Progress Plan for Maintaining Academy Center Certification
World Premier International Research Center Initiative (WPI)

Host Institution	National Institute for Materials Science (NIMS)
Research Center	International Center for Materials Nanoarchitectonics
Host Institution Head	Kazuhito Hashimoto
Center Director	Takashi Taniguchi
Administrative Director	Tomonobu Nakayama

Please prepare this application based on the content of your center's progress report and the progress plan you submitted for the center's final evaluation. Summarize the center's future plans with regard to the following 6 items within three A-4 pages. (Also fill out the appendices at the end of this form.)

1. Overall Image of Your Center

* Describe the Center's overall image including its current identity.

1-1. MANA background

When MANA was established, nanotechnology (and the nanoscience on which it is based) was in a state of rapid development globally and becoming an essential part of materials science. It was in this context that we designed MANA with the intention of creating a world-class research center that would effectively employ nanotechnology to make powerful advances in the research and development of new materials. In designing MANA, we were strongly aware of the common mistake of considering nanotechnology to be a continuation of conventional microtechnology, and moreover that nanotechnology's true power cannot be effectively harnessed unless nanotechnology is properly recognized as being qualitatively different from microtechnology. The concept of "nanoarchitectonics" was proposed as a straightforward expression of these truths. Nanoarchitectonics is a new technological paradigm built on the following four primary pillars:

1) Create *reliable* nanomaterials or nanosystems by organizing nanoscale structures (nano-parts) even with some unavoidable *unreliability*. "Unreliability-tolerant reliability"
2) Note that the *main players* are not individual nanoparts but *their interactions*, which cause a new functionality to emerge. "From nano-functionality to nanosystem-functionality"
3) Recognize unexpected *emergent functionalities* that can result from assembling or organizing *a huge number of nanoparts*. "More is different"
4) Create *a new theoretical field* where conventional first principles computations are combined with novel *bold approximations*. "Truth can be described with plain words"

The concept of nanoarchitectonics is a distinguishing part of MANA's research and makes MANA unparalleled among the world's nanotechnology research institutions.

1-2. MANA: Vision, missions, and organization

MANA's guiding vision is "Toward a better global future, we pioneer a new paradigm in materials development on the basis of nanoarchitectonics concept.

The previously proposed four missions are now reformed into the following three missions in place to achieve this vision:

1. World-leading scientific excellence and recognition in new materials development, based on nanoarchitectonics: Fusion of interdisciplinary research fields to open up new research fields.
2. Culturing global research environment and an international research collaboration network.
3. Fostering next-generation young research leaders.

1-3. MANA today

Founded on the concept of nanoarchitectonics, today MANA has grown into a world-class research center that produces much ground-breaking research and attracts global attention.

The present state of MANA can be summarized by the following five points:

★ World-class research activities

★ International character due to nearly half of researchers being of foreign nationality
★ Active fusion research that combines nanotechnology and other fields
★ Steadily fulfilling its responsibility to reform its host institution, NIMS
★ Training excellent young researchers who work throughout the world

2. Research Activities

* Describe how the center will challenge new research fields and adopt new strategies.

2-1. Research Results to Date

MANA was established for the purpose of establishing a new nanotechnology paradigm based on the concept of nanoarchitectonics, and to bring about innovation in new materials development through this paradigm. These objectives are steadily being accomplished. In reality, a number of concepts based on nanoarchitectonics have emerged from MANA's research, including soft chemical nanoarchitectonics, interface nanoarchitectonics, neuromorphic nanoarchitectonics, topological nanoarchitectonics, and in-vivo nanoarchitectonics. Research based on these topics is steadily progressing.

Here, we describe MANA's results by several key indicators. In the period of 2007-2020, MANA has published 5,892 papers till the end of 2020 and, among these, A) 193 of MANA's papers are now among the top 1% most cited papers in the world (2007-2020); B) The number of internationally coauthored papers are 3,195 (47.6 % of published papers in 2008-2016 and 66.6 % in 2017-2020); and C) MANA's papers are printed in journals with an extremely high average Impact Factor (IF) of 7.98 (most recent average expected for 2020). MANA's scores for these indicators are superior to those of many world-class research institutions.

2-2. Research plan towards the future

MANA will generally continue to maintain and develop the present direction of research in the future, but it will attempt the following new developments. After analyzing MANA's research accomplishments thus far, the efficacy of two areas was brought into sharp relief: the fusion of "theoretical research and experimental research", and the creation of nanoarchitectonic perception by merging "nanotechnology", "atomic/molecular science", "informatics" and "mathematics". Therefore, these two fusional areas will be the focus of intensive research in the future. In addition to the above areas, MANA will further strengthen a functionality-oriented research area by setting a new grand challenge, "Quantum nanoarchitectonics". Since MANA has developed a variety of nanomaterials and related characterization techniques, combining various nanomaterials and structures can be tackled to provide quantum functionalities through nanoarchitectonic systems, which has been so far lacking in previous research and development because quantum mechanical phenomena have been studied and explored mainly as a part of physics research.

MANA's research was divided into five fields: Nano-Materials, Nano-System, Nano-Power, Nano-Life and Nano-Theory, and n reformed into three fundamental fields: Nano-Materials, Nano-System, Nano-Theory in 2017. This simplification gives more freedom to create new ideas based on "Nanoarchitectonics" towards the future. Regarding a newly launched NIMS's "Quantum Materials" project of NIMS, MANA will take a leadership of the project but will seek for ground-breaking outcomes with higher-level of directions by taking actions toward quantum nanoarchitectonics.

The Nano-Theory field will further empower MANA to effectively utilize some of the world's most advanced computers (FUGAKU-computer, etc.). However, one of MANA's most important objectives is to lead the world to a new paradigm of theoretical research that is free from a prioritization of first-principles calculations over all else. Despite the fact that many interesting nanoscale phenomena are accompanied by excited states, dynamic processes, and many-body effects, contemporary methods of first-principles calculation are not necessarily good at handling these elements. To overcome this obstacle, MANA will introduce bold yet appropriate methods of approximation to inspire new developments in theoretical research. Further, this will serve to promote the fusion of theoretical and experimental research. Moreover, not only will the field of Nano-Theory serve to fuse theory and experimentation, it will also play a role in promoting interdisciplinary fusion research among MANA's other two fields of research, both of which have experimental research at their core.

Although MANA's research has thus far been conducted, in accordance with the WPI program's basic policy, under the leadership of the former Director Masakazu Aono, Dr. Takayoshi Sasaki (MANA PI of Nano-Materials Field, Fellow of NIMS), has taken over the Director position from April 1st, 2017.

2-3. MANA's Grand Challenge research themes

MANA has had four Grand Challenge research targets thus far:

★ **Nanoarchitectonic artificial brain (since 2007)**
★ **Room-temperature superconductivity (since 2007)**
★ **Practical artificial photosynthesis (since 2007)**
★ **Nanoarchitectonic perception systems (since 2017)**

MANA will raise the fifth Grand Challenge target as follows.

★ **Quantum nanoarchitectonics (since 2021):** This target is to establish materials science and technology to control coherence/decoherence and to transfer/transduce quantum information using nanoscale materials and systems comprising of them. Building fully quantum-based information processing systems is one of demanded ways to overcome social problems arising from huge energy consumption. To achieve this target, MANA will synthesize nanomaterials providing controllable quantum effects and will explore advanced nanoarchitectonics for achieving functional binding between nanocomponents to manipulate and manifest quantized information.

2-4. Research in the fields of Nano-Materials, Nano-System, and Nano-Theory

In the present three research fields, clear distinctions were made between clear opposites: e.g., fundamental vs. applied research, materials vs. systems, and experimental vs. theoretical. Below are representative examples of the challenging research that will be undertaken in these three fields.

Nano-Materials field: This field aims to exploit the science and technology for the creation of new nanosheet-based materials that MANA has accumulated to date to realize metamaterials (e.g. a material not found in nature that possesses a negative refractive index) and room-temperature superconducting devices by using nanosheets with massive electric permittivity, etc. MANA will also develop more novel nano-measurement methods to support these kinds of research projects.

Nano-System field: This field aims to use a network of atomic switches to realize the basic unit of a nanoarchitectonic artificial brain; to achieve the world's first truly monomolecular device; to develop a new, decoherence-free quantum bit using topological insulators and other quantum materials; to develop a room temperature superconducting device etc. MANA will also promote the novel methodologies including multiple-probe SPMs and others not yet established for evaluating nanosystems.

Nano-Theory field: As mentioned above in "Fusion of theoretical and experimental research," MANA aims to develop new theoretical research techniques driven by rare event sampling instead of the high-level first-principles calculations performed on the world's fastest supercomputer like K-computer. MANA will promote the fusion of theory and experimentation in a wide range of research, including theoretical research into the latest topological insulators.

3. System for Managing the Research Organization

* Describe the research organization and management system that the center will use to carry out the research strategy and plan described above.
* In Appendix 1-3, list the Principle Investigators, enter the number of center personnel, and provide a diagram of the center's management system.

MANA has already implemented structural reforms based on the following key points:

i) From April 2021 Dr. Takashi Taniguchi becomes the new Director of NIMS-MANA while Dr. Takayoshi Sasaki remains as the Director of WPI-MANA till completing smooth transfer WPI-MANA from Dr. Sasaki to Dr. Taniguchi. Deputy Directors of NIMS- and WPI-MANA are Dr. Tomonobu Nakayama and Dr. Yutaka Wakayama. Dr. Nakayama also takes the responsibility as the Administrative Director. After Dr. Sasaki resigns from the Director of WPI-MANA, he continues to perform top-level research and to help the new Director, Dr. Taniguchi.

ii) PIs will be replaced to breathe new life into the ranks of PIs. Associate PIs (aPIs) will be promoted to PIs, and new aPIs will be appointed from young researchers. The performance of all PIs will be evaluated by professionals from outside MANA.

iii) MANA will maintain its satellites, which have contributed significantly to MANA's achievements by raising the quality of research, training young researchers, and internationalizing the center, among other things.

iv) To further activate the Nano-Theory field, MANA will continue a "Theorist-Experimentalist Pairing Program" or equivalent to enforce the fusion of theoretical and experimental research.

v) Many of MANA's unique seeds outcomes in Nanoarchitectonics should be consistent with demands from society. To improve potential matching between seeds and needs and to cultivate

necessary nanoarchitectonics to open routes to demands, MANA will implement "Synthesis-Characterization Pairing" program.

vi) Aiming to achieve the five goals of the MANA Grand Challenges, MANA will strategically invest research resources (e.g., research funds, post-docs etc.) into these topics. MANA will also invite guest researchers to lead workshops and brainstorming sessions on specific topics.

4. International Circulation of Best Brains

* Describe your policy and concrete plan for promoting the international circulation of the world's best brains, which is an important function of the WPI Academy.

4-1. Participation of top-world researchers from abroad

MANA has established satellite labs (hereinafter "MANA Satellites") at research institutions to which satellite PIs (sPIs) belong. MANA Satellites have been established at four institutions: the University of California Los Angeles (UCLA, sPI: Prof. James Gimzewski), the Georgia Institute of Technology (GETECH, sPI: Prof. Zhong Lin Wang), the Center for Materials Elaboration and Structural Studies of French National Centre for Scientific Research (CEMES-CNRS, sPI: Dr. Christian Joachim), and the University of Montreal(sPI: Prof. Francoise Winnik). These satellites play a role in MANA's research in various fields and are also training grounds for young scientists of MANA. MANA will continue reforming MANA satellites depending on the progress of MANA's activity.

4-2. Employment of young researchers at the Center and their job placement after leaving the Center

Young researchers, mainly fixed-term researchers consisting of doctoral students and post-doctoral scholars, account for more than half of all researchers. In addition to typical post-docs, MANA keeps a higher position, "ICYS-WPI-MANA researcher." This is a post-doctoral scholar who is independent of any specific group and pursues his/her own individual research topics. With this, MANA can keep close relationship with ICYS which is a center that serves as a tenure-track system leading to permanent positions of NIMS.

MANA's policy is not merely to gather young researchers from throughout the world and cultivate them into excellent researchers. Rather, MANA seeks to endow these researchers with a thorough understanding of Japan such that they can advance their careers in countries throughout the world. Till the end of 2020, 413 MANA's young researchers have "graduated" MANA. 5.3% of them were selected for permanent research positions at NIMS and 52.3% became faculty members (professor, associate professor and so on) of universities inside and outside Japan. Also, 17.4% have advanced in their careers to become researchers at universities and research institutions, and 18.6% have moved to private companies. 33.7% of those who made research at MANA found employment within Japan, and the remaining 60.0% found positions in the world, primarily in Asia. In this way, there is a growing network of nanotechnology researchers for which MANA is the hub.

4-3. Overseas satellites and other cooperative organizations

Building a network of the world's nanotech centers with MANA as the hub is one of MANA's organizational missions. MANA has to date signed MOUs with 85 research institutions in 24 countries with which it conducts research and personnel exchange.

In order to strengthen MANA research conducted by PIs at MANA satellites, NIMS/MANA has established a system through which it provides travel support for the PIs and his/her research associates. Under this system, NIMS contracts with satellite institutions for joint research and allocates the necessary funds for the satellites from WPI-academy's and NIMS's budgets. This results in a large contribution of the satellites' activity together with MANA.

4-4. Holding International Symposia, Workshops, Research Meetings and Others

Each MANA international symposium brought over 400 participants and was praised as a fruitful, high-level event. In order to promote discussion between young personnel and the world-leading researchers at the MANA International Symposium, several awards were presented to young personnel such as the Best Poster Award and other excellent presentation awards sponsored by academic organizations and private companies. All invited speakers attend the poster session to grade the posters after engaging in direct discussion with the presenters.

Meanwhile, there are many government agencies, universities, research institutions, and other organizations that issue requests for MANA to host research conferences. As a result, country-level bilateral workshops have been hosted with Canada, Australia, Switzerland, Spain, and Taiwan, while symposiums have also been conducted with several Japanese and non-Japanese universities. Furthermore, MANA contributed in training PhD candidates through "Nanotechnology Students' Summer School" co-organized by UCLA, UCL, Flinders University and other overseas organizations. MANA will reform such a summer school more open to the world.

4-5. System for Supporting the Research Activities of Overseas Researchers

All staff in MANA's Administrative Office speak English and provide comprehensive Japanese-style service to all researchers, regardless of age and nationality. According to one non-Japanese researcher, "Although I have worked at several institutions in America and Europe, MANA provides the best research environment."

4-6. Others

In terms of acquiring and training young researchers, both independent researchers who do not belong to any specific group and the ICYS researcher system have made notable achievements. In particular, the 3D System (Triple Double: double-mentor, double-discipline, double affiliation system) serves to promote diligent study by young researchers overseas by allowing such researchers to pursue interdisciplinary, fusion research under first-tier mentors. This system is now mainly applied to independent scientists not only in MANA but also in NIMS. Also, MANA promotes short-term dispatch program to perform research at major research institutions overseas as an effective way of internationalize young Japanese researchers.

Thus, MANA plays an important role in NIMS's effort to build an international research center, and MANA's efforts to create global environment where non-Japanese researchers can succeed was featured as a "best practice" case study in the 2014 White Paper on Science and Technology.

5. Support by Host institution

* Describe measures that the host institution will take to support and sustain your WPI center. Describe your strategy for extending the system reforms achieved by the center via the WPI program to the host institution and other institutions.

For sustaining and advancing MANA as a World Premier International Research Center, NIMS has promised to provide MANA with the following supports and to continue its basic activities.

i) Approximately 90 core members, including principal investigators, associate principal investigators, group leaders, MANA researchers, independent researchers and administrative staff will be kept assigned to MANA as "permanent employees of NIMS assigned to MANA."
As of January 1st, 2020, MANA has a total of 87 permanent staff.

ii) R&D expenses required to sustain basic and fundamental research at MANA such as research project expenses, facility utilities, and other expenses necessary in performing fundamental / foundational research and for WPI center operation will be contributed out of NIMS's management expenses.

iii) Post-doctoral scholars and other fixed-term staff are hired using NIMS's special funds to the Director of MANA and various external funding.

iv) A part of programs characteristic of MANA—such as young researcher training programs (ICYS-MANA, independent scientist, etc.) —was already transferred to and implemented at NIMS to ensure sustainability of the WPI programs.

v) NIMS keeps technical support that have been of especially high quality developed in MANA.

vi) NIMS established the Materials Open Platform which provides opportunity to work with external institutions especially with private companies. Also, NIMS helps international networking of MANA through Materials Global Center for sustainable operation of MANA.

6. Financial Measures

* In Appendix 4, describe the measures to be taken by the host institution for sustaining the center's functions and activities over a period of 5 years, and describe what external funding will be used to carry out the center's research activities.

NIMS plans to maintain the MANA research workforce of about 90 permanent staffs (scientists, engineers and administration staffs) as a WPI center. Also, NIMS plans to maintain or even increase the size of MANA by hiring several permanent researchers every year.

NIMS has allocated the two buildings to MANA: MANA Building (12,934m^2) in October 2008 and WPI-MANA Building (7,629m^2) in April 2012. NIMS renovated an old building (519m^2) adjacent to the two MANA Buildings and reopened it as Theoretical Research Building in April 2014. NIMS allocates this building to MANA in April 2016 when NIMS moves a large part of theoreticians from NIMS's Computational Materials Science Unit to the new Nano-Theory Field of MANA. NIMS keeps allocating these buildings and facilities to MANA.

MANA continues tremendous efforts to increase the amount of funding from external sources, such as CREST, PRESTO, and Kakenhi grants by promoting strategic research collaborations between MANA and major universities in Japan. Also, MANA will explicitly participate in the NIMS's strategy to realize open-innovation with private companies to increase investment from the companies.

FY 2021 List of Principal Investigators

NOTE:
*Underline names of principal investigators who belong to an overseas research institution.
*Indicate newly added researchers in FY 2021 (2021.4.1-2021.7.1) in the "Notes" column.

		<Principal Investigators as of July 1, FY2021>				**Principal Investigators Total: 25**	
Name	Age	Affiliation (Position title, department, organization)	Academic degree, Specialty	Effort (%)*	Starting date of participation	Status of participation (Describe in concrete terms)	Note
Director Takashi Taniguchi	61	Director International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Engineering, Tokyo Institute of Technology, 1987, High Pressure Materials Science	100	4/1/2020	usually stays at the center	
Deputy Director/ Administrative Director Tomonobu Nakayama	59	Deputy Director/Administrative Director, International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Physics, The University of Tokyo, 1999, Scanning Probe Microscopy	100	10/1/2008	usually stays at the center	
Takayoshi Sasaki	66	International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS)	Ph.D. in Science, The University of Tokyo, 1985, Nanosheet and Soft Chemistry	100	10/1/2007	usually stays at the center	
Yusuke Yamauchi	40	Professor, Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland	Ph.D. in Engineering, Waseda University, 2007, Inorganic Synthetic Chemistry, Inorganic Materials Chemistry	20	Independent Scientist: 10/1/2007 PI: 4/1/2016	stays at the center several times a year, usually stays at UQ (Cross-appointed with UQ / MANA)	
Katsuhiko Ariga	59	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Tokyo Inst. Tech., 1990, Supramolecular Chemistry and Surface Science	80	10/1/2007	stays at the center (Cross-appointed with The University of Tokyo / MANA)	
Junichi Takeya	54	Professor, Department of Advanced Materials Science, Graduate School of Frontier Sciences, The University of Tokyo	Ph.D. in Physics, The University of Tokyo, 2001, Organic semiconductors	20	4/1/2017	usually stays at The University of Tokyo, stays at the center several days a month (Cross-appointed with MANA	
Takao Mori	54	Research Center for Functional Materials, National Institute for Materials Science (NIMS)	Ph.D. in Science, The University of Tokyo, 1996, Materials Science, Solid State Chemistry & Physics	40	MANA Scientist: 10/1/2008 PI: 4/1/2016	stays at the center	
Naoki Fukata	50	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Engineering, University of Tsukuba, 1998, Semiconductor physics and engineering	100	Independent Scientist: 10/1/2007 PI: 4/1/2018	usually stays at the center	
Jinhua Ye	58	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., The University of Tokyo, 1990, Photocatalyst, Eco-materials	100	10/1/2007	usually stays at the center	
Kazuya Terabe	58	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Materials Science, Nagoya Institute of Technology, 1992, Nanoionics, Solid State Electrochemistry and Nanoferroelectronics	100	MANA Scientist: 10/1/2008 PI: 4/1/2016	usually stays at the center	
Kazuhito Tsukagoshi	53	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Osaka University, 1995, Nano Electronics	100	1/1/2009	usually stays at the center	
Xiao Hu	59	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Physics, The University of Tokyo, 1990, Condensed Matter Physics	100	10/1/2007	usually stays at the center	
Yoshihiko Takano	56	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Yokohama City University, 1995, Superconducting Materials, Nanomaterials, Physics	100	4/1/2016	usually stays at the center	
Tadaaki Nagao	54	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Waseda University, 1995, Surface and Interface Nanoscale Physics, Plasmonics, Nanoscale Materials Optics	100	Independent Scientist: 10/1/2007 PI: 4/1/2017	usually stays at the center	

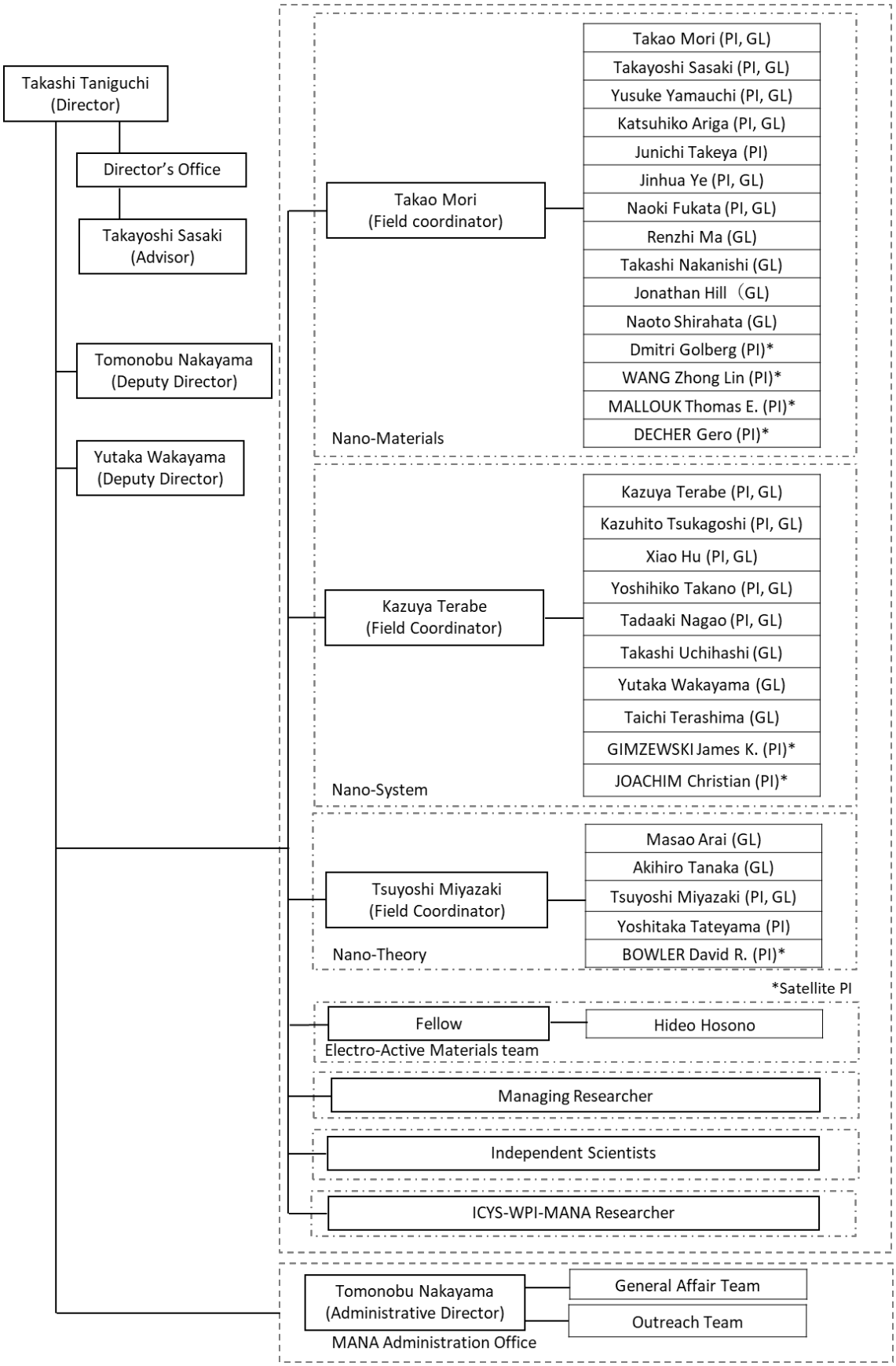
Name	Age	Affiliation (Position title, department, organization)	Academic degree, Specialty	Effort (%)*	Starting date of participation	Status of participation (Describe in concrete terms)	Note
Tsuyoshi Miyazaki	55	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., The University of Tokyo, 1995 first-principles calculation	100	4/1/2016	usually stays at the center	
Yoshitaka Tateyama	51	Center for Green Research on Energy and Environmental Materials, National Institute for Materials Science (NIMS)	Ph.D., The University of Tokyo, 1998, Condensed-matter Theory, Computational Physical Chemistry	5	Independent Scientist: 10/1/2007 PI: 7/19/2016	stays at the center	
Zhong Lin Wang	59	Professor, School of Materials Science and Engineering, Georgia Institute of Technology	Ph.D. in Physics, Arizona State University, 1987, Emerging Devices for Energy Generation	10	10/1/2007	stays at the center several times a year, usually at GT satellite	
James K. Gimzewski	69	Professor, Chemistry and Biochemistry, University of California, Los Angeles	Ph.D. in Physical Chemistry, University of Strathclyde, 1977, Neuromorphic Network	20	10/1/2007	stays at the center several times a year, usually at UCLA satellite	
Christian Joachim	63	Professor, CEMES, Centre National de la Recherche Scientifique (CNRS)	Ph.D. in Applied Mathematics, Ph.D. in Quantum Physics, Molecular Device Engineering	20	10/1/2007	stays at the center several times a year, usually at CNRS satellite	
David R. Bowler	50	Professor, Department of Physics & Astronomy, University College London	Ph.D., University of Oxford, 1997, Large-scale Order-N DFT Calculations	20	API: 4/1/2013 PI: 4/1/2016	stays at the center several times a year, usually at UCL satellite	
Thomas E. Mallouk	66	Professor, Department of Chemistry, University of Pennsylvania	Ph.D. in Chemistry, University of California, Berkeley, 1983, Nanoscale Chemistry	10	10/5/2018	stays at the center several times a year, usually at University of Pennsylvania satellite	
Gero Decher	64	Professor, the Faculty of Chemistry, University of Strasbourg	Ph.D., Johannes Gutenberg University Mainz, 1986, Fazzy Assembly	10	2/1/2019	stays at the center several times a year, usually at University of Strasbourg satellite	
Dmitri Golberg	60	Professor, Science and Engineering Faculty, School of Chemistry & Physics, Queensland University of Technology	Ph.D. Moscow Institute for Ferrous Metallurgy, 1990, Nanotubes and nanowires	20	10/1/2007	stays at the center several times a year, usually stays at QUT	

*Percentage of time that the principal investigator devotes to his/her work for the Academy center vis-à-vis his/her total working hours.

Principal Investigators resigned since FY 2021

Name	Next Affiliation (Position title, department, organization)	Period of participation
Taizo Sasaki	Chief Researcher, Center for Green Research on Energy and Environmental Materials, National Institute for Materials Science (NIMS)	4/1/2016 (Until 6/1/2017)
Minoru Osada	Professor, Institute of Materials and Systems for Sustainability (IMaSS), Nagoya University	MANA Scientist: 10/1/2007 PI: 4/1/2016 (Until 12/31/2017)
Toyohiro Chikyow	Deputy Director, Research and Services Division of Materials Data and Integrated System, National Institute for Materials Science (NIMS)	MANA Scientist: 10/1/2007 PI: 4/1/2011 (Until 4/1/2018)
Françoise M. Winnik	N/A: passed away on 2/13/2021	4/1/2011 (Unitl 2/13/2021)

World Premier International Research Center Initiative (WPI)
Diagram of management system



Vision of MANA's New Director

Host Institution: National Institute for Material Science (NIMS)
WPI Center: International Center for Materials Nanoarchitectonics (MANA)
Head of Host Institution: HASHIMOTO Kazuhito
Center Director: TANIGUCHI Takashi
Administrative Director: NAKAYAMA Tomonobu

MANA has as its vision leading the world in the development of new materials by pioneering the new technological paradigm of "Nanoarchitectonics." In this pursuit, MANA has three missions:

1. Fuse interdisciplinary fields in advancing research on developing new materials base on the new concept of "Nanoarchitectonics."
2. Cultivate a research environment that assembles researchers from around the world and build international networks for promoting research collaboration
3. Foster courageous young researchers who will boldly tackle challenging research topics

As it works toward achieving the above three missions, MANA has evolved into an international research center while focusing on the following five points.

- World-class research activities
- International persona characterized by nearly half of its researchers being foreign nationals
- Actively implementing fused research that combines nanotechnology with other fields
- Contributing to the reform of the host institution, NIMS
- Fostering excellent young researchers capable of working throughout the world

As we move forward, MANA will continue to maintain these principles.

MANA's management system has a 3-executive framework: the center director, administrative director, and deputy center director. While maintaining a consensus-based approach in operating the center's program, each of their responsibilities is clearly delineated. When deemed needed, additional guidance may be sought from Executive Advisor Aono and former Center Director Sasaki.

MANA's current research structure comprises three fields, 23 groups, 2 teams, independent researchers, and ICYS-WPI-MANA fellows. Plans are to maintain this scale into the future.

In the short term, adjustments may be made as needed in pursuit of the center's goals, including creating new groups, moving people from other centers to MANA, and augmenting personnel. In NIMS's next medium- to long-term plan, there is a goal to realize MANA's optimal structure from a long-term perspective of 10 years from now.

The trajectory of MANA's research involves further pursuit and advancement of Nanoarchitectonics, along with the creation, integration and hierarchical structuring of new nanomaterials, carried out with emphasis on collaboration between experimental and theoretical approaches and on expansion to large-scale and complex systems. Its new trajectory includes strengthening the coordinative framework between new materials creation and functional evaluation, and contributing to research on quantum materials and AI materials.

MANA has set long-term research goals, which it calls "Grand Challenges." They are as follows:

- Nanoarchitectonic artificial brain
- Room-temperature superconductivity
- Practical artificial photosynthesis
- Nanoarchitectonic perception system

We are adding a new research goal to these four challenges: Quantum materials.

The innovation of quantum technology needed to realize quantum computing, communications, sensing and other quantum applications is considered a critical S&T challenge in advancing to the next generation of technologies. With long-term goals for developing new materials spawned by its basic concept of Nanoarchitectonics, MANA intends to contribute to quantum materials development by achieving technological breakthroughs.

With a goal of further enhancing its operation, MANA is moving forward in restructuring its framework of satellites, which have already contributed significantly to MANA's achievement in raising research quality, training young researchers, and internationalizing its center. MANA will continue to maintain the system it has built for promoting international collaboration, including carrying out join research based on MoUs, dispatching researchers and students to other countries and inviting them to Japan, and holding international symposiums and workshops. While proactively carrying forward MANA's on-

going strategies, we will adjust them flexibly in response to such things as the onset of viral pandemics and changing export regulations.

Center director Taniguchi has been engaged in basic research on organic materials development at the National Institute for Research in Inorganic Materials, the predecessor of NIMS, for a period of more than 30 years from 1989. What he has learned from his experience is that global perspectives are important is attaining research originality and that long-term patience in needed in achieving breakthroughs in materials research. Thus, it remains important that environments be established in which research can be perused patiently, without regard to prevailing trends. It is particularly important to continue providing such environments for talented young researchers.

Considered “products of chance,” research outputs can crop up in directions unanticipated by the researchers. The importance of innovation has been increasingly recognized over recent years. Now, it will be necessary to create a research system that is further innovated to accommodate the inevitable occurrence of serendipity.

MANA has its own unique research methods. Its many talented researchers, each with their own focus, are advancing the creation of new materials. However, insights when looking into the functional expression of newly developed materials may not always be sufficiently accurate, especially with scenarios that extend beyond the researchers’ own specialized fields. Up to now, new materials development has been advanced at MANA by harmonizing researchers in experimental and theoretical fields. Now, we’d like to accelerate interdisciplinary research in a way that transcends the specialized fields of synthesis and evaluation/analysis.

Against a backdrop of research accomplishments, what has attributed to MANA’s good international appraisal are the research and leadership systems created by the former Center Director Sasaki. Inheriting his vision, we will continue working to build even further MANA as a global research institute.