

ICC-IMR FY2024 Activity Report

ICC-IMR FY2024

Activity Report

International Collaboration Center

Institute for Materials Research
Tohoku University

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Mission

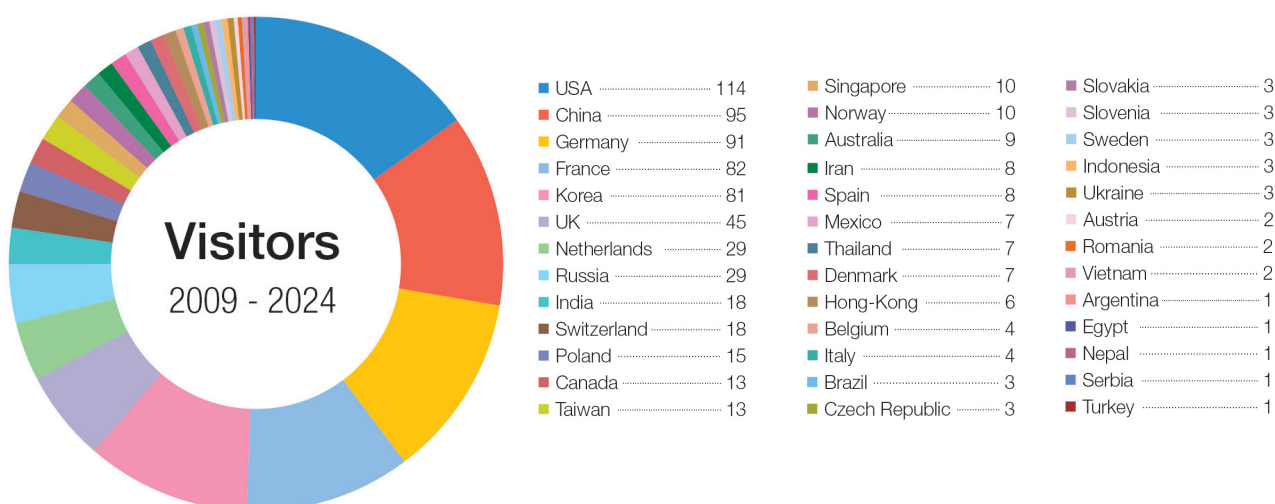
The ICC-IMR was founded in April 2008 as the center for international collaboration of the Institute for Materials Research (IMR) a center of excellence in material science, consisting of 27 research groups and six research centers. The ICC-IMR works as a gateway of diverse collaborations between overseas and IMR researchers. The ICC-IMR has invited 94 visiting professors and conducted 26 international research projects since its start-up (please inspect the graph below for more details,). The applications are open to foreign researchers and the projects are evaluated by a peer-review process involving international reviewers.

ICC-IMR coordinates five different programs:

- 1) International Integrated Project Research
- 2) Visiting Professorships
- 3) International Workshops
- 4) Fellowships for Young Researcher and PhD Student
- 5) Material Transfer Program

We welcome applicants from around the globe to submit proposals!

Visitors supported by ICC-Programs



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Activity Report

Visiting Professors



Visiting Professors

No.	Title in IMR	Name	Affiliation	Host Professor	Proposed Research	Term
24G1	Visiting Professor	Jean-Marc Debierre	Aix-Marseille University, France	Prof. Fujiwara	Theoretical Study on Kinetics at Crystal/Melt Interface	2024.5.15-2024.6.14
24G2	Visiting Assistant Professor	Arvind Maurya	Mizoram University, India	Prof. Aoki	Search for Quantum Criticality in Low Dimensional Ferromagnet UNi_4P_2	2024.11.1-2025.1.28
24G3	Visiting Professor	Zhongwen Ouyang	Huazhong University of Science and Technology, China	Prof. Nojiri	Investigation on New Quantum States in Triangular-Lattice Dimer Antiferromagnets	2024.10.11-2024.11.19
24G4	Visiting Professor	Jaegeun Hah	Kwangwoon University, Korea	Prof. Seki	Novel Fabrication of Self-Organized Nano-Thin Films	2025.1.20-2025.2.26
24G5	Visiting Lecturer	Jack C. Gartside	University College London, UK	Prof. Seki	Fabricating 3D Nanomagnetic Arrays for Reconfigurable Magnon Frequency Combs and Neuromorphic Computing	2025.2.17-2025.3.28

Silicon solidification near a well-characterized grain boundary: comparison between experiment and analytical model

Abstract: A model based on Ben Amar-Pomeau (BAP) equation for faceted solid-liquid interfaces is proposed, in order to interpret experimental results obtained in silicon solidification experiments. We focus here on the case of a $\Sigma 27a$ grain boundary. The dynamics of the grain boundary groove displays pinning of the groove bottom, steady increase of the facets that bound the groove, and, at regular time intervals, rapid solidification of the liquid trapped inside the groove. The proposed model produces a time evolution of the solid-liquid interface that compares very quantitatively with the experiments.

Grain boundaries usually have detrimental effects on the conduction properties of silicon. These effects can result from local breaking of the crystalline translational order and/or breaking of the chemical purity. Understanding the role of grain boundaries is thus crucial to help controlling the quality of silicon produced through a solidification process for applications such as solar energy conversion.

During my visit at IMR Sendai, one year ago, I worked in Pr. Fujiwara's group, specifically discussing one of their experiments where the time evolution of a grain boundary of the $\Sigma 27a$ type was observed [1]. Near the grain boundary, the solid-liquid (S-L) interface forms a wedge groove limited by two (111) facets. The deepest point of the groove appears to be pinned at a fixed location. As time flows, the two facets that bound the groove increase in size. At regular time intervals, rapid solidification of the liquid trapped inside the groove occurs (see Fig.1) and the groove recovers its initial small size. This evolution has a period of a few tens of seconds.

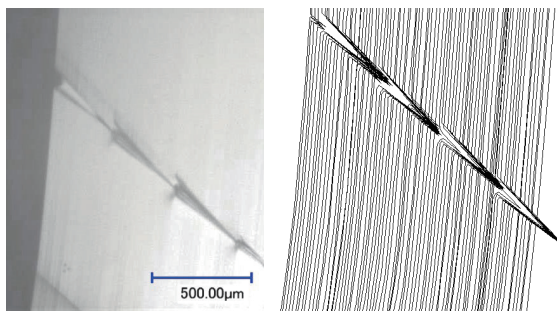


Fig. 1 S-L front evolution in the experiment

In order to interpret this experiment, I proposed a simple model based on the following assumptions [2]:

1. BAP interface equation holds any time
2. Groove bottom is fixed
3. Facet normal velocity is zero
4. Global front velocity V is constant
5. Temperature gradient G in the groove reduces in time, due to thermal effects

A simple code based on this model was implemented with the experimental values $V=15.7 \mu\text{m/s}$ and $G=3.7 \text{ K/cm}$ that correspond to Fig.1. Time evolution of the front over a period of 30 s is represented in Fig.2.

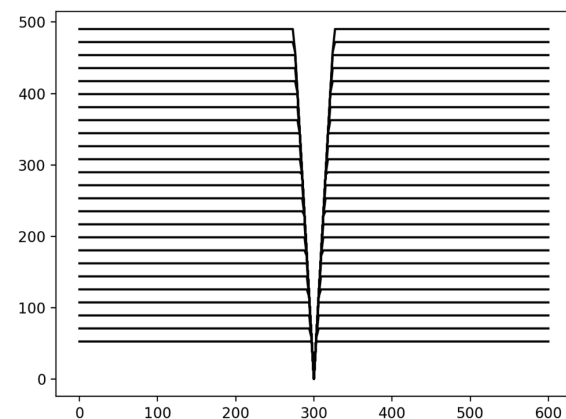


Fig. 2 S-L front evolution in the model (scales in μm)

The proposed model produces a time evolution of the solid-liquid interface that compares very quantitatively with the experiments. Possible improvements of the model would consist in relaxing some of the assumptions made (1 to 5). For instance, assumption 4 may be made less stringent to mimic the experimental observation that the outer front velocity is not perfectly constant (see Fig.1).

References

- [1] Lu-Chung Chuang and K. Fujiwara, unpublished results.
- [2] Jean-Marc Debierre, unpublished results.

Search for quantum criticality in low dimensional ferromagnet UNi_4P_2

Abstract: Single crystals of $\text{UNi}_4(\text{P}_{1-x}\text{As}_x)_2$ have been grown successfully and are found to emulate negative pressure on the parent stoichiometric quasi-one dimensional ferromagnet UNi_4P_2 . The substitution suppresses the ferromagnetic order marginally but overall it remains robust against the negative chemical pressure. Higher concentration samples ($x = 0.4$ and $x = 0.5$) exhibit additional peak in heat capacity, origin of which is yet to be confirmed.

Existence of a ferromagnetic quantum critical point in correlated electron materials is not only elusive but efforts to search for it have brought in exotic phenomena that have led to a better understanding of correlated electron matter at low temperatures.

UNi_4P_2 is a quasi-low dimensional ferromagnet with a Curie temperature of 25 K. It exhibits anisotropic *cf*-hybridization and Ising type magnetocrystalline anisotropy as reported in our previous study [1].

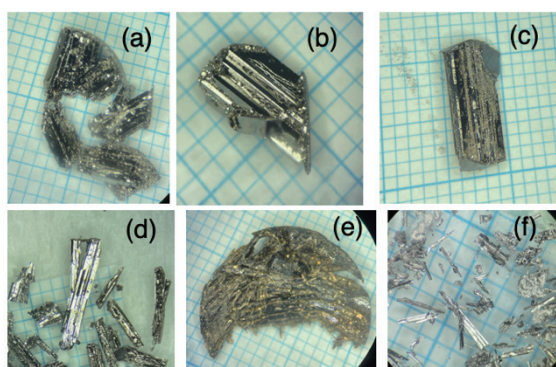


Figure 1: Single crystals of $\text{UNi}_4(\text{P}_{1-x}\text{As}_x)_2$ with (a) $x = 0.05$, (b) $x = 0.1$, (c) $x = 0.2$, (d) $x = 0.3$, (e) $x = 0.4$, and (f) $x = 0.5$.

In the present work, our motivation has been to tune the ferromagnetic (FM) order in UNi_4P_2 by means of negative chemical pressure achieved by an iso-electronic partial substitution of phosphorous atoms with arsenic atoms. The single crystals of the targeted materials could be successfully grown by high temperature flux method (Fig. 1). The actual composition of the crystals determined from electron dispersive analysis by X-rays (EDAX) turns out to be slightly lower than the targeted ones but the Vegard's law is followed across the series. A unit-cell volume expansion up to 4.8 % for the As-substituted samples with respect to the parent compound has been observed as per the powder X-ray

diffraction.

The heat capacity versus temperature measurements reveal the characteristic transition temperatures as shown in Fig. 2(a). An initial trend of suppression of the Curie temperature can be clearly seen. However, at higher doping concentrations, namely at $x=0.4$ and $x=0.5$, an additional peak is observed, which surprisingly

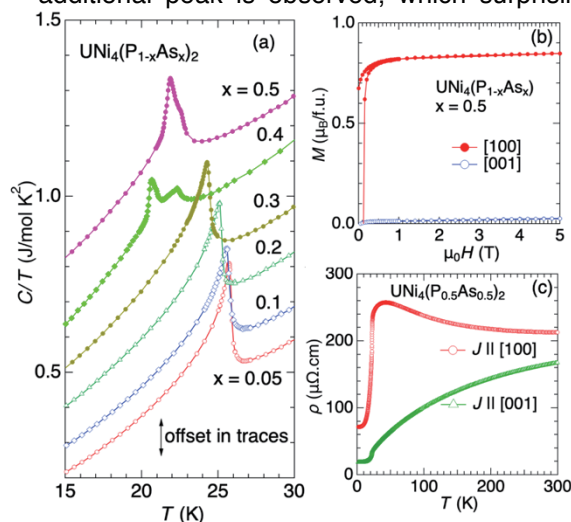


Figure 2: (a) Evolution of ferromagnetic order with arsenic substitution in $\text{UNi}_4(\text{P}_{1-x}\text{As}_x)_2$. (b) Anisotropic magnetization and (c) electrical resistivity in $\text{UNi}_4(\text{P}_{0.5}\text{As}_{0.5})_2$.

does not appear in magnetization and electrical resistivity. The origin of the second peak henceforth is yet to be confirmed.

The anisotropy in magnetization (Fig. 2(b)) and electrical resistivity (Fig. 2(c)) of $x = 0.5$ sample is qualitatively identical to that of the parent compound UNi_4P_2 .

In summary, an attempt to apply negative chemical pressure in UNi_4P_2 is successful and the FM order overall remains robust against it.

References

[1] A. Maurya, A. Miyake, H. Kotegawa, Y. Shimizu, Y. J. Sato, A. Nakamura, D. X. Li, Y. Homma, F. Honda, M. Tokunaga, and D. Aoki Phys. Rev. B 107, 085142 (2023).

Keywords: actinide, crystal growth, magnetic properties
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Tremendous difference in magnetism between the triangular-dimer-lattice antiferromagnets $\text{Rb}_2\text{Ni}_2(\text{SeO}_3)_3$ and $\text{K}_2\text{Co}_2(\text{SeO}_3)_3$

We found the tremendous difference in magnetism between the triangular-dimer-lattice compounds $\text{Rb}_2\text{Ni}_2(\text{SeO}_3)_3$ and $\text{K}_2\text{Co}_2(\text{SeO}_3)_3$ by structure and magnetic characterization, high magnetic field magnetization measurements, as well as density-functional theory calculations.

The newly synthesized $\text{Rb}_2\text{Ni}_2(\text{SeO}_3)_3$ is magnetically ordered at 5.8 K and undergoes two-step antiferromagnetic (AFM) transitions when magnetic field is applied along the easy c axis ($H//c$). The high-field magnetization at 2 K for $H//c$ demonstrates a $1/3$ magnetization plateau within 17.6 - 25.1 T, followed by a possible narrow $1/2$ plateau within 27.4 - 28.6 T (see Fig. 1). No plateau is observed for $H//ab$. The density functional theory (DFT) calculations reveal that the exchange within the structural dimer (J_0) is significantly smaller than the exchange in the triangular-lattice layer (J_1), which explains why $\text{Rb}_2\text{Ni}_2(\text{SeO}_3)_3$ behaves like an easy-axis triangular lattice antiferromagnet (TLAF).

However, for $\text{K}_2\text{Co}_2(\text{SeO}_3)_3$, which is disordered down to 2 K, the high-field magnetization at 1.6 K shows a $1/3$ magnetization plateau within 3.6 - 7.7 T and a $1/2$ plateau within 10.1 - 13.0 T for $H//c$, and only a wide $1/3$ plateau within 9.1 - 15.5 T for $H//ab$ (see Fig. 2). The DFT calculations reveal that J_0 is much larger than the J_1 , in contrast with the Ni compound. Thus, $\text{K}_2\text{Co}_2(\text{SeO}_3)_3$ is a coupled dimer antiferromagnet that combines the characteristics of AFM dimer and TLAF. Two phenomenological models, including AFM singlet dimers in $\text{K}_2\text{Co}_2(\text{SeO}_3)_3$ and ferromagnetic structural dimers in $\text{Rb}_2\text{Ni}_2(\text{SeO}_3)_3$, are proposed to explain the magnetization plateaus along the c axis.

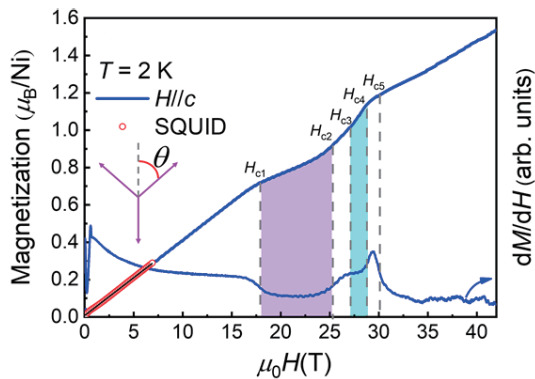


Fig.1 High magnetic field magnetization of $\text{Rb}_2\text{Ni}_2(\text{SeO}_3)_3$

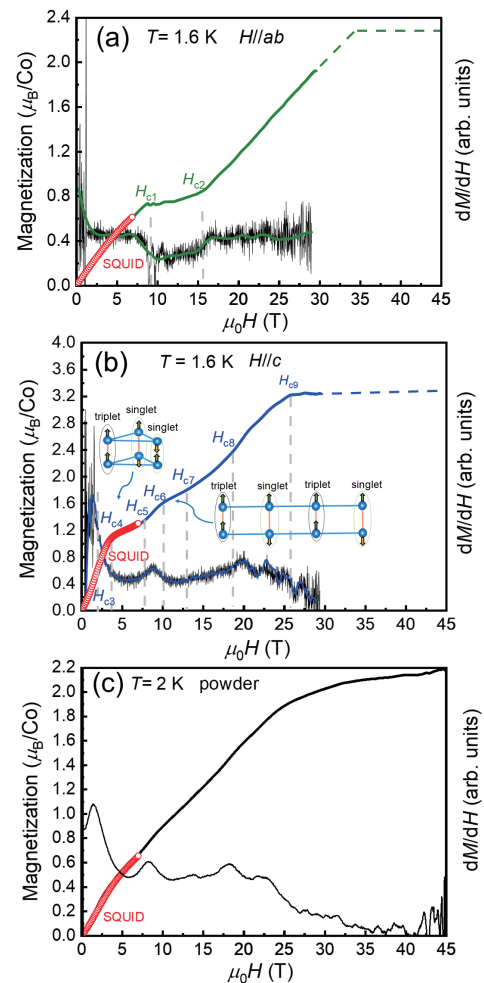


Fig.2 High magnetic field magnetization of $\text{K}_2\text{Co}_2(\text{SeO}_3)_3$

Keywords: high field, magnetism

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References

- [1] Z. R. Li, L. Wang, J. J. Cao, Z. M. Tian, Z. X. Wang, Z. C. Xia, H. Nojiri, and Z. W. Ouyang, Phys. Rev. B (accepted, 2025)

Title: Dewetting effect of Ag thin film by new seed layer Zr

Abstract: It was confirmed that the dewetting behavior of Ag/Zr thin films varies significantly depending on the presence of Zr. Ag thin films deposited on MgO (001) substrates rearranged into dot-like structures after heat treatment, and during this process, the Zr layer played an important role in the nucleation and growth rates.

This study confirmed that the dewetting behavior of Ag/Zr thin films varies significantly depending on the presence and thickness of the Zr layer, the amount of Ag deposition, and the annealing conditions. Ag thin films deposited on MgO (001) substrates were rearranged into dot-like structures after heat treatment, during which the Zr layer played a critical role in nucleation and growth rates [1-5].

These findings provide valuable fundamental data for applications involving thermal stability and patterning of thin films. They also suggest that similar approaches

Specifically, in the absence of Zr (i.e., 10 nm Ag deposited alone), the surface showed relatively high RMS roughness, low coverage, and a high dot density. In contrast, when a 3 nm Zr layer was introduced, RMS and coverage tended to stabilize, which is interpreted as the result of the Zr layer modulating the surface energy and promoting more uniform dot formation. Notably, the combination of 7 nm Ag / 3 nm Zr yielded the highest coverage and dot density, suggesting that the Ag thickness was sufficient and the Zr effectively acted as a diffusion barrier.

However, as this study was conducted under limited sample sets and conditions, follow-up experiments covering a broader range of variables are needed.

These findings provide valuable fundamental data for applications involving thermal stability and patterning of thin films. They also suggest that similar approaches may be applicable to various other metal/interface combinations. Furthermore, the results demonstrate how the presence of a thin layer such as Zr can control surface behavior, indicating potential applications in nanoscale thin film structure control and materials engineering.

However, as this study was conducted under limited sample sets and conditions, follow-up experiments covering a broader range of variables are needed. Future work should include advanced analysis techniques such as TEM and XPS to elucidate mechanisms at the atomic structure level.

References

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- [2] E.M. Hicks, S. Zou, G.C. Schatz, et al., "Controlling plasmon line shapes through diffractive coupling in linear arrays of cylindrical nanoparticles fabricated by electron beam lithography," *Nano Lett.*, **5**, (2005) 1065–1070.
- [3] C. Favazza, R. Kalyanaraman, and R. Sureshkumar, "Robust nanopatterning by laser-induced dewetting of metal nanofilms," *Nano*, **17**, (2006) 4229–4234.
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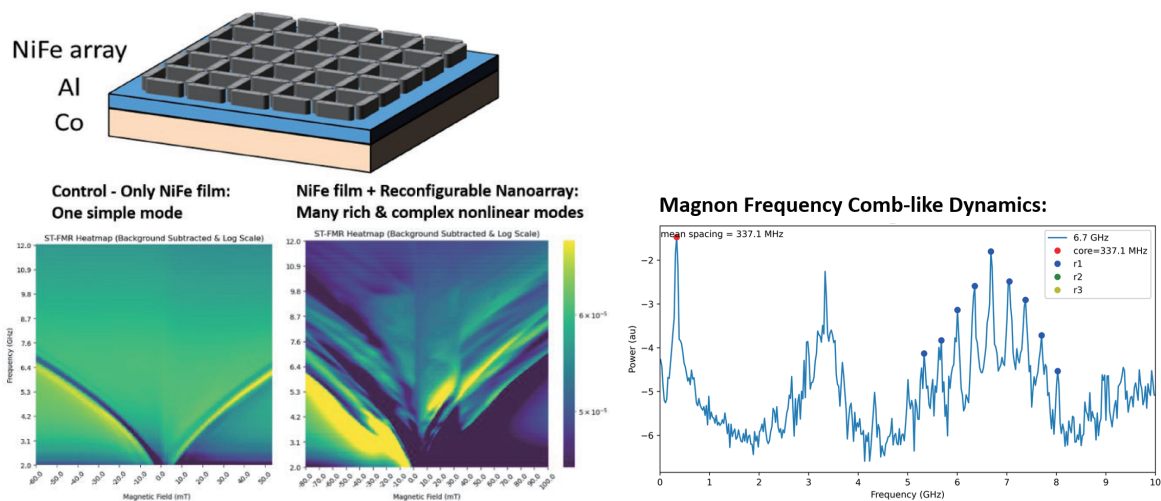
Keywords: nanostructure

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Fabricating 3D Nanomagnetic Arrays for Reconfigurable Magnon Frequency Combs and Neuromorphic Computing

With the kind support of the IMR & Tohoku University, a breakthrough result was obtained where for the first time it was demonstrated that fabrication of a quasi 3D magnetic nanodevice comprising a reconfigurable nanomagnetic array strongly dipolar-coupled to a continuous thin magnetic film can lead to the generation of a huge number of reconfigurable magnon modes and magnon frequency comb-like phenomena



Figures 1 & 2: **Top** Schematic of the device architecture comprising NiFe nanoarray, coupled via dipolar magnetic field through a nonmagnetic spacer (here Al) to a continuous ferromagnetic film (here Co, also NiFe). **Bottom Left** Control broadband ferromagnetic resonance spectra – bare thin film with no nanoarray. A simple, single resonant magnon mode is observed. **Bottom middle** Equivalent spectra for device comprising a nanoarray coupled to the film, as shown in the schematic at the top. Here, a broad variety of complex ferromagnetic resonant modes are observed – dynamically imprinted by the reconfigurable nanorray. **Bottom right** Data showing an evenly spaced set of comb-like resonant modes – magnon frequency comb behaviour.

The study and visit confirmed that coupling a magnetic nanoarray with programmable state allows for the imprinting of a broad range of

complex, reconfigurable magnon modes with frequency comb-like dynamics into a simple ferromagnetic continuous thin film. This was hypothesized in our initial proposal, but until the visit to the IMR at Tohoku this had not been observed. This is a significant finding and represents strong progress and scientific value & international collaboration enabled by the IMR visiting professor scheme. These results would not have been possible at Imperial College London or Tohoku alone, requiring careful combination of nanoarray design and magnetic state control developed at Imperial College London, UK with advanced thin film technologies and GHz magnetic spectroscopy facilities and expertise provided by the IMR in Tohoku, Japan and the expertise, skills and facilities provided by host Prof. Seki and group, notably PDRA Varun Kushwara.

The expanded range of frequency dynamics will enable for far stronger parallelization of GHz neuromorphic computing processing, a key step

towards delivering low carbon AI-specific hardware for future computing technologies, alongside enabling study of intriguing emergent physical phenomena – namely the imprinting of complex magnon dynamics with non-trivial spatial and dynamic character into magnetic thin films.

This study represents the first step towards a larger

continued research programme between the UK and Japan, and Imperial College London and Tohoku University – ideally supported by future international visits and exchange of personnel, skills and ideas.

Keywords: nanostructure, ferromagnetic, lithography
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Activity Report

Workshops



Workshops

No.	Chairperson or Committee Member	Title of Workshop	Place	Term
24WS1	Assoc. Prof. Yamanaka	GIMRT Workshop: The 19th International Workshop on Biomaterials in Interface Science	Sendai	2024.8.6
24WS2	Prof. Fujita	GIMRT Workshop: Workshop on Polarized Neutron Sciences and Technology	Sendai	2024.10.21-22
24WS3	Prof. Orimo	GIMRT Workshop: The 8th Symposium for the Core Research Clusters for Materials Science and Spintronics and the 7th Symposium on International Joint Graduate Programs in Materials Science and Spintronics (CRCGP-MSSP2024)	Sendai	2024.11.18-21
SMS2024	Prof. Sasaki	Summit of Materials Science 2024 and GIMRT User Meeting 2024	Sendai	2024.11.27-28

The 19th International Workshop on Biomaterials in Interface Science

研究代表者：東北大金研 山中謙太

研究分担者：東北大歯学 金高弘恭 高橋信博 鈴木治 東北大医工学 西條芳文 成島尚之

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1. 概要

高機能で自律的なインテリジェントインターフェースを創出するためには、生体材料、その評価技術、口腔科学、再生口腔科学、医工学などの分野を統合することが必要である。東北大学では、金属材料研究所、大学院歯学研究科、大学院医工学研究科が協力し、人間の構成要素と生体材料の間の材料やシステムを探究することを目的とした「生物-非生物インテリジェント界面科学」という新しい概念を確立するためにバイオマテリアルプロジェクトに取り組んでいる。一方、複雑な現象を理解し、生命と非生命のインターフェースを最適化するためには、学際的かつ国際的な研究活動がますます重要となっており、これにより未来の生体材料や医療機器の革新が可能となる。

The 19th International Workshop on Biomaterials in Interface Science は、2024 年 8 月 6 日に開催され、生体材料に関連するさまざまな分野の第一線の研究者と学生が集まった。4 名の専門家による招待講演と 22 件の口頭発表が行われ、生体材料に関するインテリジェント界面科学の確立に向けた、分野を超えた議論、学際的なアイデアの共有、新しいコラボレーションの貴重な機会となった。

2. 内容

今回は東北大学金属材料研究所講堂を会場とし、オンライン参加を含めたハイブリッド開催された。Biomaterials、Oral Health Care、Young Innovators、Biomedical Engineering と 4 つのセッションに分け、中国東北大学 Xiaoli Zhao 准教授による“Low-cost surface modification of the Zr-containing biomedical alloys”、台湾国立陽明交通大学 Her-Hsiung Huang 教授による“Surface Modifications for Dental Implants”、京都大学 新宅先博文教授による“Linking cellular behaviors to transcriptomics at single-cell resolution”、台湾成功大学 Chih-Chung Huang 教授による“Ultrafast High Frequency Ultrasound Imaging and Its Biomedical Applications”の計 4 件の招待講演がそれぞれ行われた。また、それぞれのセッ

ョンにおいて若手研究者および学生による口頭発表が行われた。

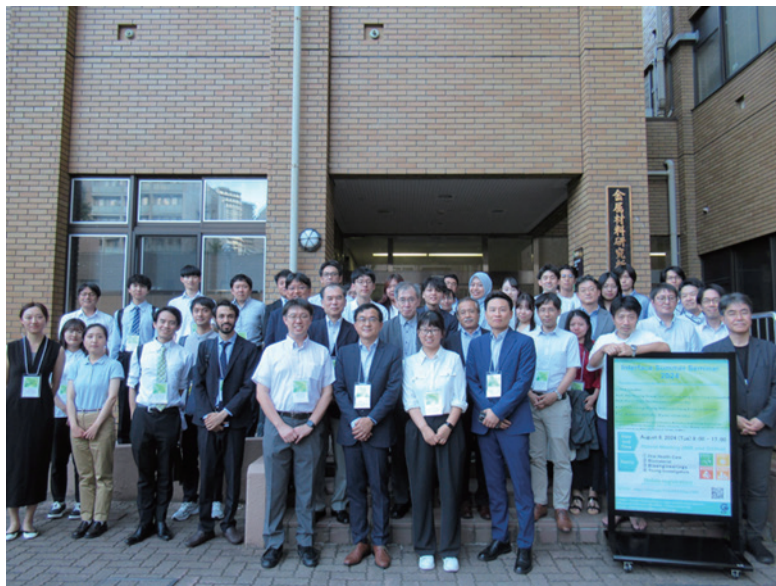
参加者は79名（オンサイト58名、オンライン21名）であった。対面での参加者が多く、長時間にわたる活発な議論が交わされるとともに、異分野間での交流が行われた。



Xiaoli Zhao 准教授による招待講演

3. 謝辞

本ワークショップは、東北大学金属材料研究所 国際・産学連携インヴァースイノベーション材料創出プロジェクトが主催し、GIMRTの助成により実施された。運営にご支援いただいたすべての方に謝意を表する。



参加者による集合写真

Workshop on Polarized Neutron Science and Technology

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日本原子力研究開発機構 原子力科学研究所 金子 耕土、奥 隆之、森 道康、河村 聖子

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Keywords: Polarized Neutron Scattering/Diffraction

Workshop on Polarized Neutron Scattering was held at the Institute for Materials Research, Tohoku University, on October 21–22, 2024. We had over 60 participants each day, including researchers from major international neutron facilities such as ANSTO (Australia), CSNS (China), ILL (France), ISIS (UK), and ORNL (USA). The program featured 18 oral presentations across four themed sessions, along with 14 poster presentations. Discussions covered advanced polarized neutron techniques, developments in ^3He spin filters, and their applications in materials science and fundamental physics. The workshop provided a valuable opportunity to strengthen international collaboration and promote the complementary use of J-PARC and JRR-3. The active participation of young researchers also highlighted the event's role in fostering the next generation of scientists.

1. 緒言 (Introduction.)

中性子散乱は、軽元素や電子スピンを含む原子の位置や運動に関する情報を取得ができるユニークな研究手法で、物質科学にとって不可欠な計測ツールである。さらに、スピン偏極中性子ビームを用いることで、電子の複合自由度が絡み合った複合相関から磁性成分を選択的に抽出できなど、高度な研究が行える。エキゾチックな量子物質における複雑な磁気構造の決定や、キラル磁性秩序物質のキラル項に関する情報の提供は最近注目されている研究の一例である。

偏極中性子技術が、次世代の中性子科学を切り開く戦略アイテムとして、世界中の中性子研究施設で開発が進められている状況において、東北大学金属材料研究所（金研）では、スピン交換光ポンピング(SEOP)法に基づく偏極システム開発とその分光器への導入を継続的に行い、高エネルギー中性子偏極非弾性散乱実験のための環境開発を進めている。また、日本原子力研究開発機構、高エネルギー加速器研究機構、茨城大学などと協働で、SEOP システムを J-PARC 物質・生命科学実験施設の中性子散乱装置に設置し、偏極中性子実験環境を利用者に供している。そこで、この機会に偏極中性子研究を加速し、J-PARC と研究用原子炉 JRR-3 の相補的利用による新しい科学の方向性について、世界の専門家を招いて議論する国際ワークショップを開催することとした。

2. 開催内容 (Experimental procedure)

ワークショップは、2024 年 10 月 21 日（月）、22 日（火）の二日間、東北大学金属材料研究所の講堂にて開催した。プログラムは表 1、2 の通りである。施設と大学の研究者を結びつけ、偏極中性子をより幅広い科学コミュニティに普及させることを念頭に、口頭発表セッションでは以下の 4 つのトピックを取り上げ、合計 18 件の発表枠を設けた。

1. 施設とビームラインにおける偏極中性子利用

- ^3He スピンフィルター・偏極デバイスの開発と活用
- 偏極中性子を用いた物性研究（実験・理論）
- 広範な科学テーマにおける先端利用

一方、ポスター発表は、希望者が申請する形式とし、合計 14 件の発表があった。講演は対面形式で実施し、現地参加のみとしたが、両日ともに 60 名以上の参加があり、活発な議論が交わされました。また、海外からは、ANSTO（オーストラリア）、CSNS（中国）、ILL（フランス）、ISIS（イギリス）、ORNL（アメリカ）などの主要研究機関から参加があり、貴重な国際交流の場となった。

Oral presentation

1st day		21 Oct	Name	Title	2nd day		22 Oct	Name	Title
opening		10:00-10:15	M. Fujita		S5	Hard matter I Y. Ikeda	9:00-9:15	H. Cao (ORNL)	Unveil hidden spin order and magnetic symmetry through polarized neutron diffraction
S1	Facility I K. Kakurai	10:15-10:30	G. Nilsen (ISIS)	Wide-angle Polarization Analysis for Energy and Quantum Materials			9:15-9:30	N. Terada (NIMS)	Polarized and Unpolarized neutron diffraction experiments under high pressure in multiferroic compounds
		10:30-10:45	A. Manning (ANSTO)				9:30-9:45	K. Kodama (JAEA)	Magnetic pair distribution function (mPDF) analysis on short-range ordering state in frustrated metallic magnets
		10:45-11:00					9:45-10:00		
		11:00-11:15					10:00-10:15		
break		11:15-11:30			break		10:15-10:30		
S2	3He spin filter M. Iinuma	11:30-11:45	T. Ino (KEK)	3He Neutron Spin Filter Development at J-PARC	S6	Hard matter II M. Mori	10:30-10:45	T. Kikkawa (JAEA)	Spintronic functionalities based on magnon and nuclear spin dynamics and their development into the polarized neutron scattering
		11:45-12:00	S. Takada (Tohoku Univ.)	Operational applications of 3He neutron spin filters at JRR-3 and J-PARC			10:45-11:00	T. Ziman (ILL)	Crystal field excitations, Double Umbrellas and Theory of the Spin Seebeck effect in Terbium Iron Garnet.
		12:00-12:15					11:00-11:15		
		12:15-12:30					11:15-11:30		
		12:30-12:45					11:30-11:45		
lunch		12:45-13:00			lunch		11:45-12:00		
		13:00-13:15					12:00-12:15		
		13:15-13:30					12:15-12:30		
		13:30-13:45					12:30-12:45		
		13:45-14:00					12:45-13:00		
S3	Facility II K. Ohishi	14:00-14:15	X. Tong (CSNS)	Update of polarized neutron R&D from CSNS	S7	Facility + device S. Yano	13:00-13:15	T. Bigault (ILL)	Polarized neutrons and supermirrors at the ILL
		14:15-14:30	M. Matsuda (ORNL)	Polarized 3-axis spectrometer PTAX (HB-1) at HFIR: instrumentation and science			13:15-13:30	R. Maruyama (JAEA)	Wide bandwidth neutron polarizing supermirror due to ferromagnetic interlayer exchange coupling
		14:30-14:45	K. Kaneko (JAEA)	Polarized neutron scattering capability under extreme conditions at JRR-3			13:30-13:45	K. Hiroi (JAEA)	Polarization analysis instruments for separation of incoherent scattering at BL15 TAIKAN and SANS-J
		14:45-15:00					13:45-14:00		
		15:00-15:15					14:00-14:15		
S4	poster	15:15-15:30			S8	Advanced Application M. Fujita	14:15-14:30	T. Kumada (JAEA)	Recent progress in our spin-contrast-variation neutron scattering
		15:30-15:45					14:30-14:45	T. Okudaira (Nagoya Univ.)	Development and applications of the 3He spin filter for the fundamental physics at J-PARC
		15:45-16:00					14:45-15:00	T. Higuchi (Kyoto Univ.)	Development of ultracold-neutron spin analyzers for the neutron EDM experiment at TRIUMF
		16:00-16:15					15:00-15:15		
		16:15-16:30					15:15-15:30		
		16:30-16:45					15:30-15:45		
		16:45-17:00					15:45-16:00		
					closing		16:00-16:15	H. Cao/K. Kaneko	

表 1 ワークショップのプログラム。

Poster presentation

S4-1	M. Iinuma (Hiroshima Univ.)	Development of a polarized La target with a perovskite crystal for exploration of the T-violation with a polarized slow neutron
S4-2	C. Tabata (JAEA)	The Superconducting Magnet Suite for Polarized Neutrons at JRR-3: Horizontal-Field Magnet
S4-3	Y. Ikeda (Tohoku Univ.)	Current Status of the Tohoku University Polarization Analysis Neutron Spectrometer 6G-TOPAN in 2024
S4-4	S. Takada (Tohoku Univ.)	Recent Advancements and Operational Applications of 3He Spin Filters at MLF Beamlines
S4-5	S. Takahashi (Ibaraki Univ.)	Half-polarized neutron diffraction experiment using an in-situ 3He neutron spin filter at SENSU
S4-6	T. Okudaira (Nagoya Univ.)	Search for time-reversal symmetry violation using a polarized neutron beam and a polarized target
S4-7	T. Ino (KEK)	In-situ polarized 3He neutron spin filter on POLANO
S4-8	M. Okuzumi (Nagoya Univ.)	Development of an In-situ SEOP System for the Measurement of Spin Correlation Terms in (n, γ) Reactions
S4-9	K. Asai (JAEA)	Development of an epitaxial neutron polarization device for the T-violation search experiment using compound nuclei
S4-10	R. Kobayashi (Nagoya Univ.)	Fabrication and Evaluation of 3He Neutron Spin Filter in J-PARC MLF
S4-11	T. Oda (Univ. of Tokyo)	Introduction of the neutron spin echo spectrometers at JRR-3 and J-PARC MLF
S4-12	M. Fujita (Tohoku Univ.)	Exploring neutron spin polarization science

表 2 ポスター発表のリスト

3. 成果 (Results)

本ワークショップでは、日本および海外における偏極中性子に関する最新の研究成果や技術開発が集中的に共有され、参加者間の活発な意見交換が行われた。日本からは、 ^3He スピンフィルターの開発や国内施設における利用の現状が紹介された。特に J-PARC では ^3He スピンフィルターの in-situ 偏極化技術の高度化や、極低温・高圧磁場下での散乱測定を可能とする装置整備が進展していることを踏まえ、J-PARC と JRR-3 という二つの主要施設間での相補的な研究の可能性についての議論が深まった。また、エネルギー材料や量子物質、スピントロニクス材料などを対象に、構造解析・スピンドイナミクスの解明を目指した最新の実験成果や技術開発が報告された。一方、海外での偏極中性子利用については、イギリス ISIS における広角偏極解析の取り組みとして、 ^3He ガスを用いたスピンフィ

ルターの応用により、電池材料や液体、ソフトマターにおける拡散挙動の解析が行われていることが紹介された。またオーストラリア ANSTO では、ソフトマターやキラル磁性体の研究を目的とした新たな磁場環境下での偏極測定法の開発が進んでいることが示された。

より具体的な研究内容として、 CuFeO_2 や CuO などのマルチフェロイクスにおける高圧下の偏極回折実験や、磁気ペア分布関数 (mPDF) による短距離磁気相関の解析やスピンセーバック効果を担うマグノンの振る舞いを中性子散乱によって検証した研究の成果が発表された。また、 $\text{Tb}_3\text{Fe}_5\text{O}_{12}$ などのスピンセーバックシグナルが特異な温度・磁場依存性を示す磁性ガーネットに対する理論的検討も発表され、参加者との間で深い議論が起こった。

さらに、エピサーマル中性子を用いた対称性破れ (T-非保存) 探索のための ^3He スピンフィルターや偏極標的の開発、カナダ TRIUMF における超冷中性子の電気双極子モーメント測定のためのスピン解析器開発など、基礎物理学への応用にも踏み込んだ内容がみられた。加えて、時間反転対称性の破れを探る NOPTREX 実験に向けた標的や偏極ビームの開発も進展しており、基礎物理への貢献も進んでいることが共有された。これらの講演を通じて、偏極中性子技術は材料科学から素粒子物理まで、幅広い分野における強力なプローブとしての存在感を増しており、今後も国際的連携のもとでさらなる発展が期待されることが示された。ポスター発表も含めて、偏極中性子科学の今後の発展に向けた展望が共有された場となっただけでなく、本ワークショップには大学院生を含む若手研究者の積極的な参加が目立ち、次世代研究者の育成という観点からも意義深い交流の場となった。



図3 ワークショップでの講演の様子と参加者の集合写真

4. まとめ (Conclusion)

コロナ禍明けに日本で初めて開催された偏極中性子に関する国際ワークショップでは、国内外の研究者が集まり、最新の技術や研究成果を共有する貴重な機会となった。偏極中性子技術の多分野への応用や、国際的な発展の可能性が改めて確認された。また、本ワークショップを通じて、研究施設と大学に所属する研究者同士の連携も一層深まった。参加者からは開催に対して高い評価が寄せられ、次回開催を望む声も多く聞かれた。若手研究者の積極的な参加も見られ、今後の研究の発展につながる内容となった。

謝辞 (Acknowledgement)

本ワークショップは、J-PARC シンポジウムのサテライトミーティングとして開催され、東北大学金属材料研究所の共同利用・共同研究事業（GIMRT）及び科研費基盤研究(S)「中性子スピン偏極物性科学の開拓（21H04987）」の支援を受けて実現しました。関係各位に深く感謝申し上げます。

The 8th Symposium for the Core Research Clusters for Materials Science and Spintronics, and the 7th Symposium on International Joint Graduate

Program in Materials Science

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Keywords: materials science, core research cluster, international joint graduate program

Tohoku University was named one of the first three Designated National Universities in Japan on June 30, 2017 by the Japanese Government. As a Designated National University, we initiated the “Core Research Clusters” to strengthen four research fields: materials science, spintronics, next-generation medical care and disaster science. Also, International Joint Graduate Program in Materials Science aims to cultivate internationally capable and highly creative professionals in the materials science field. In order to present research activities and discuss future prospects, we hold, continuing from past years, the international symposium on the Materials Science and Spintronics on November 18 – December 1, 2023.

1. 緒言

東北大学は、2017年6月30日、日本で最初の3つの指定国立大学の一つに選ばれた指定国立大学の事業として、東北大学が強みを有する材料科学、スピントロニクス、未来型医療、災害科学の4つの研究分野を世界トップレベル研究拠点として整備し研究推進してきた。また、材料科学研究分野では国際的に活躍できる創造性豊かな人材を育成することを目的とした「材料科学国際共同大学院プログラム」(GP-MS)を実施している。この材料科学世界トップレベル研究拠点(CRC-MS)、スピントロニクス世界トップレベル研究拠点(CSIS)および材料科学とスピントロニクスそれぞれの大学院プログラム(GP-MSおよびGP-Spin)の活動と研究成果を発表し、今後の展望を議論するために、2024年11月18–11月21日に第8回目となる国際シンポジウムを対面形式(一部はハイブリッド形式)にて開催した。なお、2023年のシンポジウムに引き続き今回も本学の世界トップレベル研究拠点の目標の1つである学内の卓越したリソースの結集の一環として、各拠点やセンター、プログラム等の構成部局に加えて、金属材料研究所国際共同利用・共同研究拠点(GIMRT)も共催として合同で開催した。



2. 開催内容

第8回目となる本国際シンポジウムでは、CRC-MSの4領域を重点テーマに若手独立教員5名が中心となって企画を進めた企画セッションのほか、CSISによるセッション、第7回目となるGP-MSに参画する大学院生による企画セッション、GP-Spinによるセッションが、AIMR2階セミナールーム、5階コンビネーションルーム、ナノスピ棟カンファレンスルームの3会場を使用して行われた。一部（プレナリー講演やGP-MSセッションなど）はハイブリッドで開催した。4日間の会期中に4件のプレナリー講演（うち2名が外国人）のほか、国内外および学内からの招待講演により、CRC-MSでは4セッション16名、GP-MSでは4セッション23名、CSISでは3セッション8名、GP-Spinでは2セッション6名の合計19セッション53名の口頭発表が行われた。また、19日にCRC-Spin Award受賞者1名による受賞講演、20日にCRC-MS Award受賞者2名による受賞講演を行った。夕刻のレセプションにて授賞式を執り行い、受賞した3名の若手研究者の研究を世界へ発信する機会とした。シンポジウムのポスターセッションでは、102件の発表があり、審査により海外（上海交通大学）からの参加者1名を含む10名のベストポスター賞受賞者が選ばれた。

- ・参加者：合計332名（日本：290名、海外：42名）

【セッション概要】

(1)Plenary セッション

- ・Plenary 講演：4セッションー海外2名

(2)Invited セッション

- ・CRC-MS：4セッション16名ー学内3名、学外13名（うち海外13名）
- ・GP-MS：4セッション23名ー学内7名、学外16名（うち海外16名）
- ・CSIS（CRC-Spin）：3セッション8名ー学内3名、学外5名（うち海外2名）
- ・GP-Spin：2セッション6名ー学内0名、学外6名（うち海外3名）

(3)Poster セッション

- ・102件

● 1日目（2024年11月18日）

杉本亜砂子研究担当理事臨席のもと、富永悌二東北大学総長の開会ビデオメッセージに引き続き、村上修一東京科学大学教授によるプレナリー講演”Theory of chiral phonons and their conversions to spin polarizations”がナノスピ棟にて行われた。その後、3会場にわかれてCSISの3セッション、CRC-MSのセッション、GP-MSの3セッションが行われた。午後6時からレセプションパーティが行われ、研究者同士の交流を深めた。

● 2日目（2024年11月19日）

AIMR2階セミナールームにて、プレナリー講演2件（テネシー大学 Peter Liaw 教授 ”An Introduction and Superior High-Temperature Strength in a Refractory High-Entropy Alloy”、九州大学/東北大学 山内 美穂教授”Nanocatalysts for a low carbon society: upgrading chemicals through hydrogenation”）があり、次にポスターセッションが午前と午後にわかれてAIMR1階ロビーおよび会議室にて開催された。次に、CRC-MSのセッション1件とGP-MSセッション1件のほか、CRC-Spin 受賞講演が行われた。

● 3日目（2024年11月20日）

プレナリー講演としてメルボルン大学 Frank Caruso 教授による講演 ”Nanoparticle Platforms for Therapeutic Applications”があった。その後、CRC-MS Award 受賞講演、CRC-MSのセッション1件、GP-MSのセッション2件、GP-Spinのセッション1件があった。午前中にCRC-MSのセッション1件とGP-MSセッション1件、GP-Spinセッション2件が開催された。夕方にベストポスター賞の発表・表彰があり、折茂クラスター長、深見クラスター長によるクロージングがあった。

● 4日目（2024年11月21日）

最終日は、プログラム編成上3日目までに開催できなかったGP-MSの2つのセッションが開催された。

3. まとめ

第8回となる本シンポジウムでは、参加者数、参加国が増え、ポスター発表件数の増加および海外からの参加者1名がベストポスター賞に選ばれるなど、世界中から研究者がつどい、学術的な議論をする場を提供することができた。さらに、若手研究者や大学院生によるセッション企画など若手研究者が国際的な研究者とネットワークを築く機会となり、本学の優れた研究成果を国内外により広くアピールすることができた。次回以降の国際シンポジウムでは、国際卓越研究大学に認定された東北大学の新たな取組としてふさわしい国際学術交流の場となるように、準備を進めていく予定である。

謝辞 (Acknowledgement)

本シンポジウムは、材料科学世界トップレベル研究拠点(CRC-MS)、スピントロニクス世界トップレベル研究拠点(CSIS)、材料科学国際共同大学院プログラム(GP-MS)、スピントロニクス国際共同大学院プログラム(GP-Spin)、が共同主催し、東北大学高等研究機構 International Affairs Center(IAC)の協力のもと GIMRT の共催により実施されたものです。また、助成いただいた仙台国際観光協会と、運営・企画に参画されたすべての方に謝意を表します。

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Summit of Materials Science (SMS) 2024 and Global Institute for Materials Research Tohoku (GIMRT) User Meeting 2024, November 27-28, 2024

SMS2024 was successfully held at IMR auditorium with almost 300 participants (including online participants) in 2 days from November 27 to 28.

The conference started with welcome greetings by Prof. Rie Umetsu, Deputy Director of IMR, and Prof. Takahiko Sasaki, Director of IMR.

The conference was divided into 7 fields, “Strong Correlation and Topology”, “Energy Materials”, “Computational Materials Science and Informatics”, “Structural Materials”, “Nuclear Materials”, “Frontier in Metal and New Materials”, and “Functional Magnetic, Electronic, and Semiconducting Materials”.

The total number of speakers this time was 27, of which 10 were invited, including 8 from overseas. The venue was full, a hot discussion was exchanged at every field.

The poster session was held on the evening of the 1st day, and researchers and students presented their recent research topics.

The discussion was overflowing until the next program Mixer, a lively discussion ensued.



Summit of Materials Science 2024 and GIMRT User Meeting 2024

Date: November 27-28, 2024

Venue: IMR Auditorium, Tohoku University (Onsite)

Day 1: Nov. 27

Opening					
	10:00	10:05	Rie Umetsu	IMR	Opening
	10:05	10:20	Takahiko Sasaki	IMR	Welcome Address

Number	Time		Name	Affiliation	Title
Session A Strong Correlation and Topology (Chair: Yusuke Nomura, IMR)					
A-1	10:20	10:50	Roser Maria Valentí	Goethe University Frankfurt	Strategies to Design Quantum Materials with Exotic Properties
A-2	10:50	11:20	Yoshinori Onose	IMR	Chirality Control and Detection in Metallic Helimagnets
A-3	11:20	11:35	Yoshihiro Okamura	The University of Tokyo	Magneto-Optical Study on Topological Magnets
A-4	11:35	11:50	Takuya Aoyama	Hiroshima University	Piezomagnetism in Antiferromagnets with Broken Time-Reversal Symmetry
A-5	11:50	12:20	Masaki Fujita	IMR	Neutron Scattering Study on Spin Excitations Coupled with Charge and Lattice Dynamics
	12:20	13:50	Lunch Break (Photo Session @1st Building Lobby)		
Session B Energy Materials (Chair: Hidemi Kato, IMR)					
B-1	13:50	14:20	Tetsuya Uda	Kyoto University	Lithium-Ion Battery Recycling through Comminution in Water in Inert Atmosphere
B-2	14:20	14:50	Andreas Züttel	EPFL	Power Plant Units for CO ₂ Neutral Energy Security
B-3	14:50	15:20	Tetsu Ichitsubo	IMR	Development of Metal-Anode Battery and Dual Ion Battery Systems with Multivalent Cation
B-4	15:20	15:50	Kozo Fujiwara	IMR	Fundamental and Applied Research on Crystal Growth
	15:50	16:00	Break		
Session C Computational Materials Science and Informatics (Chair: Momoji Kubo, IMR)					
C-1	16:00	16:30	Maria Clelia Righi	University of Bologna	Advancing Solid Interface and Lubricants by First Principles
C-2	16:30	17:00	Emi Minamitani	Osaka University	Elucidating Structure-Property Correlation in Amorphous Materials by Persistent Homology
C-3	17:00	17:30	Yu Kumagai	IMR	Defects in Semiconductors: A First-Principles Investigation
C-4	17:30	17:45	Kazushi Fujimoto	Kansai University	Mechanical Response Mechanisms during Compression Fracture of Polymer Particles
	17:45	19:00	Poster Session @2nd Building Lobby		
	19:00	20:30	Mixer @Lounge		

Day 2: Nov. 28

Number	Time		Name	Affiliation	Title
Session D Structural Materials (Chair: Kenta Yamanaka, IMR)					
D-1	9:30	10:00	Young-Kook Lee	Yonsei University	Hydrogen Embrittlement of High-Strength Martensitic Steel
D-2	10:00	10:30	Tadashi Furuhashi	IMR	Alloying Effects on Microstructure Development in High Strength Steels – from Bulk to Surface
D-3	10:30	11:00	Martin Luckabauer	University of Twente	Tailoring Omega Transformation Kinetics in Beta Titanium Alloys for Biomedical Applications
	11:00	11:10	Break		
Session E Nuclear Materials (Chair: Dai Aoki, IMR)					
E-1	11:10	11:40	Jean-Pascal Brison	CEA-Grenoble	Field and Pressure Tuning of the Superconducting Pairing Mechanisms in UTe ₂
E-2	11:40	12:10	Ryuta Kasada	IMR	Redesigning, Restructuring and Reviving Nuclear Materials Research in Japan towards a New Concept of Irradiation 3.0
E-3	12:10	12:25	Hirofumi Kazama	Osaka University	Gas-Phase Oxidation of Actinide Ions in Triple Quadrupole Inductively Coupled Plasma Mass Spectrometry
E-4	12:25	12:40	Sayuri Takatori	Okayama University	Spectroscopy of Thorium-229 Nuclear Clock Transition in ²²⁹ Th:CaF ₂ Crystal
	12:40	13:40	Lunch Break		
Session F Frontier in Metal and New Materials (Chair: Eiji Akiyama, IMR)					
F-1	13:40	14:10	Eun Soo Park	Seoul National University	High Entropy Alloy Foam: Open a New Era of Thermal Protection Utilizing Metals
F-2	14:10	14:40	Hidemi Kato	IMR	Dissimilar Joining of Immiscible Metals by Eutectic Melting Induced Liquid Metal Dealloying
F-3	14:40	15:10	Hitoshi Miyasaka	IMR	Chemo-Switchable MOF Magnets
	15:10	15:20	Break		
Session G Functional Magnetic, Electronic and Semiconducting Materials (Chair: Yoshinori Onose, IMR)					
G-1	15:20	15:50	Kiyonori Suzuki	Monash University	Ultra-Low Core Loss of Nanocrystalline Soft Magnetic Alloys Brought about by Near-Zero Magnetostriction
G-2	15:50	16:20	Takeshi Seki	IMR	Control of Magneto-Elasticity in Magnetic Thin Films
G-3	16:20	16:35	Takamasa Hirai	NIMS	Elastocaloric Kirigami Temperature Modulator
G-4	16:35	16:50	Yoshitomo Nose	Kyoto University	Processing for Group IV Chalcogenides with 2D Structure Based on Thermodynamics
	16:50	17:00	Closing		

Poster Session

Number	Name	Affiliation	Title
PS01	Mayurkumar Ashwinbhai Makhesana	Nirma University	Synthesis and Characterization of Metallic Nanoparticles via Laser Ablation Synthesis in Solution and Aerosol Jet Printing
PS02	Anna Kosogor	Institute of Magnetism NASU and MESU	Magnetic Properties, Phase Diagram and Low-Temperature Specific Heat of $\text{Ni}_{50}\text{Mn}_{50-x}\text{Sb}_x$ Alloys
PS03	Yoichi Ikeda	IMR	Current Status of a Triple-Axis Neutron Spectrometer 6G-TOPAN
PS04	Shigeru Okada	Kanagawa University	Syntheses and Properties of Single-Phase RuB_2 Material by Arc Melt Method
PS05	Yulin Xie	IMR	High-Throughput Investigation of Cr-N Cluster Formation in Fe-35Ni-Cr System during Low-Temperature Nitriding
PS06	Taiki Miura	IMR	Effect of Ligament Crystal Ordering on Porous Structure Formation and Coarsening in Liquid Metal Dealloying
PS07	Toyoto Sato	IMR	Hydrogen Absorption Reactions and Crystal Structure of $(\text{Y, Mg})\text{Co}_3$
PS08	Kenji Yoshino	University of Miyazaki	Development of Low-Temperature Non-Vacuum Growth of ZnO Protective Film for Mg-Ion Battery
PS09	Kaoru Kouzu	Kokushikan University	Syntheses and Its Properties of $R(\text{Al,Mo})\text{B}_4$ (R =Rare Earth) Compounds by High-Temperature Al Melt Method
PS10	Takeshi Hagiwara	Kanagawa University	Synthesis of AlMgB_{14} Crystal Using Magnesium Fluoride by Al-Self Flux and Its Physicochemical Properties
PS11	Hong-Fei Zhao	IMR	Search for Short-Range Ordering in Medium-Entropy Alloys (Mn-Co-Ni and Cr-Co-Ni) via Neutron Scattering
PS12	Zaskia Alifia	University of Toyama	Nanoparticle Synthesis of BiVO_4/Ag for Enhanced Dye Photodegradation Illuminated by Visible Light
PS13	Hiroya Ishii	IMR	Effects of Composition and Processing on the Microstructures, Mechanical Properties and Corrosion Behavior of Biodegradable Fe-Mn Alloys
PS14	Takumi Yamazaki	IMR	Figure of Merit of Transverse Thermoelectric Conversion for Magnetic Thin Film Measured by All-in-One Evaluation Method
PS15	Hidetoshi Masuda	IMR	Nonreciprocal Electronic Transport Induced by Current-Induced Deformation of Helimagnetic Structure in YMn_6Sn_6
PS16	Hsiao-Yi Chen	IMR	Development of an Ab Initio Method for Non-Coplanar Chiral Magnets and Response Properties
PS17	Rico Pohle	IMR	Spin Nematics Meet Spin Liquids: Exotic Phases in the Spin-1 Bilinear-Biquadratic Model with Kitaev Interactions
PS18	Yoichi Nii	IMR	Gigahertz Topological Surface Acoustic Wave on a Nano-Scaled Honeycomb Phononic Crystal
PS19	Hiroshi Kakinuma	IMR	Microscopic Imaging of Hydrogen Diffusion in Metals Using Polyaniline
PS20	Junyi Luo	IMR	Anisotropy of Critical Current Density Properties of the High-Performance SS/Ag-Sheathed $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$ Tapes
PS21	Chanhyeon Lee	IMR	Emergent $\sqrt{3} \times \sqrt{3}$ Type Gapless Quantum Spin Liquid in Spin – 1/2 Random Kagome Antiferromagnet $\text{YCu}_3(\text{OD})_{6.5}\text{Br}_{2.5}$
PS22	Yuji Seki	Keio University	Theoretical Calculation of Transport Coefficients in Infinite-Layer Nickelates
PS23	Koji Inoue	IMR	Effects of P on Formation and Growth of Mn-Ni-Si Clusters in Low-Cu Reactor Pressure Vessel Steel
PS24	Haruka Yoshino	IMR	Ultrafast Luminescence Sensing with Selective Adsorption of Carbon Disulfide in an Au(I) Metal-Organic Framework

Number	Name	Affiliation	Title
PS25	Satoshi Iguchi	IMR	Magneto-Optical Detection of Altermagnetism in Organic Antiferromagnet
PS26	Oleksandr Prokhnenko	Helmholtz-Zentrum Berlin	Magnetic Order and Spin Dynamics in Natural Mineral Brochantite $\text{Cu}_4\text{SO}_4(\text{OH})_6$
PS27	Qingxin Liu	IMR	Dynamical Spin Reordering in a Hybrid Layered Ferrimagnet with Biferrocenium Radicals
PS28	Ke Ji	IMR	Intra-Lattice Hydrogen Bonds-Related Charge Manipulations Associated with Guest Removal in Charge Transferred Layered Metal-Organic Frameworks
PS29	Tetsuya Furukawa	IMR	Thermoelectric Properties of an Ambient-Pressure Organic Dirac Electron System $\alpha\text{-(BETS)}_2\text{I}_3$
PS30	Ali Md. Arafat	Tohoku University	High-Resolution Spatial Mapping of π -Radical Spin States in Single-Molecule Magnets with Electron Spin Resonance
PS31	Tsutomu Nojima	IMR	Research on Polar Superconductivity in Ion-Gated SrTiO_3
PS32	Yixin Su	IMR	Reactive Molecular Dynamics Simulations Revealing the Impact of Carbon Nanotube (CNT) Volume Fraction on the Mechanical Properties of SiC/CNT Composites
PS33	Muhammad Khalish Nuryadin	IMR	Disorder Effect Induced by X-ray Irradiation on a Monomer Mott Insulator $(\text{BEDT-TTF})\text{Cu}[\text{N}(\text{CN})_2]_2$
PS34	Shiori Sugiura	IMR	Disorder Effect to the High-Field FFLO Phase in Layered Organic Superconductor $\kappa\text{-(BEDT-TTF)}_2\text{Cu}(\text{NCS})_2$
PS35	Yuta Kimoto	IMR	Observation of Spin Motive Force and Conduction Noise in a Sliding Helimagnetic Structure
PS36	Ryo Kawakami	University of Tsukuba	Synthesis and Characterization of Polyaniline Type Metal-Doped Magnetic Conjugated Polymers

Activity Report

Young Researcher Fellowships



Young Researcher Fellowships

No.	Title	Applicant	Affiliation	Host Professor	Proposed Research	Term
24FS1	Ph.D. Student	Yunxuan Wei	Harbin Engineering University, China	Prof. Furuhara	Formation Mechanism of "Nodular" Ferrite in Interphase Precipitation Strengthened Steel	2024.7.28-2024.10.26

Formation Mechanism of “Nodular” Ferrite in Interphase Precipitation Strengthened Steel

Abstract: -- In this study, nodular ferrite is observed to form in vanadium microalloyed steels after isothermal transformation at different temperatures, showing no significant difference in hardness compared to the normal grain boundary allotriomorphic ferrite. In addition, during growth, nodular ferrite always maintains an orientation relationship with austenite that deviates from the ideal K-S relationship within 15-30°, with a specific rotation axis. This suggests that austenite and three VC variants, which hold B-N orientation relationship with ferrite, may have a specific orientation relationship.

Ferrite transformation behavior in steel has been widely investigated in the past decades for its industrial importance. Morphology of ferrite is known to be allotriomorphic or idiomorphic at high transformation temperature and Widmanstätten or acicular at low transformation temperature. However, we revealed that the isothermal transformation product of a low carbon V-containing steel (Fe-0.1C-0.4V-1.5Mn, wt. %) exhibits abnormal ferrite morphology, with some ferrite turning into “nodular” one that grows radially into austenite. In this study, a series of vanadium-containing low carbon steels were systematically investigated with the aim to clarify the temperature and composition dependence of the hardness of nodular ferrite, as well as its crystallographic characteristics.

To compare the micromechanical properties of two different types of ferrite, nanoindentation tests were performed on fully transformed specimens using a load of 5000 μN . As shown in Fig. 1, the hardness of both the 0.1C-0.4V and 0.3-1.3V alloys increases with decreasing temperature or increasing vanadium content. However, the hardness difference between the two types of ferrite remains within the error range.

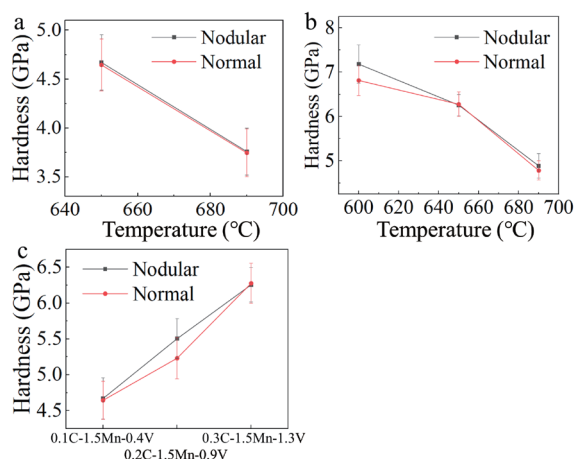


Fig. 1 Hardness of nodular ferrite and normal ferrite: (a) 0.1C-0.4V; (b) 0.3C-1.3V alloys transformed at different temperatures; (c) different alloys transformed at 650°C.

To clarify the crystallographic characteristics of nodular ferrite with an orientation relationship (OR) deviating from the exact K-S OR for around 15-30° as reported by Wang et al. [1], the experimental results were analyzed in detail, and the austenite to ferrite rotation axes was calculated, as shown in Fig. 2. The rotation axes tend to be concentrated around $\langle 111 \rangle_\gamma$. Furthermore, based on the experimentally observed OR between ferrite and austenite, and the fact that multiple VC variants holding B-N OR with ferrite are present in nodular ferrite observed in the previous work [1], the OR between VC and austenite is determined to be $(012)_{\text{VC}} // (012)_\gamma$, $[0-21]_{\text{VC}} // [100]_\gamma$, for all three VC variants.

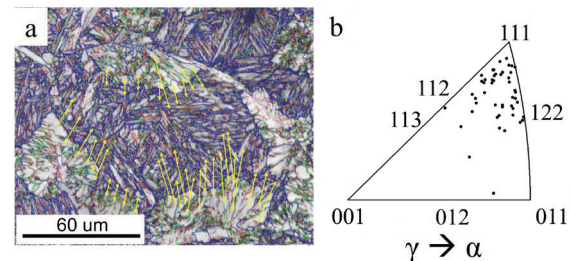


Fig. 2 (a) Grain boundary map of 0.3-1.3V alloy transformed at 600°C; (b) distribution of rotation axes from austenite to nodular ferrite.

This short visit focused on whether there is any difference in mechanical performance between the two types of ferrite and the interpretation of the OR between nodular ferrite and austenite. Whether the maintenance of a specific OR between austenite and the three VC variants is responsible for the austenite-ferrite OR needs further detailed investigation in the future.

References

- [1] Z.-Q. Wang, et al., *Scr. Mater.*, 198 (2021) 113823.

Activity Report

Overseas Visits for IMR Young Researchers



Overseas Visits for IMR Young Researchers

No.	Title	Applicant	Visiting Country, City	Supervisor	Proposed Research, Conference	Term
24IS1	Postdoctoral Researcher	Rama Srinivas Varanasi	Zagreb, Croatia	Prof. Akiyama	Microstructural Origins of Enhanced Resistance to H-Assisted Fatigue Crack Growth in Ausformed and Tempered Martensitic Steels Conference: The 24th European Conference on Fracture (ECF24) Symposium: TC 21: Hydrogen Embrittlement in Metallic Materials: Pipeline Transport, Hydrogen Storage, and other Applications	2024.8.24-2024.8.31

Microstructural origins of enhanced resistance to H-assisted fatigue crack growth in ausformed and tempered martensitic steels

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⁴ National Institute for Materials Science, Tsukuba 305-0047, Japan

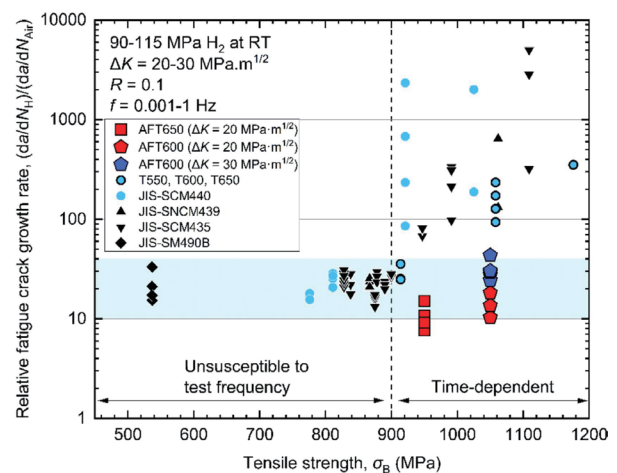
⁵ Research Center for Hydrogen Industrial Use and Storage (HYDROGENIUS), Kyushu University, Motooka 744, Fukuoka, 819-0395, Japan

Oral presentation at the 24th European Conference on Fracture (ECF24), held in Zagreb, Croatia, from 26 - 30 August 2024. The talk was part of the symposium titled "Hydrogen embrittlement in metallic materials: pipeline transport, hydrogen storage, and other applications."

Lean-alloyed martensitic steels are promising, cost-effective materials for the storage and transportation of hydrogen gas. Previous studies [1] showed that martensitic steels with tensile strength (TS) below 900 MPa exhibited cycle-dependent H-assisted fatigue crack growth (HAFCG), while those above 900 MPa showed time-dependent (or frequency-dependent) HAFCG—undesirable for fatigue life design [1] (Fig. 1). Recently, Redarce et al. [2] developed an ausformed and tempered martensitic (AFT) steel with a TS of 1050 MPa that displayed cycle-dependent HAFCG (Fig. 1). In the presented study, we quantify the microstructural crack paths of HAFCG in AFT steel and compare them with their tempered counterparts. Detailed characterization was performed using electron backscatter diffraction, transmission Kikuchi diffraction, and transmission electron microscopy to understand the microstructural origins of enhanced resistance to HAFCG in ausformed and tempered martensitic steels. H-permeation studies were performed to study the H diffusion behavior of the tempered and AFT steels.

The hydrogen embrittlement (HE) symposium spanned all five days of the conference. It provided a great opportunity to interact with researchers from both academia and industry, from across the globe, working on HE. I gained valuable insights into HAFCG in a hydrogen atmosphere & the micro-mechanisms of HE. Conversations with experts in martensitic steels were helpful in deepening my understanding of HAFCG in ausformed steels.

Fig. 1: The relationship between the relative FCG rate and tensile strength (from Redarce et al. [2] (CC BY 4.0))



References

- [1] A. Setoyama, Y. Ogawa, M. Nakamura, Y. Tanaka, T. Chen, M. Koyama, H. Matsunaga, International Journal of Fatigue 163 (2022) 107039
- [2] T. Redarce, K. Iwata, Y. Ogawa, K. Tsuzaki, A. Shibata, H. Matsunaga, International Journal of Fatigue 193 (2025) 108814.

Keywords: High strength steel, Embrittlement, Fatigue
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