. doi

H. Miao, S. Tsutsumi, T. Yamashita, Y. Morisada, and H. Fujii, "Fatigue strength improvement of linear friction welded butt joints of low carbon steel by pressurizing after oscillation", J. Manf. Process., 102(2023), 795-805. 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

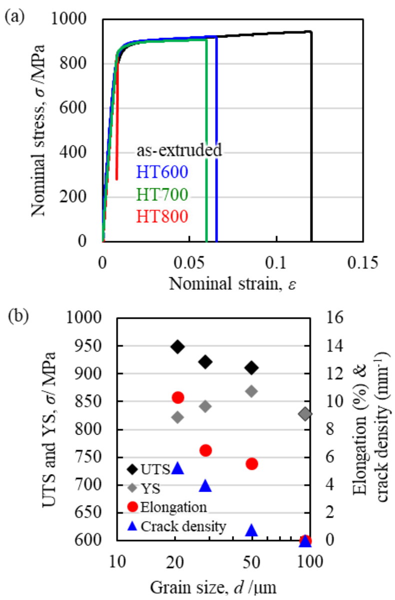
(2) Core-shell structured Ti-N composite powders via solid-gas reaction

(3) Laser powder bed fusion titanium alloys strengthened by solid-solution and nano-dispersoids

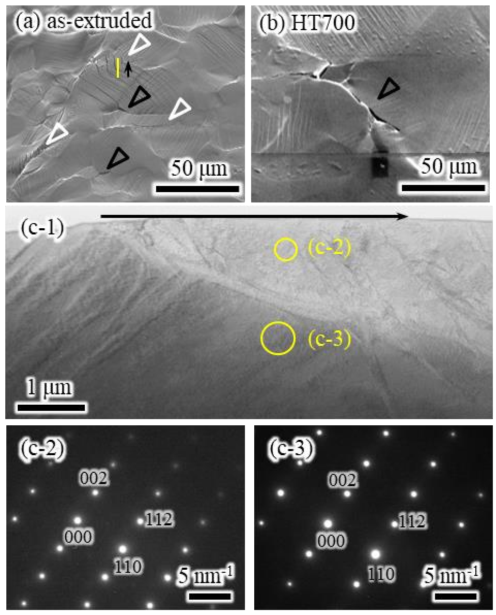
(4) Nano-carbon materials reinforced metal matrix composites via local interface mechanics

(5) Direct bonding of plastic materials to metals by molecular structure and fine bubbles control

(6) Local surface potential difference in CNTs reinforced metal materials and its applications



(a) Stress-strain curves for the as-extruded and heat-treated Ti-0.77O samples and (b) Dependence of the tensile properties and crack density on the grain size of Ti-0.77O.



Secondary electron images confirming the presence of cracks after the tensile tests in (a) as-extruded and (b) 700 °C heat-treated of Ti-0.77O. (c-1) TEM image of the closed cracks area and (c-2 and c-3) SAD patterns of the yellow circles in (c-1).

Major Papers

S. Kariya, A. Issariyapat, A. Bahador, J. Umeda, J. Shen, K. Kondoh, "Effect of grain size on the tensile ductility and fracture mechanism of Ti–O alloys", Materials Science and Engineering A 874 (2023) 145068. doi

S. Abolkassem, A. Elsayed, S. Kariya, J. Umeda, K. Kondoh, "Influence of thermo-mechanical processing on microstructure and properties of bulk metallic glassy alloys-reinforced Al matrix composites prepared by powder metallurgy", Journal of Materials Research and Technology 27 (2023) 8197-8208. doi

P. Nyanor, H. M. Yehia, A. Bahador, J. Umeda, K. Kondoh, M. A. Hassan, "Microstructure and mechanical properties of hybrid nano-titanium carbide-carbon nanotubes (nano-TiC-CNT) reinforced aluminium matrix composite", Advanced Composite Materials (2023) 1-19. doi

A. Bahador, A. Amrin, S. Kariya, A. Issariyapat, O. Gokcekaya, G. Zhao, J. Umeda, Y. Yang, M. Qian, K. Kondoh, "Excellent tensile yield strength with ultrafine grain and tailored microstructure in plastically deformed Ti–Re alloys", Journal of Alloys and Compounds 967 (2023) 171544. doi

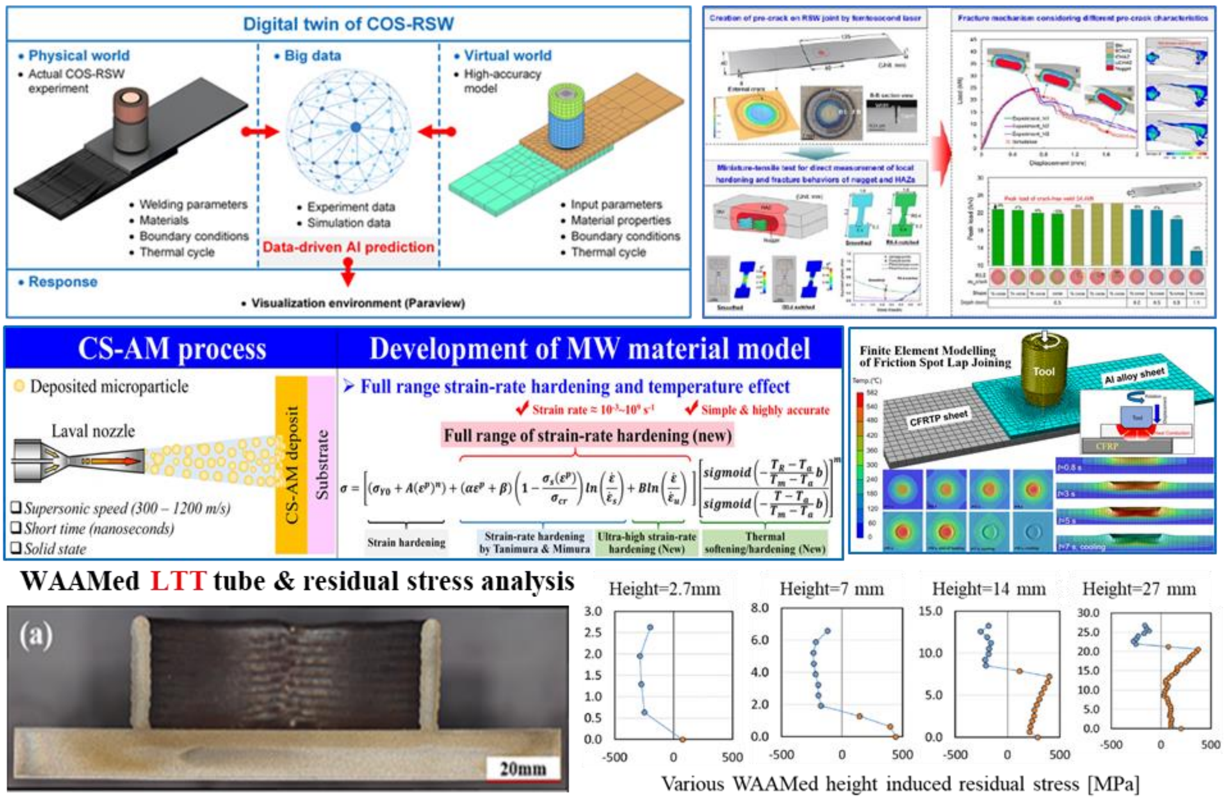
Research Division of Materials Joining Assessment, Dep. of Joining Mechanics and Analyses

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.
(3) Extended Iso-Geometric Analysis (X-IGA) for structure sensing and anisotropic hardening material model



Major Papers

Q. Wang, N. Ma, J.M. Shi, W. Huang, X.T. Luo, P.H. Geng, M.X. Zhang, C.J. Li, "Unraveling microforging principle during in situ shot-peening-assisted cold spray additive manufacturing", Materials&Design, 236 (2023) 112451, 1-14. doi

W. Huang, Q. Wang, N. Ma, H. Kitano, "Residual stress distribution characteristics in wire-arc additive manufactured layers of low transformation temperature materials", International Communications in Heat and Mass Transfer, 148 (2023) 107066, 1-11. doi

Z.X. Yu, N. Ma, H. Murakawa, G Watanabe, M. Liu, Y.W Ma, "Prediction of the fatigue curve of high-strength steel resistance spot welding joints by finite element analysis and machine learning", The International Journal of Advanced Manufacturing Technology, 128 (2023), 2763–2779. doi

T.L. Aung, N. Ma, K. Kishida, F.G. Lu, "Unified inverse isogeometric analysis and distributed fiber optic strain sensing for monitoring structure deformation and stress", Applied Mathematical Modelling, 120 (2023) 733–751. doi

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

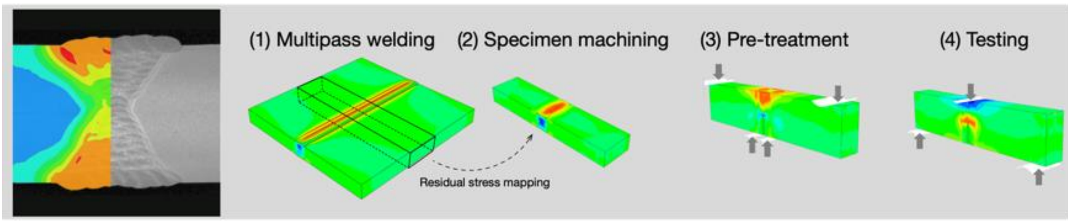
Research summary

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.

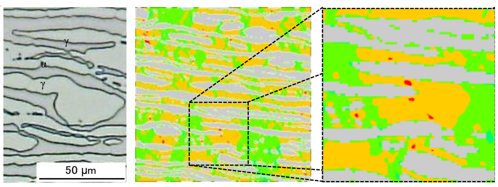
We research the evaluation of the performance and reliability of various structures at each of these stages and scales. In particular, the effects of thermal processing, represented by residual stresses and deformations, on the performance of welded and joined components and structures will be clarified from microscopic and macroscopic perspectives. We will also develop a detailed and intelligent evaluation method based on these findings. Our goal is 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 crack initiation characteristics of structural materials considering microstructure.

Evaluation of mechanical properties of various members by large-scale structural performance evaluation system

Major Papers

T. Ozawa, T. Kawabata, Y. Mikami, “Local compression process avoiding toughness change”, Weld. World, 67 (2023), 607-615.
doi

T. Ozawa, T. Kawabata, Y. Mikami, “Improvement of local compression condition for fracture toughness test with Bayesian optimization”, Weld. World, 67 (2023), 2315-2322.
doi

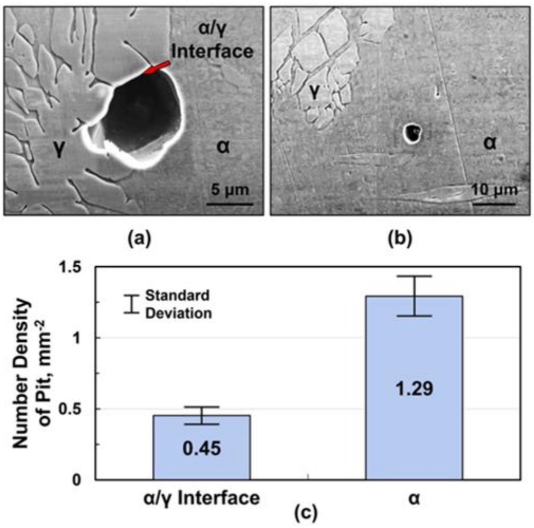
Research Division of Materials Joining Assessment, Dep. of Joining Metallurgical Evaluation

Research summary

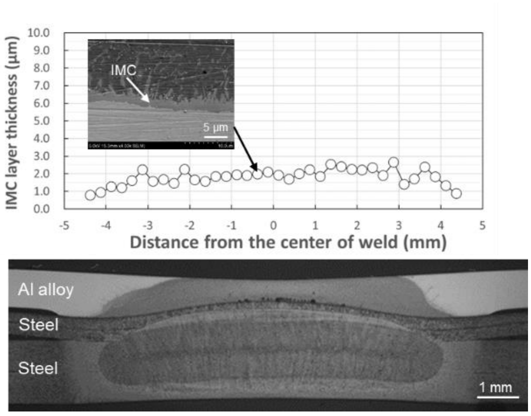
Development of innovative manufacturing technology is required to manufacture high-performance machine products and structures for the next generation. Department of Joining Metallurgical Evaluation conducts research and education for elucidation and control of the factors on weldment properties to create 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

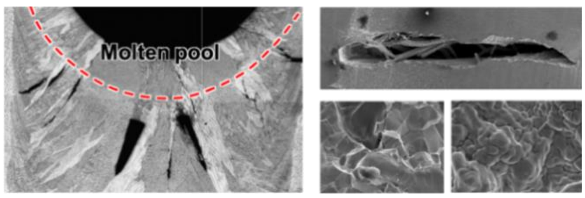
(1) Development of improvement technology of joint properties of various spot welds.
(2) Reliability assessment of resistance spot welds.
(3) Microstructural evolution during solidification and solid state in welds.
(4) Hot cracking during welding and additive manufacturing process and the prediction 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, “Effect of Ferrite Morphology on Pitting Corrosion Resistance of Austenitic Stainless Steel Weld Metals”, Corrosion Sci. , (2023), 11356.
doi

S. Singh, K. Kadoi, B. Alexandrov, J. Andersson, “The Effects of Chemistry Variations on Hot Cracking Susceptibility of Haynes® 282® for Aerospace Applications”, Mater. Des. , Vol. 228 (2023), 111853.
doi

K. Kadoi, S. Ueno, H. Inoue, “Effects of Ferrite Content and Concentrations of Carbon and Silicon on Weld Solidification Cracking Susceptibility of Stainless Steels”, J. Mater. Res. Technol-JMRT , 25 (2023), 1314-1321.
doi

Y. Hou, K. Kadoi, “Nucleation of Equiaxed δ-ferrite by Accelerating Tin Formation Controlled by Oxide During Welding of Ferritic Stainless Steel”, Mater. Charact. , 204 (2023), 113212.
doi

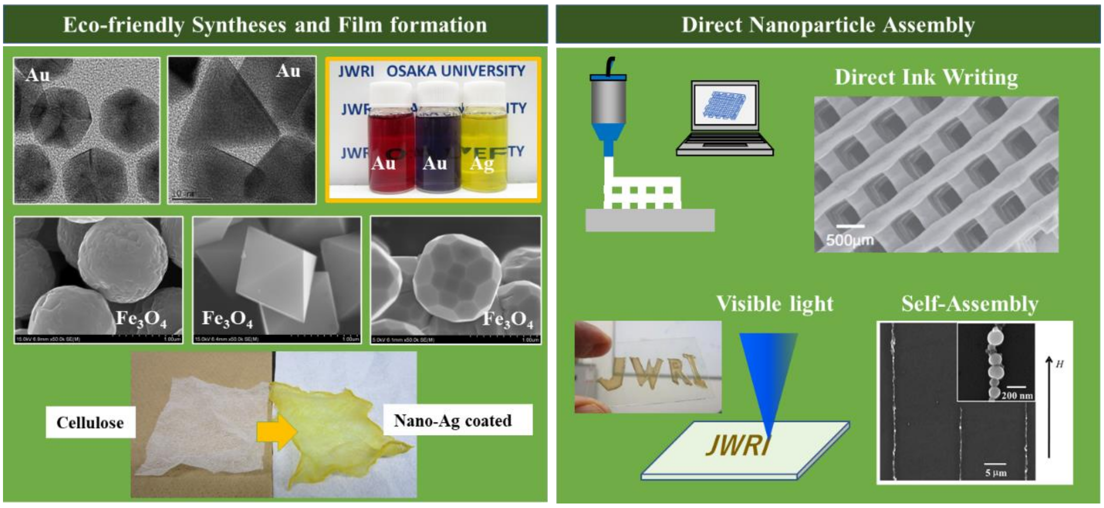
Research Center for Additive Joining Application, Dep. of Green Additive Manufacturing

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

T. Naka, J. Valenta, T. Nakane, S. Ishii, M. Nakayama, H. Mamiya, K. Takehana, N. Tsujii, Y. Imanaka, Y. Matsushita, H. Abe, T. Uchikoshi, H. Yusa, "Phase transitions and slow spin dynamics of slightly inverted A-site spinel CoAl2-xGaxO4", J. Phys. Cond. Matter., 36, (2023) 125801. doi

F. Li, N. Kannnari, J. Maruyama, K. Sato, H. Abe, "Defective multi-element hydroxides nanosheets for rapid removal of anionic organic dyes from water and oxygen evolution reaction", J. Hazardous Mater., 447, (2023), 130803 doi

G. Uchida, K. Masumoto, M. Sakakibara, Y. Ikebe, S. Ono, K. Koga, T. Kozawa, "Single-step fabrication of fibrous Si/Sn composite nanowire anodes by high-pressure He plasma sputtering for high-capacity Li-ion batteries", Sci. Rep., 13 (2023) 14280. doi

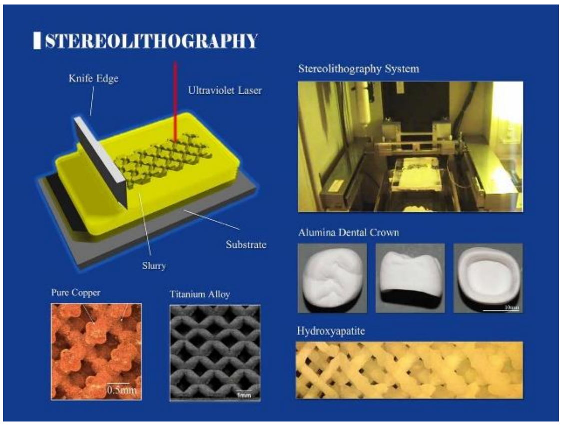
Research Center for Additive Joining Application, Dep. of Lithographic Additive Manufacturing

Research summary

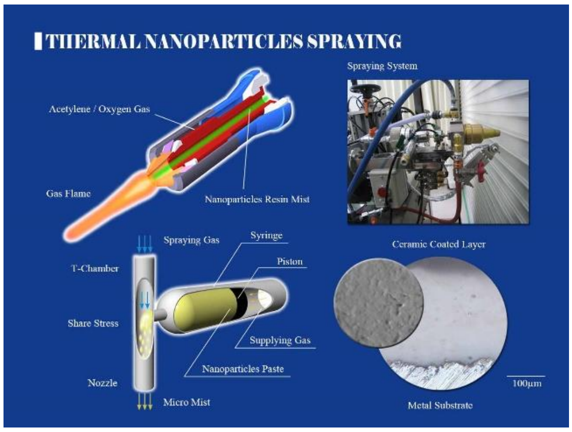
Additive Manufacturing (AM) was newly developed as novel process to create three dimensional (3D) structures through two dimensional (2D) layer laminations. Metal and ceramic nanoparticles were dispersed into resin paste to use for our original process. In lithography techniques, a high power laser beam 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, "Additive manufacturing of composite glass/ceramic structures with self-similar geometries", Open Ceramics", 17(2023), 100509.
doi

A. Oi, F. Spirrett, S. Kirihara, "Stereolithography additive manufacturing of glass/ceramic composite Components with self-similar structures", J. Smart Process., 12(4)(2023), 229-235.
doi

F. Spirrett, S. Kirihara, "Environmental control of solid electrolyte by stereolithography additive manufacturing", J. Smart Process, 12(4)(2023), 219-224.

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.

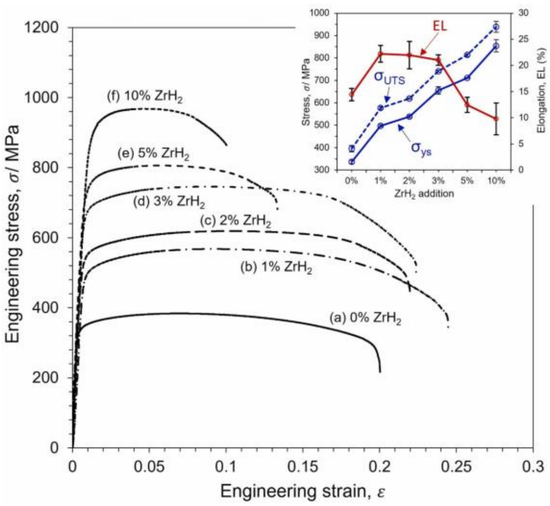
Research subjects

(1) Formation mechanism of unique fine microstructures and orientations of L-PBF Ti alloys

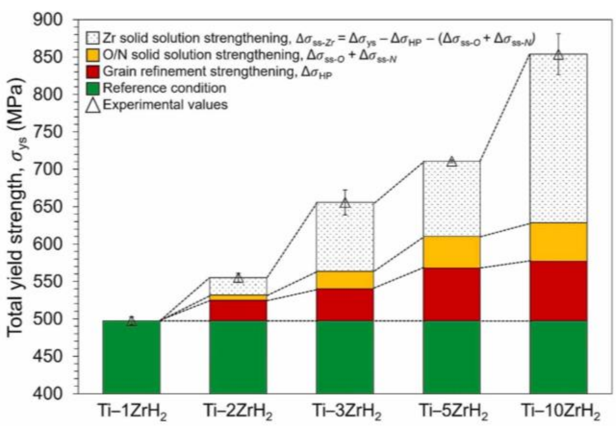
(2) High-strengthen metal matrix composites fabricated by L-PBF process

(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



Stress–strain curves of LPBF-fabricated Ti with ZrH_2 additions of (a) 0%, (b) 1%, (c) 2%, (d) 3%, (e) 5%, and (f) 10%. Inset shows the dependency of tensile properties on ZrH_2 additions. σ_{ys}: 0.2% offset tensile yield strength, σ_{UTS}: ultimate tensile strength, EL: elongation.



Total yield strength (σ_{ys}) of LPBF-fabricated samples with various ZrH_2 additions calculated for grain refinement and O/N solid solution strengthening compared with the experimental results. The estimated solid solution strengthening by Zr ($\Delta\sigma_{ss\text{-}Zr}$) is calculated by formula $\Delta\sigma_{ys} - \Delta\sigma_{HP} - (\Delta\sigma_{ss\text{-}O} + \Delta\sigma_{ss\text{-}N})$.

Major Papers

A. Issariyapat, J. Huang, T. Teramae, S. Kariya, A. Bahador, P. Visuttipitukul, J. Umeda, A. Alhazaa, K. Kondoh, "Microstructure refinement and strengthening mechanisms of additively manufactured Ti-Zr alloys prepared from pre-mixed feedstock", Addit. Manuf., 73 5 (2023), 103649.
doi

J. Peterson, A. Issariyapat, S. Kariya, J. Umeda, K. Kondoh, "The mechanical and microstructural behavior of heat treated, texture-controlled Ti-10%Mo alloys manufactured by laser powder bed fusion", Mater. Sci. Eng. A-Struct. Mater., 884 (2023), 145553.
doi

J. Peterson, S. Kariya, A. Issariyapat, J. Umeda, K. Kondoh, "Experimentally mapping the oriented-to-misoriented transition in laser powder bed fusion Ti-10%Mo alloys", Scr. Mater., 231 (2023), 115472.
doi

H. Hanada, S. Kariya, K. Shitara, J. Umeda, K. Kondoh, "Controlling Intermetallic Compound Distribution in Additively Manufactured Ti-Cu Alloys by Heat Treatment", J. Jpn. Soc. Powder and Powder Metallurgy, 70 6 (2023), 290-297.
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.

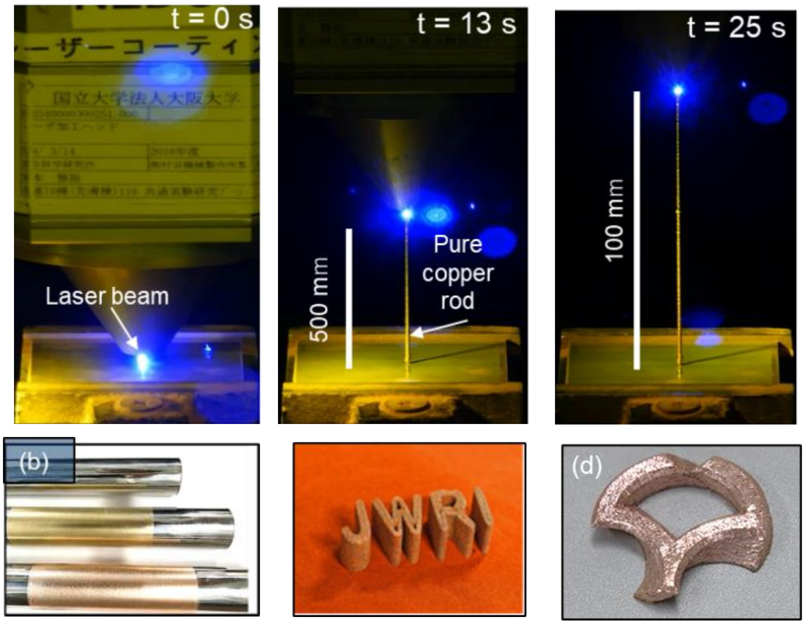
In particular, the apparatuses installed with high power blue diode lasers are also developed since those lasers enable stable and high efficient melting of metal materials such as copper.

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 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 SLM (d) Osaka University's school emblem by SLM

Major Papers

Takazawa, Y., Sato, Y., Takenaka, K., Yamashita, Y., Kunimine, T., & Tsukamoto, M., "High speed coating for pure copper by multi-beam laser metal deposition method with high intensity blue diode lasers", J. Laser Appl., 35(1) (2023), 012029. doi

Promoppatum, P., Chayasombat, B., Soe, A. N., Sombatmai, A., Sato, Y., Suga, T., & Tsukamoto, M., "In-situ modification of thermal, microstructural, and mechanical responses by altering scan lengths in laser powder bed fusion additive manufacturing of Ti-6Al-4V", Opt. Laser Technol., 164(2023), 109525. doi

O. C. Ozaner, A. Kapil, Y. Sato, Y. Hayashi, K. Ikeda, T. Suga, M. Tsukamoto, S. Karabulut, M. Bilgin and A. Sharma., "Dry and Minimum Quantity Lubrication Machining of Additively Manufactured IN718 Produced via Laser Metal Deposition", Lubricants, 11(12) (2023), 523. 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(1) (2023), 012010. doi

Joint Interface Microstructure Characterization Room

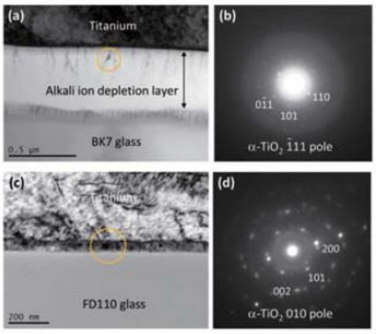
Research summary

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.

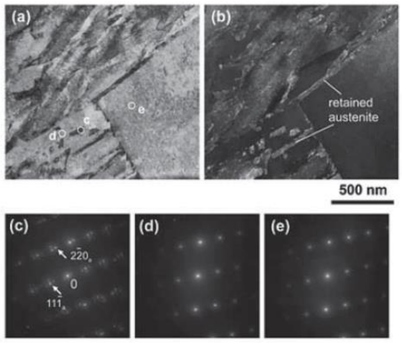
As a unique activity of the analysis room, we perform basic study on the bonding mechanism of anodic bonding, which is a method of bonding glass to conductors at relatively low temperatures, and develop new bonding methods and high-function bonding interfaces by applying that knowledges.

Research subjects

(1) Microstructural analysis of various bonding interfaces and material structures
(2) Fundamental research on the anodic bonding process of glass to various metals
(3) High functionalize of glass-to-glassanodic 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

Makoto Takahashi, “Dissimilar glass-to-glass bonding by Low-temperature Anodic Bonding” (In Japanese), 29th Symposium on Microjoining and Assembly Technology in Electronics, held on 24-25 January in Yokohama, Japan.
doi

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 2023, major activity that Global D&I Promotion Office has worked on was the preparation for operation of “Joining and Welding Research Institute HUST-OU” established in January 2023 in Hanoi, Vietnam under collaboration with Hanoi University of Science and Technology, as well as strengthening the collaboration ties with industries and oversea universities. It is expected those expanded collaborations will broaden the diversity of the JWRI through active international joint research and through exchange of the researchers and students in Southeast Asia and wider regions.

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 the role model series in Nagaoka University of Technology.

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

Name	Contents
Preparation for operation of “Joining and Welding Research Institute HUST-OU” (HUST-OU)	Preparation for procurement of research equipment for HUST-OU established on January 10th, 2023
Vietnam Welding Research Club	Tow Seminars were held: 1) June 26th, 2023 in Hanoi, Vietnam (Hybrid) 2) November 24th, 2023 in Ho Chi Minh City (Vung Tau), Vietnam
New Industry-Academia Collaboration	Concluded on November 13th, 2023: Yamamoto Metal Techno; Yamamoto Metal Precision Vietnam; HUST; JWRI.
Japan International Cooperation Agency (JICA) Partnership Program	Strengthening training and education capacity on Welding Engineers at HUST (preparing for kick-off)
JST Sakura Science Exchange Program	Invited 5 students and researchers between Nov.22-Dec.13, 2023: From Malaya University; Indian Institute of Technology Hyderabad; and Vietnam Academy of Science and Technology.

Vietnam Welding Research Club: Factory Visit

International Researchers Orientation

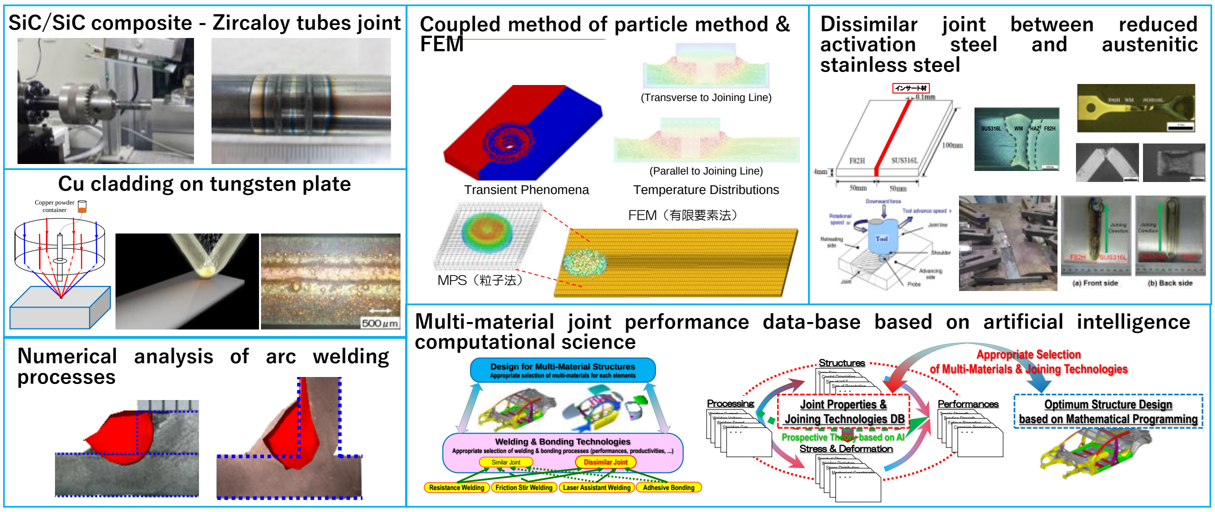
New Normal Manufacturing Consortium Office

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



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Osaka Fuji "Advanced Functional Processing" Joint Research Chair

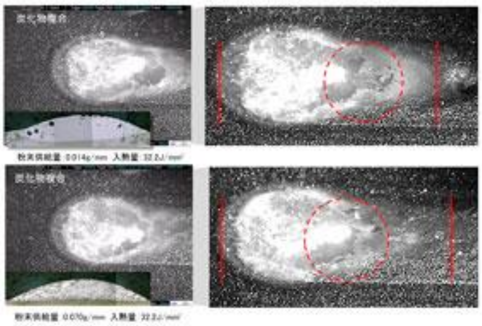
Research summary

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.

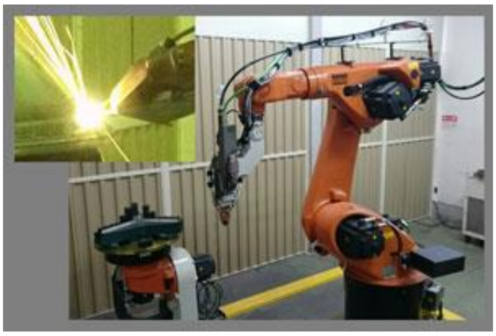
The main purpose is to develop the surface functioning of various materials by laser cladding method, low weldability materials. Finally, these fruits are applied to the next generation of manufacturing technology for various industrial fields.

Research subjects

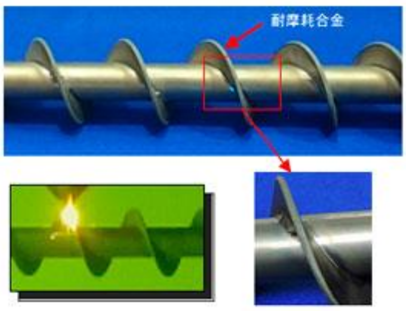
(1) Development of highly functional surface by laser cladding
(2) Development of functional surfaces of small or thin parts
(3) Development of hybrid technology of laser and conventional surfacing technologies
(4) Fundamental research of laser additive manufacturing technology



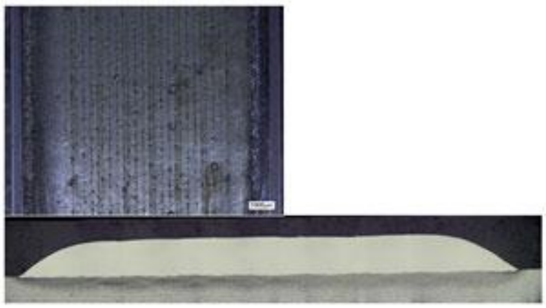
Dynamic observation of molten pool behavior for analysis of blow halls formation using high-speed camera



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

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Strategy Office for Promotion of Inter-Institute Collaborations

Research summary

The Project, Design & Engineering by Joint Inverse Innovation for Materials Architecture - DEJI^{2}MA Project -, has started from 2021 as inter-university cooperative research project (Osaka Univ., Tohoku Univ., Tokyo Institute of Tech., Nagoya Univ., Tokyo Medical and Dental Univ., Waseda Univ.). This project promotes the joint research for development of Inverse Innovation Materials for applications in such as environmental, energy and biomedical fields through the inter-university cooperative researches by the 6 research institutes at 6 universities.

Research subjects

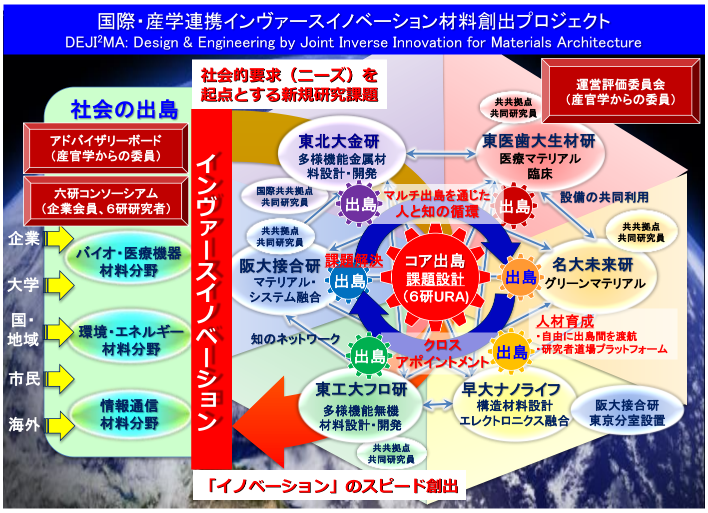
(1) Environmental and Energy Materials
(2) Biomedical and Healthcare Materials
(3) Information and Communication Materials

6 universities cooperative research project

(1) Joining and Welding Research Institute, Osaka Univ.
(2) Institute for Materials Research, Tohoku Univ.
(3) Laboratory for Materials and Structures, Tokyo Institute of Tech.
(4) Institute of Materials and Systems for Sustainability, Nagoya Univ.
(5) Institute of Biomaterials and Bioengineering, Tokyo Medical and Dental Univ.
(6) Research Organization for Nano & Life Innovation, Waseda Univ.

Research topics

(1) Synthesis and integration of nanomaterials towards environmental and energy applications
(2) Synthesis and coating of titan nanocrystals towards biomedical applications



Cooperation system of the six research institutes at six universities

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