Structural Materials for Innovation

SIP-SM4
Structural Materials for Innovation

SIP Cross-ministerial Strategic Innovation Promotion Program

Cross-ministerial Strategic Innovation Promotion Program (SIP)

Introduction to "Structural Materials for Innovation"

Program Director's Introductory Address

SIP (Cross-ministerial Strategic Innovation Promotion Program) was established by the Council for Science, Technology and Innovation (CSTI) of the Cabinet Office in order to realize scientific and technological innovation strategically under its initiative. In SIP, industry-academia-government collaboration is emphasized to link between fundamental scientific research and applied technology development.

SM^4I (Structural Materials for Innovation) is one of the 11 R&D subjects of SIP. Material industry of Japan, especially structural materials, has been the backbone of the whole Japanese industry. However, in addition to the United States and Europe, several emerging countries are catching up, and strengthening the global competitiveness is one of the most important issues of Japan. Besides, from a viewpoint of energy and environment, the reduction of greenhouse gas emission is also a critical issue.

In the project on Structural Materials for Innovation, the R&D target is strong, light, and heat-resistant materials for the application in transportation industry including aircrafts and energy industry and the improvement of energy conversion and usage efficiencies. Furthermore, the great contribution of materials technologies to the development of the aircraft industry of Japan and its related industries is expected.

For the achievement of the above objectives, the following R&D domains on the development of aircraft engines and airframes have been designated.

(A) Polymers and FRP
(B) Heat resistant alloys and intermetallic compounds
(C) Ceramics coatings
(D) Materials integration

As well as R&D, the establishment of research centers and researcher networks for structural materials, capacity building, and international collaboration are also key issues of SM^4I.

Your support for SM^4I is greatly appreciated.

Program Director
Teruo KISHI, Prof.
Prof.Emeritus
The Univ. of Tokyo
Former President, NIMS

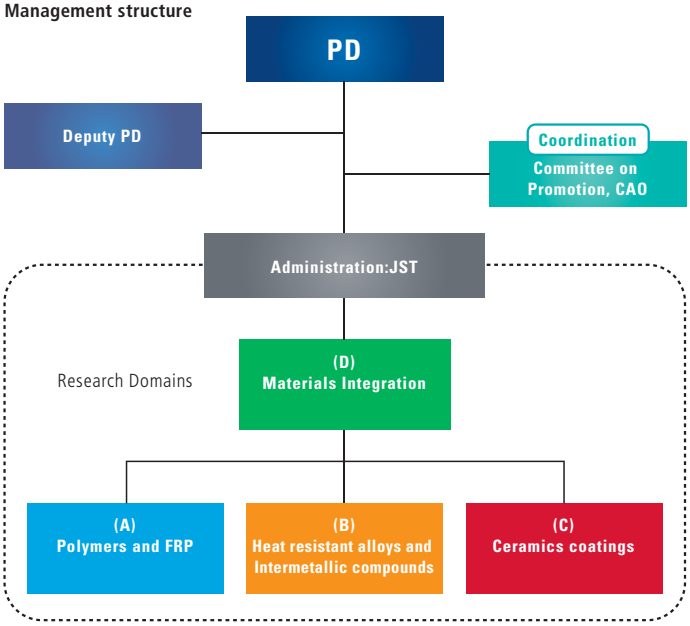
Outline

- PD Teruo Kishi (Professor Emeritus, The University of Tokyo)
- Deputy PD Yutaka Kagawa (Professor, The University of Tokyo)
  Chiaki Tanaka (Advisor, Toray Industries, Inc.)
  Yasuo Kitaoka (Professor, Osaka University)
- Administrative Institution Japan Science and Technology Agency
- Research domains
  (A) Polymers and FRP
  (B) Heat resistant alloys and intermetallic compounds
  (C) Ceramics coatings
  (D) Materials integration
- Number of members 77(FY2016)
  (industry: 29, university: 39, public (non-profit) institution: 9
- Implementation period FY2014～2018
- Annual budget 3.690 billion JPY for FY2016

CAO SIP website
http://www8.cao.go.jp/cstp/gaiyo/sip/

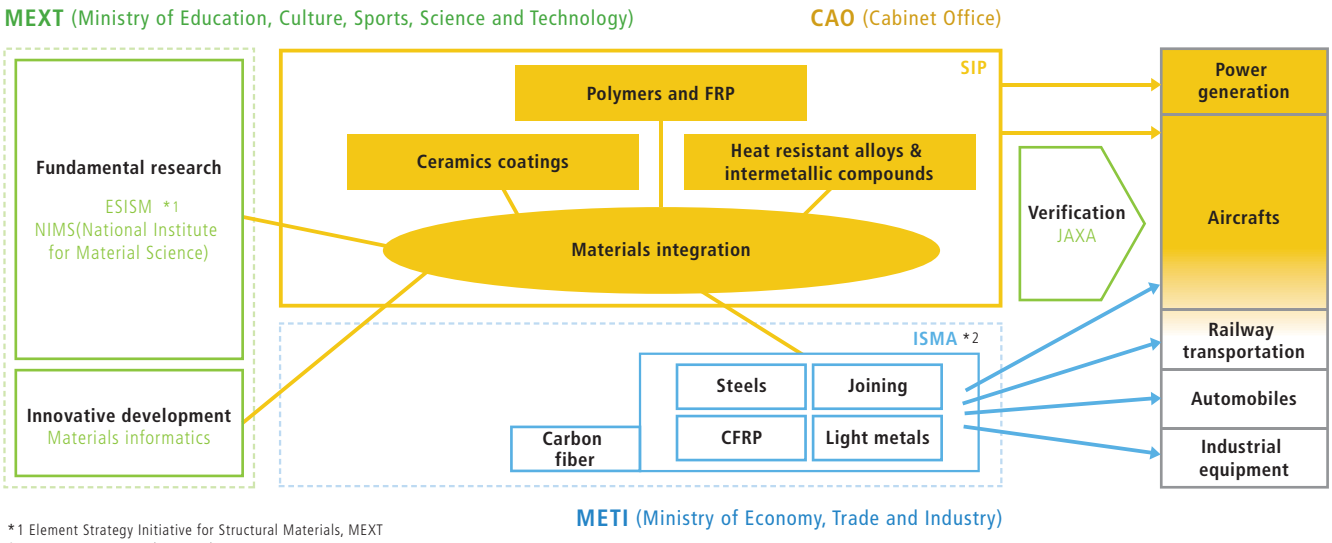
JST SIP website
http://www.jst.go.jp/sip/

Management structure



SIP-SM⁴I
Structural Materials for Innovation

Framework for Structural Materials Research Supported by the Government of Japan



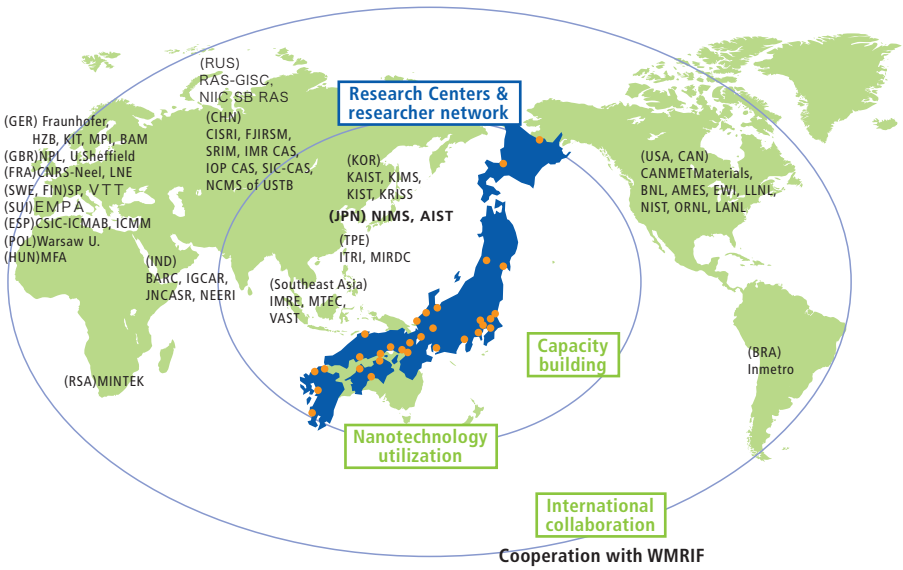
*1 Element Strategy Initiative for Structural Materials, MEXT
*2 Innovative Structural Material Association, 2014～, NEDO-METI

Establishment of Research Centers and Researcher Network and Capacity Building

Research centers and researcher network covering are being established for the sustainable materials research in Japan even after the SIP-SM⁴I Project is completed. On this basis, advanced nano-scale characterization technologies utilization for breakthrough of unsolved issues, capacity building for young scientists, and international collaboration by cooperating with WMRIF* are being promoted.

Required Functions of Research Centers

- Core Competence: forging simulators (1,500 ton), MI system, CFRP performance evaluation technologies, ceramics coating technologies, etc.
- Industry-academia-government R&D collaboration
  - •Supporting researcher network (portal site, etc.)
  - •Organizing symposia and workshops
  - •Strategy and management of intellectual property rights, survey, benchmarking, etc.
- Organizing capacity building programs
- Organizing international collaboration



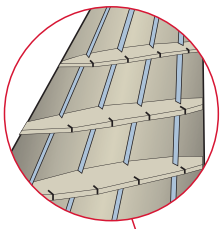
*WMRIF: World Materials Research Institute Forum
The Meeting of 15 directors of national materials research institutes from 8 countries was organized by NIMS in 2005, and the forum was founded to promote networking, research collaboration, capacity building, and benchmarking among the member institutes. As of 2014, 50 institutes from 21 countries are members.

Development of Polymer Based Materials and Fiber Reinforced Plastics (FRP)

- Alternative to the existing autoclave method, development of material and its application technologies for structural members (tail etc.) with high-quality(toughness), low-production cost and high-productivity. And development of low-cost and high-quality (toughness) prepreg aiming at the application of the main structural members (main wing, airframe etc.).
- Weight savings of aero engine parts through development of heat resistant and impact resistant thermoplastic matrix prepregs and their manufacturing technology, and development of parts manufacturing technology with heat resistant thermosetting resin matrix composites.
- Monitoring technology of curing process, quality assurance technology and contactless and nondestructive inspection technology.

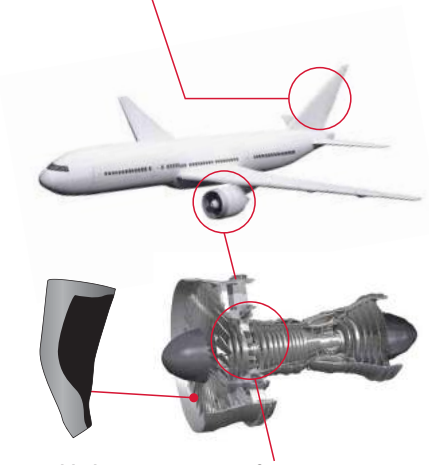
PMC;Polymer Matrix Composites

Applied materials parts



Tail skin

Advanced cost-saving and productive molding technology replacing autoclave molding technology

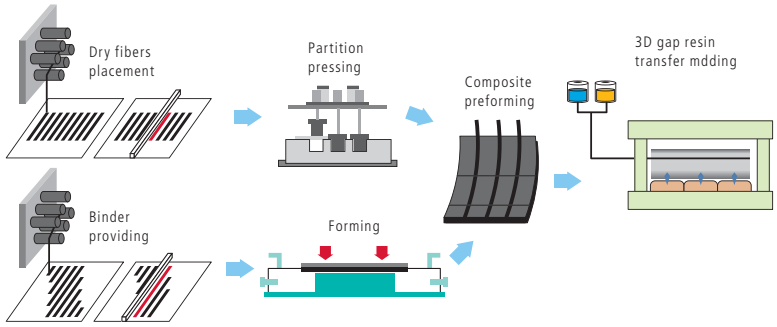


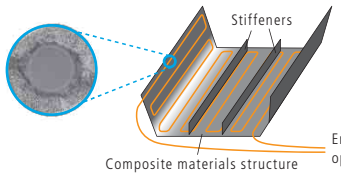
Fan blade **Inner frame**

Light weight, cost saving and increase in domestic production ratio.
Advanced prepreg (heat and impact resistant properties) and processing technologies.

Materials processing and Technology

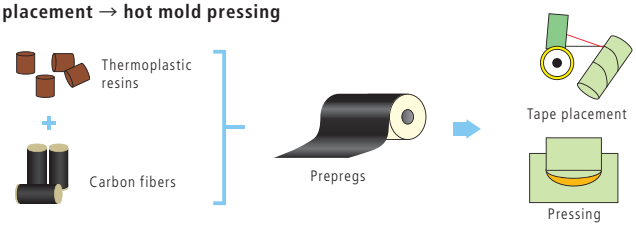
- to place carbon fibers → apply binders → composite preform forming → forming by 3D-gap RTM

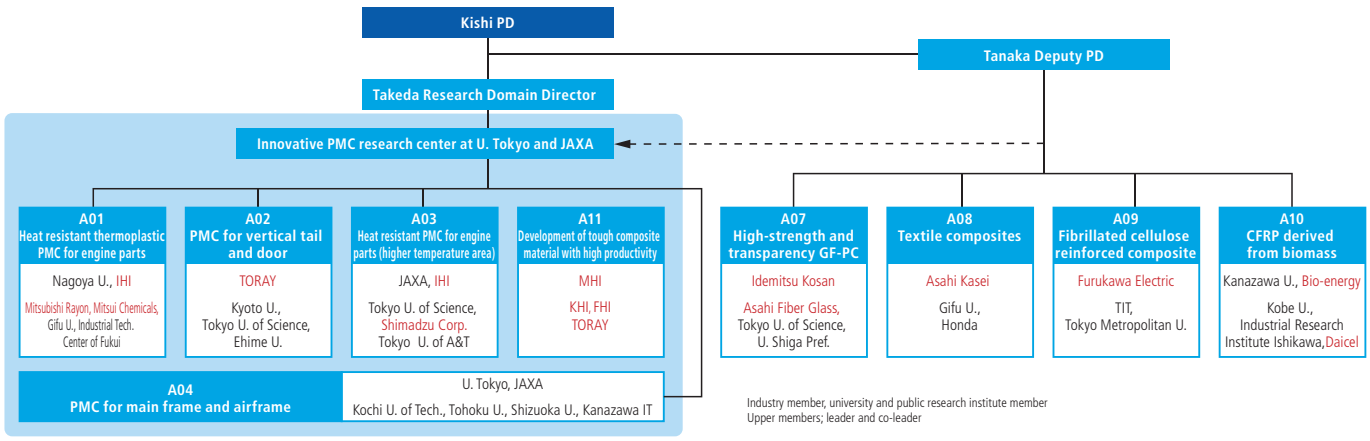




- In-situ measurement of temperature, strain etc. by embedded optical fiber → increase in inspection performance and reliability

- Prepregs impregnate thermo-plastic polymers into carbon fibers → tape placement → hot mold pressing

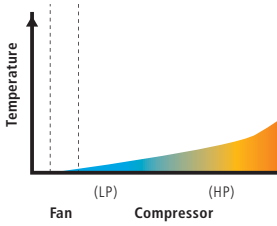




Industry member, university and public research institute member
Upper members; leader and co-leader

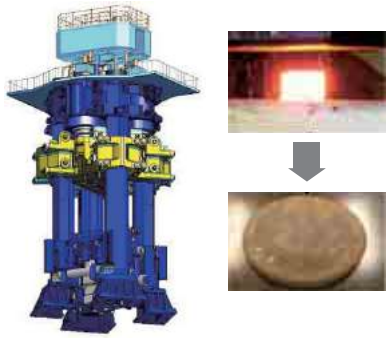
Development of Innovative Technology of High Temperature Ti- and Ni-based Alloys and TiAl-Intermetallic Compounds

- Innovative large-scale and practical forging technology using computer simulation and material data base for Ti- and Ni-based alloys which are key materials in aero engines and power generation turbines.
- Laser metal deposition with excellent workability and productivity, and metal injection molding with high dimensional accuracy and fatigue performance, both of technologies being applied to key components of aircrafts and turbines.
- Fundamental technology of Ti- and Ni-based alloys for new alloy design.
- Material designing, casting and forging technologies of TiAl-intermetallic compounds for high-pressure compressor and low-pressure turbine blades.



Materials processing and technology

Forging technology



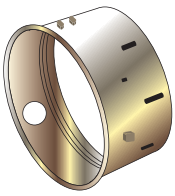
Melting technology

Consistent process technology development from melting to manufacturing

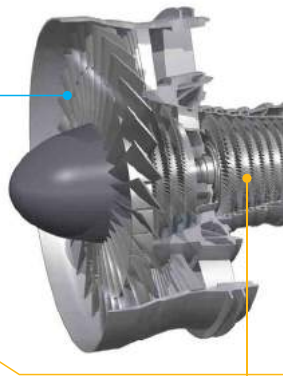
Casting technology

Applied materials parts

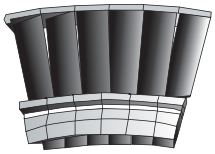
Ti-Alloys



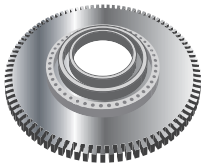
Fan Case
Near-net shape forming by laser powder metal deposition or metal injection molding



Ti- and Ni-Based Alloy



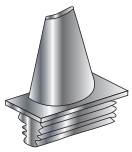
Compressor and Turbine Stator Vane



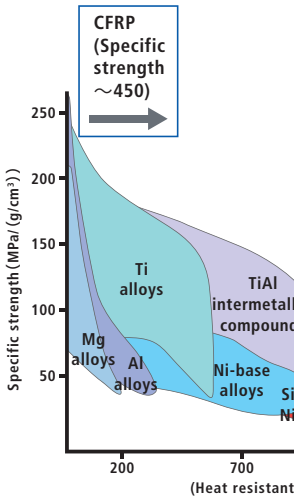
Compressor and Turbine Disk

TiAl-intermetallic compounds

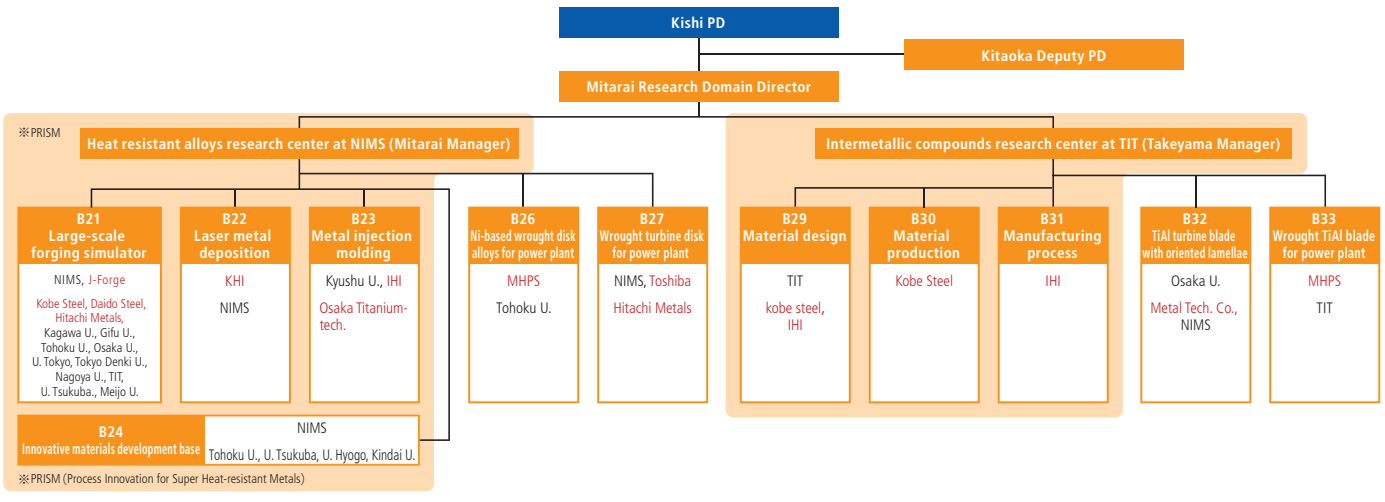
Low Pressure Turbine Rotor Blade
Near-net shape casting



High Pressure Compressor Rotor Blade
High-speed forging without temperature controller



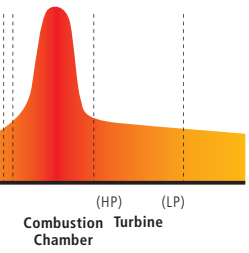
Heat Resistance of

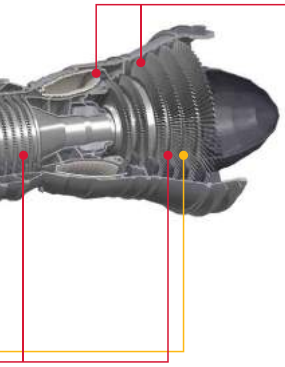


Development of Ceramic Environmental Barrier Coating

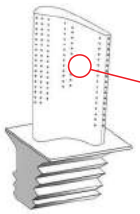
■ Environmental barrier coating (EBC) protects the surface of heat-resistant and light-weight ceramic components from harsh external environmental for long-term use. Development of EBC technology is necessary for the practical application of the ceramic components expected to contribute significantly to improve fuel efficiency and reducing CO_2 emissions from aircraft jet engines.

■ EBC technology is applicable to the production of the light-weight ceramic components with high toughness and heat resistibility.



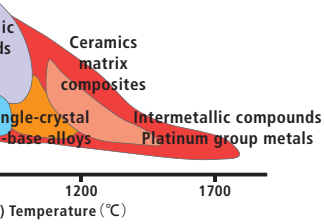


Heat-resistant & light-weight ceramics parts



Liner in combustion chamber
High-pressure turbine
(blade, vane, shroud)
oxygen and water-vapor
at high temperatures

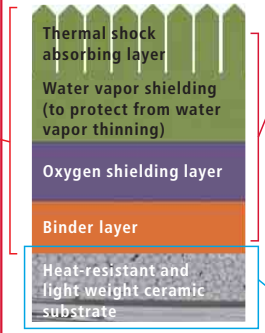
Development of EBC (Environmental Barrier Coating) is indispensable for long-time use and protection of the ceramics.



Target Materials

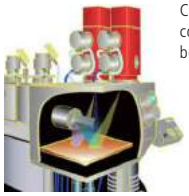
Material processing and technology

Coating design and deposition process

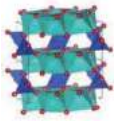


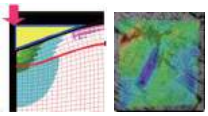
Environmental shielding design
Oxygen and water vapor at 1400℃

Environmental barrier coating



Controlling of EBC structure and composition of the layer by electron beam PVD





Analysis and evaluation of EBC by thermomechanical durability

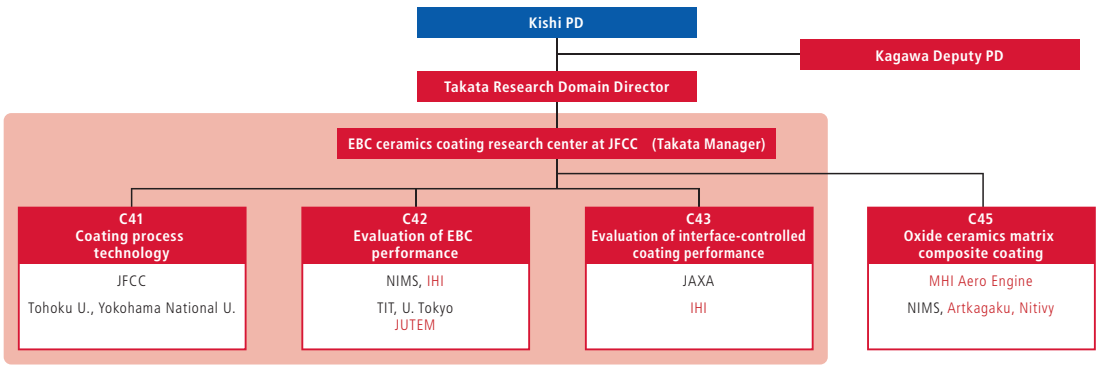
Interface-controlled coating

Analysis and evaluation of Interface-controlled coating by mechanical and damage tolerance properties

Laser CVD, etc.

Evaluation of coating

Evaluation of applicability to actual equipment by thermal cycling with combustion gas

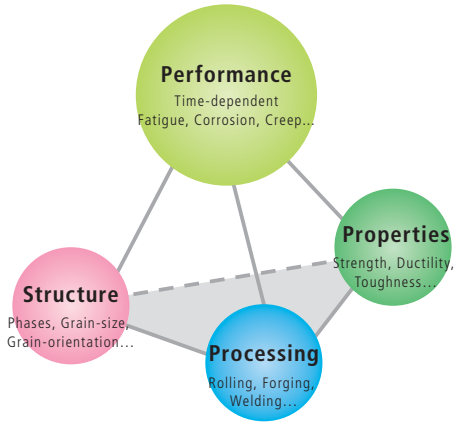


Materials Integration (MI)

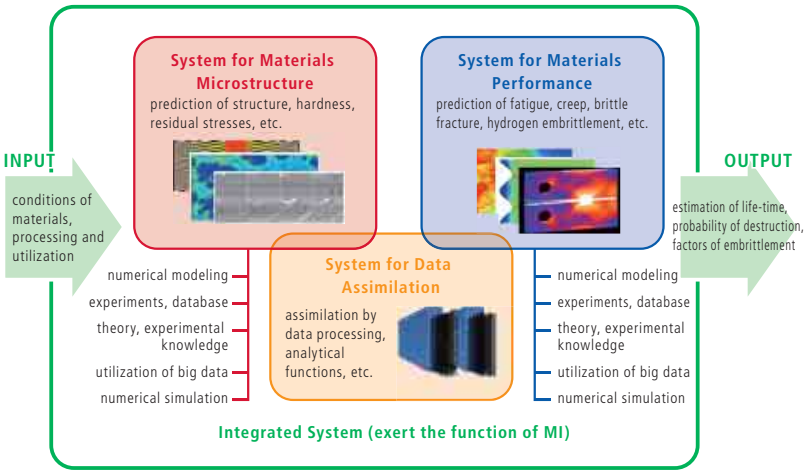
Materials Integration system is an infrastructure to support and to accelerate developments of advanced materials from engineering viewpoint by utilizing accumulated theoretical and practical knowledge of materials science, and by integrating advanced technologies such as database, experiment, computational simulation, big data analysis, and so on.

Main subjects of Materials Integration system are to contribute to the large reduction of development time and cost, to optimization of the selection of materials and processes, to improvements of the reliability prediction, to the reduction of diagnosis and maintenance cost. We are going to develop Materials Integration systems for metallic, polymeric and ceramic materials, and also aiming to establish R&D center, capacity building and global network.

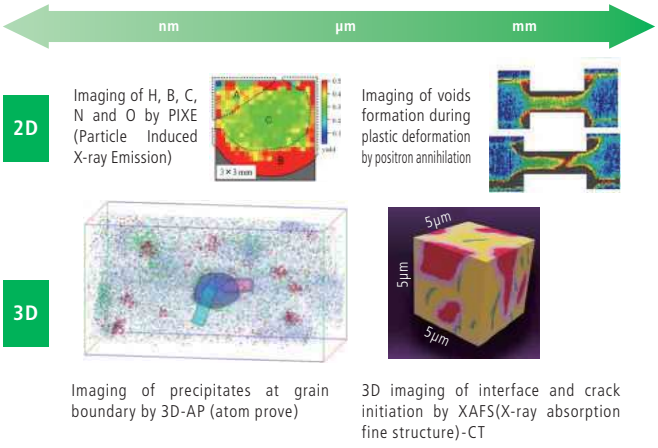
MI; Integration of theories, experiments, computation and data



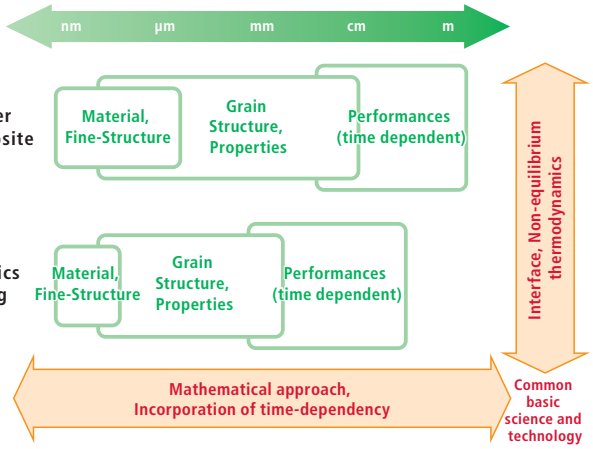
MI for Metals (weld joint of HSS is implemented in advance as a typical challenge)

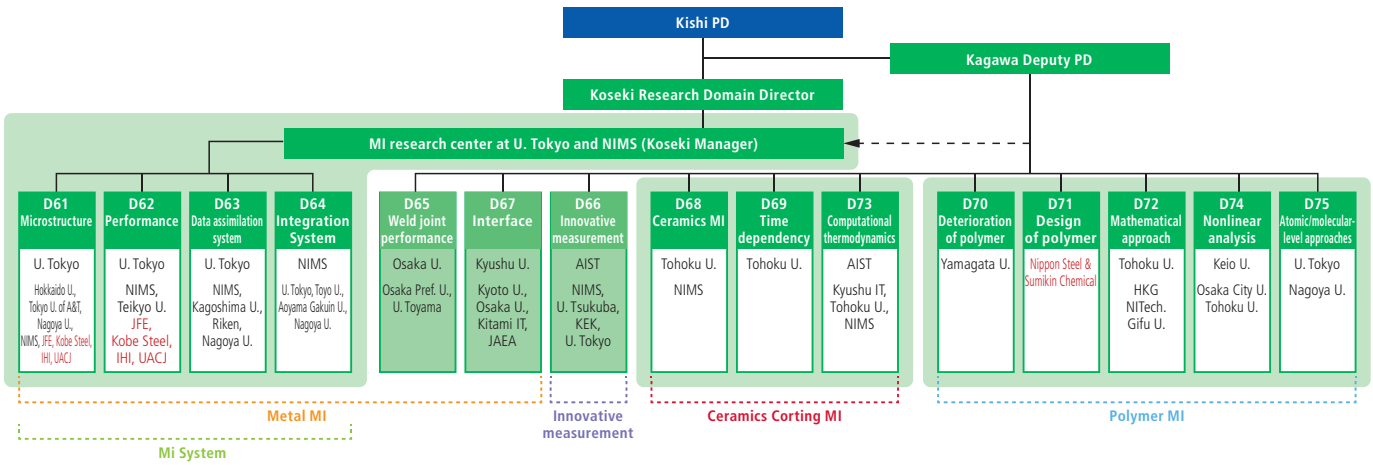


Prediction of life-times or performances by innovative measurement and analysis for structural materials (SIP-IMASM)



MI for Various Structural Materials





SIP-SM4I

Structural Materials for Innovation

Department of Innovation Platform
Japan Science and Technology Agency(JST)
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http://www.jst.go.jp/sip/k03.html

2016.6

List of Research Projects

Development of Polymer Based Materials and Fiber Reinforced Plastics (FRP)

	No.	Research Project	Research Unit	Unit Leader
Project at research center	A01	Development of Innovative Manufacturing Process and Quality Assurance Technology of Highly Productive Polymer Matrix Composites for Aircraft (Innovative Aircraft PMC)	Thermoplastic Composites for Aero-engines	Masahiro Arai (Nagoya Univ.) katsuyoshi Moriya (IHI Co.)
	A02		Highly Productive and Innovative non-autoclave CFRP Production Technologies	Makoto Endo (Toray Industries, Inc.)
	A03		High Temperatrue Polymer Matrix Composites	Yuichi Ishida (JAXA) katsuyoshi Moriya (IHI Co.)
	A04		Fundamental Study of Process Monitoring and Modeling	◎○ Nobuo Takeda (Univ. Tokyo) Yutaka Iwahori (JAXA)
	A11	Development of tough composite material with high productivity		Abe Toshio (Mitsubishi Heavy Industries, Ltd.)
Unit Project	A07	Development of High-strength and High-transparency GF-PC Composite		Shinobu Yamao (Idemitsu Kosan Co., Ltd.)
	A08	Textile Composites for Structural Materials		Sadahiko Yamaguchi (Asahi Kasei Co.)
	A09	Development of Fibrillated Cellulose Reinforced Composite		Yasuo Nakajima (Furukawa Electric Co., Ltd.)
	A10	Development of Carbon Fiber Reinforced Plastic Derived from Plant Biomass		Kazuaki Ninomiya (Kanazawa Univ.) Shinji Hama (Bio-energy Co.)

Director of research domain：Nobuo Takeda (Univ. Tokyo) ◎：Director of research domain ○：Manager of Reserch Center

Development of Innovative Technology of High Temperature Ti- and Ni-based Alloys and TiAl-Intermetallic Compounds

	No.	Research Project	Research Unit	Unit Leader
Project at research center	B21	Process Innovation for Super Heat-resistant Metals (PRISM)	Development of Innovative Forging Process Technology and Construction of Material/Process Database with the Large-scale and Precise Forging Simulator	◎○ Yoko Mitarai (NIMS) Shinya Ishigai (Japan Aeroforge,Ltd.)
	B22		Development of Innovative Production Technology Utilizing Laser Metal Deposition for Aero Engine Components	Kenichiro Igashira (Kawasaki Heavy Industries, Ltd.)
	B23		Development of Metal Injection Molding Process Technique for Aero Engine Components	Hideshi Miura (Kyushu Univ.) Hiroshi Kuroki (IHI Co.)
	B24		Development of Elemental Technology for New Alloy Design	◎○ Yoko Mitarai (NIMS)
Unit Project	B26	Development of Practical Forming Process Technology for High Strength Ni-Based Wrought Disk Alloys		Shinya Imano (Mitsubishi Hitachi Power Systems, Ltd.)
	B27	Development of Large Scale and High Strength Wrought Turbine Disk Components for Steam Power Generation		Kazuhiro Kimura (NIMS) Takahiro Kubo (Toshiba Co.)
Project at research center	B29	Innovative Design and Production Technology of Novel TiAl Alloys for Jet-engine Applications	Design Principle of Microstructure and Processing for Innovative TiAl Alloys	○ Masao Takeyama (Tokyo Institute of Technology)
	B30		Development of New Manufacturing Process for High Quality and Low Cost TiAl Ingot	Koichi Sakamoto (Kobe Steel,Ltd.)
	B31		Development of Innovative Manufacturing Process for TiAl Blade	Satoshi Takahashi (IHI Co.)
Unit Project	B32	Development of Manufacturing Technique for TiAl Turbine Blade with Oriented Lamellae		Hiroyuki Yasuda (Osaka Univ.)
	B33	Development of Wrought TiAl Alloy Blade for Steam Power Generation		Jun Sato (Mitsubishi Hitachi Power Systems, Ltd.)

Director of research domain：Yoko Mitarai (NIMS) ◎：Director of research domain ○：Manager of Reserch Center

Development of Ceramic Environmental Barrier Coating

	No.	Research Project	Research Unit	Unit Leader
Project at research center	C41	Structural Optimization and Reliability Improvement of Ceramic Environmental Barrier Coating	Development of Coating Processes	◎○ Masasuke Takata (JFCC)
	C42		Evaluation Analysis of EBC Performance	Takeshi Nakamura (IHI Co.) Hideki Kakisawa (NIMS)
	C43		Evaluation Analysis of Interface-controlled Coating Performance	Ken Goto (JAXA)
Unit Project	C45	Development on the oxide ceramics matrix composite coating sheet		Masanori Ushida (Mitsubishi Heavy Industries Aero Engines, Ltd.)

Director of research domain：Masasuke Takata (JFCC) ◎：Director of research domain ○：Manager of Reserch Center

Materials Integration (MI)

	No.	Research Project	Research Unit	Unit Leader
Project at research center	D61	Development of Materials Integration System	Development of System for Materials Microstructure	◎○ Toshihiko Koseki (Univ. Tokyo)
	D62		Development of System for Materials Performance	Manabu Enoki (Univ. Tokyo)
	D63		Development of System for Data Assimilation (Metal MI)	Junya Inoue (Univ. Tokyo)
	D64		Development of Intergrated System	Makoto Watanabe (NIMS)
Project at research center	D65	Development of Simulation Technique for Performance Assurance of Weld Joints		○ Akio Hirose (Osaka Univ.)
Project at research center	D67	Fundamental Research Focusing on Interface for Overcoming Unsolved Issues in Structural Materials		○ Kaneaki Tsuzaki (Kyushu Univ.)
Project at research center	D66	Innovative Measurement and Analysis for Structural Materials (IMASM)		○ Masataka Ohkubo (AIST)
Unit Project	D68	Development of Simulation for Mass Transfer at High Temperature and Time Dependent Behavior of Microstructure	(Ceramics Corting MI)	Hideaki Matsubara (Tohoku Univ.)
	D69	Development of Computational Tools to Predict Time Dependent Phenomena in Structural Materials		Tetsuo Mohri (Tohoku Univ.)
	D73	Establishment of Domestic Technology base for Computational Thermodynamics for Development of Advanced Structural Materials		Kazuhisa Shobu (AIST)
	D70	Development of Prediction Tools for Long-term Properties of High Performance Engineering Plastics	(Polymer MI)	Takashi Kuriyama (Yamagata Univ.)
	D71	Development of Practical Optimal Design and Comprehensive Evaluation Support Tool for Advanced Structural Polymer Materials		Shin-etsu Fujimoto (Nippon Steel & Sumikin Chemical)
	D72	Mathematical Approach Toward Materials Integration and its Applications		Yasumasa Nishiura (Tohoku Univ.)
	D74	Performance prediction for polymers by nonlinear analysis		Kazuyuki Shizawa (Keio Univ.)
	D75	Atomic/molecular-level approaches for designing novel polymeric materials		Takefumi Yamashita (Univ. Tokyo)

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