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NIMS Superconductivity Research

Up to Now & From Now on

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A century has now passed since the discovery of superconductivity. Giving society a material with a property like magic, namely, zero electrical resistance, was the dream of researchers. Today, that dream is at last becoming a reality in this society.

Transmission of electric power with zero resistance is just one example. If realized, this will make an enormous contribution to solving the energy problem. The technology is now in the demonstration experiment stage, and power may soon come to your home and society from a superconducting power grid.

Steady progress is also being made in other applications, such as medical MRI for diagnosis in hospitals, high resolution magnetic sensors with sensitivity at the single flux quantum level, and energy-saving high speed devices. And the day when business trips are made on the superconducting linear motor car may not be so far away.

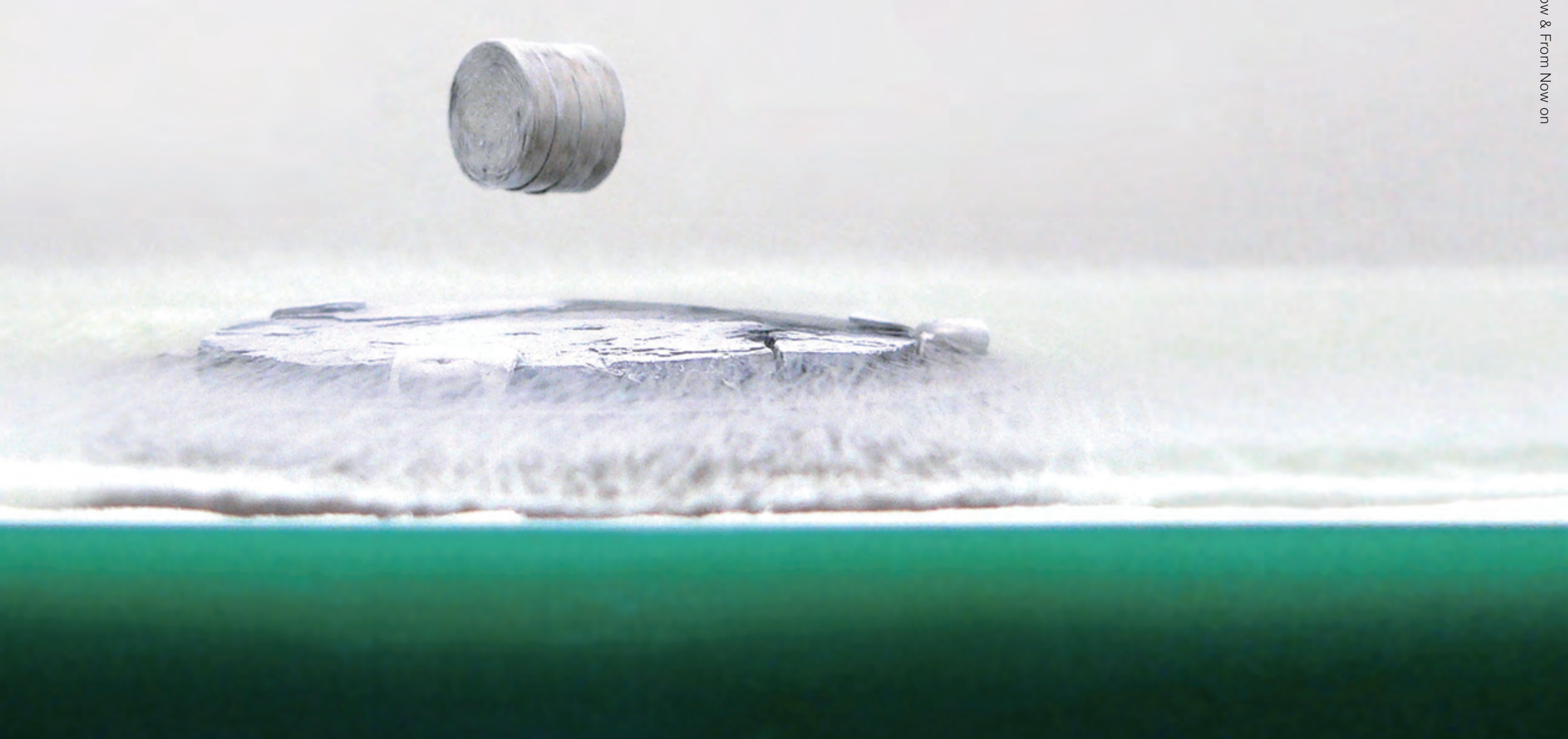
With these technologies already on the horizon, what other possibilities does the future hold?

Technologies that apply the phenomenon of superconductivity are steadily becoming a reality. However, many questions remain in elucidation of the mechanism of superconductivity, in other words, why the phenomenon of superconductivity occurs. In fact, it would be more accurate to say that these questions are still virtually all unanswered. Why do some materials become superconductors at temperatures higher than that of liquid nitrogen? Is it possible to realize superconductivity in room temperature? For example, the movement of electrons is only one of many questions that cannot be explained by existing theory. “Why does this happen?” is still unknown.

The NIMS 3rd Five-year Plan takes up the project “Research on Advanced Superconducting Materials” as a new area of study. This project represents the compilation of know-how that is only possible at NIMS, which has already developed many superconductors and is transferring the fruits of that work to society. This will be fed back to the evaluation of basic properties and elucidation of the mechanism of superconductivity.

The phenomenon of superconductivity still has infinite potential. The cycle of research and application through this NIMS project will lead to the elucidation of the phenomenon of superconductivity, and to further contributions to society and breakthroughs to new knowledge.

A “dream” that has come true.



Advanced Superconducting Materials Project

- From the History of Superconductivity Research at NIMS to a New Project -

Unit Director, Superconducting Properties Unit,
Environment and Energy Materials Division

Shinya Uji

Expectations for superconductivity

Superconductivity is a phenomenon in which voltage is not generated when an electrical current is passed, in other words, resistance is zero. This means that electric power can be transmitted to distant locations with no energy loss if electric current is passed through a superconducting material. For this reason, superconducting materials are expected to make a great contribution to energy conservation.

Using this property of zero resistance, superconducting materials can also be applied in a wide range of fields other than power transmission. As shown in Figure 1, these include the high efficiency next-generation energy field, for example, in superconducting magnetic energy storage and nuclear fusion reactors, the electronics field, as represented by energy saving ultra-high speed devices (superconducting devices), low environmental load transportation, such as linear motor cars and high efficiency motors, and the next-generation medicine and life sciences field, in image diagnosis, structural analyses of biomolecules, and other technologies.

History of superconductivity research and contribution of NIMS

The phenomenon of superconductivity was first discovered in mercury in 1911 in Holland. At that time, the superconducting transition temperature (T_C) was 4.2K.* Thereafter, rapid progress was made in research on superconductivity, and superconductivity was discovered in various materials, including alloys, copper oxides, iron-arsenic compounds, and organic materials, among others. T_C has also increased, and a number of superconductors with T_C above the boiling point of liquid nitrogen (77K) have now been discovered.

Accompanying higher T_C, many new physical phenomena which cannot be explained within the existing theoretical framework have been discovered, and theoretical physics to explain those phenomena has been developed at a dramatic pace.

NIMS had already begun research on superconducting materials in the 1960s at a NIMS predecessor organization, National Research Institute for Metals (NRIM). The main research at that time was aimed at producing superconducting wires of Nb-Zr intermetallic compounds (T_C = approx. 10K). Following this, NRIM conducted ongoing research on superconducting wires in the 1970s, and made important achievements including production process for multifilament wires of Nb_3Sn (T_C = 18K) and V_3Ga (T_C = 14.5K) superconducting tapes, which are used today as practical wire materials.

The discovery of La-based copper oxide high temperature (T_C=38K) superconductors encouraged an active search for other new superconductors as well as basic physical research, and in 1988, the news that NRIM had discovered a Bi-based copper oxide high temperature superconductor with a T_C of 110K was announced to an astonished world. In the years that followed, NIMS recorded many other important achievements in the development of new superconducting materials, the basic research on physical properties, and the production process of superconducting wires.

Aims of the Advanced Superconducting Materials Project

At present, NIMS is actively engaged in research on superconducting materials at the global scale, which spans a wide range from basic research to applied research. Japan is currently among the world's leaders in this field, but there is no room for complacency. Considering the great potential of superconducting materials and their importance, no delays in research can be allowed.

In projects on superconductivity carried out

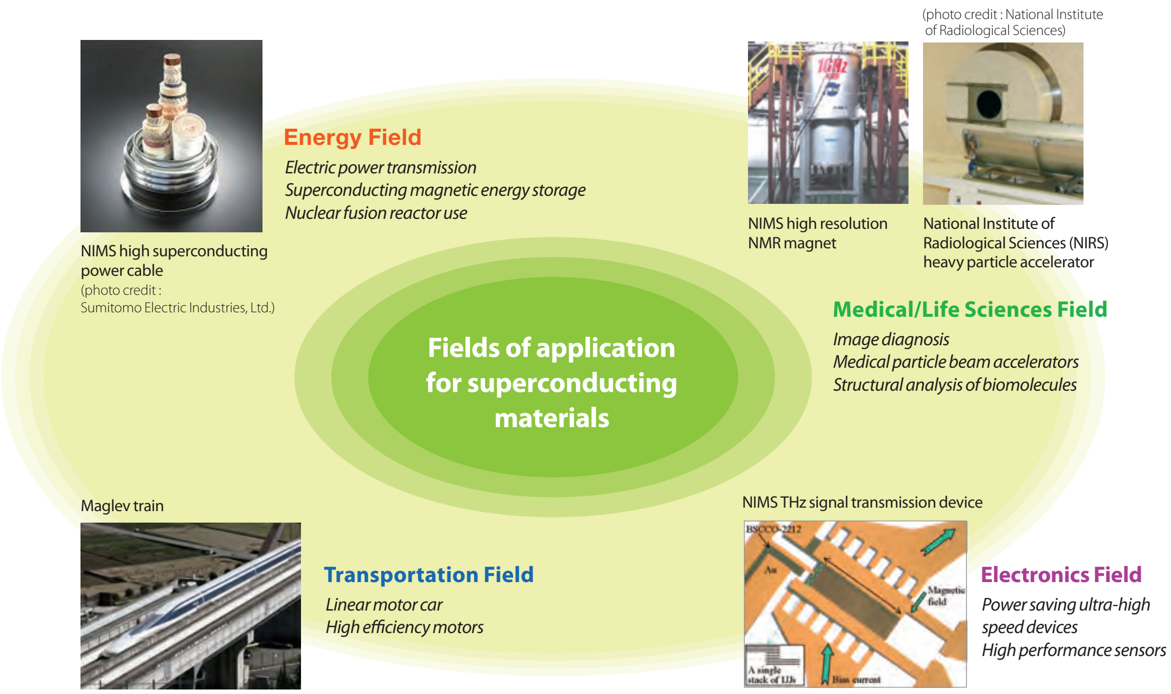


Fig. 1 Fields of application for superconducting materials research

in NIMS up to fiscal year 2010, research on production process of superconducting wires had been the primary theme. While great effort has been made to improve the performance of superconducting wires to date, this has deepened our recognition that close collaboration with basic research, grounded in basic materials science and condensed matter physics, is necessary and indispensable in order to achieve further improvements in performance.

In addition to the high power application, the low power application, such as superconducting devices, is also considered to be an important area in this project. Of course, the upstream fields of this research including the discovery of new superconducting materials, the superconductivity mechanism, and related areas are also important subjects. Dramatic progress in research will be made by complementary, comprehensive research in these areas.

The Advanced Superconducting Materials Project, which began from the present fiscal year, brings together 38 frontline superconductivity researchers (including persons in concurrent positions), who had been dispersed in the NIMS organization until now, to carry out development of new superconducting materials, elucidation of the superconductivity mechanism, and basic research on device and wire applications in a total and comprehensive manner. Through this project, we hope to make important contributions to the environment and energy fields.

From development of new superconductors to application fundamentals

Research in this project will be divided into 4 sub-themes, as shown in Fig. 2.

First, in "Materials development and basic physical properties, P.6" we aim to develop new superconducting materials and evaluate their basic physical properties. NIMS has already developed many superconductors up to the present, and we hope to develop innovative new superconductors by making the maximum possible use of that know-how.

In "Electronic structures and mechanisms of superconductivity, P.7" our aim is to elucidate the superconductivity mechanism and carry out detailed analyses of the electronic structures of superconductors (Fig. 3). Elucidation of the superconductivity mechanism has extremely high scientific value from the viewpoint of providing new concepts in condensed matter physics, and will provide large guidelines for material design aiming at higher T_C.

"Superconducting vortex dynamics and device fundamentals P.8" will offer clues for the manifestation of new flux quantum phenomena and elucidation of their mechanisms (Fig. 4). Here, we will conduct comprehensive flux quantum research, aiming as far as the search for operating principles of next-generation quantum devices.

Finally, in "Production processes of superconducting wires and application fundamentals, P.9" we will conduct research on structural and reaction controls of new or existing superconductors, elucidation of the mechanism of flux pinning, pinning control, and related issues, and basic research on the wire application which can make an important contribution to energy conservation.

We hope to achieve major breakthroughs by carrying out this research with mutual cooperation between these sub-themes.

* K (Kelvin) is a unit expressing absolute temperature. (–273.15 ° C = 0K (absolute 0); 0 ° C = 273.15K). For example, 7.2K = –265.95°C.

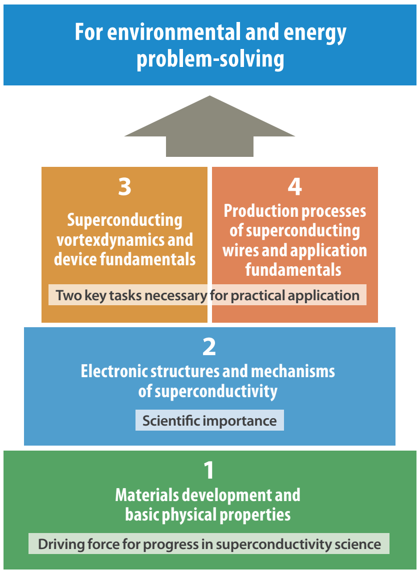


Fig. 2 Composition of research sub-themes

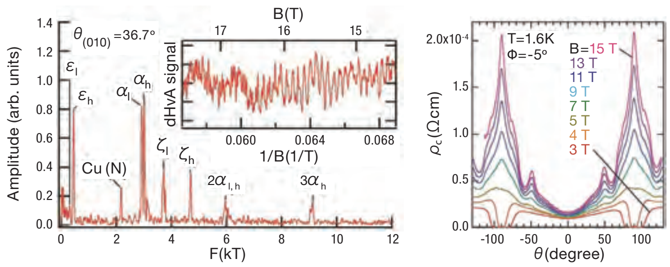


Fig. 3 (left) Quantum oscillation of Fe-based superconductor and its Fourier transform spectrum, and (right) angular-dependent magnetoresistance oscillation. The electronic structures of superconductors can be determined from analyses of these data

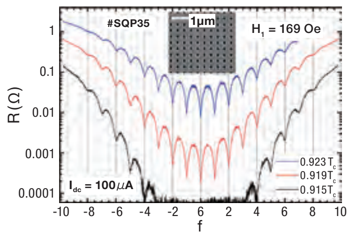


Fig. 4 Magnetic field dependence of resistance for NbN superconductor with a nano-scale antidot structure. Characteristic dynamics (resistance oscillation phenomenon) of the vortex depending on the dot structure can be observed

Fig. 5 NIMS Bi-based high T_c superconducting wire Multi-filaments of $(Bi,Pb)_2Sr_2Ca_2Ca_2Cu_3O_x$ superconductor are dispersed in a silver and silver alloy matrix

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Toward the Development of New Superconducting Materials

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Motoharu Imai

Importance of material synthesis in superconductivity science

The discovery of new superconducting materials is the key driving force for creating new concepts in connection with superconductivity and advancing superconductivity science. In elucidation of the mechanism of superconductivity in new materials which are discovered, precise measurement of the composition, crystal structure, and basic physical properties (superconducting critical temperature (T_C), critical magnetic field (H_C) and specific heat), and determination of the superconductivity phase diagram by carrier density, element substitution, etc. are necessary.

For this, high quality test materials which enable accurate evaluation of basic physical properties are required. Moreover, even with known superconductors, there are many cases in which research has not progressed because pure single crystals cannot be obtained.

Based on these facts, the aims of this sub-theme are, 1) to discover new superconducting material, 2) to achieve higher T_C by optimizing the parameters (composition, chemical pressure, carrier density, etc.) of known materials by elemental substitution, etc., and 3) to synthesize high quality test materials for use in precise property measurement. As a further aim, by precise evaluation of the physical properties of the synthesized test materials, this sub-theme will also contribute to further activation of Japanese superconductivity research and progress in superconductivity science.

Synthesis of superconducting materials under high temperature, high pressure conditions

As a distinctive feature of this sub-theme, we will make full use of high pressure synthesis methods and soft chemistry synthesis methods, in addition to synthesis at atmospheric pressure (normal pressure synthesis methods). This has made it possible to synthesize new materials which cannot be obtained by ordinary normal pressure synthesis, including intermetallic compounds, transition metal oxides, etc. [1,2]

The following explains the synthesis of superconducting materials under high temperature, high pressure conditions, using the filled skutterudite compound $La_xRh_4P_{12}$ ($0 < x < 1.0$) as an example.

The skutterudite compound RhP_3 exists in Rh-P system compounds which can be synthesized at atmospheric pressure. Its crystal structure is shown in Fig. 1(a). In this compound, P atoms form an octahedron with an Rh atom in the center, and the crystal structure is formed by joining the apexes. Large voids exist between these octahedrons. The voids are only filled with La atoms when high temperature, high pressure conditions are applied, enabling synthesis of the filled skutterudite compound $La_xRh_4P_{12}$, as shown in Fig. 1(b) (four times RhP_3 gives Rh_4P_{12}).

$La_xRh_4P_{12}$ is the compound with the highest superconducting critical temperature T_C among the filled skutterudite compounds that exhibit superconductivity. [3,4] We clarified the fact that the La concentration changes when the high temperature, high pressure conditions used in synthesis of this compound are changed, and T_C and other physical properties also change reflecting the different La concentration.

Figure 2 shows the synthesis pressure dependence of the La concentration x of $La_xRh_4P_{12}$ when synthesized at 4.0-9.4GPa and 1370 and 1470K. Figure 3 shows the synthesis pressure dependence of T_C. The broken line in Fig. 2 represents x. The La concentration becomes 5.88% when $x = 1.0$. From this result, it was found that T_C increases as the La concentration x of $La_xRh_4P_{12}$ increases with increase of synthesis pressure. We have been working on this research as a joint research with Ultra-high Pressure Process Group at Materials Processing Unit.

As described above, we plan to carry out research in this sub-theme with "high temperature, high pressure synthesis" as one keyword.

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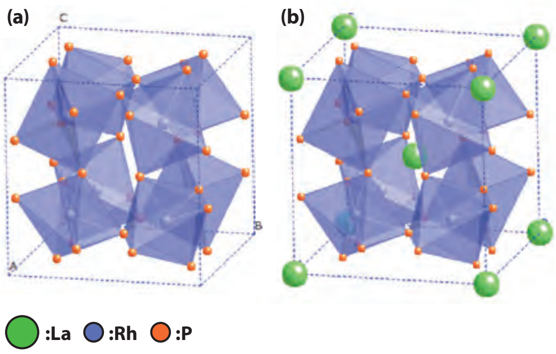

Fig. 1 The crystal structure of **(a)** RhP_3 and **(b)** $La_xRh_4P_{12}$

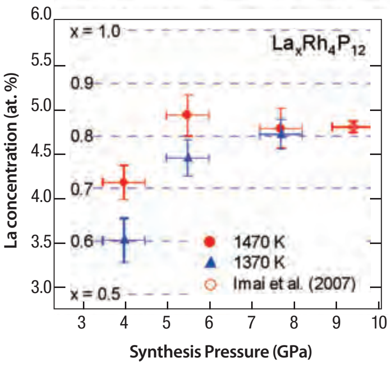

Fig. 2 La concentration in $La_xRh_4P_{12}$ as a function of the synthesis pressure

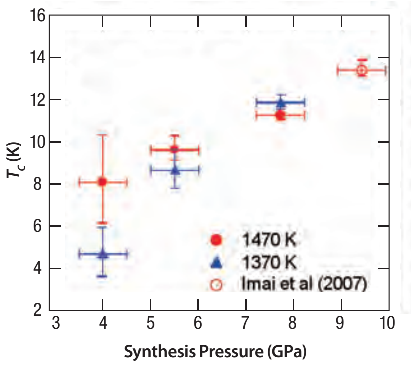

Fig. 3 Superconducting critical temperature T_c as a function of the synthesis pressure

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Aiming at Elucidation of Mechanisms of Superconductivity

Quantum Properties Group,
Superconducting Properties Unit
Taichi Terashima

NIMS Postdoctoral Researcher
Nobuyuki Kurita

Challenging elucidation of mechanisms of superconductivity using high magnetic fields

The iron-based superconductor containing iron and arsenic which was discovered in Japan in 2008 becomes a superconductor at a comparatively high absolute temperature of 55K (–218°C). This superconductor became a topic of interest after being reported in newspapers and other media and may become a powerful rival to the copper oxide high temperature superconductors which are currently being developed.

Why does this material have a high superconducting transition temperature? Elucidation of the mechanism responsible for high temperature superconductivity is not only important for science, but is also essential research for obtaining guidelines for the search for other new superconductors, with the ultimate aim of room temperature superconductivity.

We have taken up this challenge using the high field magnets at the NIMS High Magnetic Field Station, which are the world's top level instruments in this field. The following describes two recent research results.

Application of high pressure to iron-based superconductivity

Understanding the conditions under which superconductivity appears is the first step toward elucidation of the mechanism of superconductivity. Therefore, we carried out a detailed investigation of the changes associated with the appearance of superconductivity when high pressure is applied to a parent compound of an iron-based superconductor $EuFe_2As_2$ (Fig. 1). At ambient pressure, below the temperature denoted by T_0, the crystal lattice is deformed, iron atoms enter a magnetic state called antiferromagnetism, and the material does not display superconductivity. When pressure is applied, T_0 gradually decreases, and at high pressures of 25,000atm and higher, the anomaly at the temperature T_0 does not occur, but rather, superconductivity appears at an absolute temperature of around 30K. However, we found that superconductivity disappears at higher pressures exceeding 30,000atm. We discovered that this superconductivity is a rare type which coexists with the antiferromagnetic state of Eu (europium).

Observation of quantum oscillation under high field

Because superconductivity is a phenomenon which occurs when the conductive electrons responsible for electrical conductivity form pairs, the next step is to determine how electronic states (state and properties of electrons) change when superconductivity appears. For this, we observe quantum oscillation using a high field magnet. Quantum oscillation is a phenomenon in which the magnetization and electrical resistance of a metal oscillate corresponding to changes in the magnetic field, when a high magnetic field is applied to the metal at a low temperature approaching absolute zero.

Figure 2 shows an example of measurement of the electrical resistance of the iron-based superconductor $BaFe_2As_2$ at 0.2K under high magnetic fields up to 17T. The rippling pattern of resistance which can be seen under high fields exceeding approximately 7T is quantum oscillation. By analyzing this pattern and comparing it with theory, it is possible to understand the Fermi surface, which represents the electronic state most directly, the strength of interactions between electrons, and other characteristics.

Through this type of research, we intend to contribute to elucidation of the mechanism of superconductivity.

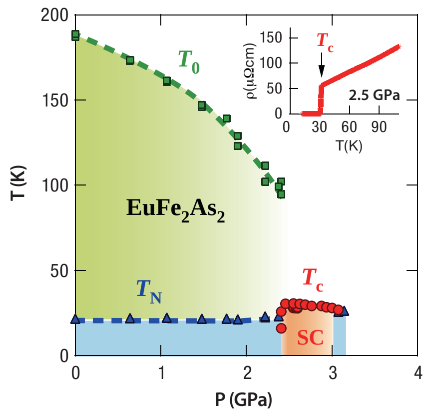

Fig. 1 High pressure phase diagram of the iron-based superconductor $EuFe_2As_2$. At temperature T_0, the lattice is deformed and the iron enters the antiferromagnetic state. Superconductivity appears at temperatures under T_0 within a limited pressure range. Temperature T_N is the temperature at which Eu becomes antiferromagnetic, and this also exists at pressures where superconductivity appears. The inset shows the superconducting transition as seen by the temperature dependence of electrical resistance. Resistance becomes zero at temperature T_c and lower

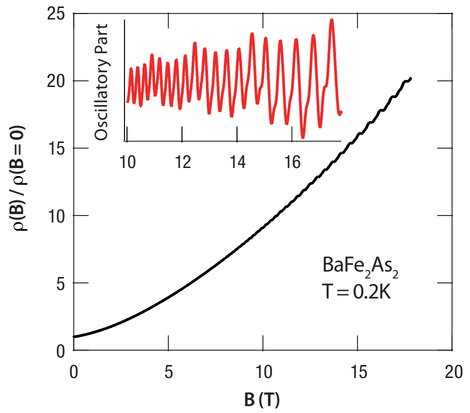

Fig. 2 Quantum oscillation which appeared in the electrical resistance of the iron-based superconductor $BaFe_2As_2$. The inset shows the quantum oscillation component after removing the smooth background

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New Quantum Functions by Vortex Control

Vortex Dynamics Group,
Superconducting Properties Unit

Kazuto Hirata

Controlling superconducting amplitude and phase

Superconductivity/superfluidity is one of the quantum mechanics phenomena, and also the only physical phenomenon, which can actually be seen with the eyes. Superconductivity is basically characterized by the parameters of superconducting amplitude and phase, and control of the amplitude and the phase determines superconducting phenomena and their applications.

Amplitude is related to the magnitude of the critical current density or the number of charges in superconductivity and is mainly important in power electricity applications such as superconducting power transmission, superconducting magnets, etc., while phase is important in electronic devices, such as quantum bits and flux-flow quantum devices, which employ phase control.

One of what is responsible for or controls phase is a magnetic flux quantum. Because the flux quantum is vortex-like with a superconducting current around quantized lines of magnetic flux, it is also called a “vortex” based on its structure. Normally, “one” vortex that exists in a uniform superconductor changes the phase by 2π when it makes one revolution around its center. In non-uniform superconductors, the value of the flux quantum will vary from 2π.

Controlling the motion of vortices in order to control phase

Several methods of controlling phase are possible. Two examples are shown in Fig. 1. In the method in Fig. 1(a), when the *s*-wave superconductor is placed in contact with the *d*-wave superconductor, a half-integer flux quantum is formed at the contact surface due to the different superconducting state, and in Fig. 1 (b), a ferroelectric material is sandwiched between two superconductors.

Among methods of controlling the motion of vortices, Figure 2 shows an example in which a periodic array of artificial nanoscale holes is introduced in a superconducting sample by micro-processing. This type of device structure is fabricated using micro-processing, and the motion of vortices can be controlled by applying an external force to the device, such as a magnetic field, electric current, microwaves, etc. As high quality superconducting single crystals with minimal crystal defects are required for this type of control, collaboration with the Materials Development Group is necessary.

Observation of the movement of vortices in these devices is also important. We are developing an STM, STEM-SQUID, magneto-optical system, and others for this purpose, and will investigate the mechanism of superconductivity by observing the electronic structures in the vortex, obtain an understanding of the dynamic motion of vortices and search its dynamics. This group includes a theory group, which supports our research from the viewpoints of simulation of vortex dynamics, the proposal of device structures and operating principles, and analysis of the results of measurements, etc.

Controlling the motion of the Josephson vortices using a nano-processing technique

Vortex in a Josephson junction is called a Josephson vortex. Because it is capable of transfer at a very high speed approaching to the speed of light, if the motion of the Josephson vortex can be controlled using nano-processing techniques, realization of energy saving vortex devices which also operate at extremely high speeds in comparison with conventional electronic devices can be expected. Using intrinsic Josephson junctions of the copper oxide superconductors with high superconducting transition temperature, we will propose the realization of high intensity terahertz radiation (see cover photo) and functional devices which utilize the vortex dynamics phenomena found in the project.

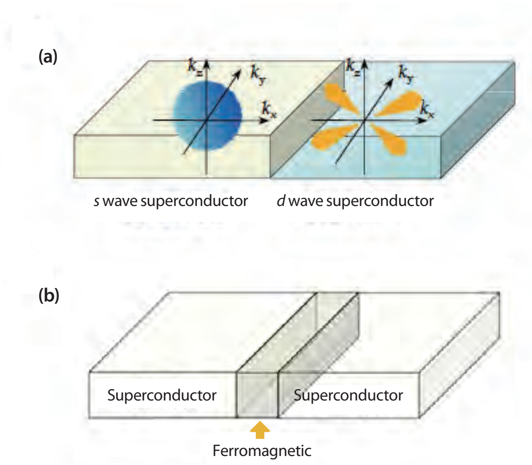

Fig. 1 Examples of phase control in superconductivity. **(a)** Junction between different superconductors, and **(b)** superconducting junction sandwiching a ferroelectric

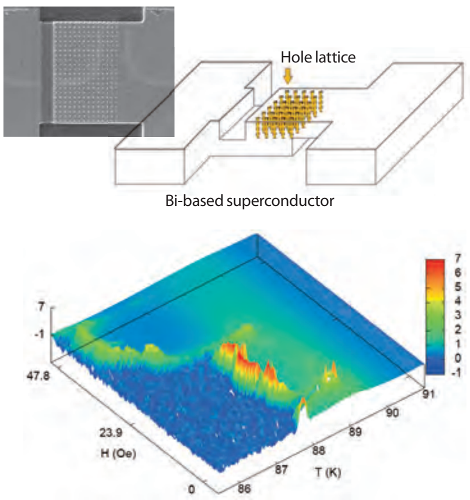

Fig. 2 Bi-based superconductor with a hole lattice structure. **(a)** Schematic drawing and photograph of an actual specimen taken from above in the drawing. The lattice spacing is 1 μm. **(b)** Logarithmic derivative of the flux-flow resistance measured on the specimen above plotted in H-T. Red color parts show steap changes of the resistance, which may be related to the phase transition

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Development of Next-Generation Superconducting Materials

– Road to Energy Saving Power Transmission –

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Hitoshi Kitaguchi

Possibility of superconducting power transmission cables

Global scale environmental problems, increasing population, and depletion of underground resources and fuels are all serious concerns. In future power systems, stable, high efficiency operation must be realized by combining diverse power sources and transmission and distribution technologies.

Given these circumstances, high expectations are placed on the performance characteristic of superconductivity, namely, zero electrical resistance, as this is directly linked to energy conservation.

The essence and attractiveness of applied superconductivity technologies in the energy field is the fact that these materials realize high energy density which cannot be achieved with other technologies in equipment. For example, in transmission cables, it is possible to transport current with a high current density and low loss which cannot be achieved without superconductivity.

Likewise, in equipment which uses a magnetic field, such as motors and generators, high magnetic fields which are only possible with superconductivity can be realized with compact size and at low operating cost.

In order to realize these features, higher performance is demanded in the superconducting materials which carry current in devices.

Realizing high performance in steadily-progressing bismuth-based high temperature superconducting wire materials

Because materials like electric wires are the most suitable for applications which involve passing an electric current, a variety of superconducting wire materials have been developed. In general, these are composite wire materials in which multiple superconducting materials having a fine, string-like form are embedded in a metal.

If it were possible for these wire materials to carry an unlimited amount of electric power with no loss, this would be a dream come true, but in fact, there are many limitations. In particular, the fact that the superconducting wire must be cooled to a sufficiently low temperature, and there is an upper limit on the current that can pass in the superconducting state (this upper limit is called the critical current, I_C), are major limitations.

The development of superconducting materials challenges these limitations. The aims are to enable use at higher temperature and transmission of larger currents with zero resistance.

We are engaged in research and development centering on bismuth (Bi)-based high temperature superconducting oxide wire materials that enter the superconducting state when cooled using liquid nitrogen, which is cheap and abundant.

Higher performance is gradually being achieved in Bi-based high temperature superconducting wire materials. As shown in the figure, the critical current at the temperature of liquid nitrogen with no external magnetic field now exceeds 200A/mm^2. As it is expected to be possible to realize superconducting power transmission and distribution at a sufficiently economical cost, even considering the cooling cost, development of high temperature superconducting power cables is underway in countries around the world. This work has now reached the stage of demonstration tests, in which superconducting cables are incorporated in the grid that actually supplies electric power to general households and businesses. In the future, further improvement in wire material performance will be necessary for expansion of superconducting power transmission.

We are targeting improvement of the critical current of Bi-based high temperature superconducting oxide wire materials from the present 200A/mm^2 to 300A/mm^2 within several years and 400A/mm^2 in the future.

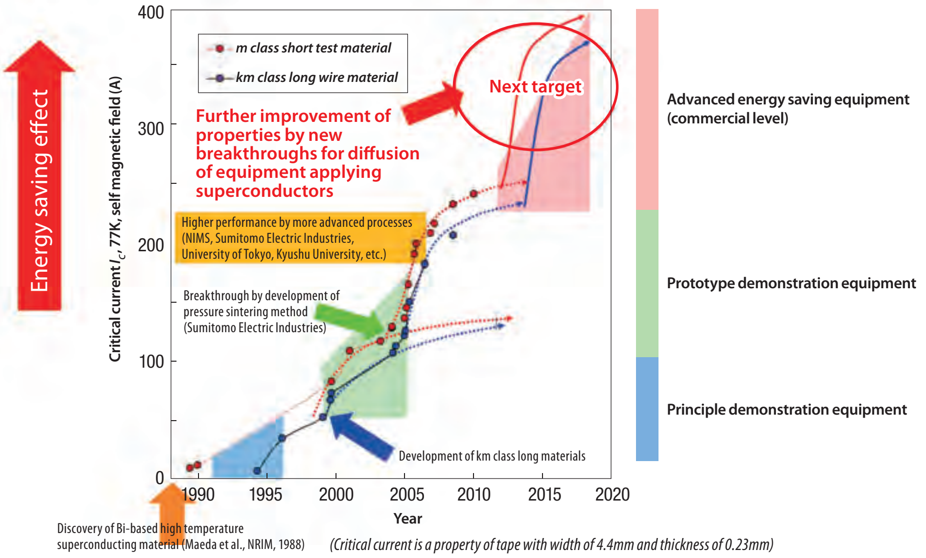

Figure History and outlook for the development of bismuth-based high temperature superconducting wire materials

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High-κ Dielectric Nanosheets: Tailor-Made Dielectrics *via* Controlled Nanoscale Doping

Soft Chemistry Group, Soft Chemistry Unit
Nano-Materials Field, MANA
Minoru Osada

NIMS Fellow, Unit Director, Soft Chemistry Unit,
Nano-Materials Field, MANA
Takayoshi Sasaki

High-κ Nanodielectrics for Future Electronic Devices

As electronics continue to decrease in size, new classes of materials are necessary to continue this downsizing trend. Of particular importance to miniaturizing electronics are capacitor components based on dielectric thin films, a central component to integrated circuits. High dielectric constant, or high-κ, oxides are a promising potential component for capacitors, and several current research efforts are focused on developing new versions of these materials that offer high capacitances and low leakage currents at several nanometer thicknesses. Many groups have directed their research toward perovskite oxide thin films, but these materials often yield dielectric constants an order of magnitude smaller than bulk material. This so-called size effect is a long-standing conundrum in current dielectrics, which limits further miniaturization in capacitor components. Attempts to design robust high-κ properties in nanofilms are not as yet solved but challenging issue in nanoelectronics.

Nanosheets: New Solution to Nanoelectronics

Aiming to develop high-κ oxides that operate at the nanometer level, we utilize a new approach to produce nanodielectrics using two-dimensional (2D) oxide nanosheets. 2D nanosheets obtained via exfoliation of layered compounds have attracted intensive research in recent years. In particular, recent development of graphene (carbon nanosheet) has sparked new discoveries in condensed matter physics and nanoelectronics. Oxide nanosheets are less common, but in many ways similar to graphene. Oxide nanosheets with a thickness of ~1 nm and lateral dimensions up to a few μm are the thinnest self-standing 2D nanostructures in oxide systems. We thus consider that oxide nanosheets are an important testing system for oxide electronics with the critical thickness.

World's Highest Performance Nanodielectrics

We apply titano-niobates nanosheets ($TiNbO_5$, Ti_2NbO_7, Ti_5NbO_{14}) to high-κ dielectrics since these nanosheets consist only of key building blocks of highly polarizable TiO_6/NbO_6 octahedra, which make an ideal base for high-κ dielectrics. Most importantly, these nanosheets provide great flexibility of site engineering (i.e., controlled doping) in individual nanocrystals through controlled doping in starting layered compounds. The octahedral distortion inherent to site engineering by controlled doping results in giant molecular polarizability, and their multilayer nanofilms indeed exhibit high dielectric constant (> 300), the largest value seen so far in high-κ oxide films with the thickness down to 10 nm. Furthermore, these superior high-κ properties are fairly temperature-independent with low leakage current density (< 10^{-7} A cm^{-2}). Our work thus provides a new recipe for designing nanodielectrics desirable for practical high-κ devices.

The perturbing impact of doping on dielectric properties is a well-known technique in conventional bulk materials. Surprisingly, this technique has now turned out to be useful for controlled properties of individual nanocrystals. Our doping technique also opens up new possibilities to systematically select well-defined compositions of 2D nanosheets for designing various functional materials such as ferromagnets and phosphors.

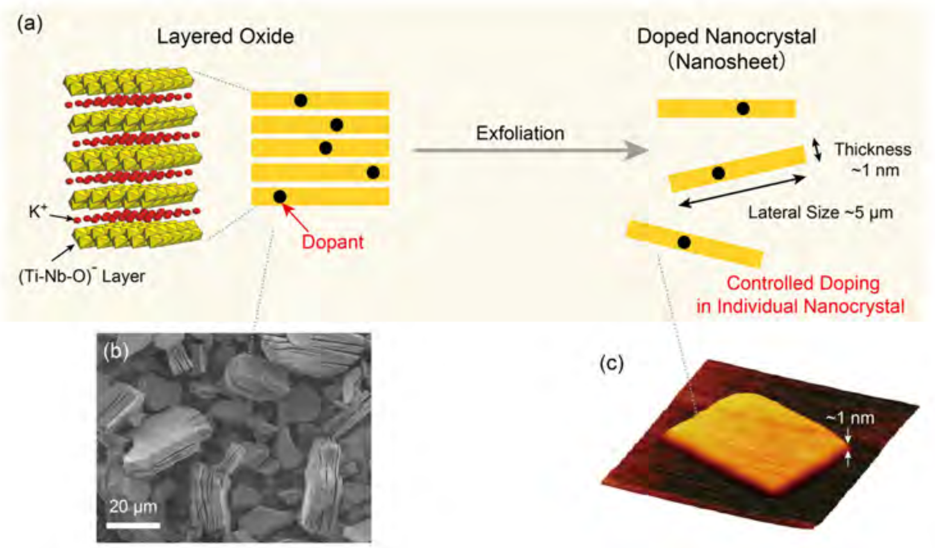
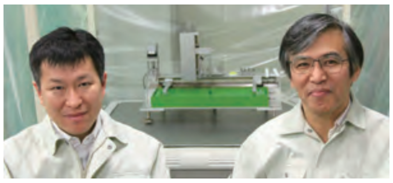


Figure. Tailor-made dielectric nanosheet via controlled nanoscale doping
(a) Schematic illustration showing how to make doped nanocrystal via nanosheet technique,
(b) scanning electron microscope image of layered oxide used as a starting material, and
(c) atomic force microscope image of Nb-doped nanosheet



Minoru Osada (left) Received his PhD in Materials Science from Tokyo Institute of Technology in 1998. Prior to joining NIMS in 2003, he was a RIKEN Special Postdoctoral Researcher and a JST PRESTO Researcher. He is currently a MANA Scientist and an Associate Professor of the Waseda University-NIMS Joint Graduate School.

Takayoshi Sasaki (right) Received his PhD in Chemistry from the University of Tokyo in 1985. Since 1980, he has worked for National Institute for Research in Inorganic Materials (NIRIM, now NIMS), Japan. He is now a NIMS Fellow and a MANA Principal Investigator.

11th NIMS Forum

Material Innovation for Tomorrow

The 11th NIMS Forum was held on Wednesday, October 26 at the Tokyo International Forum. The NIMS Forum has been held each year since NIMS was established in 2001 to inform a larger number of persons, both inside and outside NIMS, of the organization's research results.

The theme of this year's NIMS Forum was "Materials Innovation for Tomorrow." As 2011 marks the start of the 3rd Five-year Plan at NIMS, the focus this year was mainly on exhibition/introduction of the research capabilities cultivated during the 1st and 2nd Five-year Plan (which began in 2001 and 2006) and the research achievements under those programs.

As a new feature, a person who is active outside of NIMS was invited to present a special lecture. Two lectures on research results in the green field were also presented by NIMS researchers.

Opening greetings and oral session

Following opening greetings by the President of NIMS, Prof. Sukekatsu Ushioda, and guest's remarks by Mr. Takao Kuramochi, Director-General of the Research Promotion Bureau, Ministry of Education, Culture, Sports, Science and Technology (MEXT), the oral session presented the image of NIMS in the 3rd Five-year Plan, which began this year. The activities of the four research divisions and one center, and the base which serves as a hub for various research institutions in Japan and other countries were introduced.

President Sukekatsu Ushioda introduces NIMS

Mr. Takao Kuramochi, Director-General of the Research Promotion Bureau, MEXT

Special Lecture: "Smart Grids, Smart Communities, and Electric Vehicles"

An invited speaker, Mr. Tsuguo Nobe, who plays an active role as the Program Director of the Vehicle Information Technology Division at Nissan Motor Co., Ltd., delivered this Special Lecture to an enthusiastic audience, which listened intently to his discussion of the electric vehicles and EV society of the future. Mr. Nobe's lecture contained a wealth of suggestions, and many questions were also posed at the Q & A session that followed.

Mr. Tsuguo Nobe of Nissan Motor Co., Ltd.

Scene at the oral session

Lectures on NIMS Research Results

The Special Lecture by Mr. Nobe was followed by two lectures on NIMS research results in the green field. Dr. Kazunori Takada, who is Unit Director of the Soft Ionics Unit in the MANA/Nano-Green Field, delivered a lecture on "Solid-state Lithium Batteries," and Dr. Kohei Uosaki, Unit Director of the Nano Interface Unit, also in the MANA/Nano-Green Field, spoke on "High Resolution In-situ Measurement of Solid-Liquid Interfacial Structures." The audience listened with great interest to these presentations of recent NIMS research results which will contribute to solving environmental and energy problems.

Dr.K.Takada

Dr.K.Uosaki

Poster Session

In the poster session, a total of 61 posters introduced research results which are only possible at NIMS, including "Immobilization of Cesium in a Nano-porous Titanate," "Next-generation Solar Cells using Semiconductor Nanostructures," " 'Smart' Biomaterials for the Future Medicine," and others. The session also featured mini-lectures on 10 promising research topics for future development. The atmosphere at this session was excited, with many visitors hoping to exchange information through direct conversation with the researchers.

A mini-lecture at the poster session

The poster session area, showing the large turnout of visitors

NIMS NEWS

1 General Director of Mechanical and Systems Research Laboratories (MSL), Industrial Technology Research Institute (ITRI) of Taiwan visit NIMS

(November 9, 2011) General Director Dr. Tung-Chuan Wu, Deputy General Director Dr. Lai-Sheng Chen and three other members of MSL-ITRI visited NIMS. ITRI is one of the largest public research institutions in Taiwan having over 6,000 researchers, similar to AIST in Japan and Mechanical and Systems Research Laboratories is one of the six core laboratories and in charge of a research and development of machinery technology.

The MSL-ITRI delegates received introduction of NIMS and had a meeting with Executive Vice President and the Director in charge of external collaboration. Then, the delegates paid a courtesy visit to NIMS President, Prof. Sukekatsu Ushioda, and they explained about their laboratories and discussed how to promote the future collaboration between the two institutes.

After these meetings, they visited laboratories at Sengen site and Namiki site and listen to the explanation on the latest research results eagerly.

President Ushioda (left) and Dr. Wu (right)

2 Official Delegation from Ukraine visit NIMS

(November 18, 2011) Dr. Boris Grinyov, First Deputy Chairman of the State Agency on Science, Innovation and Informatization of Ukraine, and Director of Institute for Scintillation Materials, National Academy of Sciences of Ukraine (NASU) and Dr. Andrii Ragulia, Director of Ukrainian Nano-Program, and Deputy Director of the Institute for Problems of Materials Science, NASU visited NIMS. They had a meeting with Executive Vice Presidents and received introduction of NIMS. After that, they gave a presentation of their laboratories and how to promote the future collaboration between the two institutes and joint graduate school program were discussed.

Following the meeting, they visited laboratories at Sengen site and Namiki site and listened to the briefings of the latest research results eagerly.

Dr. Grinyov (right) and Dr. Ragulia (left)

3 MEXT Minister Nakagawa Visits NIMS

(November 19, 2011) Mr. Masaharu Nakagawa, who is Japan's Minister of Education, Culture, Sports, Science and Technology (MEXT), visited NIMS Namiki Site and Sakura Site. After a briefing on NIMS by Vice President Eiji Muromachi of NIMS, Unit Director Kazuhiro Hono of the Magnetic Materials Unit described the development of a neodymium magnet in which rare elements are not used. Minister Nakagawa asked about collaboration between NIMS and private-sector companies, which led to an active exchange of views on research funding by private companies and long-term big projects with industry. During this discussion, Minister Nakagawa commented that he "hope NIMS would make efforts so as to serve as a model case for Independent Administrative Institutions."

During the tour of the Namiki Site, Minister visited the MANA Foundry operated by the International Center for Materials Nanoarchitectonics (MANA), as well as the high efficiency fuel cell laboratory and SiAlON phosphor development laboratory, and also had a friendly conversation with foreign researchers. At the Sakura Site, Minister viewed the world's largest class NMR facility and the high voltage electron microscope facility. These are NIMS "user facilities" that are available for use by outside researchers. After the lab tour, they had a discussion on strategic installation policies for infra-structure facilities and other related issues.

MEXT Minister Nakagawa views a superconducting power transmission cable

Hello from NIMS

Dear NIMS NOW readers,

Two years ago, after I received doctoral degree from Peking University, China, I came to Japan to work in NIMS as a postdoctoral researcher. In the past two years, I lived alone in Tsukuba, but, as a foreigner who cannot speak Japanese, I did not feel lonely. NIMS is a very international institute and I have many friends here. I spend each weekend with them. Good athletic facilities in NIMS and Tsukuba city enable us to enjoy many sports and pleasure lives. Usually, I play basketball in the morning of Saturday and also tennis if weather is good and go fishing or swimming in the afternoon. Fishing in Japan is really enjoyable. On one day of this summer, I got 14 fishes in 4 hours and one of them was 70 centimeter long. I like traveling in Japan because of not only beautiful sceneries but also friendly Japanese people. I have traveled many famous cities, such as Tokyo, Kyoto, Fukushima, Kagoshima et al. This August I spent six hours and an half from the fifth station to the summit of Mount Fuji. It is really an unforgettable climbing experience.

My wife and me on the summit of Mt. Fuji

At Lake Kawaguchiko with my friends

Xianlong Wei (China)
from Sep. 2, 2009 – present
ICYS-MANA researcher, MANA

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cover image: 20T superconducting magnet / top loading dilution refrigerator

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