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JOINING AND WELDING RESEARCH INSTITUTE
OSAKA UNVERSITY
JAPAN

# Organization and Staff (December 2021)

**Director** Dr. TANAKA Manabu

**1. Research Division of Materials Joining Process**

1) Energy Control of Processing

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| Associate Professor | Dr. KOMEN Hisaya |
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| | |
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| | |
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| Guest Professor | Dr. UCHIDA Shigeaki |
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| Guest Professor | Dr. CHAN Yan Cheong |
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| Guest Researcher | Dr. PU Juan |

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| | |
|---|---|
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**2. Research Division of Materials Joining Mechanism**

1) Welding Mechanism

| | |
|---|---|
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| Associate Professor * | Dr. TAKAHASHI Makoto |
| Assistant Professor | Dr. YAMAMOTO Hajime |
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| | |
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| Specially Appointed Researcher | Mr. AIBARA Takumi |

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| Assistant Professor | Dr. SHITARA Kazuki |
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| Guest Professor | Dr. MIURA Hideshi |
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| Specially Appointed Researcher | Ms. FUJII Hiroko |
| Specially Appointed Researcher | Mr. MINAMITANI Ryoji |
| Specially Appointed Researcher | Mr. PETERSON Jack Edward |

**3. Research Division of Materials Joining Assessment**

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| Associate Professor | Dr. SERIZAWA Hisashi |
| Assistant Professor | Dr. GENG Peihao |
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| Specially Appointed Researcher | Mr. NARASAKI Kunio |
| Guest Researcher | Dr. WU Dongsheng |

2) Structural Integrity and Failure Assessments

| | |
|---|---|
| Professor * | Dr. INOUE Hiroshige |

3) Joining Design and Dependability

| | |
|---|---|
| Professor | Dr. MIKAMI Yoshiki |
| Associate Professor | Dr. TSUTSUMI Seiichiro |
| Specially Appointed Associate Professor | Dr. FINCATO Riccardo |
| Specially Appointed Researcher | Dr. LUO Pengjun |

4) Reliability Evaluation & Simulation

| | |
|---|---|
| Professor | Dr. INOUE Hiroshige |
| Associate Professor | Dr. KADOI Kota |
| Assistant Professor | Dr. HOU Yuyang |
| Guest Researcher | Dr. SINGH Handa Sukhdeep |

**4. Smart Processing Research Center**

| | |
|---|---|
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1) Smart Coating Processing

| | |
|---|---|
| Professor | Dr. NAITO Makio |
| Assistant Professor | Dr. KOZAWA Takahiro |
| Guest Associate Professor | Dr. KAMITANI Masataka |
| Specially Appointed Researcher | Dr. KONDO Akira |

2) Nano/Micro Structure Control

| | |
|---|---|
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| Assistant Professor | Dr. SPIRRETT Fiona |

3) Smart Green Processing

| | |
|---|---|
| Professor * | Dr. NISHIKAWA Hiroshi |
| Associate Professor | Dr. ABE Hiroya |
| Specially Appointed Researcher | Dr. LI Fei |

**5. Joint Interface Microstructure Characterization Room**

| | |
|---|---|
| Associate Professor | Dr. TAKAHASHI Makoto |

**6. JFE Welding Research Alliance Laboratories**

| | |
|---|---|
| Director, Professor * | Dr. TANAKA Manabu |
| Vice Director, Guest Professor | Dr. OI Kenji |
| Vice Director, Guest Professor | Dr. TAGAWA Tetsuya |
| Professor * | Dr. FUJII Hidetoshi |
| Professor * | Dr. ITO Kazuhiro |
| Professor * | Dr. TSUKAMOTO Masahiro |
| Professor * | Dr. INOUE Hiroshige |
| Professor * | Dr. MIKAMI Yoshiki |
| Associate Professor * | Dr. TSUTSUMI Seiichiro |
| Associate Professor * | Dr. KADOI Kota |
| Associate Professor * | Dr. SATO Yuji |

**7. DAIHEN Welding and Joining Research Alliance Laboratories**

| | |
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| Director, Professor * | Dr. INOUE Hiroshige |
| Vice Director, Professor * | Dr. TANAKA Manabu |
| Vice Director, Guest Professor | Dr. ERA Tetsuo |
| Specially Appointed Professor | Dr. ASAI Satoru |
| Specially Appointed Assistant Professor | Ms. MATSUDA Natsume |
| Guest Associate Professor | Dr. KADOTA Keiji |
| Professor * | Dr. ITO Kazuhiro |
| Professor * | Dr. TSUKAMOTO Masahiro |

**8. Nippon Steel Future Manufacturing Research Alliance Laboratories**

| | |
|---|---|
| Director, Professor * | Dr. FUJII Hidetoshi |
| Vice Director, Professor * | Dr. INOUE Hiroshige |
| Vice Director, Guest Professor | Dr. HIRATA Hiroyuki |
| Guest Associate Professor | Dr. FUJIMOTO Hiroki |
| Guest Researcher | Ms. JOTOKU Kana |
| Guest Researcher | Mr. WATANABE Koutarou |
| Guest Researcher | Mr. MATSUI Sho |
| Guest Researcher | Mr. NOMOTO Masashi |

**9. Hitachi Zosen Advanced Welding Technology Joint Research Chair**

| | |
|---|---|
| Specially Appointed Associate Professor | Dr. KAMIKAWA Kenji |
| Specially Appointed Assistant Professor | Dr. ABE Yohei |
| Specially Appointed Assistant Professor | Mr. FUJIMOTO Takahiro |
| Guest Professor | Dr. NAKATANI Mitsuyoshi |
| Guest Professor | Dr. KATAYAMA Seiji |
| Guest Professor | Dr. MINAMI Fumiyoshi |
| Guest Researcher | Dr. TANIGAWA Daichi |
| Professor * | Dr. TANAKA Manabu |
| Professor * | Dr. TSUKAMOTO Masahiro |

**10. Osaka Fuji "Advanced Functional Processing" Joint Research Chair**

| | |
|---|---|
| Specially Appointed Professor | Dr. ABE Nobuyuki |
| Specially Appointed Assistant Professor | Mr. HAYASHI Yoshihiko |
| Specially Appointed Assistant Professor | Mr. MIZUTANI Masami |
| Specially Appointed Researcher | Mr. IKEDA Keiichirou |
| Guest Researcher | Mr. AZUMI Kazuyuki |
| Guest Researcher | Mr. TATSUMI Yoshihiro |
| Professor * | Dr. TSUKAMOTO Masahiro |
| Associate Professor * | Dr. SATO Yuji |

**11. Advanced Joint Production System Joint Research Chair**

| | |
|---|---|
| Specially Appointed Professor | Mr. MUKUDA Muneaki |
| Guest Researcher | Mr. AMASAKI Tetsuya |
| Guest Researcher | Mr. HARADA Naohiko |
| Guest Researcher | Mr. MURASE Keisuke |
| Professor * | Dr. FUJII Hidetoshi |
| Specially Appointed Associate Professor * | Dr. MORISADA Yoshiaki |

**12. Design & Engineering by Joint Inverse Innovation for Materials Architecture — DEJI²MA Project —**

| | |
|---|---|
| Leader, Professor * | Dr. SETSUHARA Yuichi |
| Specially Appointed Professor | Dr. OHARA Satoshi |

**13. Center to Create Research and Educational Hubs for Innovative Manufacturing in Asia / "Division of International Collaboration Research" and "Division of Global Human Resource Development"**

| | |
|---|---|
| Director, Professor * | Dr. TANAKA Manabu |
| Leader, Professor * | Dr. KONDOH Katsuyoshi |
| Leader, Professor * | Dr. NISHIKAWA Hiroshi |
| Specially Appointed Associate Professor | Ms. KATSUMATA Mihoko |
| Specially Appointed Assistant Professor | Ms. TERANISHI Misa |
| Specially Appointed Assistant Professor | Dr. BAHADOR Abdollah |
| Specially Appointed Assistant Professor | Dr. MA Yunwu |

**14. Global Collaborative Research Center for Computational Welding Science (CCWS)**

| | |
|---|---|
| Leader, Professor * | Dr. MA Ninshu |
| Guest Professor | Dr. MURAKAWA Hidekazu |
| Guest Professor | Dr. HIRAOKA Kazuo |
| Guest Professor | Dr. MATSUYAMA Kinichi |
| Guest Professor | Dr. LI ChangJiu |
| Guest Professor | Dr. YASUKI Tsuyoshi |
| Guest Associate Professor | Dr. SHIBAHARA Masakazu |
| Associate Professor * | Dr. SERIZAWA Hisashi |

**15. International Research Center for Fatigue Design of Weld Structures (FDWS)**

| | |
|---|---|
| Leader, Professor * | Dr. FUJII Hidetoshi |
| Guest Professor | Dr. TERADA Kenjiro |
| Associate Professor * | Dr. TSUTSUMI Seiichiro |
| Specially Appointed Associate Professor * | Dr. FINCATO Riccardo |

**16. Joining Technology Hub**

| | |
|---|---|
| Leader, Professor * | Dr. FUJII Hidetoshi |
| Professor * | Dr. TANAKA Manabu |
| Professor * | Dr. ITO Kazuhiro |
| Associate Professor * | Dr. SERIZAWA Hisashi |
| Specially Appointed Associate Professor * | Dr. MORISADA Yoshiaki |
| Specially Appointed Associate Professor * | Dr. AOKI Yasuhiro |
| Guest Academic Staff * | Mr. KAGIYA Kei |
| Researcher | Mr. OGURA Takuya |
| Graduate School of Engineering, Professor * | Dr. HIROSE Akio |
| Graduate School of Engineering, Professor * | Dr. SAIDA Kazuyoshi |
| Graduate School of Engineering, Professor * | Dr. OHATA Mitsuru |
| Graduate School of Engineering, Professor * | Dr. SANO Tomokazu |
| Graduate School of Engineering, Associate Professor * | Dr. OGURA Tomo |
| Graduate School of Engineering, Assistant Professor * | Dr. MATSUDA Tomoki |

**17. Research Institute for Joining and Welding with Blue Diode Laser**

| | |
|---|---|
| Professor * | Dr. TSUKAMOTO Masahiro |
| Associate Professor * | Dr. SATO Yuji |
| Specially Appointed Professor * | Dr. ABE Nobuyuki |
| Specially Appointed Researcher * | Mr. TAKENAKA Keisuke |
| Specially Appointed Researcher * | Ms. HIGASHINO Ritsuko |

**18. Industry Cooperation Office**

| | |
|---|---|
| Professor * | Dr. SETSUHARA Yuichi |
| Specially Appointed Professor | Dr. SUGA Tetsuo |

***** Supplementary Assignment

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CONTENTS

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

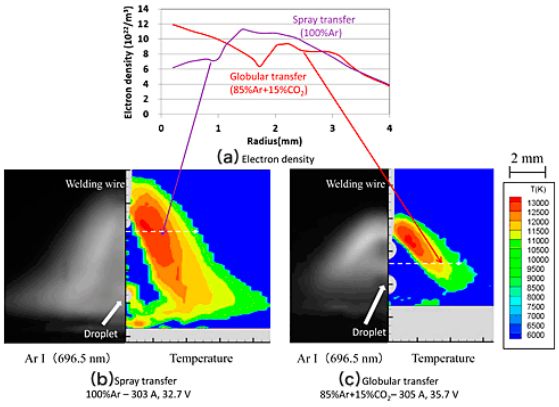
### *Research summary*

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.

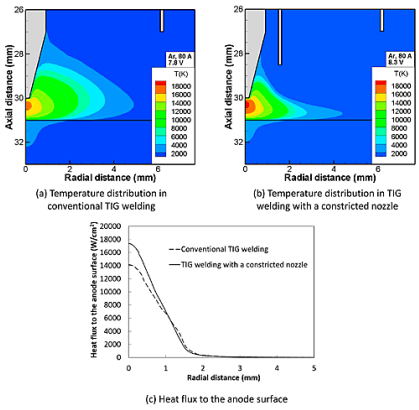
Major emphasis is placed on the generation, control and energy transport in arc plasmas, which are a high density energy source which have been applied to a variety of materials processing techniques such as welding, cutting, heating, high temperature processing, surface modification and the creation 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. Tanaka, M. Shigeta, H. Komen and M. Tanaka, "Electrode Contamination Caused by Metal Vapour Transport during Tungsten Inert Gas Welding", Sci. Technol. Weld. Joining, 26, 3 (2021), 258-263. doi

H. Komen, M. Shigeta, M. Tanaka, Y. Abe, T. Fujimoto, M. Nakatani and A. B. Murphy, "Numerical Investigation of Heat Transfer During Submerged Arc Welding Phenomena by Coupled DEM-ISPH Simulation", Int. J. Heat Mass Transf., 171 (2021), 121062. doi

S. Tashiro, S. Miki, A. B. Murphy, M. Tanaka, Y. Kisaka, F. Kimura, T. Suwa and Y. Takahashi, "Influence of Groove on Metal Vapour Behavior and Arc Characteristics in TIG Welding of High Manganese Stainless Steels", Plasma Chem. Plasma Process. (2021) doi

N. Q. Trinh, S. Tashiro, K. Tanaka, T. Suga, T. Kakizaki, K. Yamazaki, T. Morimoto, H. Shimizu, A. Lersvanichkool, A. B. Murphy, H. V. Bui and M. Tanaka, "Effects of Alkaline Elements on the Metal Transfer Behavior in Metal Cored Arc Welding", J. Manuf. Process., 68 (2021), 1448-1457. doi

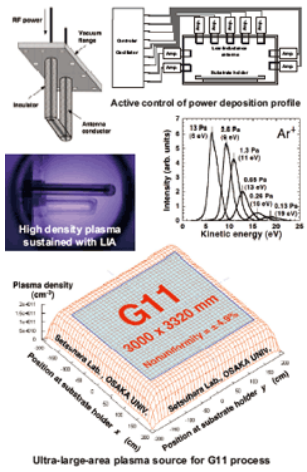
## Research Division of Materials Joining Process, Dep. of Energy Transfer Dynamics

### *Research summary*

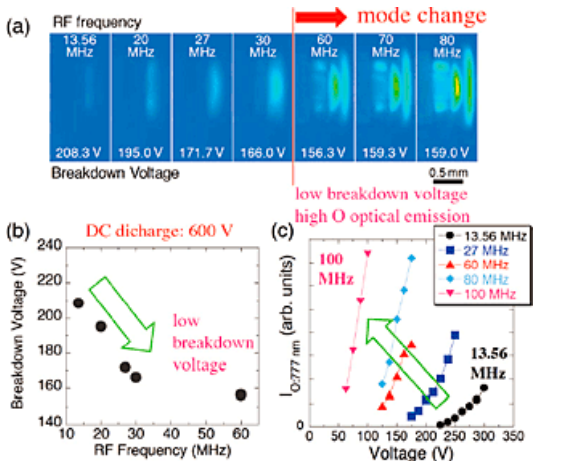
Our research activities encompass works on development of process control technologies of surface and interface for advancement of materials joining science and processing technologies through creation of novel process-energy sources (plasmas and particle beams), and span the range of applications from 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, Y. Setsuhara, G. Uchida and A. Ebe, "Amorphous $InGaZnO_x$ Thin Film Formation by a Plasma-Assisted Reactive Process", OYO BUTSURI, 90, 1 (2021), 35-39. doi

K. Takenaka and Y. Setsuhara, "Formation of Functional Oxide Thin Film by Plasma-assisted Reactive Process Using Mist", J. Smart Process., 10, 1 (2021), 10-14.

J. Hayashi, K. Nagai, Y. Habu, Y. Ikebe, M. Hiramatsu, R. Narishige, N. Itagaki, M. Shiratani, Y. Setsuhara and G. Uchida, "Morphological Control of Nanostructured Ge Films in High Ar-gas-pressure Plasma Sputtering Process for Li Ion Batteries", Jpn. J. Appl. Phys., 61 (2021), SA1002. doi

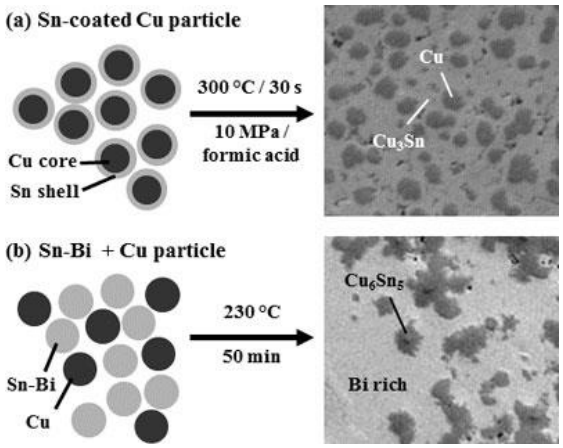
## Research Division of Materials Joining Process, Dep. of Manufacturing Process

### *Research summary*

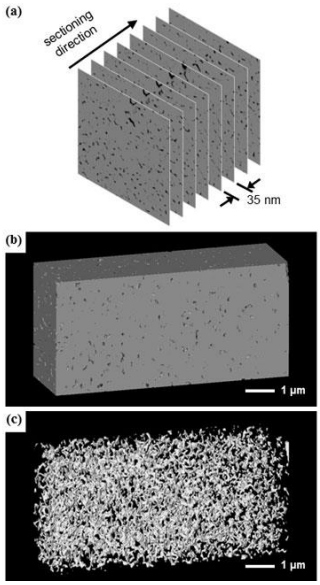
The main research objectives are to analyze the mechanisms of material process including joining by various energy sources, and to develop advanced processes with high efficiency and high productivity. Especially, for a micro joining process in electronics packaging, the creation of the functional joint materials, the development of novel advanced micro processes by various energy sources, and the enhancement of the highly reliable joints based on the control of interfacial structure and performance are performed to produce micro joints with superb functionality and high reliability. In addition, we are resolving the joining problems of newly-developed materials. And we are aiming to develop new appropriate material processes for these materials.

### *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




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*


Z. Jin, Y.-A. Shen, F. Huo, Y. C .Chan and H. Nishikawa, "Electromigration Behavior of Silver Thin Film Fabricated by Electron-Beam Physical Vapor Deposition", J. Mater. Sci., 56 (2021), 9769-9779. doi

Y. Hirata, C.-H. Yang, S.-K. Lin and H. Nishikawa, "Improvements in Mechanical Properties of Sn-Bi Alloys with Addition of Zn and In", Mater. Sci. Eng. A., 813 (2021), 141131. doi

Z. Jin, Y.-A. Shen, Y. Zuo, Y. C .Chan, S. H. Mannan and H. Nishikawa, "Observation of Void Formation Patterns in SnAg Films Undergoing Electromigration and Simulation Using Random Walk Methods", Sci. Rep., 11 (2021), 8668. doi

F. Hou, Z. Jin, D. L. Han, K. Zhang and H. Nishikawa, "Interface Design and the Strengthening-Ductility Behavior of Tetra-Needle-Like ZnO Whisker Reinforced Sn1.0Ag0.5Cu Composite Solders Prepared with Ultrasonic Agitation", Mater. Des., 210 (2021), 110038. doi

Y.-J. Kim, B.-H. Park, S. K. Hyun and H. Nishikawa, "The Influence of Porosity and Pore Shape on the Thermal Conductivity of Silver Sintered Joint for Die Attach", Mater. Today Commun., 29 (2021), 102772. doi

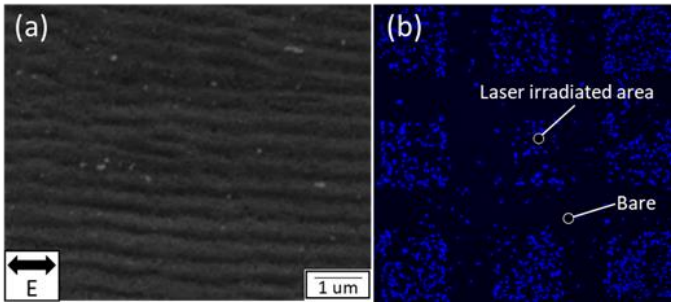
## Research Division of Materials Joining Process, Dep. of Laser Materials Processing

### *Research summary*

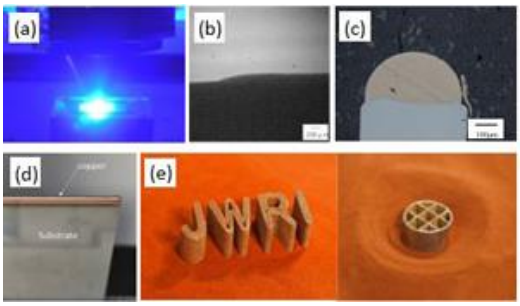
Fundamental studies are performed concerning welding, joining, cutting, surface modification and removal processing with laser beams, aimed at advanced fusion between laser science and production engineering. We focus on clarification of welding or joining mechanisms on the basis of the visualization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




Copper cladding using blue diode laser (a)Blue diode laser (b) X ray observation of laser coating with blue laser (c) Cross section image (d) Surface image of pure copper coating layer (e) 3D object of pure copper by Blue diode laser

### *Major Papers*

Y. Sato, N. Shinohara, T. Arita, M. Mizutani, T. Ohkubo, H. Nakano and M. Tsukamoto, "In Situ X-Ray Observation of Keyhole Dynamics for Laser Beam Welding of Stainless Steel with 16 kW Disk Laser", J. Laser Appl., 33 (2021), 042043. doi

K. Takenaka, N. Shinohara, M. Hashida, M. Kusaba, H. Sakagami, Y. Sato, S. Masuno, T. Nagashima and M. Tsukamoto, "Delay Times for Ablation Rate Suppression by Femtosecond Laser Irradiation with a Two-Color Double-Pulse Beam" Appl. Phys. Lett., 119 (2021), 231603. doi

T. Pasang, B. Tavlovich, O. Yannay, B. Jackson, M. Fry, Y. Tao, C. Turangi, J.-C. Wang, C.-P. Jiang, Y. Sato, M. Tsukamoto and W. Z. Misiolek, "Directionally-Dependent Mechanical Properties of Ti6Al4V Manufactured by Electron Beam Melting (EBM) and Selective Laser Melting (SLM)", Materials, 14, 13 (2021), 3603. doi

Y. Sato, K. Ono, K. Takenaka, K. Morimoto, Y. Funada, Y. Yamashita, T. Ohkubo, N. Abe and M. Tsukamoto, "Fabrication of Pure Copper Rod by Multi-beam Laser Metal Deposition with Blue Diode Lasers", J. Laser Micro Nanoeng., 16, 3 (2021), 189-193. doi

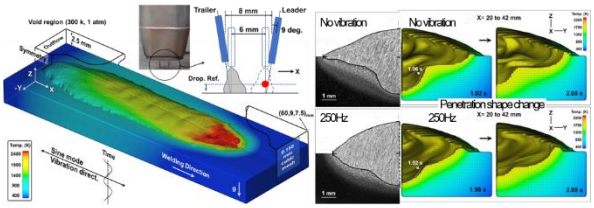
## Research Division of Materials Joining Mechanism, Dep. of Welding Mechanism

### *Research summary*

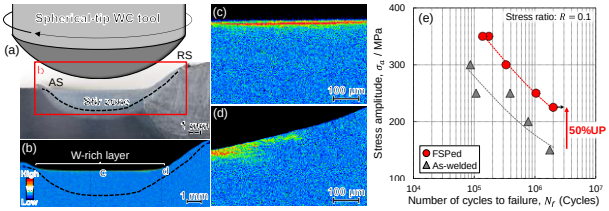
Mechanisms controlling the joint performance of structural and functional materials, which obtained by fusion welding, liquid-state/solid-state bonding, and solid-state bonding, are metallographically characterized to establish a scientific basis to produce joint materials featuring superior performance.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

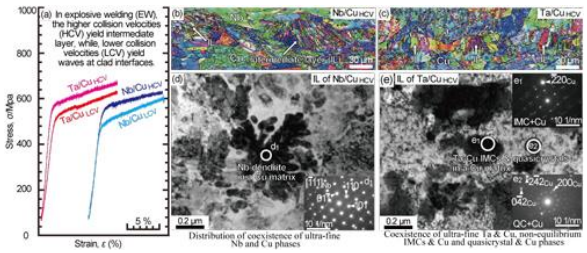
(1) Weld microstructure analyses of structural material such as steel
(2) Bonding mechanism of solid-state joining of metals and ceramics, and its application to microstructural control
(3) Application of welding and joining phenomena to development of advanced materials
(4) Synthesis of new functional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



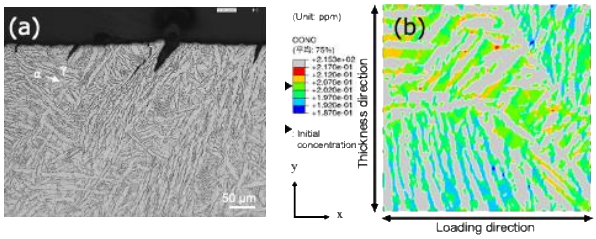

Welding-time variation of penetration shape change in the simulated vibration assisted tandem-pulsed GMAW using the Flow-3D commercial software in the presence of sine-vibration parallel to the welding direction (250 Hz) and the surface tension active elements.




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.




Designing high bending strength Nb/Cu and Ta/Cu clads produced by explosive welding (EW) with high micro-hardness intermediate layers (ILs) at their interfaces.




Cracks observed in hydrogen charged weld metal after slow strain rate tensile test (a), and numerical simulation of diffusible hydrogen concentration distribution in weld metal (b).

### *Major Papers*


T. Kakizaki, S. Koga, H. Yamamoto, Y. Mikami, K. Ito, K. Yamazaki, S. Sasakura and H. Watanabe, "Microstructure Features and Formation Mechanism in a Newly Developed Electroslag Welding", Weld. World (2021), 1-12. doi

H. Yamamoto, Y. Imagawa, K. Ito, K. Chen and L. Zhang, "Alloying a Topmost Steel-Plate Layer with WC-tool Constituent Elements during Friction Stir Processing", J. Manuf. Process., 69 (2021), 311-319. doi

J. D. Kulkarni, S. B. Goka, P. K. Parchuri, H. Yamamoto, K. Ito and S. Simhambhatla, "Microstructure Evolution along Build Direction for Thin-Wall Components Fabricated with Wire-Direct Energy Deposition", Rapid Prototyping J., 27, 7 (2021), 1289-1301. doi

P. K. Parchuri, S. Kotegawa, K. Ito, H. Yamamoto, A. Mori, S. Tanaka and K. Hokamoto, "Characterization of Shock Wave Damages in Explosion Welded Mo/Cu Clads", Metals, 11, 3 (2021), 501. doi

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

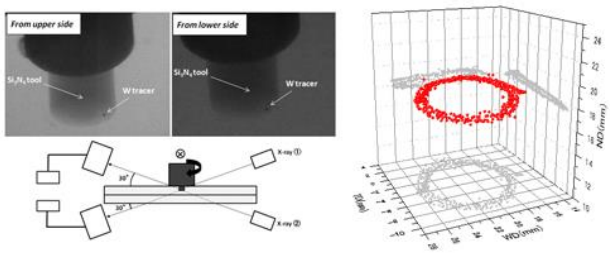
### *Research summary*

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.

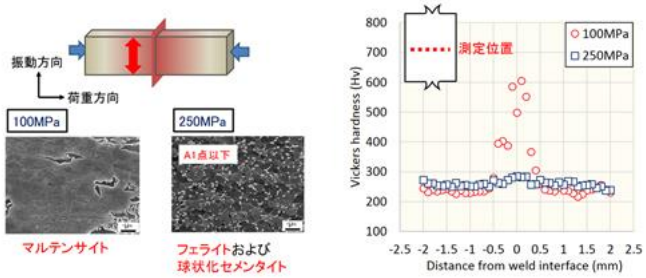
In addition, novel welding and modification processes are developed, mainly based on fusion welding methods and friction welding methods such as the friction stir welding, rotary friction welding and linear friction welding methods, which is the core of the fundamental technologies having a great potential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


Y.-S. Lim, Y. Morisada, H. Liu and H. Fujii, "Ti-6Al-4V/SUS316L Dissimilar Joints with Ultrahigh Joint Efficiency Fabricated by a Novel Pressure-Controlled Joule Heat Forge Welding Method", J. Mater. Process. Technol., 298 (2021), 117283. doi

X. Wang, Y. Morisada and H. Fujii, "Flat Friction Stir Spot Welding of Low Carbon Steel by Double Side Adjustable Tools", J. Mater. Sci. Technol., 66 (2021), 1-9. doi

Z. Zeng, M. Zhou, P. Lynche, F. Mompiou, Q. Gu, M. Esmaily, Y. Yan, Y. Qiu, S. Xu, H. Fujii, C. Davies, J.-F. Nie and N. Birbilis, "Deformation Modes during Room Temperature Tension of Fine-Grained Pure Magnesium", Acta Mater., 206 (2021), 116648. doi

J.-W. Choi, Y. Aoki, K. Ushioda and H. Fujii, "Linear Friction Welding of Ti-6Al-4V Alloy Fabricated below β-Phase Transformation Temperature", Scr. Mater., 191 (2021), 12-16. doi

Z. Wu, T. Nagira, K. Ushioda, G. Miyamoto and H. Fujii, "Microstructures and Tensile Properties of Friction Stir Welded 0.2%C-Si-Mn Steel", Mater. Sci. Eng. A., 799 (2021), 140068. doi

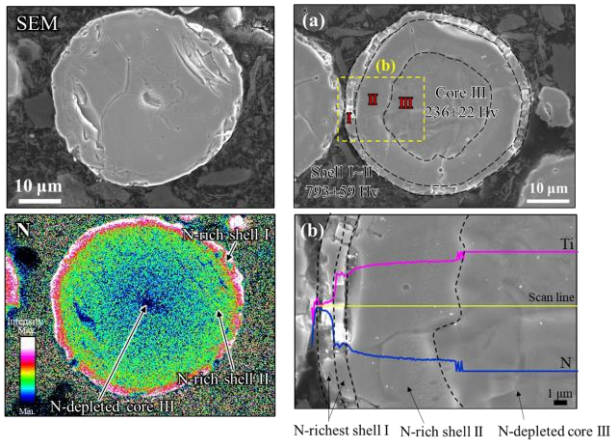
## Research Division of Materials Joining Mechanism, Dep. of Composite Materials Processing

### *Research summary*

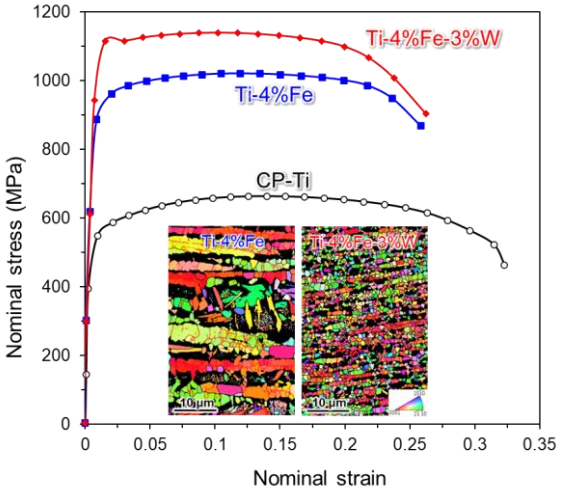
From a viewpoint of the energy saving and environmental problem solutions, the research fields of this department focus on both of the effective reuse of resources and energy including renewable ones and reduction of life hazardous materials and air pollutions. In particular, by controlling the interfacial 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) Selective laser melted 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) Ni-rich TiNi shape memory alloys with nano-precipitation and application to medical devices
(7) Local surface potential difference in CNTs reinforced metal materials and its applications




SEM-EDS analysis on core-shell structured Ti-N composite powder with two-layers shell (N-richest shell I & N-rich shell II) and N-depleted core III heat treated at 1273 K in nitrogen gas atmosphere.




Tensile properties of hot extruded Ti-4%Fe powder alloys with W solutes and CP-Ti material including IPF-maps on α-Ti of Ti-4%Fe and Ti-4%Fe-3%W.

### *Major Papers*


D. Pan, S. Li, L. Liu, X. Zhang, B. Li, B. Chen, M. Chu, X. Hou, Z. Sun, J. Umeda and K. Kondoh, "Enhanced Strength and Ductility of Nano-TiBw-Reinforced Titanium Matrix Composites Fabricated by Electron Beam Powder Bed Fusion Using Ti6Al4V-TiBw Composite Powder", Addit. Manuf., 50 (2021), 102519. doi

J. Umeda, T. Tanaka, T. Teramae, S. Kariya, J. Fujita, H. Nishikawa, Y. Shibutani, J. Shen and K. Kondoh, "Microstructures Analysis and Quantitative Strengthening Evaluation of Powder Metallurgy Ti-Fe Binary Extruded Alloys with (α+β)-dual-phase", Mater. Sci. Eng. A., 803 (2021), 140708. doi

A. Issariyapat, T. Song, P. Visuttipitukul, J. Umeda, Q. Ma and K. Kondoh, "Development of Core-Shell-Structured Ti-(N) Powders for Additive Manufacturing and Comparison of Tensile Properties of the Additively Manufactured and Spark-Plasma-Sintered Ti-N Alloys", Adv. Powder Technol., 32, 7 (2021), 2379-2389. doi

T. Song, T. Dong, S. L. Lu, K. Kondoh, R. Das, M. Brandt and Q. Ma, "Simulation-informed Laser Metal Powder Deposition of Ti-6Al-4V with Ultrafine α-β Lamellar Structures for Desired Tensile Properties", Addit. Manuf., 46 (2021), 102139. doi

A. Bahador, J. Umeda, R. Yamanoglu, A. Amrin, A. Alhazaa and K. Kondoh, "Ultrafine-grain Formation and Improved Mechanical Properties of Novel Extruded Ti-Fe-W Alloys with Complete Solid Solution of Tungsten", J. Alloy. Compd, 875 (2021), 160031. doi

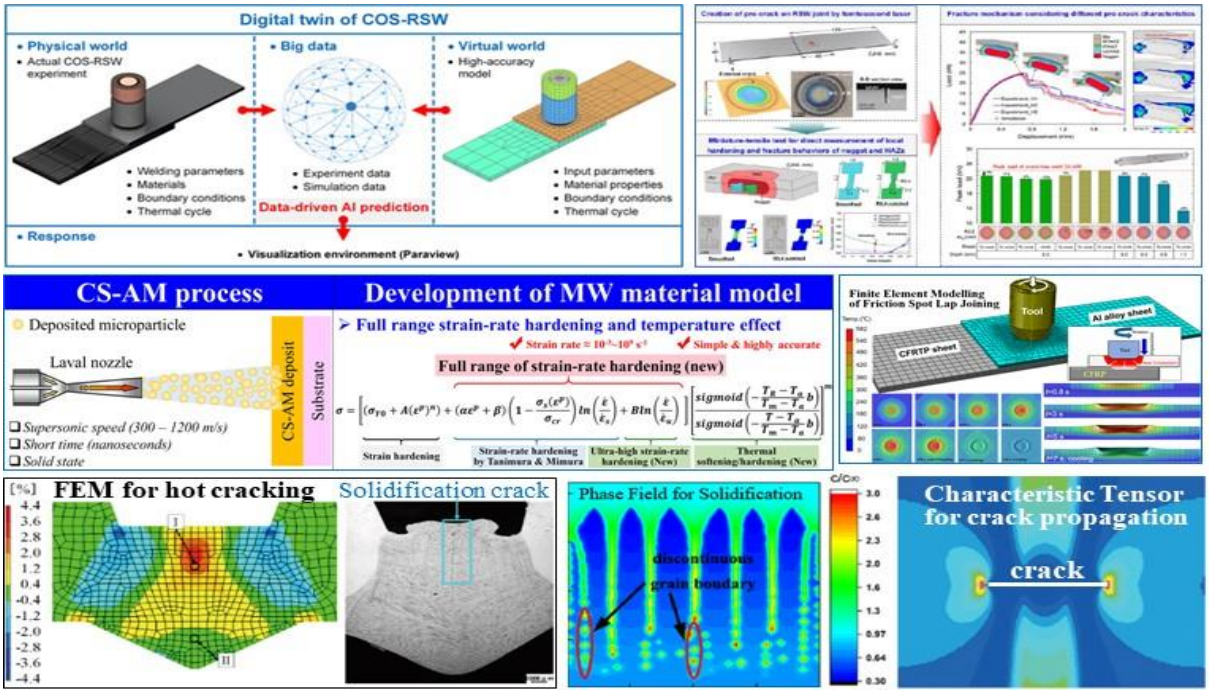
## Research Division of Materials Joining Assessment, Dep. of Joining Mechanics and Analyses

### *Research summary*

The mathematical and 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. 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) Computational modelling 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) Integration of FEM and Field Measurement (M-FEM) using DIC in various tests for identification of internal residual stress and fracture criteria of materials and various types of joints.




### *Major Papers*


S. Ren, Y. Ma, N. Ma, Q. Chen and H. Wu, "Digital Twin for the Transient Temperature Prediction during Coaxial One-Side Resistance Spot Welding of Al5052/CFRP", J. Manuf. Sci. Eng, 144, 3 (2021), 1-8. doi

Y. Ma, Y. Yu, P. Geng, R. Ihara, K. Maeda, R. Suzuki, T. Suga and N. Ma, "Fracture Modeling of Resistance Spot Welded Ultra-High Strength Steel Considering the Effect of Pre-Crack", Mater. Des., 210 (2021), 110075. doi

Q. Wang, N. Ma, X.-T. Luo and C.-J. Li, "Towards Better Understanding Supersonic Impact-Bonding Behavior of Cold Sprayed 6061-T6 Aluminum Alloy Based on a High-Accuracy Material Model", Addit. Manuf., 48 (2021), 1-11. doi

P. Geng, N. Ma, H. Ma, Y. Ma, K. Murakami, H. Liu, Y. Aoki and H. Fujii, "Flat Friction Spot Joining of Aluminum Alloy to Carbon Fiber Reinforced Polymer Sheets: Experiment and Simulation", J. Mater. Sci. Technol., 107 (2021), 266-289. doi

K. Saito, T. Hirashima, N. Ma and H. Murakawa, "Characteristic-tensor Method for Efficient Estimation of Stress-Intensity Factors of Three-Dimensional Cracks", Eng. Fract. Mech., 257, 11 (2021), 1-21. doi

## Research Division of Materials Joining Assessment, Dep. of Joining Design and Dependability

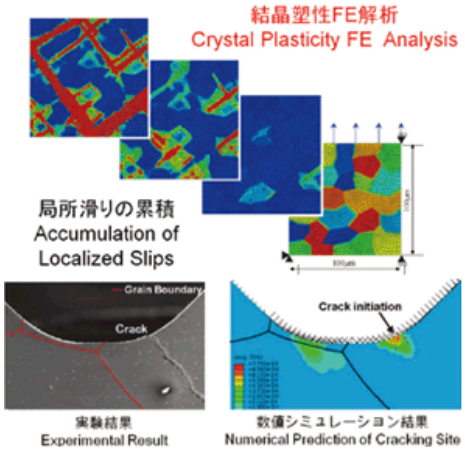
### *Research summary*

In evaluating the reliability of the structures, this department investigates not only the conventional optimization for the safety and the durability in constructing steel structures but also the reliability (Dependability) including the maintenance, the repair/reinforcement and the evaluation of lifetime considering cultural science and social science. Moreover, making researches on the procedure to safely break up the structures completing the lifetime, the circulating loop in which the members or the units are reused is concretized.

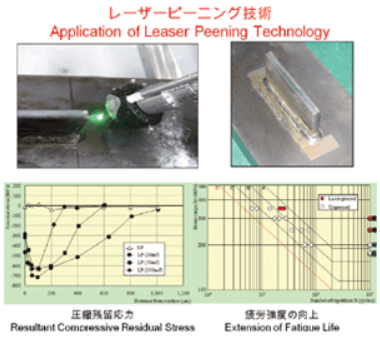
The department purposes to establish the evaluating methods to satisfy the high accuracy and the high quality in cutting, processing and assemblage for "products of steel structures" based on the dependability in the circulating loop containing the maintenance, the repair/reinforcement and the evaluation of lifetime.

### *Research subjects*

(1) Soundness diagnosis of structural members and joints
(2) Development of simulation technology of mechanical behavior
(3) Development of fatigue life assessment technology (crack nucleation, propagation)
(4) Development of measurement technology of deformation and crack
(5) Development of life extension technology for structural members and joints
(6) Assessment of Weldability and Quality of New and Functionally Graded Materials



Numerical simulation of mechanical fatigue phenomena



Development of life extension technology for steel structures


Ultra-dynamic and cyclic loading test for large structures
Soundness diagnosis of structure members by ultra-dynamic structural testing system （Speed 1,200mm/sec, Load 1,200kN, Stroke 500mm）

### *Major Papers*

R. Fincato and S. Tsutsumi, "Coupled Elasto-Viscoplastic and Damage Model Accounting for Plastic Anisotropy and Damage Evolution Dependent on Loading Conditions", Comput. Methods Appl. Mech. Engrg.,, 387 (2021), 114165. doi

T. Ozawa, H. Kosuge, Y. Mikami and T. Kawabata, "Typical Local Compression Effect on Crack Front Straightness and Fracture Toughness", Weld. World, 65 (2021), 1777-1790. doi

T. Kawabata, H. Kosuge, T. Ozawa and Y. Mikami , "Simplified Prediction Method of Stress Intensity Factor in Mid-Thick Plane in 3D Cracked Body and Its Difference from 2D Handbook Formula", J. Test. Eval., 50, 1 (2021) doi

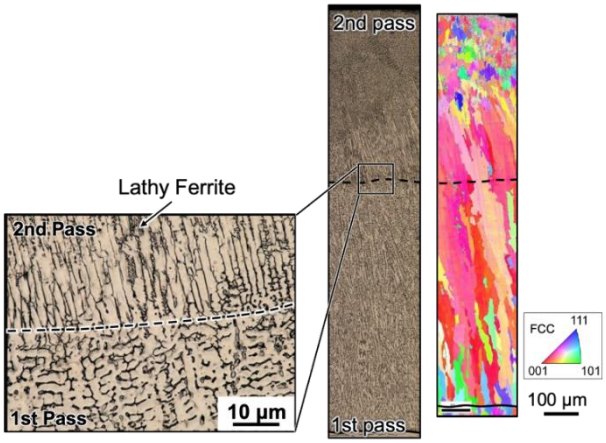
## Research Division of Materials Joining Assessment, Dep. of Reliability Evaluation & Simulation

### *Research summary*

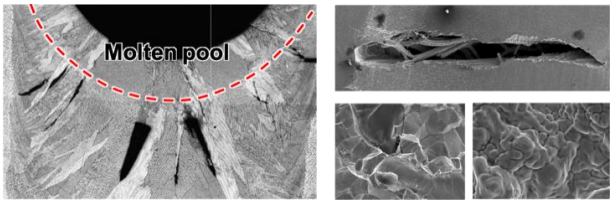
Development of innovative manufacturing technology is required to manufacture high-performance machine products and structures of the next-generation. Department of Reliability Evaluation & Simulation conducts research and education for elucidation and control of the factors on weldment properties by high accurate evaluation based on material science and engineering. In order to create innovative and attractive technique of welding & Joining as a final aim, our department are working on elucidation of metallurgical phenomenon such as solidification and transformation, and on developing the predication method for the microstructures and the properties of weldments.

### *Research subjects*

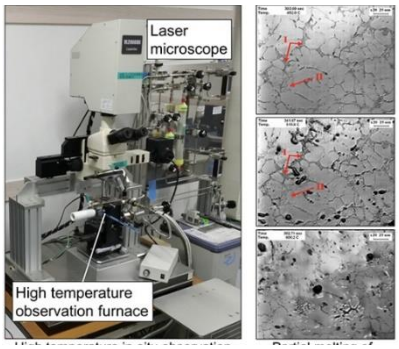
(1) Elucidation for mechanism of microstructural evolution during solidification and solid state in weld metal of stainless steels and carbon steels
(2) Investigation of controlling factor of hot cracking susceptibility and establishment of the prediction technology of the cracking during welding and additive manufacturing
(3) Clarification of influential factors of corrosion resistance of stainless steel welds
(4) Analysis of solidification/transformation behavior and accurate evaluation of hot cracking susceptibility by using In-situ observation technique
(5) Development of improvement technology of properties of weld metal by microstructural control




Control of Lathy ferrite formation in weld metal of austenitic stainless steel




Evaluation and analysis of hot cracking susceptibility test




High temperature in-situ observation by laser microscope

### *Major Papers*

R. Homma, K. Kadoi and H. Inoue, "Effects of Ti and Al on the Formation of Intragranular Ferrites in the Ultra-Low-Oxygen Si-Mn Weld Metals of Low-Carbon Steel", Mater. Today Commun., 29 (2021), 102963. doi

C. Cheng, K. Kadoi, H. Fujii, K. Ushioda and H. Inoue, "Improved Strength and Ductility Balance of Medium-carbon Steel with Chromium and Titanium Fabricated by Friction Stir Welding Process", Mater. Sci. Eng. A., 803 (2021), 140689. doi

M. Sakata, K. Kadoi and H. Inoue, "Acceleration of 475°C Embrittlement in Weld Metal of 22 mass% Cr-duplex Stainless Steel", Mater. Today Commun., 29 (2021), 102800. doi

Z. Zhang, Y. Zhao, J. Shan, A. Wu, Y. Sato, K. Kadoi, H. Inoue, H. Gu and X. Tang, "The Role of Shot Peening on Liquation Cracking in Laser Cladding of K447A Nickel Superalloy Powders Over Its Non-weldable Cast Structure", Mater. Sci. Eng. A., 823 (2021), 141678. doi

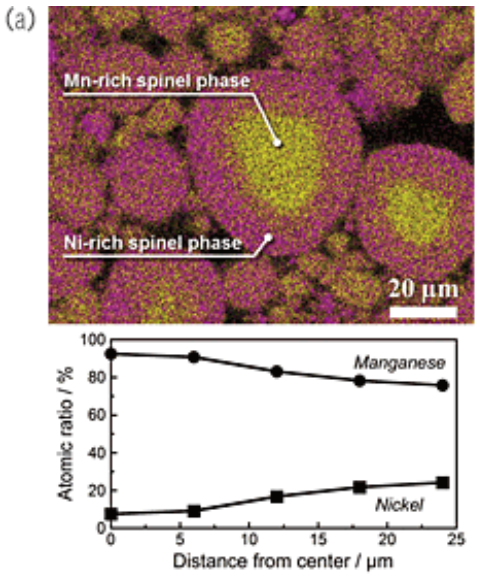
## Smart Processing Research Center, Dep. of Smart Coating Processing

### *Research summary*

This department deals with smart coating processing based on nanoparticle processing, which leads to advanced manufacturing technology as well as safe, security, environmental and energy issues. By making use of new properties of nanoparticles, nanoporous or multi-component films can be created without any heat assistance. Nano and microscale design of particles will lead to high reliability and functional coating films with various kinds of coating processes. Smart coating on the surface of particles will make key materials for new areas such as DDS (Drug Delivery System) or Fuel Cells.

### *Research subjects*

(1) Development of solid-state processing in water vapor for functional fine-particle synthesis
(2) Low temperature synthesis of composite oxide nanoparticles by mechanochemical method
(3) Development of Li ion battery electrodes by controlling their composite structure
(4) Wet processing for composite nanoparticles and their applications for fuel cells
(5) Development of fuel cell electrodes for PEFC and SOFC
(6) Development of low thermal conductivity materials using composite particles
(7) Development of 3D direct-assembly process of nanoparticles
(8) New recycling process of composite materials by bonding and disassembling of their interface




(a) Fabrication of cathode particle with gradient composition for Li ion battery by dry processing

(b) Fabrication of both cathode and anode nanostructure for SOFC by wet processing

### *Major Papers*

T. Kozawa, K. Fukuyama, K. Kushimoto, S. Ishihara, J. Kano, A. Kondo and M. Naito, "Effect of Ball Collision Direction on a Wet Mechanochemical Reaction", Sci. Rep., 11 (2021), 210. doi

T. Kozawa, C. Zhang, T. Uchikoshi, K. Fukuyama, A. Kondo and M. Naito, "Solution-Based Approach for the Continuous Fabrication of Thin Lithium-Ion Battery Electrodes by Wet Mechanochemical Synthesis and Electrophoretic Deposition", Adv. Eng. Mater., 23 (2021), 2100524. doi

A. Kondo, T. Kozawa, T. Ishikawa and M. Naito, "Rapid Synthesis of YAG Phosphor by Facile Mechanical Method", Int. J. Appl. Ceram. Technol. 19, (2021) 681-687. doi

K. Kanai, S. Ozawa, T. Kozawa and M. Naito, "Low Temperature Synthesis of Ga-doped $Li_7La_3Zr_2O_{12}$ Garnet-Type Solid Electrolyte by Mechanical Method", Adv. Powder Technol., 32, 10 (2021), 3860-3868. doi

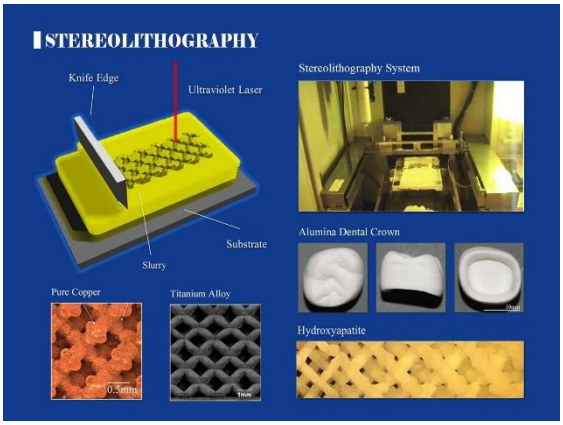
## Smart Processing Research Center, Dep. of Nano/Micro Structure Control

### *Research summary*

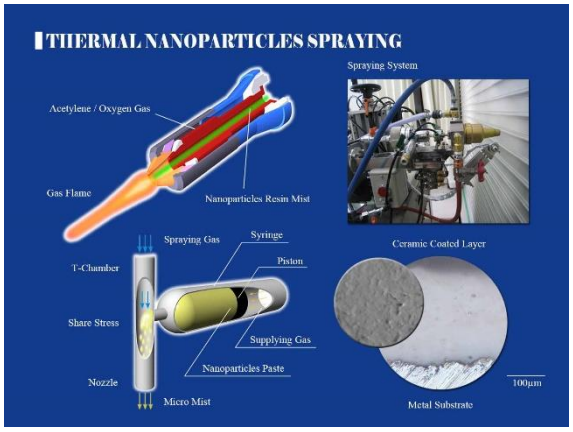
Additive Manufacturing (AM) was newly developed as novel process to create three dimensional (3D) structures through two dimensional (2D) layer laminations. Metal and ceramic nanoparticles were dispersed into resin paste to use for our original process. In lithography techniques, a high power laser beam 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*

S. Kirihara, "Systematic Compounding of Ceramic Pastes in Stereolithographic Additive Manufacturing", Materials, 14, 22 (2021), 1895611-1895945. doi

S. Kirihara, "Stereolithographic Additive Manufacturing of Acoustic Devices with Spatially Modulated Cavities" Int. J. Appl. Ceram. Technol. (2021), 13925-1-13925-8. doi

S. Kirihara, "Stereolithographic Additive Manufacturing of Ceramic Components with Functionally Modulated Structures" Open Ceramics, 5, 100068 (2021), 1-8. doi

M. Takahash and S. Kirihara, "Stereolithographic Additive Manufacturing of Zirconia Electrodes with Dendritic Patterns for Aluminum Smelting" Appl. Sci., 11, 17 (2021), 8168. doi

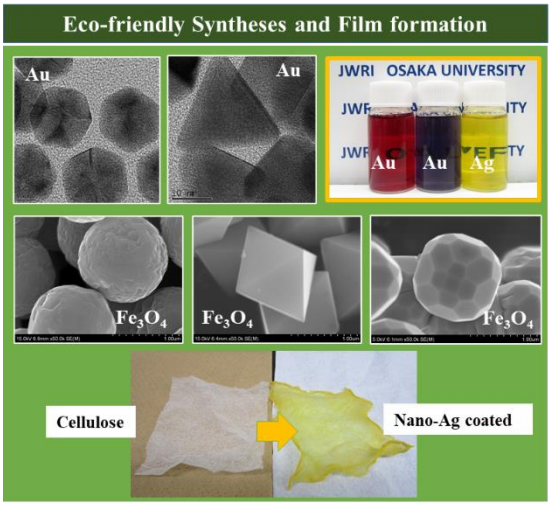
## Smart Processing Research Center, Dep. of Smart Green Processing

### *Research summary*

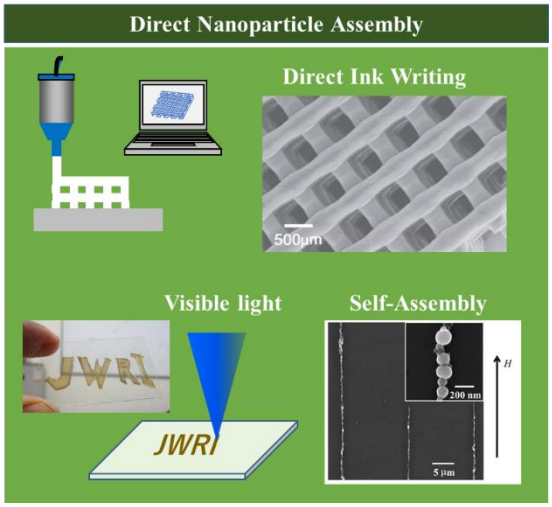
As environmental and energy problems become more serious on a global scale, we are working on research and development of material process technologies and environment-friendly materials that will greatly reduce the environmental load. We recently focus on inorganic nano- and micro-particles as building 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*


Z. Dai, X.-Z. Song, F. Tang, X. Kang, S. Liu, H. Abe, S. Ohara and Z. Tan, "Preparation of 2D Ultrathin Titanium Dioxide Nanosheets with Enhanced Visible-Light Photocatalytic Activity", Micro Nano Lett., 16 (2021), 313-318. doi

L. Zhou, F. Li, J.-X. Liu, S.-K. Sun, Y. Liang and G.-J. Zhang, "High-Entropy $A_2B_2O_7$-type Oxide Ceramics: A Potential Immobilising Matrix for High-Level Radioactive Waste", J. Hazard. Mater., 415 (2021), 125596. doi

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## Hitachi Zosen Advanced Welding Technology Joint Research Chairs

### *Research summary*

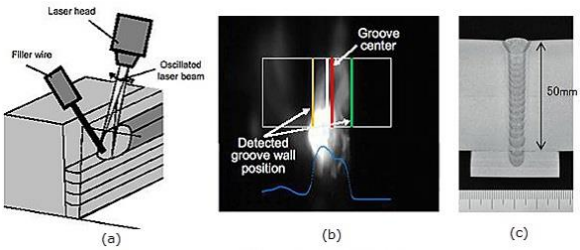
This research chair has been developing welding technology to realize international competitive manufacturing for wide range of thick-plate structures by fusing advanced technologies owned by JWRI and Hitachi Zosen Corporation. It aims to realize smart manufacturing factory.

The high power laser technology for thick plate welding developed in this chair has reached a practical level at the factory. Now, we are developing the foundation of the digital welding technology required at next generation like process simulation technology and waveform controlled the high heat input digital submerged arc welding technology.

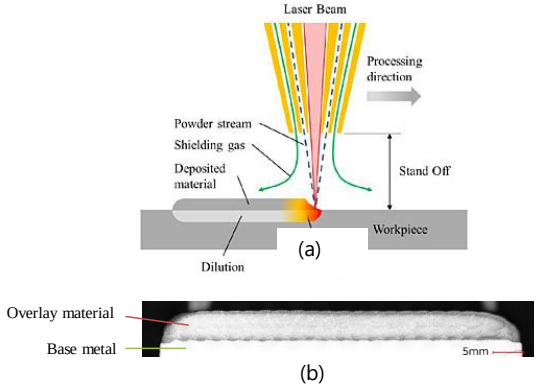
Furthermore, as a new development of laser welding technology, we promote the development of three dimensional overlay welding technology that realizes high wear resistance by utilizing diode laser etc.

### *Research subjects*

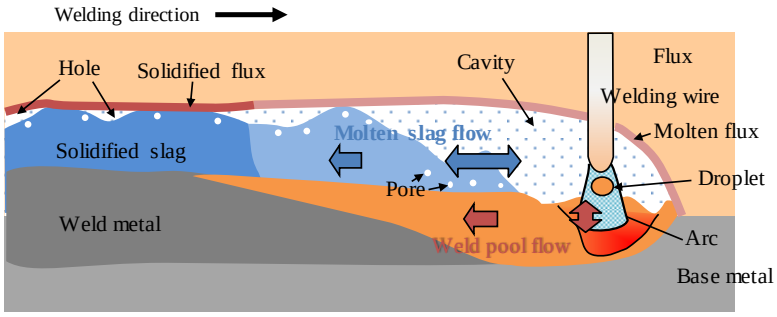
(1) Development of Laser Welding Technology for Thick Plate
(2) Development of High Efficiency SAW Technology
(3) Development of Overlay Welding Technology using Additive Manufacturing
(4) Smart Welding & Manufacturing System



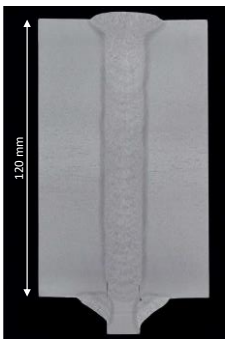

Laser Multi-layer Welding Technology for Thick Plate
(a) Schematic diagram of welding process
(b) Schematic diagram of gap sensing system
(c) Cross section of weld




Overlay Welding Technology using Additive Manufacturing
(a) Schematic diagram of welding process
(b) Cross section of weld




SAW Phenomena




High Efficiency SAW
Cross section of weld

### *Major Papers*


Y. Abe, T. Fujimoto, M. Nakatani, H. Komen, M. Shigeta and M. Tanaka, "High Speed X-ray Observation of Digital Controlled Submerged Arc Welding Phenomena", Sci. Technol. Weld. Join., 26, 4 (2021), 332-340. doi

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## Osaka Fuji "Advanced Functional Processing" Joint Research Chairs

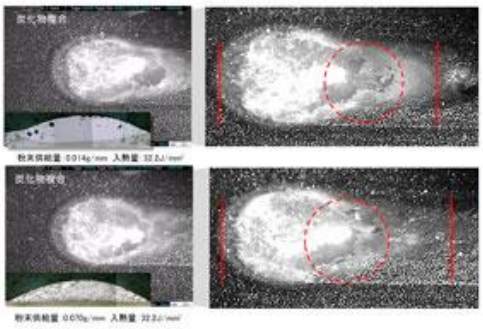
### *Research summary*

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.

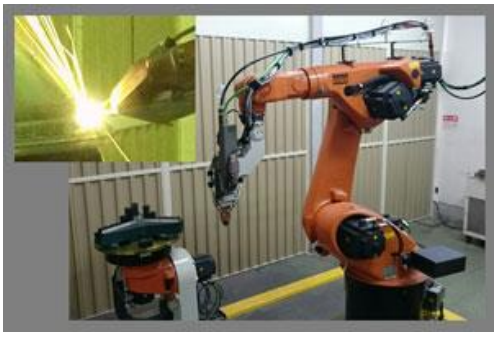
The main purpose is to develop the surface functioning of various materials by laser cladding method, low weldability materials. Finally, these fruits are applied to the next generation of manufacturing technology for various industrial fields.

### *Research subjects*

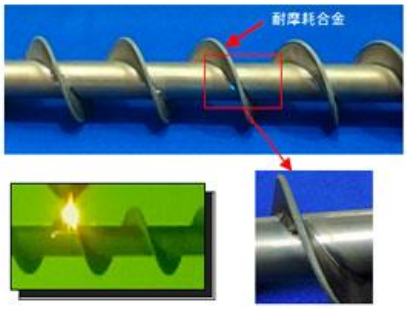
(1) Development of highly functional surface by laser cladding
(2) Development of functional surfaces of small or thin parts
(3) Development of hybrid technology of laser and conventional surfacing technologies
(4) Fundamental research of laser additive manufacturing technology



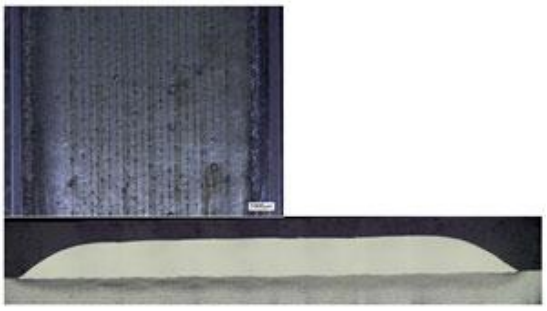
Dynamic observation of molten pool behavior for analysis of blow halls formation using high-speed camera



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*

Y. Sato, K. Ono, K. Takenaka, K. Morimoto, Y. Funada, Y. Yamashita, T. Ohkubo, N. Abe and M. Tsukamoto, “Fabrication of Pure Copper Rod by Multi-beam Laser Metal Deposition with Blue Diode Lasers”, J. Laser Micro Nanoeng., 16, 3 (2021), 189-193. doi

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## Design & Engineering by Joint Inverse Innovation for Materials Architecture – DEJI²MA Project –

### *Research summary*

The Project, Design & Engineering by Joint Inverse Innovation for Materials Architecture - DEJI²MA 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*

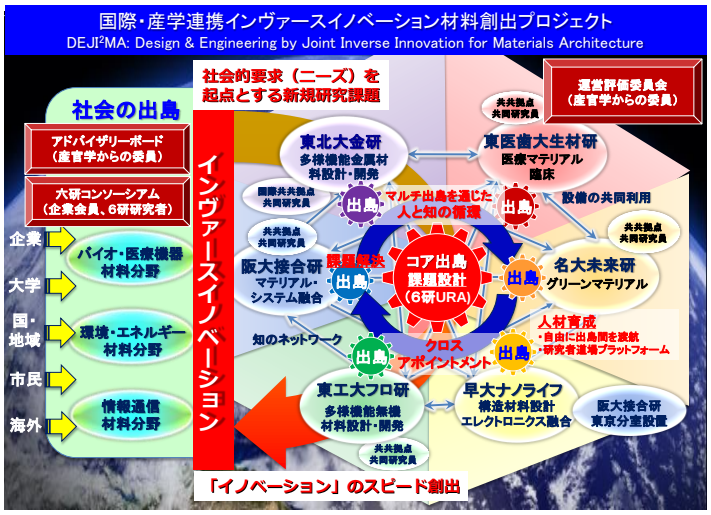
(1) Environmental and Energy Materials
(2) Biomedical and Healthcare Materials
(3) Information and Communication Materials

### *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 ceria nanocubes towards environmental and energy applications
(2) Synthesis and coating of titan oxide nanocrystals towards biomedical applications




Cooperation system of the six research institutes at six universities

### *Major Papers*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M. Ozawa, K. Higuchi, K. Nakamura, M. Hattori, S. Ohara, and S. Arai, "In situ Observation of Catalytic $CeO_2$-Nanocube (100) Surface with Carbon Contamination by Environmental TEM: A Model for Soot Combustion", Jpn. J. Appl. Phys., 60, (2021), SAAC04-1-6. doi

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## Center to Create Research and Educational Hubs for Innovative Manufacturing in Asia


*Summary*

From FY 2013-FY 2017, the project called "Center for the Project to Create Research and Educational Hubs for Innovative Manufacturing in Asia" were implemented to establish new joining and welding technologies, to create research networks, and to cultivate global leaders in the region.

Since FY 2018 namely the second phase, based on the research network established through former activities, the project has been continued to strengthen and obtain higher international competency both in institution wide and in university wide through high quality international collaborative research achieved by having organic cooperation with ASEAN Campus Programme and with Global Knowledge Partners promoted by Osaka University.

As in detail, two pillars are set as follows: 1) Strengthen International Collaborative Research: Increase number of co-authored papers by implementing international collaborative research with overseas universities, establish international joint laboratory, 2) Conduct practical Global Leader Training: Implement Inbound & Outbound Coupling Internship (CIS) takes place both overseas and domestic which is composed of students from different majors and different cultures.

From FY 2020, the CIS starts to award 2 credits for participants. Due to the COVID-19 situation, all activities for the CIS in FY 2021 had been implemented by online, as in FY2020, providing a new type of opportunity for interaction and learnings.


*Activities*

(1) Strengthen International Collaborative Research: Increase number of co-authored papers by implementing international collaborative research, establish international joint laboratory

(2) Conduct practical Global Leader Training: Implement Inbound & Outbound Coupling Internship (CIS) both overseas and domestic which is composed of students from different majors and different cultures.

Table.1 Some major international joint research topics in FY 2021 (Excerpt)

| Partner | Research Topics |
|---|---|
| Xi'an University of Technology: China, King Saud University: Kingdom of Saudi Arabia | Development and Quantification of Strengthening Model for TiC Nano-Precipitation and Carbon-Solution Strengthened Titanium Laminated Composites |
| Shanghai Jiao Tong University: China | Development of Plasma-MIG Hybrid Welding Method |
| Shanghai Jiao Tong University: China | Strength Evaluation of Resistance Spot Welding |
| National Cheng Kung University: Taiwan, Hanoi University of Science and Technology: Vietnam | Search and Characterization of Low Melting Point Alloys for Low Temperature Welding |

Table.2 Some major papers issued in FY 2021 (Excerpt)

| | Papers |
|---|---|
| 1 | A. Bahador, J. Umeda, R. Yamanoglu, A. Amrin, A. Alhazaa, K. Kondoh, Ultrafine-grain formation and improved mechanical properties of novel extruded Ti-Fe-W alloys with complete solid solution of tungsten, Journal of Alloys and Compounds, vol. 875, (2021) |
| 2 | A. Bahador, A. Issariyapat, J. Umeda, R. Yamanoglu, C. Pruncu, A. Amrin, K. Kondoh, Strength–ductility balance of powder metallurgy Ti–2Fe–2W alloy extruded at high-temperature, Journal of Materials Research and Technology, vol. 14, pp. 677-691 (2021). |
| 3 | Y. Ma, S. Niu, H. Liu, Y. Li, N. Ma, Microstructural evolution in friction self-piercing riveted aluminum alloy AA7075-T6 joints, Journal of Materials Science and Technology, vol.82, pp.80-95 (2021) |
| 4 | Y. Ma, Y. Yu, P. Geng, R. Ihara, K. Maeda, R. Suzuki, T. Suga, N. Ma, Fracture modeling of resistance spot welded ultra-high-strength steel considering the effect of liquid metal embrittlement crack, Materials and Design, vol. 210, (2021) |
| 5 | M. Teranishi, M. Katsumata,H. Nishikawa, K. Kondoh, M.Tanaka, The Effects of Career Education in Osaka University Coupling Internship (Analysis of Practical Short-term Overseas Internship Reports), Journal of Global Competency Education, vol.8 No.2, pp.1-12, (2021) |

Table. 3 List of Online Coupling Internship in FY 2021

| Partner Country | Host Company | Partner University |
|---|---|---|
| Thailand | OTC Daihen | Kasetsart University |
| Malaysia | IHI Aioi Workds | Universiti Malaya |
| Vietnam | IHI Infrastructure Asia | Hanoi Univ. of Science and Technology |
| Indonesia | Cilegon Fabricators | Indonesia University |

# CONTRIBUTIONS TO OTHER ORGANIZATIONS

(January 2021 ~ December 2021)

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M. TANAKA
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Weld. World, 65, 4 (2021), 1107-1117.

M. TANAKA
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Proc. 1st Okinawa-Int. Conf. on Welding and Allied Technology (OIC-WA2021), (2021), 16-23.

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A. SHARMA, U. K. MOHANTY, M. TANAKA and T. SUGA
Mechanism of Gap Bridgeability in Lap-Fillet Laser-Arc Hybrid Welding
Laser Manuf. Materi. Process., 8 (2021), 355-371.

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Welding Technol., 69, 10 (2021), 98-100 (in Japanese).

M. TANAKA
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Towards IIW2022 Tokyo with New Style International Conference
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S. CHIKUCHI, M. SHIGETA, H. KOMEN and M. TANAKA
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