International
Collaboration
Center
Institute for Materials Research
Tohoku University
ICC-IMR

ICC-IMR FY2020
Activity Report

http://www.icc-imr.imr.tohoku.ac.jp/

ICC-IMR FY2020

Activity Report

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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 five research centers. The ICC-IMR works as a gateway of diverse collaborations between overseas and IMR researchers. The ICC-IMR has invited 69 visiting professors and conducted 23 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

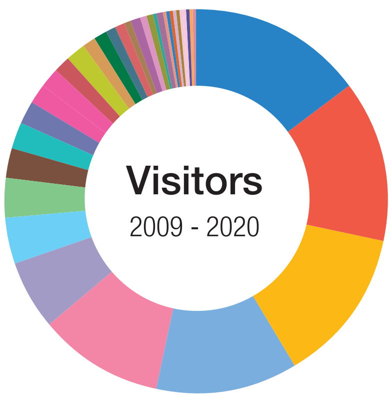
3) International Workshops

4) Fellowship 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.



USA	100	Canada	10	Brazil	2
China	91	Taiwan	10	Rumania	2
Germany	89	Singapore	8	Slovenia	2
France	81	Iran	7	Ukraine	2
Korea	71	Thailand	6	Argentina	1
UK	39	Denmark	5	Austria	1
Russia	26	Hong-Kong	5	Egypt	1
Netherlands	22	Norway	5	Indonesia	1
Switzerland	18	Mexico	4	Serbia	1
India	14	Czech Republic	3	Sweden	1
Poland	13	Italy	3	Turkey	1
Australia	12	Slovakia	3	Vietnam	1
Spain	11	Belgium	2		

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Activity Report

Visiting Professors

Visiting Professors by Online

Application No.	Title in IMR	Name	Affiliation	Host Professor	Proposed Research	Term
20G01	Visiting Professor	Amar Prasad YADAF	Tribhuvan University, Nepal	Prof. Akiyama	Effective Electropolymerization of Aniline onto Mild Steel for Corrosion Protection and Inhibition of Hydrogen Uptake	2020.1.4-2020.2.26
20G02	Visiting Professor	Thierry DUFFAR	Grenoble Institute of Technology, France	Prof. Fujiwara	Growth Kinetics at Crystal/Melt Interface	2020.1.4-2020.2.26

Activity Report

Visiting Prof. Amar Prasad Yadav (Tribhuvan University)

Effective Electropolymerization of Aniline onto Mild Steel for Corrosion Protection and Inhibition of Hydrogen Uptake

On the 27th of January, an on-line seminar was held online using Zoom and I presented a talk entitled "Selection of Electrolyte for Effective Electropolymerization of Aniline onto Mild Steel for Corrosion Protection" to the members of Akiyama Laboratory and Visiting Professor Sachiko Hiromoto (National Institute for Materials Science).

The subject of my talk was corrosion-resistant performance of polyaniline which has eco-friendly and non-toxic nature [1,2]. In my talk, selection criteria for effective electropolymerization of aniline onto mild steel and the tailoring of polyaniline film by rare earth metal ions (La and Ce) were discussed with regard to coating formation, its stability, and corrosion inhibition effect, focusing on three electrolytes, namely oxalic acid, sodium potassium tartrate, and benzoic acid in the alcohol-water (BAW) medium (Fig. 1). A host of instrumental tools as Fourier-transform infrared spectroscopy, ultraviolet-visible spectroscopy, scanning electron microscope in combination with energy dispersion spectrometer, transmission electron microscopy, and X-ray diffraction used to characterize the polyaniline coating were also discussed.

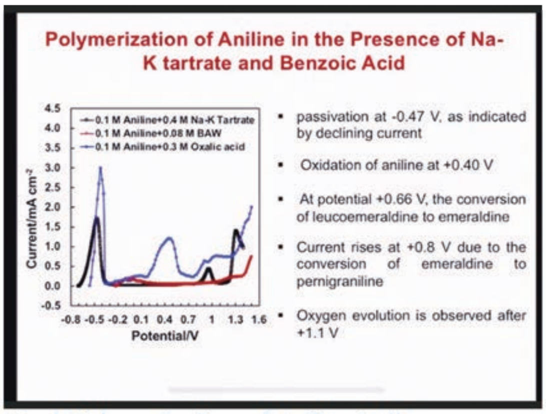

Fig. 1 Polymerization of Aniline in the presence of Na-K tartrate and benzoic acid and their effect on passivation behavior of mild steel.

The Akiyama laboratory members and I discussed about the presented subject, for instance the effect of dissolved ferrous ions from the substrate mild steel on the nature of the polyaniline coating, the difference in the property of polyaniline based on the polymerization procedure and so on.

After the seminar, the plan of the

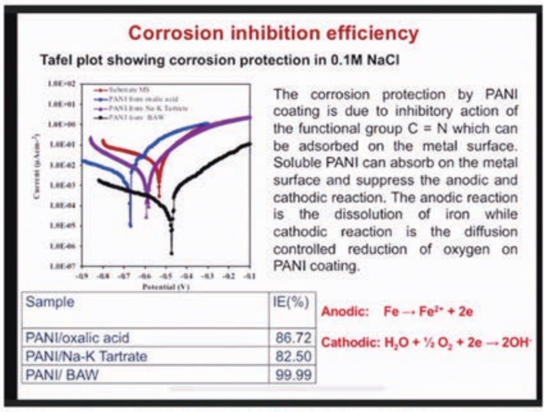

Fig. 2 Corrosion inhibition efficiency of polyaniline.

corroborative study was discussed. Since the polyaniline is effective for corrosion resistance and it shifts the open circuit potential to the positive direction, it is expected that hydrogen uptake to the substrate steel can be suppressed. Furthermore, due to the conductive property of the polymer, it is presumed that the polymer acts as the cathodic site and even when reduction reaction of proton takes place on the polymer, formed atomic hydrogen will not diffuse to the substrate steel and this effect is also expected to retard the hydrogen uptake. Consequently, polyaniline has the potential to avoid hydrogen embrittlement of high strength steels used under corrosive environments. In the future corroborative study, polyaniline will be applied on high strength steels prepared by using the optimized procedure established in my group, and its effect on inhibition of hydrogen uptake will be studied by using electrochemical techniques and thermal desorption spectroscopy.

References

[1] N.B. Devkota, S. Neupane, D.K. Gupta, U. Chaudhary and A.P. Yadav, J. Nep. Chem. Soc., 34, 72-80 (2016).
[2] N.B. Devkota, S. Singh, S. Neupane, D. K. Gupta and A.P. Yadav, J. Nep. Chem. Soc., 35, 94-103 (2016).

Activity Report

Visiting Prof. Thierry Duffar

(Grenoble Polytechnic Institute/University Grenoble-Alpes, France)

Growth kinetics at crystal/melt interface

The objective of the Visitor's research is to develop a model to predict phenomena occurring at the crystal/melt interface of semiconductor materials during their unidirectional solidification. Prof. Fujiwara's group at IMR provides experimental results about the kinetics at the crystal/melt interface of semiconductors such as Si or GaSb. These results are obtained by real-time in situ observations thanks to their unique equipment allowing video recording of the solid-liquid interface behavior at various growth rates. By combining these experimental results with our theoretical analyses, we can expect to deepen the understanding of semiconductor crystal/melt interface kinetics.

In FY 2020, it has been difficult to visit IMR due to the COVID-19 pandemic. Instead, we were able to have meaningful discussions via web seminars. In this seminar, we provided guidance on student presentations, which was a good opportunity for students to improve their presentation skills.

First, we discussed about the grain boundary kinetics at the crystal/melt interface of Si. It was clearly observed that small angle grain boundaries are formed at the crystal/melt interface due to the aggregation of dislocations during unidirectional solidification. Split of small angle grain boundary was also observed. We discussed about the possible mechanisms based on the strain energy associated to the elastic field surrounding the dislocations. It was suggested to perform experiments under various growth rates but same temperature gradient.

Secondly, we discussed the production of LB4 crystals with a periodic twin structure and their application to light conversion devices. An original and unique technique for producing LB4 crystal with a periodic twin structure was presented. This method utilizes the ease of twinning in the crystal growth process of LB4, and is expected to be used for wavelength conversion devices on non-dielectric materials. It was suggested that looking for possible periodic eutectic structures could help to produce such materials.

Thirdly, we discussed about the growth of Si clathrate crystals obtained by Na flux method. It was shown that type I and type II clathrate crystals can be produced separately by controlling the growth conditions. It was suggested to investigate the possibility of controlling the vapor pressure in the equipment in order to better control the growth process.

In all these topics, it is necessary to understand the kinetics at the crystal/melt interface. We will tackle those issues through ongoing collaborative research.

Finally, the Visitor gave an invited talk about Si grain boundary kinetics at the 8th Asian Conference on Crystal Growth and Crystal Technology (CGCT-8, 1st-3rd March 2021). The visitor quality at IMR was publicized in the Author's affiliation.

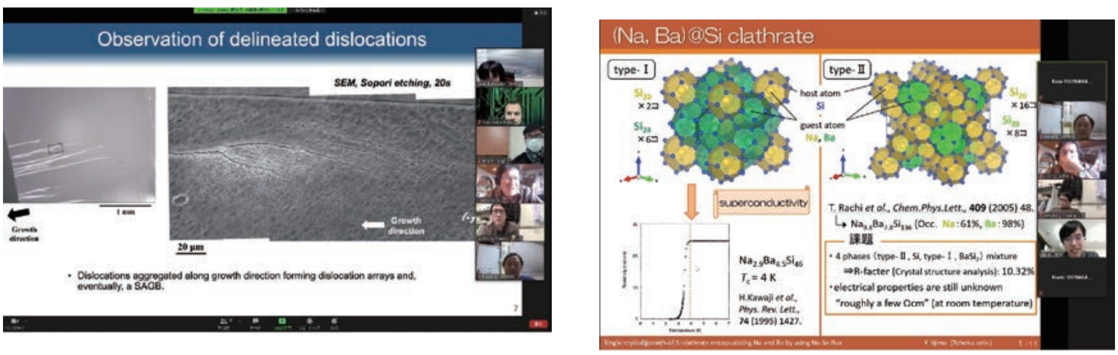

Fig 1. Snap shots of web seminar in Fujiwara's laboratory in IMR.

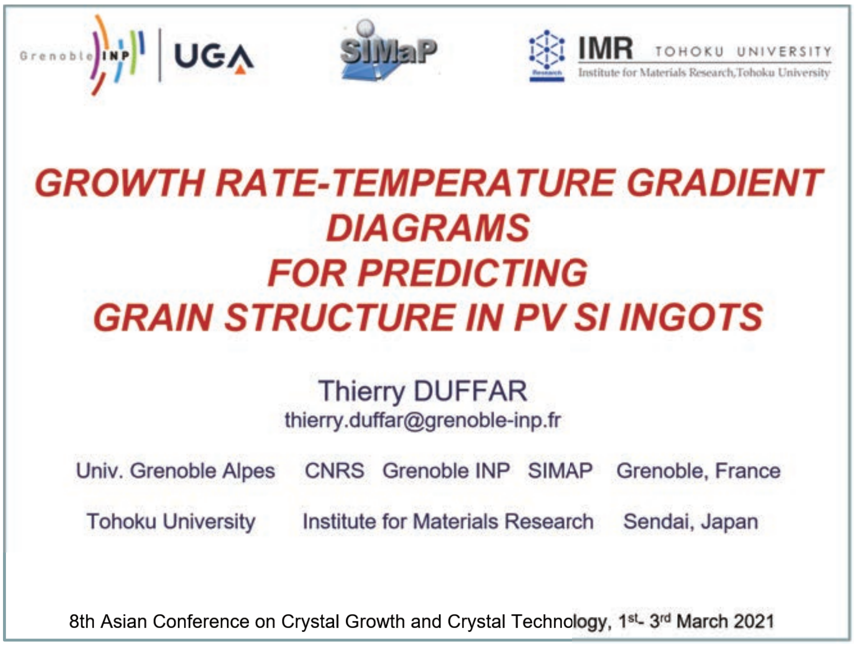

Fig 2. Title slide of Prof. Duffar's linvited lecture at CGCT-8.

Activity Report

Integrated Projects

Integrated Projects

Application No.	PI	Title	Affiliation	Proposed Research	Host	Term
2018PJT01	Johan Chang	Assistant Professor	Physics Institute, University of Zürich, Switzerland	Quantum Matter Research under Extreme Conditions-Networking of Advanced Multiple Tools	Prof. Nojiri	FY2018-2020
2019PJT01	Jean-Pascal Brison	Group Leader	Univ. Grenoble Alpes & CEA-Grenoble, France	Novel Spin Triplet Superconductivity in UTe2	Prof. Aoki	FY2019-2020

Quantum Matter Research under Extreme Conditions -Networking of Advanced Multiple Tools

For future technological advances. there is an urge to reach a better understanding of strongly correlated electron systems, materials where many-body interactions drive outstanding properties. Scattering and spectroscopy techniques are among the most powerful and promising avenues for exploration of complex quantum matter phases. Such experiments are carried out by the combinations of synchrotrons, x-ray free electron lasers (FEL), neutron sources and extreme conditions such as high magnetic fields. We have worked for establishing the network of multiple tools at different institutions for understanding of advanced functional materials.

1. High Resolution Backscattering X-ray Diffraction in very strong magnetic fields

When superconductivity is suppressed by a strong magnetic field, a normal metal state is expected to be recovered. However, it often shows non-trivial phases such as charge density wave. The nature of the ordering as well as its relationship with superconductivity have been intensively investigated for decades.

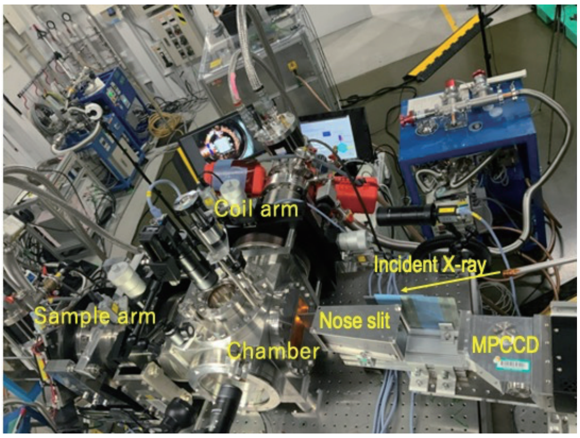

Fig. 1 Backscattering X-ray diffractometer installed at SACLA X-ray FEL beam line.

A X-ray diffraction is the most direct and the powerful tool to investigate such high field phase in terms of the crystal structure. It is very challenging because the diffractometer must be functional in very high magnetic field and in very low temperature. Moreover, the access of the reciprocal space and the resolution are limited when a high magnetic field magnet is installed to the diffractometer. To overcome these difficulties, we have developed a backscattering X-ray diffractometer with a 50 T solenoid coil at SACLA and at SwissFEL.

Figure 1 shows the developed back-scattering spectrometer installed in SACLA X-ray FEL facility. The scattering angle coverage is 2θ=140~170 with a horizontal solenoid coil with a conical opening in one side. The coil is driven by a compact capacitor bank and the maximum operating magnetic field is 50 T. A sample is cooled down by the GM-cryocooler equipped with an additional 2 K pot connected to ^{4}He gas handling line. The 30 cc liquid He is condensed by the 2nd stage of 4K-GM-cryocooler and the temperature down to 2 K is achieved by the decompression of the condensed liquid.

The first experiment was made on the optimally doped $La_{2-x}Sr_xCuO_4$ (LSCO) with x = 0.12 (T_c = 28 K). We found a magnetostriction effect as large as $\Delta c/c$ ~10^{-4}. The samples size was ~0.8 x 0.8 x 0.5 mm^3 with the c-axis tilted in the direction of the a-axis by 32 degrees. The sample was mounted on a sapphire rod such that a back-scattering geometry allowed access to the (h, 0, l) scattering plane with 6.58 keV, pink beam x-ray pulses.

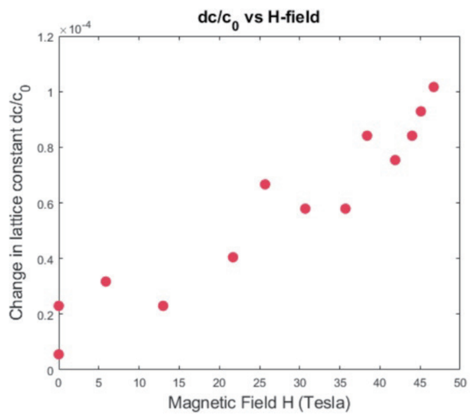

Fig. 2 Magnetic field driven expansion of c-axis in high magnetic field. For the a-axis, the lattice shows the shrinkage.

We have not observed a field variation of charge density wave peak, but found a large magnetostriction effect witnessed by a shift in 2θ position of the Bragg peak (2, 0, 12) at high magnetic fields. As shown in Fig. 2, out-of-plane lattice constant *c* is changed as a function of magnetic field. At our maximum field strength H = 46.7 Tesla, the relative change in lattice parameter Δc/c is as large as 10^{-4}. As expected Δc/c is consistent with a quadratic field dependence. This effect is interesting as it demonstrates that LSCO is becoming more two-dimensional in high magnetic fields.

We have also conducted the diffraction experiments on HOPG and kish graphite in SWiSSFEL and in SACLA and excluded the presence of the lattice-folding related superlattice peak in part of the reciprocal space. The exploring of the entire brillouin zone is under further experiments.

2. X-ray Magnetic Circular Dichroism

X-ray magnetic circular dichroism(XMCD) is a unique tool to determine the element specific magnetization in complex magnetic materials. We have conducted XCMD with pulsed magnetic fields in SPring8 and in BESSYII. The latter is the site newly developed in this project.

We report an example on $MnCr_2S_4$ spinel. The magnetic frustration causes instabilities in various physical properties such as a magnetic plateau stabilized by structural displacement under a strong magnetic field. There is a theoretical prediction that the intermediate phase corresponds to the super solid phase appears. We examined the phase diagram by measuring the sublattice magnetization of Mn and Cr.

The measurement was performed at BL25SU of SPring8 by using a soft X-ray XMCD system developed by the Tohoku University group. A magnetic field of up to 40 Tesla was applied parallel to the [110] direction. The Mn and Cr, *L*-edge XAS/XMCD measurements were performed under a zero magnetic field with residual magnetization to determine the base spectra. The XAS shows that Mn and Cr are in valences 2 and 3, respectively. In the XCMD, it is confirmed that the magnetic field parallel components of two ions are in antiferromagnetic arrangement. It corresponds to the Japheth-Kittel phase of Mn and Cr, which occupy two non-equivalent sites.

Next, we measured high magnetic field XCMD at L_3 edge peaks of Mn and Cr. At each temperature, 7 pairs of left and right circularly polarized light were measured, and the magnetic field dependence of the XMCD at the fixed energy was obtained by averaging the signals of14 shots in total.

At the lowest temperature of 8 K, the transition from the Yafet-Kittel phase (superfluid phase) to the intermediate super solid phase was observed at around 10 T and then to the magnetic plateau phase at around 27 T. The temperature dependences of the high magnetic field XMCD show the boundaries of these phases. They are consistent with the boundaries determined by macroscopic measurements. In the XCMD, we can determine the directions of each sublattice moments.

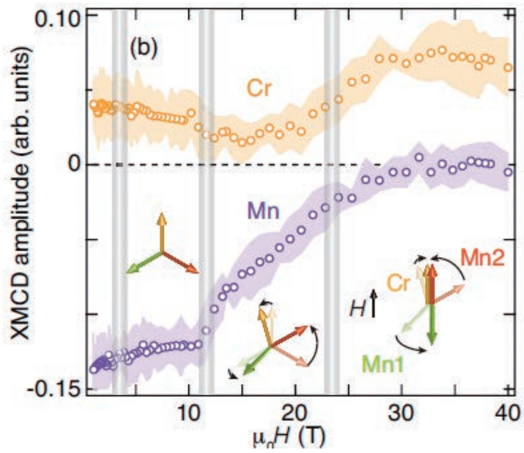

Fig. 3 Magnetic field dependences of Mn and Cr XMCD and the phased boundaries. (after ref. [1].)

3. Neutron Diffractions

For magnetic structure determinations, neutron diffraction is the standard method and X-ray magnetic scattering is also used complementary. In this project, we have developed a semi-automatic 30 T high magnetic field neutron diffraction system in J-PARC. The magnetic field is generated by the compact capacitor bank of 16 KJ energy and the sample is cooled down by the GM-refrigerator.

Summary

By this project, the network of high magnetic field X-ray and neutron diffractions and X-ray spectroscopy has been established. It contributes to investigations of quantum matters and advanced materials.

References

[1] S. Yamamoto et al., Phys. Rev. B **103,** L020408(2021)

Keywords: High Magnetic Field, Phase Transition, X-ray
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Spin-Triplet Superconductivity in UTe_2

Spin triplet superconductivity in UTe_2 is now one of the hottest topics in condensed matter physics. In two years (2019-2020), the international collaboration project on UTe_2 were carried out and many important results have been published. Here we present our results focusing on field-reentrant superconductivity, which appears at high magnetic fields.

Superconductivity of heavy fermion UTe2 was discovered only recently at the end of 2018 and attracted enormous attention. In this project we focus on the high quality single crystal growth of UTe_2 and the magnetic and electronic properties under extreme conditions (low temperature, high field, high pressure) using the various experimental technique in order to clarify the spin-triplet superconductivity.

UTe_2 is a heavy fermion paramagnet with the body-centered orthorhombic structure with the space group *Immm*. Although the global inversion symmetry exists in the crystal structure, the local inversion symmetry is broken, indicating that the inversion center is located not at the U site but at the middle of the two U atoms of the next nearest neighbors. The structure without local inversion symmetry will generally give rise to the various interesting physical properties, such as the non-trivial parity of superconducting order parameters, electrical current induced phenomena, and non-reciprocal conductivity. Indeed, UTe2 shows a variety of superconducting and magnetic properties on the basis of this unique structure.

Although UTe_2 is a paramagnet, the similarity to ferromagnetic superconductors, that is URhGe and UCoGe, has been pointed out from the beginning, meaning that UTe_2 in the spin-triplet superconductors. This is a good starting point to understand UTe_2. One of the most remarkable points in both systems is the huge and anisotropic upper critical field H_{c2}. Figure1 shows the angular dependence of H_{c2} in URhGe, UCoGe and UTe_2. In URhGe, the field-reentrant superconductivity appears for the field along b-axis (hard-magnetization axis). Similarly, the acute enhancement of H_{c2} is observed in UCoGe for a and b-axes (hard magnetization axes). The superconducting critical temperatures are 0.25 and 0.6K for URhGe and UCoGe, respectively. Of course, these unusual behaviors of H_{c2} cannot be explained by the conventional BCS theory, indicating spin-triplet superconductivity with the odd parity. Since superconductivity is realized in the ferromagnetic state, the ferromagnetic fluctuations, which are sensitive to the field direction with the Ising magnetic property, play a role for the "glue" of the superconducting Cooper pairs.

In UTe_2, H_{c2} is again huge and anisotropic, as shown in Fig.1(c). T_c is about 1.7K, but H_{c2} is ranging from 7 to 35T depending on the field direction, highly exceeding the Pauli limit (~3T) based on the weak coupling BCS theory. This is a strong support for spin-triplet superconductivity in UTe_2. An important

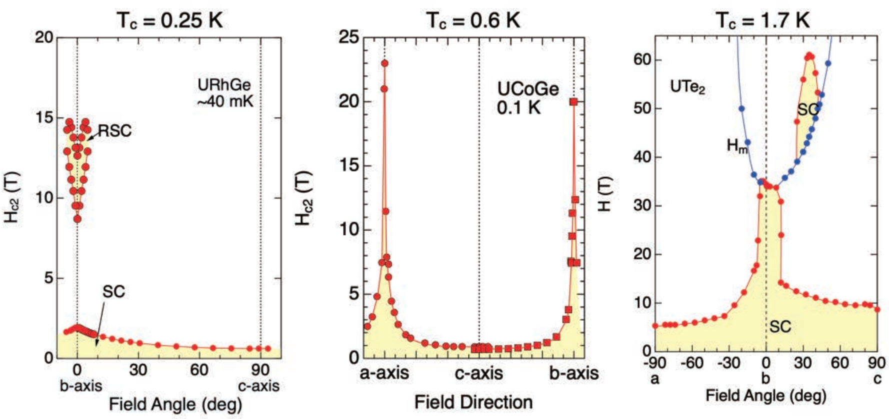

Fig. 1 Angular dependence of the superconducting upper critical field H_{c2} in ferromagnetic superconductors (URhGe, UCoGe) and UTe_2

might be located at the ferromagnetic end

1

question is what is the origin of the pairing glue, because UTe_2 is a paramagnet and the ferromagnetic fluctuations are not trivial.

When the field is applied along b-axis, field-reentrant superconductivity is observed as shown in Fig.2(a) [1]. T_c is reduced with increasing field up to 15T, but it is enhanced again with further increasing field. Finally superconductivity is abruptly suppressed at 35T due to the first order metamagnetic transition Hm associated with the drastic change of the electronic state.

Surprisingly, when the field is tilted by 27 deg from b to c-axis retaining perpendicular to easy magnetization axis, superconductivity appears at high fields region (40-60T) above H_m, as shown in Fig. 2(b). This totally unusual H_{c2} behavior at so-called "magic angle" cannot be explained neither by the conventional BCS theory nor by a spin-triplet scenario based on the simple ferromagnetic fluctuations. In the polarized paramagnetic state (PPM), the electronic state is drastically changed, indicating the Fermi surface reconstruction as evidenced by the Hall effect and thermopower experiments. Above H_m in the spin-polarized regime, one can naively expect the suppression of ferromagnetic fluctuations, if it exits. However, regarding other fluctuations, such as antiferromagnetic fluctuations, valence instabilities and Fermi surface instabilities, the field response below/above H_m is not very clear. The reappearance of superconductivity at high fields at magic angle may suggest the existence of multiple fluctuations in this system. In fact, recent high field magnetization measurements clearly demonstrated that the field response of effective mass is quite different between b-axis and the magic angle from the analysis based on the thermodynamics [2]. The multiple fluctuations are also inferred from the magnetic susceptibility and magnetization measurements under pressure [3].

This project was performed in strong international collaboration between IMR, CEA-Grenoble, LNCMI-Toulouse, LNCMI-Grenoble, ILL, ESRF, KIT together with domestic collaborations with JAEA, Kyoto University, ISSP, Osaka University, Hokkaido University.

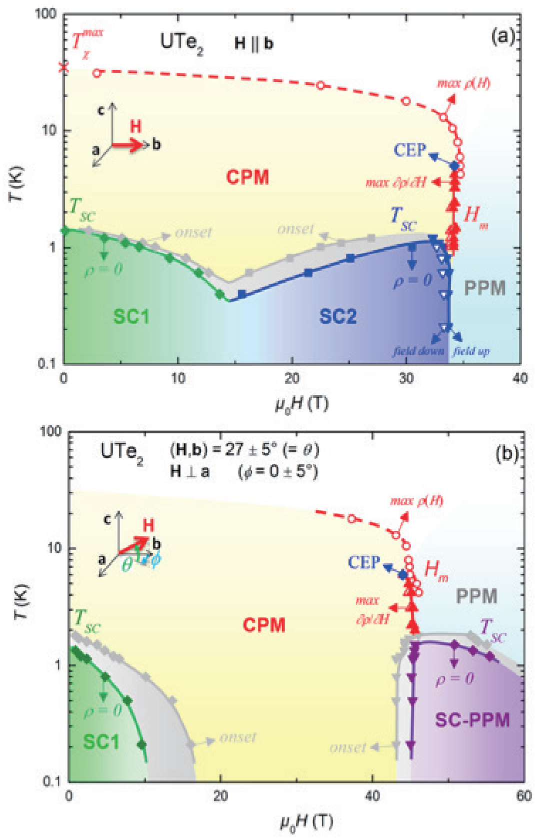

Fig. 2 temperature-field phase diagrams for the field along b-axis (a) and for the field tilted by 27 deg from b to c-axis (b) in UTe_2. SC, CPM and PPM denote superconductivity, correlated paramagnetic state and polarized paramagnetic state, respectively. [1]

References

[1] W. Knafo, M. Nardone, M. Valiska, A. Zitouni, G. Lapertot, D. Aoki, G. Knebel, and D. Braithwaite, Commun. Phys. 4, 40 (2021)

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Keywords:superconductivity,magnetism,actinide
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Activity Report

Workshops

Workshops

Application No.	Chairperson or Committee Member	Title of Workshop	Place	Term
20WS01	Prof. Nagai	International Workshop on Joint-Use at IRCNMS	online	2020.9.30-10.3
20WS02	Prof. Kato	15th International Workshop on Biomaterials in Interface Science	online	2020.12.14-15
20WS03	Prof. Sasaki	The 4th Symposium for The World Leading Research Centers -Materials Science-	online	2020.11.16-18
20WS04	Prof. Nojiri	ARHMF2020 & KINKEN Materials Science School 2020 for Young Scientists	online	2020.12.1-3
20WS05	Prof. Nojiri	Round Table for Condensed Matter Physics in Asia-Pacific	online	2020.12.4-5

International Workshop on Joint-Use at IRCNMS

Yasuyoshi Nagai

Institute for Materials Research, Tohoku University, Oarai, Iabaraki 311-1313

Keywords: nuclear materials, actinide science,

International Research Center of Nuclear Materials Science (IRCNMS) hosted "International Workshop on Joint-Use at IRCNMS," co-organized with the other workshops "Workshop of Laboratory of Alpha-Ray Emitters" and "Workshop on Radiation Effects in Materials: towards Irradiation 3.0," in on-line style due to COVID-19 pandemic from September 30th to October 3rd in 2020. The workshop had fruitful discussions on (1) the results of joint use, (2) future plans and research proposals for joint use, and (3) the irradiation plan etc.

1. Introduction

IRCNMS hosts "Oarai workshop" every year as a meeting to report the results of joint use research and to present future research proposals on various research field including future nuclear materials development, safety issues of light water reactors, Actinide sciences, etc. The future neutron irradiations using foreign research reactors are also discussed.

In 2020, the workshop was held as an international workshop: "International Workshop on Joint-Use at ICRNMS." The reasons why it should be international in 2020 are as follows; (1) At present, all neutron irradiation is carried out using Belgium Reactor 2 (BR2), the research reactor owned by SCK/CEN, based on an academic agreement with SCK/CEN, called "MICADO" project since 2005. It is a good opportunity to summarize the results of research on BR2 irradiation and discuss future irradiation plans since the academic agreement is renewed in 2020. (2) IRCNMS has accepted 23 overseas research proposals in the first year of GIMRT. It is very meaningful to share the results with the research community and promote international joint research among users. (3) IRCNMS had the 50 years anniversary since founded in 2019. We had the ceremony but it was domestic because the president of the local government and MEXT etc. are the guests.

It should be mentioned that the workshop was co-organized with the other two workshops: "Workshop of Laboratory of Alpha-Ray Emitters" and "Workshop on Radiation Effects in Materials: towards Irradiation 3.0." These workshops is reported elsewhere.

2. Content of the Workshop

Due to the COVID-19 pandemic, the workshop was held as completely on-line conference using ZOOM system from September 30th to October 3rd in 2020. We had 4 invited speakers from USA and Europe, 36 oral and 30 poster presentations for irradiated and related material studies, 17 oral and 7 poster presentations for Actinide science studies, and 10 oral presentations from users of laboratory of alpha-ray emitters. Totally, 137 attendees join the on-line workshop.

In addition to these conventional presentations, we had discussion of irradiation plan which will be performed in BR2. Attendees from SCK/CEN introduced BR2 status, operation plan, possible irradiation conditions and irradiation schedule. Taking users irradiation request into account, the irradiation capsules (named as LIBERTY, HTHF, and BAMI) and conditions (fluences, fluxes and temperatures) are fixed.

The program is shown below.

3. Results and Conclusions

We discussed (1) the results of joint use, (2) future plans and research proposals for joint use, and (3) the irradiation plan, and discuss international joint use at IRCNMS. Through the discussion, the joint users in Japan and overseas shared the research and the domestic researches will be internationalized. In addition, SCK/CEN directly understand the Japanese irradiation needs, and understand the future direction of the irradiation researches. These could contribute further activation of international joint research and joint use at IRCNMS.

Acknowledgement

We thank the international committee members (6 from overseas and 2 domestic) outside IMR, in addition to all the participants. We also thank IRCNMS members and GIMRT office staffs for great support on the remote conference organization.

30th Sep.(JST)		Institute for Materials Research, Tohoku University, Sendai, Japan, ONLINE		
9:05 - 9:10		Tohoku Univ.	Tadashi Furuhara	Opening remarks
9:10 - 9:15		Tohoku Univ.	Yasuyoshi Nagai	Introduction of Oarai Workshop
9:15 - 9:20		Tohoku Univ.	Ryuta Kasada	Introduction of REMAS2020, Irradiation 3.0
9:20 - 9:30		Tohoku Univ.	Yusei Shimizu	Announcements from the web conference office
9:30 - 10:10	Chair: S. Kondo	ORNL	Takaaki Koyanagi	***Plenary Talk:*** Additive manufacturing of silicon carbide for nuclear applications
10:10 - 10:20				Coffee break
10:20 - 10:40	Chair: R. Kasada	Tohoku Univ.	Akira Hasegawa	Current research status of neutron irradiation effects on advanced Tungsten alloys
10:40 - 11:00		Toyama Univ.	Yuji Hatano	Deuterium Retention in Irradiated W and W-Re, Cr, Mo and Ta Binary Alloys
11:00 - 11:20		NIFS	Takuya Nagasaka	Re-optimaization of composition for vanadium alloys for fusion reactors based on low-activation characteristics and irradiation properties.
11:20 - 11:40		Tohoku Univ.	Shuhei Nogami	Neutron Irradiation Tolerance of Potassium-Doped Tungsten-Rhenium Alloys
11:40 - 12:00		JAEA	Eiichi Wakai	Recent research on the effects of displacement damage and helium atoms on creep properties of austenitic stainless steel using research and test reactors and accelerators for innovated reactor development
12:00 - 13:00				Lunch
13:00 - 13:20	Chair: T. Toyama	Tohoku Univ.	Ryuta Kasada	Ultra-Small Testing Technologies for Irradiated Materials: A key of "Micro-Hot-Laboratory"
13:20 - 13:40		Hokaido Univ.	Naoyuki Hashimoto	Development and study of radiation damage in high entropy alloys for nuclear application
13:40 - 14:00		Fukui Univ.	Kenichi Fukumoto	Irradiation behavior of vanadium alloy with/without temperature transient effect during neutron irradiation using MARICO-II capsule in Joyo
14:00 - 14:20		Chongqing Univ.	Akihiko Kimura	Radiation effects on the EB-weld bonding of ODS ferritic steel —Comparison between neutron and ion irradiation--
14:20 - 14:30				Coffee break
14:30 - 14:50	Chair: K. Yoshida	USTB	Xiaoou Yi	Effect of radiation damage on thermal diffusivity and gas emission property in neutron irradiated tungsten
14:50 - 15:10		Guilin Univ. Electr. Tech.	Miao Lei	Observation of structural imperfectness in thermoelectric materials by advanced analytical microscopy
15:10 - 15:30		York. Univ.	Atsufumi Hirohata	Cross-sectional TEM imaging of NiCrMnSi and CoFe:N alloys for magnetic tunnel junctions
15:30 - 15:50		Russian Academy of Science	Vladimir Alimov	Deuterium release from deuterium plasma-exposed neutron-irradiated and non-neutron-irradiated tungsten samples during annealing
15:50 - 16:00				Coffee break
16:00 - 18:00	Chair: T.Toyama	SCK/CEN	Steven Van Dyck, Patrice Jacquet Bert Rossaert Dmitry Terentyev Inge Uytdenhouwen	15 years of MICADO collaboration Status of the BR2 reactor Material irradiations – devices used for MICADO Material irradiations – other existing devices and devices in development Fuel irradiations – existing devices and devices in development Laboratories and PIE Fusion related research RPV related research
18:00 - 19:30				Poster

1st Oct.(JST)			Institute for Materials Research, Tohoku University, Sendai, Japan, ONLINE		
9:00 - 9:35	Chair: R. Kasada	KLA Corporation	W.C. Oliver	***Plenary Talk:*** The use of nanindentation as a strength microprobe to investigate properties alterations associated with radiation damage
9:35 - 10:10	Chair: Y. Nagai	UCSB	Odette G Robert	***Plenary Talk:*** Measuring, Modeling and Managing RPV Embrittlement: Low Flux-High Fluence Shift Predictions
10:10 - 10:15				Coffee break
10:15 - 10:35	Chair: K. Yoshida	USTB	Somei Ohnuki	Anomalous phase separation in Fe-Cr alloys under three types of irradiation
10:35 - 10:55		Hokkaido Univ.	Naoko Oono	Radiation-induced microstructure and mechanical property modification in FeCrAl-ODS Alloy after Neutron Irradiation at an Operating Temperature
10:55 - 11:15		Tohoku Univ.	Takeshi Toyama	Microstructural analysis of RPV steels in joint research between SCK.CEN and IMR
11:15 - 11:35		Kyushu Univ.	Hideo Watanabe	Study of radiation induced microstructure of Fe-(Mn,Ni) model alloys under neutron irradiaton
11:35 - 11:55		Tohoku Univ.	Sosuke Kondo	Role of SiC dangling bonds in the irradiation assisted corrosion
11:55 - 12:15		NIFS	Arata Nishimura	Neutron Irradiation Effect on Critical Current of Nb3Sn Wire for ITER TF Coil.
12:15 - 13:15				Lunch
13:15 - 13:35	Chair: K. Inoue	Muroran Inst. Tech.	Hirotatsu Kishimoto	Investigation of environmental durability of NITE-SiC/SiC Composites under neutron irradiation environments
13:35 - 13:55		JAEA	Tomoaki Suzudo	Cleavage and dislocation emissions in BCC iron: A molecular dynamics study
13:55 - 14:15		Tokyo Univ.	Sho Kano	Radiation-Induced Amorphization of $M_{23}C_6$ in Reduced Activation Ferritic/Martensitic Steels: An atomic-Scale Observation
14:15 - 14:35		Kyoto Univ.	Toshimasa Yoshiie	The formation of iron nitride, α”-$Fe_{16}N_2$, around <100> interstitial type dislocation loops in neutron-irradiated iron
14:35 - 14:55		JAEA	Takashi Tannno	Development of miniature fracture toughness test technique for thin martensitic steel wrapper tube of fast reactor
14:55 - 15:05				Coffee break
15:05 - 15:25	Chair: Y. Shimada	KEK	Tatsushi Nakamoto	Development of radiation resistant materials for superconducting magnet system for high intensity proton beam line
15:25 - 15:45		NIMS	Yasuo Shimizu	Atom probe analysis of dopant distributionin commercial solar cells
15:45 - 16:05		INSS	Katsuhiko Fujii	Effects of cold work on solute atom clustering during thermal aging in RPV model alloy
16:05 - 16:25		Tohoku Univ.	Kenta Yoshida	In-situ weak-beam STEM for quantitative dislocation analysis in nuclear materials during post-irradiation annealing
16:25 - 16:35				Coffee break
16:35 - 17:30				Discussion for future irradiation plan using BR2
17:30 - 19:00				Poster

2nd Oct.(JST)		Institute for Materials Research, Tohoku University, Sendai, Japan, ONLINE		
9:00 - 9:10		Tohoku Univ.	Dai Aoki	Introduction of Oarai Workshop on Actinoid Science
9:10 - 9:40	Chair: D. Aoki	UC-Davis	Valentin Taufour	New compounds with novel type of ferromagnetic quantum criticality
9:40 - 10:00		Kobe Univ.	Hitoshi Sugawara	Study of Electronic States in Multipolar Conductors and Related Materials
10:00 - 10:20		Kobe Univ.	Hisashi Kotegawa	Single crystal growth and NMR studies of Uranium based superconductors and related materials
10:20 - 10:40		Kinki Univ.	Masanobu Nogami	Development of novel cyclic monoamide extractants for selective separation of uranium(VI)
10:40 - 10:50				Coffee break
10:50 - 11:10	Chair: F. Honda	Hokkaido Univ.	Hiroshi Amitsuka	Search for Uranium Compounds with Odd-Parity Cluster Multipole Ordering
11:10 - 11:30		RIKEN, CEMS	Yoshichika Onuki	Single Crystal Growth and Unique Electronic States of Cubic Chiral EuPtSi and Related Compounds
11:30 - 11:50		Ibaraki Univ.	Makoto Yokoyama	Relationship between quantum critical fluctuations and anomalous superconductivity in $CeCoIn_5$ and its ionic substitutions
11:50 - 12:10		Kyoto Univ.	Shunsaku Kitagawa	New avenue of outreach activities - how to become a YouTuber -

12:10	-	13:30				Lunch
13:30	-	13:50	Chair: H. Amitsuka	Tohoku Univ.	Dai Aoki	Field-reentrant and multiple superconductivity in UTe_2
13:50	-	14:10		Osaka.Univ.	Koichi Izawa	Nodal structure of UTe_2 studied by thermal conductivity
14:10	-	14:30		JAEA	Yo Tokunaga	NMR Study of Magnetic Fluctuations in Heavy Fermion Superconductor UTe_2
14:30	-	14:50		Kyoto Univ.	Kenji Ishida	NMR Study on the Superconducting State of UTe_2
14:50	-	15:00				Coffee break
15:00	-	15:30	Chair: F. Honda	Tata Inst. of Fundamental Research	Arumugam Thamizhavel	Extremely large magnetoresistance and Fermi surface properties of $MoSi_2$ and WSi_2 Single crystals
15:30	-	16:00		Charles Univ.	Ladislav Havela	Tuning of the 5f magnetism in U intermetallics by polar bonds
16:00	-	16:15				Coffee break
16:15	-	16:45	Chair: Y. Shimizu	CEA	Georg Knebel	Field Enhancement of Superconductivity in UTe_2
16:45	-	17:15		CEA	Daniel Braithwaite	The nearly ferromagnetic superconductor UTe_2 under pressure
17:15	-	17:45		CNRS	Ilya Sheikin	The mystery of $CeRhIn_5$ in high magnetic fields

3rd Oct.(JST)				Institute for Materials Research, Tohoku University, Sendai, Japan, ONLINE		
8:55	-	9:00		Tohoku Univ.	Kenji Shirasaki	Introduction of Workshop of Laboratory of Alpha-Ray Emitters
9:00	-	9:20	Chair: K. Tsukada	Nat. Cancer Centr.	Mitsuyoshi Yoshimoto	Targeted alpha therapy using 225Ac-RGD peptide for pancreatic cancer
9:20	-	9:40		Osaka Univ.	Yoshifumi Shirakami	Development of targeted alpha therapy using Actinium-225
9:40	-	10:00		JAEA	Toru Kitagaki	Analysis of the alteration behavior of zircon mineral in the three different pH solutions
10:00	-	10:10				Coffee break
10:10	-	10:30	Chair : T. Yamamura	Shimane Univ.	Gaku Motoyama	Study of Magnetoelectric Effect on Antiferromagnetic Compounds of Ce_3TiSb_5 and Ce_3TiBi_5 with Ce Zig-Zag Chain
10:30	-	10:50		Okayama Univ.	Koji Yoshimura	Novel Production Method of the Lowest-Energy Nuclear State - Thorium-229 Isomer
10:50	-	11:10		RIKEN	Atsushi Yamaguchi	Energy of the Th-+G10:I10229 nuclear clock isomer determined by absolute γ-ray energy difference
11:10	-	11:20				Coffee break
11:20	-	11:40	Chair: K. Shirasaki	Kyushu Univ.	Kazuya Idemitsu	Diffusion behavior of Pu and Np in bentonite
11:40	-	12:00		Nagaoka Univ. of Tech.	Tatsuya Suzuki	Fundamental Study for Precise Analysis of Actinides in Hardly Soluble Substances Containing Uranium Oxides
12:00	-	12:20		Kyoto Univ.	Chihiro Tabata	Crystal structure and magnetism of uranium phthalocyanine complex
12:20	-	12:40		Tokyo Inst. Tech.	Masahiko Nakase	Relation between ion recognition of f-block elements and polymeric characteristics by extractant-immobilized hydrogel adsorbents
12:40	-	12:50		Tohoku Univ.	Yasuyoshi Nagai	Closing Remarks

15th International Workshop on Biomaterials in Interface Science

研究代表者：東北大金研 加藤秀実

研究分担者：東北大歯 佐々木 啓一 高橋 信博 鈴木 治　東北大歯医工 西條 芳文

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Keywords: international workshop, biomaterials, interface science, bioengineering, oral health

The international joint symposium 2020 was held online on December 14-15, 2020, which was co-sponsored by the Institute of Biomaterials and Bioengineering (IBB) at Tokyo Medical and Dental University, the Institute for Materials Research (IMR), Graduate School of Dentistry, Graduate School of Biomedical Engineering and Medical Science, and the IDEA at Tohoku University, as well as the Laboratory for Future Interdisciplinary Research of Science and Technology (FIRST) at Tokyo Institute of Technology. The symposium contains six sessions, including the Oral Health Care, Innovative Dental-Engineering Alliance, Biomaterials, Industry-academia-government collaboration, Young innovators' session, Bioengineering. During the symposium, 25 oral presentations including 6 invited lectures and other 19 oral talks were given by the researchers from Korea, Japan, New Zealand, China, Taiwan. Interdisciplinary discussions and state-of-the-art research presentations on various types of materials were progressed by international researchers and students from wide research fields such as material science, dentistry, and medical engineering, which contributes significantly to the progress of researches among both domestic and overseas researchers.

1. 概要

生体材料研究を中心とした研究発表の場として毎年開催しているワークショップである。今年度は東北大学歯学研究科と東京工業大学の科学技術創成研究院 未来産業技術研究所とで行われている東北大学-東京工業大学 歯工連携イノベーション機構(IDEA)連携シンポジウムと合同で開催された。開催形式はオンラインで開催され、ニュージーランド、韓国、中国からも参加があった。研究内容としては研究テーマごとに 6 セッションにわけて行われ、招待講演、口頭発表からなる共同ワークショップとなった。

2. 内容

生体材料研究を中心として 2020 年 12 月 14 日-15 日、International Joint Symposium 2020 (共催)The 15th International Workshop on Biomaterials in Interface Science

The 11th Symposium on Innovative Dental-Engineering Alliance (IDEA)International Joint Symposium 2020 としてオンラインで開催された。組織メンバーは、東北大学（大学院医工学研究科、大学院工学研究科マテリアル、大学院歯学研究科、金属材料研究所)、東京医科歯科大学（生体材料工学研究所)、歯工連携イノベーション機構 IDEA （東京工業大学：科学技術創成研究院 未来産業技術研究所）であった。セッションテーマとしては、① Oral Health Care、② Innovative Dental-Engineering Alliance、③ Biomaterials、④ Industry-academia-government collaboration、⑤Young innovators' session、⑥ Bioengineering の 6 テーマとなり、招待講演者 6 名、口頭発表 19 名であった。特に、今回は Young innovators' session を設け、座長を含め進行も若手研究者で取り組むなど新しい試みが行われた。海外講演者の招待講演としては Sei Kwang Hahn 先生より、「Multifunctional Biomaterials for Smart Wearable Healthcare Devices」というタイトルで、 Frédérique Vanholsbeeck 先生より、「Birefringence as a proxy for viscoelastic properties of cartilage using polarisation sensitive optical coherence tomography」というタイトルで、Guangyin Yuan 先生より、「Viewpoints on R&D of innovative biodegradable Mg alloys from the aspect of accelerating clinical transformation」というタイトルで、Ming-Long Yeh 先生より、「Gallic-acids Loaded PLGA Coating on Biodegradable ZK60」というタイトルでそれぞれ講演が行われた。

オンラインでの開催ではあったが、国内外からの参加者は約 100 名となり有意義な会であった。

Schedule at a Glance

14 Dec. 2020

Session	Start	Time	No.		Speaker
Opening Session					
	9:00	0:05		Opening address	Nobuhiro TAKAHASHI
Session I: Oral Health Care					Chair: Hiroshi EGUSA
	9:05	0:30	I-01	Invited Lecture	Sei Kwang Hahn
	9:35	0:20	O-01	Oral talk	Kyosuke Ueda
	9:55	0:20	O-02	Oral talk	Haruki Otani
	10:15	0:20	O-03	Oral talk	Fumitoshi Ohori
	10:35	0:15	Break		
Session II: IDEA					Chair: Hideki HOSODA
	10:50	0:30	I-02	Invited Lecture	Frédérique Vanholsbeeck
	11:20	0:20	O-04	Oral talk	Shoichi Hasegawa
	11:40	0:20	O-05	Oral talk	Ryo Hamai
	12:00	0:20	O-06	Oral talk	Takashi Obi
	12:20	1:00	Break		
Session III: Biomaterials					Chair: Osamu SUZUKI & Masakazu KAWASHITA
	13:20	0:30	I-03	Invited Lecture	Masato Ueda
	13:50	0:20	O-07	Oral talk	Peng Chen
	14:10	0:20	O-08	Oral talk	Jiang Jing
	14:30	0:20	O-09	Oral talk	Weidong Zhang
	14:50	0:20	O-10	Oral talk	Yingchen Wang
	15:10	0:15	Break		
Session IV: Industry-academia-government collaboration					Chair: Keiichi SASAKI
	15:25	0:30	I-04	Invited Lecture	Shipei Sato
	15:55	0:20	O-11	Oral talk	Weiwei Zhou
	16:15	0:20	O-12	Oral talk	Shokouh Attarilar
	16:35	0:20	O-13	Oral talk	Nobuyuki Morimoto

15 Dec. 2020

Session	Start	Time	No.		Speaker
Session V: Young innovators'session					Chair: Jumpei WASHIO & Wan-Ting CHIU
	9:00	0:30	I-05	Invited Lecture	Guangyin Yuan
	9:30	0:20	O-14	Oral talk	Naohiro Sugita
	9:50	0:20	O-15	Oral talk	Wan–Ting Chiu
	10:10	0:20	O-16	Oral talk	Hiroki Chigama
	10:30	0:15	Break		
Session Ⅵ: Bioengineering					Chair: Ryoichi NAGATOMI
	10:45	0:30	I-06	Invited Lecture	Ming-Long Yeh
	11:15	0:20	O-17	Oral talk	Ryo Shintate
	11:35	0:20	O-18	Oral talk	Daixiu Wei
	11:55	0:20	O-19	Oral talk	Ariunbuyan Sukhbaatar
Closing Session					
	12:15	0:05		Closing	Takao HANAWA

The 4th Symposium for The World Leading Research Centers

-Materials Science-

研究代表者：東北大金研　佐々木孝彦

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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 on November 16 – 18, 2020.

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いる。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」を実施している。この材料科学研究拠点および大学院プログラム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、2020 年 11 月 16－18 日に第４回目となる国際シンポジウムをオンライン開催した。

2. 開催内容

第４回目となる本国際シンポジウムでは、“Create New Value of Materials Science through Broad Collaboration”と題して、幅広い共同研究から新たな価値を創成していくことを目指したプログラム編成が行われた。あわせて第３回目となる材料科学国際共同大学院（GP-MS）に参画する大学院生による研究成果発表も行った。今回は新型コロナ感染症拡大防止のためにオンライン開催となったが、これまでのシンポジウムと同規模の発表数および参加者を得ることができた。３日間の会期中に海外から参加の３件のプレナリー講演とあわせて国内外および学内からの招待講演により材料科学研究拠点では５セッション１５名、GP-MS では４セッション１５名の口頭発表が行われた。また、ポスターセッションでは、オンライン開催においてもできるだけ参加者間のコミュニケーションがその場ではかれるようにバーチャルリアリティ会場を設定し、講演者、参加者がともにアバター参加する実施形式を試みた。

・参加者：合計２８４名（日本：252 名、ドイツ：7 名、中国：6 名、韓国、フランス：各 2 名、リトアニア、フランス：各 1 名）
・材料科学拠点:5 セッション 15 名：学内 8 名、学外 7 名(海外 2 名)
・GP-MS:4 セッション 15 名：学内 4 名、学外 11 名(うち海外 10 名)

図１　開催ポスター

１日目（２０２０年１１月１６日）

大野英男東北大学総長の開会挨拶に引き続き、小谷元子理事、材料科学研究拠点長を座長として Pohang University of Science and Technology の Prof. Byeong-Joo Lee により“Solute-dislocation binding: understanding the mechanism for room temperature ductility of Mg alloys”と題するプレナリー講演が行われた。引き続き、組織制御材料、高強度材料、バイオマテリアルの各プロジェクトによるセッションにおいて、国内外からの招待講演が行われた。これと並行して GP-MS による学生セッションが行われ、国際共同大学院を構成する海外大学も含めた大学院生による口頭発表が行われた。１日目の最後に、材料科学研究拠点、GP-MS の合同セッションとして、Max-Planck-Institut für Eisenforschung GmbH の Prof. Dierk Raabe による“Interplay of Chemistry and Structure at Lattice Defects studied at the Atomic Scale”と Fritz-Haber-Institut der Max-Planck-Gesellschaft の Prof. Hans-Joachim Freund による“Model Systems for Heterogeneous Catalysts at the Atomic Scale”の２件のプレナリー講演が行われた。日本と韓国、ヨーロッパのあいだの時差の関係で、朝と夕方に分けたオンラインプレナリー講演を行うことになった。

２日目（２０２０年１１月１７日）

午前には、材料科学研究拠点で先端エネルギー材料セッション、夕方―夜に GP-MS で２つの学生セッションが行われた。この２つのセッションの間に、バーチャルリアリティ空間における合同オンラインポスターセッションが行われた。オンラインシンポジウムなどでのポスター発表は、PDF ポスターの閲覧や ZOOM のブレイクアウトルームの利用など種々の開催形式が試みられている。しかし、従来のポスターを見ながら発表者・参加者間でインタラクティブにディスカッションを行うことを実現することは難しい。できるだけ従来のポスター発表形式に近づける試みとして GP-MS で VR ポスター会場・アバター参加の開催形式を開発・試行した。（図２）参加者間の音声会話はできないが、アバターとなった参加者が会場内のポスターを見て回り、発表者とポスターを前にしてチャットで議論ができるものである。発表者、参加者ともにアバター操作をするなどの、臨場感やオンライン会議の聴講だけでは味わい難いワクワク感も体感できるものとなった。

・ポスター発表数：材料科学研究拠点　５４件、GP-MS　２０件
・ポスター発表表彰：材料科学研究拠点　最優秀賞３件，優秀賞４件，GP-MS 最優秀賞２件，優秀賞３件

図２　バーチャルリアリティーポスター会場

３日目（２０２０年１１月１８日）

最終日は、材料科学研究拠点では、先端エレクトロニクス材料プロジェクト、GP-MS で学生セッションが行われ、それぞれの終了後に、合同でポスターアワードの表彰式と長坂徹也工学研究科長による closing remarks により終了した。

3. まとめ

第４回となる本シンポジウムは、オンライン開催となったが、運営・企画の工夫により、実開催と同等の成果をあげることができた。２０２１年度も含めて次回以降の開催形式は、現在のところ未定であるがオンラインを併用したハイブリッド形式が標準化すると思われる。その際には、若手研究者、学生が主体となるポスター発表の行い方が会議参加者の満足度を左右すると思われる。今回の VR ポスター会場は、改良の余地はあるが今後の方向性となるものである。

謝辞

本シンポジウムは、材料科学世界トップレベル研究拠点、材料科学国際共同大学院プログラムが主催し、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。運営・企画に参画されたすべての方に謝意を表します。

参考：シンポジウムプログラム

As of October 28, 2020

DAY 1	Nov. 16 (Mon)	
JST	Core Research Cluster for Materials Science	GP-MS
9:00	9:00-9:10 Opening Remarks: OHNO Hideo, President of Tohoku University	
9:10 9:20 9:30 9:40 9:50	9:10-9:55 Plenary Session ① Chair: KOTANI Motoko ･Byeong-Joo Lee (Pohang University of Science and Technology)	
9:55	9:55-10:00 Remarks: YAMAGUCHI Masahiro, Head of the Division for International Joint Graduate School Programs, Tohoku University	
10:00	10:00-10:10 Break (10 min.)	
10:10 10:20 10:30 10:40 10:50 11:00 11:10 11:20 11:30	10:10-11:40 <Materials Science> Session 1 Chair: FURUHARA Tadashi 1-A. OHTANI Hiroshi (Tohoku University) 1-B. MATSUBAE Kazuyo (Tohoku University) 1-C. ABE Eiji (The University of Tokyo)	
11:40 11:50 12:00 12:10 12:20 12:30 12:40 12:50	Lunch (11:40-13:00)	
13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20	13:00-14:30 <Materials Science> Session 2 Chair: YOSHIMI Kyosuke 2-A. Qiang Charles Feng (University of Science and Technology Beijing) 2-B. OHMURA Takahito (National Institute for Materials Science) 2-C. NOMURA Naoyuki (Tohoku University)	14:00-16:00 <GP-MS> Student Session 1 Chair: KOSABA Takumi 1-A. Ying Jin (University of Science and Technology Beijing) 1-B. HIROMOTO Sachiko (National Institute for Materials Science) 1-C. KOSABA Takumi (Tohoku University)
14:30 14:40	14:30-14:50 Break (20 min.)	
14:50 15:00 15:10 15:20 15:30 15:40 15:50 16:00 16:10	14:50-16:20 <Materials Science> Session 3 Chair: HIRANO-IWATA Ayumi 3-A. KURIYAGAWA Tsunemoto (Tohoku University) 3-B. UMETSU Mitsuo (Tohoku University) 3-C. Yi-tao Long (Nanjing University)	16:00-16:40 Break(40min.)
16:20 16:30	16:20-16:40 Break (20 min.)	
16:40 16:50 17:00 17:10 17:20	16:40-17:25 Plenary Session ② Chair: FURUHARA Tadashi ･Dierk Raabe (Max-Planck-Institut für Eisenforschung GmbH)	
17:30 17:40 17:50 18:00	17:25-18:10 Plenary Session ③ Chair: ORIMO Shin-ichi ･Hans-Joachim Freund (Fritz-Haber-Institut der Max-Planck-Gesellschaft)	

DAY 2	Nov. 17 (Tue)	
JST	Core Research Cluster for Materials Science	GP-MS
10:00–11:30	10:00-11:30 <Materials Science> Session 4 Chair: ORIMO Shin-ichi 4-A. MIZUGUCHI Masaki (Nagoya University) 4-B. EINAGA Mari (Osaka University) 4-C. AKAGI Kazuto (Tohoku University)	
11:30–13:00	Lunch (11:30-13:00)	
13:00–15:00	Poster Session (13:00-15:00)	
15:00–17:00		
17:00–19:00		17:00-19:00 <GP-MS> Student Session 2 Chair: YAMAGUCHI Mina 2-A. Andreas Klein (Technical University Darmstadt) 2-B. Holger Fritze (Technical University of Clausthal) 2-C. Matthias T. Elm (Justus Liebig University Gießen) 2-D. TAKAMURA Hitoshi (Tohoku University) 2-E. YAMAGUCHI Mina (Tohoku University)
19:00–19:10		19:00-19:10 Break (10 min.)
19:10–21:10		19:10-21:10 <GP-MS> Student Session 3 Chair: KURISU Minoru 3-A. Peter Walde (ETH) 3-B. Dora Tang (Max Planck Institute) 3-C. Kate Adamala (University of Minnesota) 3-D. KURISU Minoru (Tohoku University)

DAY 3	Nov. 18 (Wed)	
JST	Core Research Cluster for Materials Science	GP-MS
8:30–9:00		
9:00–10:30	9:00-10:30 <Materials Science> Session 5 Chair: FUKUMURA Tomoteru 5-A. MURAKAMI Shuichi (Tokyo Institute of Technology) 5-B. FUJIWARA Kozo (Tohoku University) 5-C. TSUDA Kenji (Tohoku University)	9:00-10:30 <GP-MS> GP-MS Session Chair: SAITO Riichiro A. Shengxi Huang (Pennsylvania State University) B. Lianming Tong (Peking University) C. Teng Yang (Institute of Metal Research, Chinese Academy of Sciences)
10:30–10:50	10:30-10:50 Break (20 min.)	10:30-10:50 Break (20 min.)
10:50–11:10	10:50-11:10 Poster Award Ceremony	
11:10–11:20	11:10-11:20 Closing Remarks: NAGASAKA Tetsuya, Dean of Graduate School of Engineering, Tohoku University	

Asia-Pacific Workshop on Research in High Magnetic Fields

H. Nojiri, S. Awaji, M. Kimata and S. Kimura
Institute for Materials Research, Tohoku University, Katahira 2-1-1, Aobaku, Sendai, 980-8577

1. Scope and format of the workshop

High Field Laboratory for Superconducting Materials in IMR is one of the three high field laboratories in the Japan High Magnetic Field Collaboratory, together with Megagauss Laboratory in ISSP, University of Tokyo and Advanced High Magnetic Field Laboratory in Osaka University. In Asia-pacific area, there are other world class laboratories in China in Wuhan and in Hefei. Activities of independent high field researches in other nations such as Korea. Recently, high magnetic research communities in Asia-pacific area join into the Asian high magnetic field forum for mutual exchange of researches and researchers. The forum was established in 2018 and there have been workshops in Tokyo and in Wuhan.

The symposium was planned to discuss the recent progresses in high magnetic field research and future directions as well as mutual collaboration among laboratories and groups in Asia-Pacific area. In the covid-19 pandemic, it was organized from December 1st to 3rd, 2020 as an online conference. The conference includes tutorial talks for students which is sponsored by KINKEN(IMR) Materials Science School 2020 for Young Scientists.

ARHMF2020 Outline of Time Table

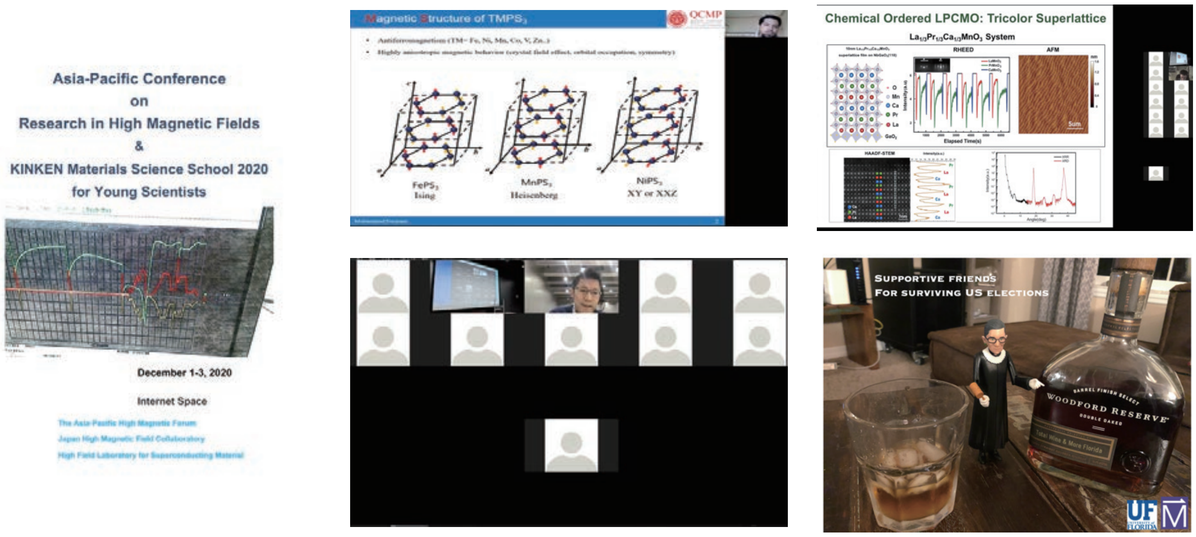
	Dec. 1	Dec. 2	Dec. 3
AM	Opening Tutorial Talks	Scientific Sessions	24 Hours Session-America 24 Hours Session-Asia
Lunch	Break	Break	Closing
PM1	Tutorial Talks	24 Hours Sessions for Young Researchers 48 invited talks from around the world	PM1&PM2 User meetings or Scientific meeting in each Associations
PM2	Scientific Sessions	24 Hours Session-Asia	
Evening	Posters	24 Hours Session-Europe	
Night	Exchange Event	24 Hours Session-Europe	
Midnight		24 Hours Session-America	

Time table of the ARHMF. There are tutorial lectures and a 24 hours non-stop session with 48 invited talks.

2. Day1, tutorial lecture, parallel sessions and poster presentation

The Day1 starts with three tutorial lectures, Practical High Temperature Super-conducting Wires for Magnets(Arnaud Badel, IMR, Tohoku Univ.), Invitation to 1000 T Science(Yasuhiro H. Matsuda, ISSP, Univ. of Tokyo) and Probing Quantum Transport in Atomically Thin Transition Metal Dichalcogenide Semiconductors (Ning Wang, HKUST). It is the joint session with KINKEN(IMR) Materials Science School 2020 organized by the school head(M. Kimata). More than 150 participants, mainly young students and researchers, have learned the most recent progresses and trends in the research area.

In the afternoon of the Day1, two parallel sessions have been organized with 18 talks from mainly by young researchers and students with some leading talks by senior experts. Topics are mixtures of transport, magnetism and inter-disciplinary science. Some of the titles are Giant anomalous Hall effect from spin-chirality scattering in a chiral magnet(N. Kanazawa), Possible liquid-liquid transition of oxygen(T. Nomura), Complex magnetic domain structures in oxides: physical origin and device application(J. Shen), Anomalous thermoelectric effects of $ZrTe_5$ in and beyond the quantum limit(J. Zhang), Magnetization plateau of the breathing kagome-lattice antiferromagnet $Li_2Cr_3SbO_8$ in ultra-high magnetic field(Y. Ishii). It was the good collection of the recent activities in high magnetic field researches. In the evening, we had 24 interactive poster presentations by using Zoom breakout function. The poster session is the one of the difficult functionality of the online conference. However, the smooth hopping among different posters is possible in the breakout room systems. There was also an online exchange event organized with REMO virtual conference room. The some of the screen shots of Zoom is combined in the figure shown below.



The screen of the talks, exchange program and the abstract book.

3. Day2, parallel session and 24 hours non-stop session

In the morning of the Day2, a single session about magnetic transport in high magnetic fields was organized. The talks included are Quantum oscillations and charge-neutral fermions in Kondo insulators(Y. Matsuda), Thermal expansion and resistivity measurements of heavy-fermion CeAuSb2 under pressure and magnetic field(S. Seo) and Enhancement of magnetoresistance anisotropy by hydrostatic pressure in a nodal line semimetal ZrSiS(D. Bhoi). The transport phenomena of Weyl-Dirac systems in high magnetic fields are one of the most active areas.

The main event of the workshop is the 24 hours non-stop session named as “Around the world”. It consists of 43 invited talks by talented young researchers and several senior lecturers. The format is chosen to enable the exchange among participants from different time zone. Another feature is that the longer talk time of 30 minutes for each lecture. The effectiveness of the session is the key to compromise the numbers of talks and the quality. The dedicated session for young researchers has played a very important role of supporting next generations of the communities

4. Day3, 24 hours non-stop session, closing and domestic meetings

In the morning of the Day3, the 24 hours session has been continued and then the closing session was hold. The alternation of presenters from three continents and the substantial overlaps among them shows the uniqueness of the session. It was really moving with the processing of the day.

In the closing, it was reported that there were 230 participants from more than 20 nations and that the even was successful to maintain the international exchange under the covid-19 pandemic. Acknowledge was expressed for the sponsors including The Global high magnetic field forum, the European High Magnetic Field Laboratory and for program committee, non-local organizing committee members from different areas and nations, chair persons contributed to the organization of the workshop. In the afternoon, the few nations hold a domestic meeting in the afternoon to discuss the issues of the national communities.

In summary, the workshop was very successful for the exchange among the international community at the point that the exchange had been suspended nearly 10 months. The participants realized the usefulness of the GIMRT program supporting such international event.

ARHMF2020 & KINKEN Materials Science School 2020 for Young Scientists Dec. 1-3, 2020

Date	S	Room	Time(JST)	Time: (CET)	Time: (CST)	Name	Affiliation	Title
		Main	21:10-21:30	13:10	6:10	Phase Recovery Time		
12/2	AW17	Main	21:30-22:00	13:30	6:30	Kimberly Modic	Inst. Sci. & Tech. Austria	Scale-invariant magnetic anisotropy in $RuCl_3$: a signature of spir liquids?
12/2	AW18	Main	22:00-22:30	14:00	7:00	Sergei A. Zvyagin	HLD-HZDR	Pressure-tuned magnetic interactions in the triangular-lattice quantum antiferromagnet Cs_2CuCl_4
12/2	AW19	Main	22:30-23:00	14:30	7:30	Atsuhiko Miyata	HLD-HZDR	Magnetoelastic coupling in frustrated magnets: The cases of $LiCuVO_4$ and $MnCr_2S_4$
12/2	AW20	Main	23:00-23:30	15:00	8:00	Denis I. Gorbunov	HLD-HZDR	Elastic response to the first-order magnetization process of $U_3Cu_4Ge_4$
12/2	AW21	Main	23:30-24:00	15:30	8:30	Shingo Yamamoto	HLD-HZDR	High-field soft x-ray dichroism of highly anisotropic ferrimagnets $R\,Fe_5Al_7$
12/3	AW22	Main	24:00-0:30	16:00	9:00	Shivani Sharma	NHMFL	Magnetostriction in $AlFe_2B_2$ investigated via In-field x-ray diffraction study under DC field of 25 Tesla
12/3		Main	0:30-0:50	16:30	9:30	Phase Recovery Time		
12/3	AW23	Main	0:50-1:20	16:50	9:50	Lucia Steinke	Phys., Univ. Florida & NHMFL	Towards a universal measurement platform for calorimetric and thermal transport measurements at the combined extremes of high magnetic fields and sub-millikelvin temperatures
12/3	AW24	Main	1:20-1:50	17:20	10:20	Mateusz Goryca	NHMFL	Revealing exciton masses and dielectric properties of monolaye semiconductors with high magnetic fields
12/3	AW25	Main	1:50-2:20	17:50	10:50	Marta De Luca	Univ. of Basel	Wurtzite III-V nanowires investigated by magneto-photoluminescence spectroscopy: effective masses and *g*-factors
12/3	AW26	Main	2:20-2:50	18:20	11:20	Jing Li	NHMFL, LANL	Spontaneous Valley Polarization of Interacting Carriers in a Monolayer Semiconductor revealed in 60 T pulsed field
12/3	AW27	Main	2:50-3:20	18:50	11:50	Rubi Km	HFML-EMFL & Radboud Univ.	High field magnetotransport in the quasi-two-dimensional electron gas at the a$LaAlO_3/KTaO_3$ interface
12/3		Main	3:20-3:40	19:20	12:20	Phase Recovery Time		
12/3	AW28	Main	3:40-4:10	19:40	12:40	Johanna C. Palmstrom	NHMFL, LANL	Elastoresistivity of Fe-based Superconductors in High Magnetic Fields
12/3	AW29	Main	4:10-4:40	20:10	13:10	Matija Culo	HFML-EMFL & IMM, Radboud Univ.	Strange metal transport in $FeSe_{1-x}S_x$
12/3	AW30	Main	4:40-5:10	20:40	13:40	Aravind Devarakonda	Phys., MIT	Clean 2D superconductivity in a bulk van der Waals superlattice
12/3	AW31	Main	5:10-5:40	21:10	14:10	Audrey D. Grockowiak	NHMFL	Hot hydride superconductivity above 550 K

The part of the program of the 24 hours non-stop session-around the world. The time is indicated by Asia, Europe and American time zones.

The sponsors of the workshop.

Asia- Round Table for Condensed Matter Physics in Asia-Pacific

[1]H. Nojiri, [2]H. Nakamura and [3]J. Park
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1. Scope and format of the workshop

Condensed Matter Physics is one of the major parts of physics that covers a wide range of disciplines. It is constantly developing with strong interactions with various scientific areas and contributes to the expansion of human knowledge and the developments of society. In the Asia-Pacific region, research and education in condensed matter physics are actively studied, and exchanges of personnel and knowledge are becoming more active across the region year by year and global international exchange.

Given this situation, there is a strong need to form an organization representing the scientific community for systematic and continuous exchanges to further develop condensed matter physics in the Asia-Pacific region. The round table was planned to establish the organization to conduct the regional international exchange. In the original form, it was planned to be hold at Sendai in the mid November. Due to the covid-19 pandemic, we organized it as on-line meeting and we also split it into two successive meetings-the pre-meeting for wide range of discussions and the round table for the finalization for the community formation.

2. Discussion in the preparation meeting-December 2nd

In the preparation meeting, we had about 10 participants from 5 associations related to condensed matter physics. The members are gathered through the collaboration with Physical societies in the region. There was an discussion on the current situation of the regional exchange. In the Asia-Pacific region, there are several regional organizations related to the condensed matter physics. The biggest organization is the Association of Asia Pacific Physical Societies (AAPPS), which was funded at 1990 at Seoul. In the neutron scattering community, the Asia-Oceania Neutron Scattering Association(AONSA) including seven neutron societies was established in 2012. The Asian Union of Magnetics Societies(AUMS) was established in 2009 with four national societies on magnetics. In the synchrotron radiation research community, the Asia-Oceania Forum for Synchrotron Radiation Research (AOFSRR) was established in 2006 with 11 members at present. There is also the Asia-Pacific Center for Theoretical Physics(APCTP). The primary aim of the APTPC was to build a hub-institute of theoretical physics in the Asia-Pacific region to facilitate collaboration and exchange of scientists and to provide a platform for scientists of less advanced region. The importance to establish an solid organization was highlighted through the discussion.

The second point of the discussion was about the areas which should be included in the division. The condensed matter physics has the large diversity in the research fields such as magnetism, strongly correlated electrons and superconductivity, semiconductors, optics and laser physics, quantum information, statistical physics and theoretical condensed matter physics, high magnetic fields, low temperature physics, molecular solids, surface & interface, crystal growth, soft-matter, chemical physics and biophysics, material physics and others. The centers of the activities varies among associations and thus it is not easy to decide which areas should be focused. The participants agreed to establish the comprehensive condensed matter physics organization which includes all areas at the starting point and to allow the spin-off of some area, if the activity becomes substantial.

In the last part, the discussion was made on the by-law and the format of the decision body. Participants agreed that the consensus building is the basis of such organization and the council consists of the representatives of the each domestic organization is the place to handle the organization, rather than a president elected from the voting

by the members. It was also agreed that the organization could be formed as a division of condensed matter physics in the AAPPS. AAPPS was originated from the first Asia-Pacific Physics Conference(APPC), held in Singapore in 1983, to create an association of physical societies aimed at the promotion of physics in the Asia Pacific region. In 2012, AAPPS made bylaws for divisions. At APPC12 in Makuhari, Japan, the Division of Plasma Physics (DPP) was established. This was the first step allowing AAPPS to have an arena to promote specific fields of physics as in national physical societies. This launch was followed by the establishment of Division of Astrophysics, Cosmology, and Gravitation (DACG), and the Division of Nuclear Physics (DNP). As such, the AAPPS provides the mechanism to form the platform of each research area in physics. It should be also noted that both Physical Society of Japan and the Japan Society of Applied Physics(JSAP) participate in the AAPPS from Japan. In fact, APPC14 in 2019, the participants from condensed matter communities have agreed to organize meetings toward division formation in condensed matter physics. Since then, the representative of condensed matter communities of Japan, Korea, China, Taiwan, India have formed the working group aiming at the formation of condensed matter platform.

3. Round table meeting-December 4th

In the round table meeting, we had representatives from associations of physics of Japan, Korea, China, India, Taiwan and an observer from the JSAP. In the begging, there are reports on the status of condensed matter physics in each association. The report includes the organization, history, divisions structure, research areas, meetings, related research institutes, large scale facilities, national research programs and others. It was the good opportunities to understand the status of the condensed matter physics in the Asia-Pacific region.

The report was followed by the presentation of the consensus made at the preparation meeting. The major points of the discussions were, the by-law, organization, membership, committee member, webpage, registration, declaration of the founding, application to AAPPS, action plan, meeting, and how to select Chair etc. The discussion was made in very friendly atmosphere and the foundation of the division was agreed by the participants.

Finally, the round table agreed to establish the condensed matter physics division at January 1st, 2021. This activity was followed up by voluntary actions from condensed matter physics communities across the region. Many contributors have been continuing discussion to form the Division of Condensed Matter Physics, despite the difficult situation due to the coronavirus in most of 2020. It is the significant steps toward the formation of the regional community. The Division will promote the progress and disseminate condensed matter physics knowledge and its application through research presentations, exchange of knowledge, and corporation among members and other academic societies. It thereby aim to contribute to the development of academic research. It will cover the diverse research fields of condensed matter physics.

The GIMRT supported workshop was extremely useful as an opportunity to revitalize regional international exchange in condensed matter physics.

Activity Report

Young Researcher Fellowships

Young Research Fellowships

Application No.	Title	Applicant	Affiliation	Host Professor	Proposed Research	Period of Stay
20FS01	PhD Student	Yumi Milene MAEDA	State University of Ponta Grossa, Brazil	Prof. Akiyama	Understanding Hydrogen Embrittlement Mechanisms of Ferrite/austenite Duplex Steels	2020.9.1-2021.2.28

Hydrogen embrittlement mechanisms of nitrogen-doped ferrite/austenite duplex steels with different pre-strains

Hydrogen embrittlement behavior of a nitrogen-doped ferrite/austenite duplex stainless steel was investigated in this study. Significant hydrogen embrittlement occurred, the cracking behavior was deformation twins and ferrite/austenite. Interestingly, the preferential hydrogen localization site and cracking sites could be altered by pre-straining, which is expected to be used to develop hydrogen-resistant high-strength steels.

Prevention of hydrogen embrittlement is an urgent issue to increase durability of high-strength steels for automobiles and hydrogen-energy-related infrastructures. An effective route to suppress the hydrogen embrittlement is developments of new high-strength hydrogen-resistant steels. In this context, microstructure and alloy design strategies for the hydrogen-resistant steels have been noted in these days. In particular, an introduction of austenite and an addition of solute nitrogen are key to achieve the high-strength with a superior hydrogen resistance. In this study, we characterized the hydrogen-related cracking behavior and associated microstructure evolution in a nitrogen-doped ferrite/austenite duplex stainless steels.

Hydrogen charging in an aqueous solution of 3%NaCl+3g/L NH_4SCN at 10 A/m^2 for 7 days introduced 498 mass ppm diffusible hydrogen, and decreased the total tensile elongation from 29% to 6%. That is, hydrogen embrittlement occurred with this condition. Figure 1(a) shows a phase map exhibiting hydrogen-induced cracks and surrounding microstructure. The preferential crack initiation sites were deformation twins in austenite and ferrite/austenite interfaces (e.g. Fig. 1(b)). The hydrogen-induced cracking behavior was unconventional compared to that of other ferrite/austenite duplex stainless steels that did not contain solute nitrogen. Therefore, it was

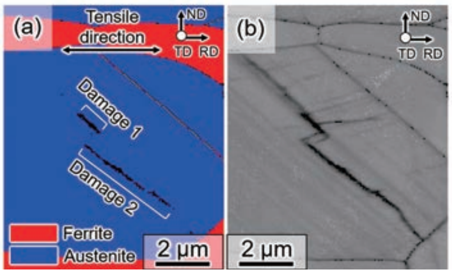

Fig.1 Micrographs obtained by electron backscatter diffraction measurements for the hydrogen-charged and fractured specimen: (a) Phase, and (b) image quality (IQ) maps [1]. The dark lines regions in the austenite in the IQ map indicate cracks and deformation twins.

considered that the characteristic hydrogen embrittlement behavior was attributed to the addition of solute nitrogen.

In addition, we carried out the same hydrogen embrittlement tests for the duplex steels with different pre-strains. Interestingly, the 22% pre-strain effect coupled with solute nitrogen achieved 1 GPa tensile strength even under the effect of hydrogen. More specifically, the pre-strain changed the preferential crack initiation site to ferrite, and suppressed the hydrogen diffusion in austenite (Fig. 2). The pre-strain effects on the cracking behavior and hydrogen diffusivity may play an important role to improve the resistance to hydrogen embrittlement of the nitrogen-doped duplex steel.

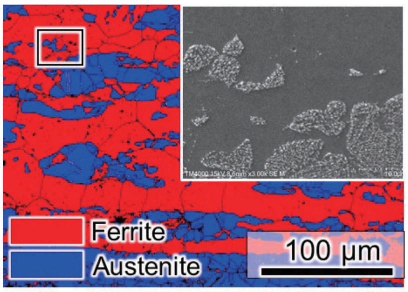

Fig. 2 Phase map and secondary electron image (inset) showing deposition of silver particles in the hydrogen-charged duplex steel with 22% pre-strain. The location of the image shown as the inset corresponds to that highlighted by the black square in the phase map. When hydrogen flux is high, silver particles are preferentially deposited on the surface consisting of the specific microstructure, which is called silver decoration technique [2]. The silver decoration experiment was carried out by immersing the hydrogen-charged specimen into an aqueous solution of 4.3 mM $Ag[K(CN)_2]$.

References

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Keywords: steel; strength; embrittlement
Milene Yumi Maeda (State University of Ponta Grossa), Motomichi Koyama (Environmentally Robust Materials, Institute for Materials Research)
E-mail: koyama@imr.tohoku.ac.jp

Activity Report

IMR Young Fellowships for Graduate Students and Young Researcher

IMR Young Fellowships for Graduate Students and Young Researcher

Application No.	Title	Applicant	Host Professor	Proposed Research
20YFP_ Covid19_01	PhD Student	Junyi Luo	Prof. Awaji	Critical Current Density Properties of Iron-Based Superconducting Tapes
20YFP_ Covid19_02	Research Student	XiaTong Ye	Prof. Ichitubo	Research on structural material/energy material development technology and related measurement technology
20YFP_ Covid19_03	Post Doctoral Fellow	Ping Tang	Prof. Bauer	Magnon Chemistry
20YFP_ Covid19_04	Research Student	Yifei Wen	Prof. Akiyama	Hydrogen Desorption behavior Caused by Transformation of Metastable Austenite
20YFP_ Covid19_05	Ph.D. Student	Kong Taein	Assoc. Prof. Koyama	A Microstructural Analysis Method for Hydrogen Embrittlement
20YFP_ Covid19_06	Ph.D. Student	Peiao Xie	Prof. Fujita	Study of the Ground State of T*-type $La_{1-x/2}Eu_{1-x/2}Sr_xCuO_4$
20YFP_ Covid19_07	Research Student	Yuyan Zhang	Prof. Ichitubo	Research of Electrode Materials for Innovative Rechargeable Batteries
20YFP_ Covid19_08	Ph.D. Student	Zhu Pengfei	Prof. Kato	Microstructure and Properties of High Entropy Alloy Prepared by Powder Metallurgy
20YFP_ Covid19_09	Ph.D. Student	Bowen Tang	Prof. Kato	Preparation of new soft magnetic Co-based amorphous alloy

Critical current density properties of iron-based superconducting tapes

Iron-based superconductors (Ba, K)Fe_2As_2 tapes (T_c ≈ 38 K) have great potential for high field applications with the largest critical current density (J_c) over 10^5 A/cm^2 at 10 T and 4.2 K [1]. For the development of J_c, this study focuses on the Ag-sheath flat-rolled (Ba, K)122 tapes. The J_c anisotropy and pinning mechanisms were discussed based on the J_c properties in high magnetic field.

It was reported that anomalous J_c anisotropy, J_c for *B* // *c* was higher than J_c for *B* // *ab*, was observed in hot-pressed (Sr, K)122 tapes at high temperature. This was inverse in the cases of flat-rolled (Sr, K)122 tapes [2]. Similar phenomenon in hot-pressed (Ba, K)122 tapes was reported at 10 T and 4.2 K [1]. After measuring the magnetic field and angular dependences of J_c at 4.2 K over 30 K for the flat-rolled (Ba, K)122 tapes, we also observed the anomalous J_c anisotropy. For instance, Fig. 1 shows the angular dependence of J_c at 35 K. Broad peak appears around 45° and a minimum appears at *B* // *ab* instead of *B* // c below 1 T. As the magnetic field increases, the peak appears at *B* // *ab* while the minimum appears around *B* // c, which is the usual effective-mass-like anisotropy. An anisotropic Ginzburg-Landau (GL) effective mass scaling [3] was adopted to analyze and confirm it.

The angular dependence of J_c was scaled by the effective magnetic field $B_{eff} = B\varepsilon(\gamma, \theta)$, where $\varepsilon(\gamma, \theta) = (\cos^2\theta + \gamma^{-2}\sin^2\theta)^{1/2}$, where γ is an effective anisotropic parameter. As shown in Fig. 2, J_c - B_{eff} over 1 T collapse onto the same black line at each temperature, which means a good scaling behavior of J_c, the same black line at each temperature, which means a good scaling behavior of J_c, while J_c can't be scaled below 1T. It indicates that J_c anisotropy is dominated by the effective-mass anisotropy over 1 T, but an additional pinning mechanism should be considered below 1 T.

Through comparing to coated conductor (Y,Gd)$Ba_2Cu_3O_{7-\delta}$ with $BaHfO_3$ nanoparticles [4], which has the similar J_c minimum at *B* // *ab*, the nanoparticle is considered to be the additional pinning that leads to the anomalous J_c anisotropy at low field for (Ba, K)122 tapes.

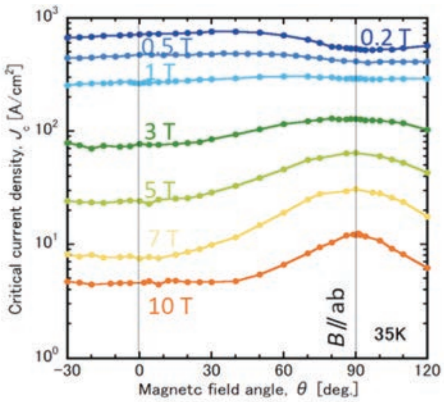

Fig. 1 Angular dependence of J_c at 35 K and at various magnetic fields.

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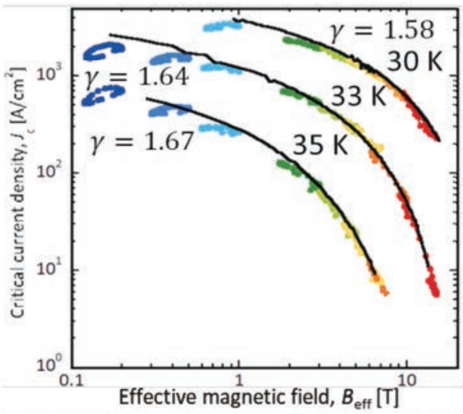

Fig. 2 Scaling plot of $J_c(B, \theta)$ at various temperatures with the effective-mass model. The black lines represent the magnetic field dependence of $J_c(B//c)$ at the same temperatures.

Keywords: high-T_c iron-based pnictide superconductors, critical current, magnetic properties, electrical properties

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Development of Manganese Oxide Cathode Materials for Room Temperature Rechargeable Magnesium Batteries

Abstract: Manganese oxides have high electrode potential and large theoretical capacity, which are promising features of cathode materials for rechargeable magnesium batteries. However, it is difficult to insert Mg^{2+} during discharging at room temperature due to the sluggish solid-state diffusion. In this study, we explore suitable electrolytes and cathodes in which reversible Mg^{2+} intercalation can be achieved at room temperature.

Rechargeable magnesium batteries have the potential to become the next generation batteries. The major advantages of Mg are its natural abundance in the earth's crust compared to Li, the high volumetric capacity, and the dendrite-free deposition upon battery charging. For cathode materials, manganese oxides have high electrode potential and large capacity[1]. In this work, hydrothermal reaction and solid-phase reaction methods were used to synthesize the samples. The three-electrode cells were used in electrochemical measurements to investigate the Mg intercalation behavior. The crystal structure and chemical composition of the synthesized samples were characterized using powder X-ray diffraction and energy dispersive X-ray spectroscopy, respectively. $Mg[Al(HFIP)_4]_2$ salt and G2 or G3 solvent were used as the electrolyte at room temperature.

Fig.1 shows the GITT curve of a α−MnO_2 cathode in $Mg[Al(HFIP)_4]_2$/G3 electrolyte and compares the effect of heat treatment on the battery capacity. The heat-treated powder has a lower capacity, which may be caused by the particle aggregation during heat-treatment retard the Mg^{2+} diffusion.

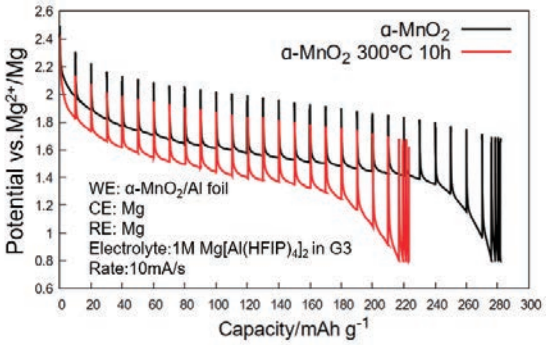

Fig 1. GITT curves of α-MnO_2

When current collector was changed from Al foil to stainless foil, the actual amount of Mg insertion changed from 10% to 40% with respect to the apparent cathodic capacity, although the capacity decreased. Therefore, the Al foil would also contributes to the capacity. Fig 2 shows the XRD images of α-MnO_2 after discharge in $Mg[Al(HFIP)_4]_2$/G2 electrolyte. The structure charged after discharge. The intensity of the peak becomes weaker after discharge, which indicates Mg^{2+} was intercalated. And after charging, the intensity of the peak returns, which suggests Mg^{2+} was deintercalated. It shows that the intercalation and deintercalation of Mg^{2+} in this cycle is reversible.

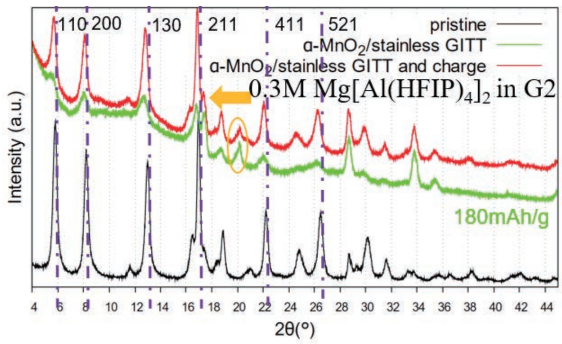

Fig 2.XRD of α-MnO_2 after Mg (de)intercalation

Although the maximum experiment capacity of $Mg[Al(HFIP)_4]_2$ is 300 mAh/g, the difference between the apparent capacity and the actual amount of Mg insertion is large. In the future, we will elucidate the apparent capacity and commercialize magnesium storage batteries at room temperature.

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Keywords: electrical properties, chemical synthesis, xrd
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Title: The ballistic thermoelectric transport of ferroelectric polarization in the presence of the electric field and temperature gradients

Abstract:

The transport of magnetic order in terms of magnons has gained much traction in spintronics. In this research, we attempt to investigate the ferroelectric counterparts of polarization transport between two ferroelectric reserviors connected by a ferroelectric lead, with both different temperatures and applied electric fields. In analogy to the magnon in the ferromagnets, the carrier for polarization can be termed as “ferron”.

Ferroelectricity refers to the spontaneous ordering of electric dipoles (or polarization) that forms below the critical temperature (Curie temperature), analogous to the magnetic ordering for magnetism. In contrast to a ferromagnet, there are some fundamentally distinct physics. For example, the occurence of polarization order is always accompanied by the lattice distortion and thus the low space symmetry of materials, indicating that the coupling of the polarization order and the lattice is much stronger than the counterpart in a ferromagnet. Besides, the electric dipolar interaction is often order of magnitude larger than the magnetic one. Nonetheless, the ferroelectric shares many phenomenological properties with the ferromagnet, such as the hysterisis response to an external driving field, the existence of domain wall and staggered polarization/ magnetization order.

For a ferromagnet, the transport of its order parameter—magnetization has been extensively studied in the past few decades [1], wherein the magnon, the quantum elementary excitation of spin waves, is responsible for the carrier of magnetization of ($-2\mu_B$). However, there have been few studies on the transport of ferroelectric polarization so far. Very recently, the polarization caloritronic properties has been studied in a ferroelectric capacitor [2], and the diffusion equation of polarization was derived under the drive of both a temperature gradient and a transient electric field.

In this research, we aim to investigate the other side of the coin—the ballistic transport of polarization in a ferroelectric lead suspended between two ferroelectric reserviors , as in Fig.1. In the linear response, the polarization and heat current are related to the driving forces by the following conductance matrix,

$$\begin{pmatrix} j_p \\ j_q \end{pmatrix} = G \begin{pmatrix} 1 & S \\ \Pi & \kappa/G \end{pmatrix} \begin{pmatrix} \Delta E \\ \Delta T \end{pmatrix}$$

where the j_p and j_q are the polarization and heat current, respectively, G the polarization conductance, S (Π) is the polarization Seebeck (Peltier) coefficients, and κ the thermal conductance.

The goal of this research is to calculate all these thermoelectric transport coefficients.

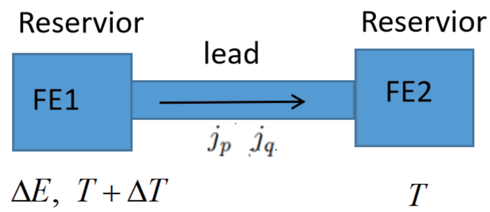

Fig.1 The schematics of polarization transport between two ferroelectric (FE) reserviors connected by a ferroelectric lead, in which the ΔE and ΔT are the differences of electric field and temperature on the two reserviors, respectively.

Keywords: ferroelectric, polarization transport
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Hydrogen desorption behavior caused by transformation of metastable austenite

Hydrogen embrittlement of steels is an important issue with the increasing needs for hydrogen energy applications. The stability of the austenite phase presumably influences the hydrogen embrittlement susceptibility because martensitic transformation and the associated change in hydrogen solubility contribute to hydrogen embrittlement in austenitic steels. The hydrogen desorption due to plastic deformation was studied in this study.

To clarify the effect of martensitic transformation and its influence on the hydrogen embrittlement properties of austenitic steels, the hydrogen desorption behaviors from metastable austenite, SUS304, and stable austenite, SUS316L, during tensile tests have been investigated using an experimental apparatus shown in Fig 1 [1]. A tensile test machine was set in a vacuum chamber equipped with a quadrupole mass spectrometer, which allows us to measure hydrogen desorption during a tensile test.

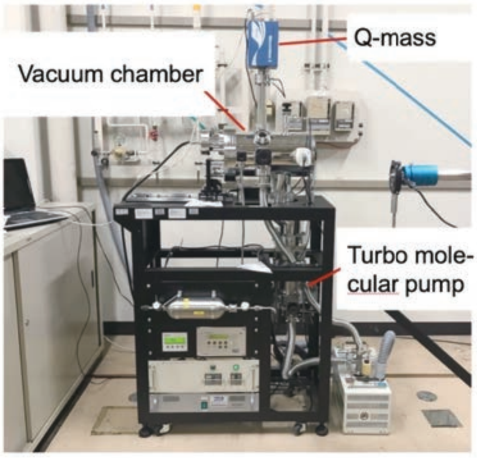

Fig. 1 An experimental apparatus used in this study.

The tensile specimens of the steels were charged with hydrogen electrochemically in a 3 weight% NaCl solution containing 5 g/L NH_4SCN at 10 A/m^2 for 4 d, and then, tensile tests were carried out at a cross-head speed of 0.3 mm/min.

Fig. 2 shows the hydrogen desorption behaviors of the SUS304 and SUS316L tensile test specimens during the tensile tests. Both specimens showed remarkable desorption of hydrogen during the tensile tests.

The hydrogen desorption is attributed to the change in solubility of hydrogen in the austenite matrix due to phase transformation from austenite (f.c.c) to martensite (b.c.c.) that is induced by the plastic deformation and probably transportation of hydrogen due to dislocation motion. Therefore, for comparison, the hydrogen desorption curve of the SUS316L specimen that does not show martensitic transformation from that of the SUS304 specimen that shows martensitic transformation. The difference shown by the orange curve is regarded as the hydrogen desorption caused by the martensitic transformation of SUS304.

The increase in the volume fraction in SUS304 specimen measured by a ferritemeter obviously increased from the strain of 20% and it can, therefore, be concluded that the increase in the hydrogen desorption shown by the orange curve is due to martensitic transformation, and the decrease from the strain of 30% is presumably due to the depletion of hydrogen in the specimen.

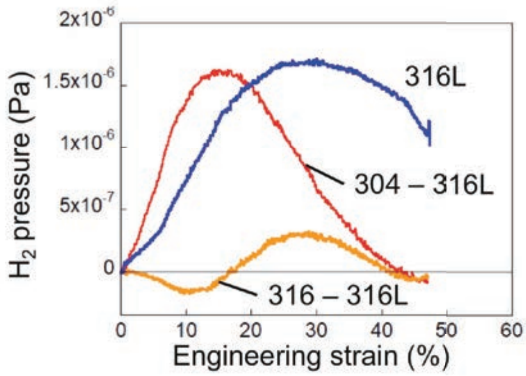

Fig. 2 The hydrogen desorption during tensile test.

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Keywords: steel, embrittlement, phase transformation
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In situ characterization of planar dislocation motion under tensile loading using electron channeling contrast imaging

In situ observations of dislocation motion under loading is key to understanding plasticity-driven fracture in metals (e.g., hydrogen embrittlement and metal fatigue). Electron channeling contrast imaging is one of techniques enabling visualization of dislocation motion, which is available for the in situ observation. This study presents a successful example of the in situ observation of dislocation motion under loading.

Ni-20Cr alloy is a representative model alloy that shows a face-centered cubic structure and planar dislocation motion during plasticity evolution [1]. The planar dislocation motion causes plasticity-induced stress concentration at grain boundaries, which is regarded as a factor that can cause intergranular cracking. Since there is a need to clarify the microscopic deformation behavior of Ni-20Cr alloys, the objective of this study was to investigate the microscopic deformation behavior and its interaction with grain boundaries in Ni-20Cr alloys. To clarify the microscopic plasticity near grain boundaries in Ni-20Cr alloy, we present an effective method to understand microscopic deformation behavior [2]. Specifically, the in situ electron channeling contrast imaging (ECCI) method was coupled with in situ microscopic deformation analysis with digital image correlation (DIC), and post-mortem electron backscatter diffraction (EBSD).

Fig. 1 shows a set of ECC images obtained from the in situ experiment. Images were taken at every 10 μm crosshead displacement as shown in Fig. 1a. Although dislocations existed randomly before deformation (Fig. 1b), planar dislocation arrays appeared immediately after yielding (Fig. 1c). The motion of the leading dislocations impinged on the grain boundary resulted in a distinct electron channeling contrast gradient, as indicated by the black arrows. This result indicates that the planar dislocation accumulation caused stress concentration at the grain boundary. The number of countable dislocations on the specific slip plane, highlighted by the dashed yellow lines, was 25. The dislocation planar array can result in 1.4 GPa shear stress at the grain boundary. The dislocation structure remained even after further deformation (Fig. 1d). Correspondingly, strain concentration and associated large orientation gradient near grain boundaries could be confirmed by DIC and EBSD analyses.

That is, coupling with DIC and post-mortem

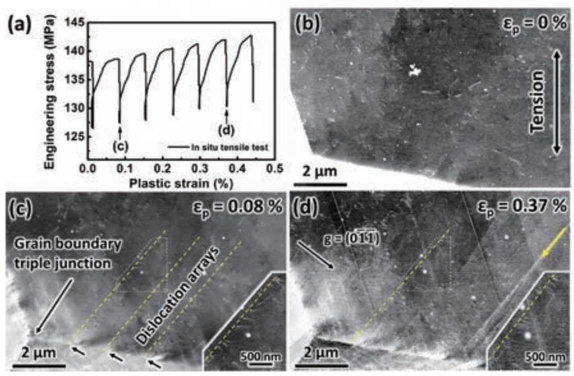

Fig. 1 (a) In situ tensile test curve, and ECC images taken at strains of (b) 0 %, (c) 0.08 %, and (d) 0.37%. The insets indicate the magnification of the highlighted region for each step that show the pile-up of dislocations. The planar dislocation arrays are marked with yellow dashed lines.

EBSD analysis, the in situ ECCI clarified that planar dislocation pile-up and local dislocation accumulation can be significant factors that cause local stress concentration at the grain boundaries and associated intergranular fracture. Specifically, the degree of plasticity-enhanced stress concentration appeared most distinctly near grain boundary triple junction. This result is consistent with previous studies that reported brittle-like cracking can preferentially occur at the grain boundary triple junction. We conclude that the plasticity-enhanced stress concentration would play a role in brittle-like intergranular cracking that occurs after significant plastic deformation under some special conditions such as hydrogen environment.

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Keywords: hydrogen, steel, defects

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Research of the ground state of T*-type $La_{1-x/2}Eu_{1-x/2}Sr_xCuO_4$

In monolayer $RCuO_4$ (R = rare earth element) cuprates research, one of the fundamental issues is determine the real ground state of parent compound. In this study, we investigate the magnetic behavior of T* phase cuprate $La_{1-x/2}Eu_{1-x/2}Sr_xCuO_4$ (LESCO) by the magnetic susceptibility measurements as the first step. We performed the as-sintered, argon and oxygen annealing samples which related to the apical oxygen effect. The results shown the drastically varies properties. Further research needs to the muon spin rotation/relaxation (μSR) technique.

In the recent study, the apical oxygens effect in R_2CuO_4 (R = rare earth element) cuprates have been deemed to strong connected with the superconductivity. For the past few years, the study of monolayer cuprates—T (CuO_6 coordinate) and T' (CuO_4 coordinate) phase cuprates has been draw more attention. Interestingly, the phase diagram of T' phase cuprates shown the coexists behavior of antiferromagnetic (AFM) and superconductivity (SC) states [1]. Further research revealed that if the excess oxygen (apical site) totally removes in the T' phase cuprates, the undoped superconductivity may emerged [2].

In monolayer cuprates family, another important family, T* phase (CuO_5 coordinate), have been left behind for a long time. From previous reported the d oxidation annealing under high pressure is essential for the emergence of superconductivity, this process can repair the oxygen deficiency of apical oxygen [3,4]. So, the nature of apical oxygen behavior is also a fundamental issue in T* phase cuprates that can give us some inspires to study the genuine ground state in cuprates.

Fig.1 shows the magnetic susceptibility of AS LESCO measurement from our previous report [5]. Compare with the O-AN superconductivity samples, the AS samples shown the spin-glass behavior in low temperature. Recently, we performed the argon annealing for LESCO which usually used by T' phase cuprates to remove the excess oxygen and shown superconductivity, the results shown in Fig. 2.

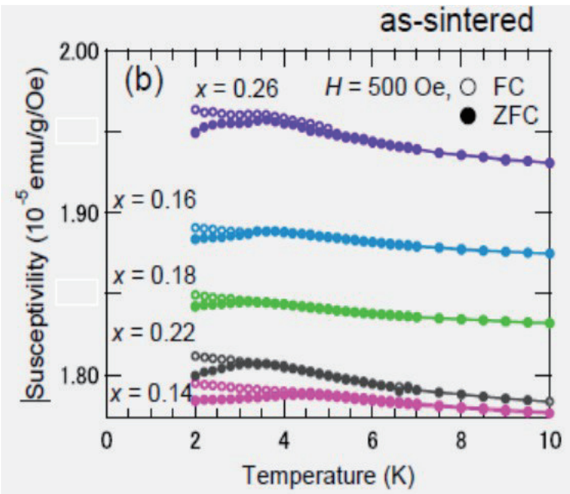

Fig. 1 Magnetic susceptibility for LESCO AS

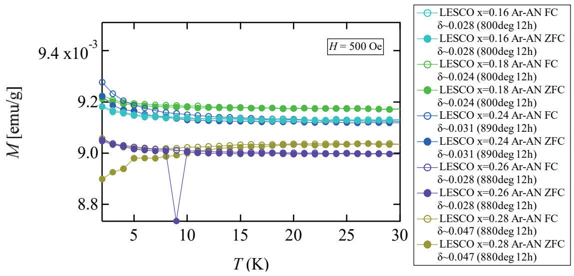

Fig. 2 Magnetic susceptibility for LESCO Ar-AN

Form such results, we can find that the typical spin-glass state has been vanished from x= 0.16 to 0.26. In the contrast, the x=0.28 shown strong spin-glass behavior with a much higher transformation temperature (T_{sg}) at around 13K, this maybe because 0.28 contained the maximum δ value and caused the disorder of crystal structure. For x=0.16-0.26, there may exist a long-rang magnetic order that need to further study by muon spin rotation/relaxation (μSR) measurement in near future.

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Keywords: magnetic, superconducting
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Crystal structure and thermoelectric properties of Cu-Te compounds

Abstract: $Cu_{2-X}Te$ compounds are promising thermoelectric materials. However, the complex intermetallic phases in the Cu-Te binary system lead to significant difficulty in evaluating the thermoelectric properties. In this study, we prepare various $Cu_{2-X}Te$ single phases and investigate the correlation between the crystal structure and thermoelectric properties.

Thermoelectric materials have attracted much attention because of their ability to directly convert thermal energy to electric energy. The energy conversion efficiency of a thermoelectric material can be determined by the dimensionless figure of merit, defined as $ZT = \sigma S^2T/(K_L + K_e)$, where σ, S, T, K_L, and K_e are the electrical conductivity, Seebeck coefficient, absolute temperature, lattice thermal conductivity, and electronic thermal conductivity, respectively. The thermoelectric materials developed so far are basically semiconductors based on heavy elements such as Bi, Pb, Te, and Sb. For the chalcogen elements of S, Se and Te, the heavy element has large atomic mass which would lead to low K_L. Besides, the heavy element has weak ionic bond and strong covalent bond, resulting in large electrical conductivity, σ. Therefore, S-based, Se-based and Te-based compounds usually show increasing *ZT* values[1] as shown in Fig. 1. However, The *ZT* value of copper chalcogenides show a different tendency. The reported *ZT* value was 1.2-1.9 for of Cu_2S, and 1.5-2.3 for Cu_2Se, whereas the value decreased to 0.4-1.4 for Cu_2Te. The reason of the unexpected low *ZT* of Cu_2Te is not well understand, therefore, detailed study is required to ascertain the thermoelectric properties of the Cu-Te compounds.

In this study, we prepare various single-phase Cu-Te compounds and investigate the correlation between the crystal structure and thermoelectric properties. Fig. 2 shows the phase diagram of Cu-Te binary system around the composition of Cu_2Te. Based on the phase diagram, we prepared samples using the solid phase reaction method with the Cu molar ratio of 33.3%, 33.6%, 35.4% and 36%. The synthesized samples were measured by SEM, TEM, XRD and EDS to identify the crystal structure and chemical composition. The XRD data show that multiple phases were obtained, including hexagonal, orthorhombic phases. After compared with the TEM data, we can identify the crystal structures of $Cu_{2-X}Te$ of different compositions. It was found that the composition of Cu-33.3%Te is Cu+$Cu_{1.81}Te$, and the composition of Cu -33.6%Te, and Cu-35.4%Te were $Cu_{1.81}Te$. The composition of Cu-36%Te is Cu_7Te_4.

In future, we will measure the thermoelectric property of each phase and clarify the correlation between the crystal structure and thermoelectric properties.

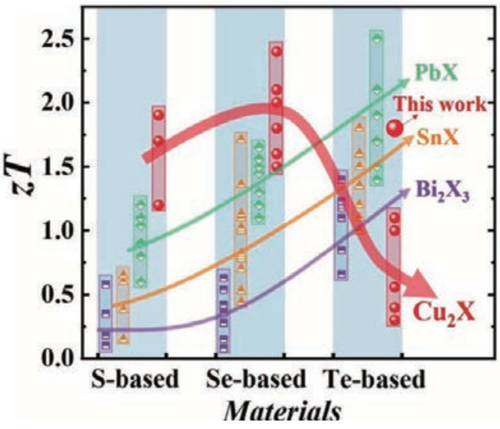

Fig.1 Reported *ZT* values of polycrystalline PbX-, SnX-, Bi_2X_3-, and Cu_2X-based (X = S, Se, and Te) thermoelectric materials[1]

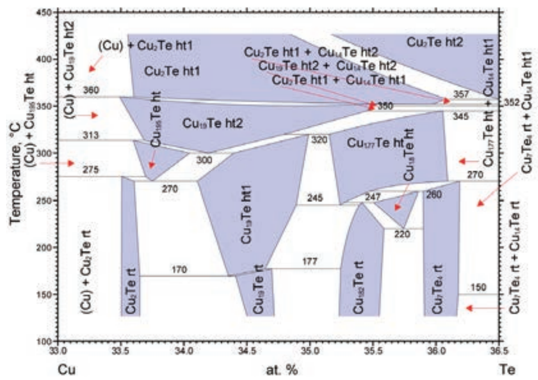

Fig.2 Phase diagram of Cu-Te binary system

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Keywords: thermoelectric, thermal conductivity
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Fabrication and application of nanoporous intermetallic by liquid metal dealloying

Abstract: variety of structural and functional nano materials which could not be synthesized by the conventional methods have been developed by Liquid metal dealloying (LMD) method.[1] Recently, fine structure nanoporous intermetallics is prepared by LMD with superior electrocatalyst property compared to other non-noble metal electrocatalyst. In this research, nanoporous Fe-Nb intermetallic is prepared by dealloying Nb-Fe-Al precursor. The kinetics is studied to clarify the mechanism of LMD in intermetallics.

Nb-Fe-Al alloy precursors with different compositions was prepared by arc melting followed by homogenization treatment. The single phase Nb-Fe-Al precursor was dealloyed by the Mg melt adjusting temperature and time. After immersion, the sample was treated in a HNO_3 solution to remove the melt. The microstructure and chemical composition were analyzed to investigate the kinetics of LMD and structural coarsening process

Fig.1 shows the structure of Nb-Fe-Al precursor prepared by arc melting.Precipitate phase can be observed.

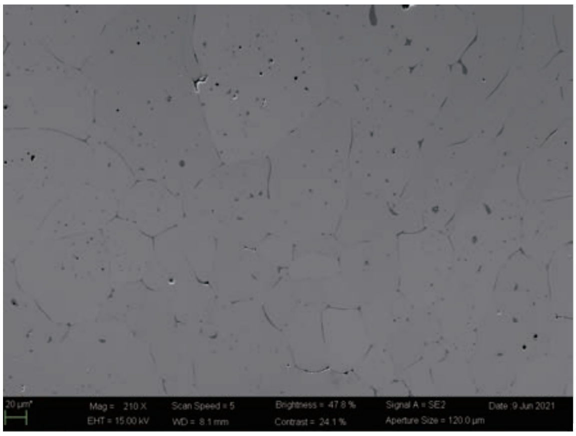

Fig. 1 SEM of Ni-Nb-Fe precursors prepared by arc melting

Single phase Nb-Fe-Al ternary alloy is prepared successfully after hear treatment at 1100C, 8hours.

After get the single phase precursor, Liquid metal dealloying is applied at 900℃, for 5min and 30min.

Fig.2 (a) shows the dealloyed sample under 900℃ for 30min. Porous structure can be observed along the interface of Mg melt and precursor.

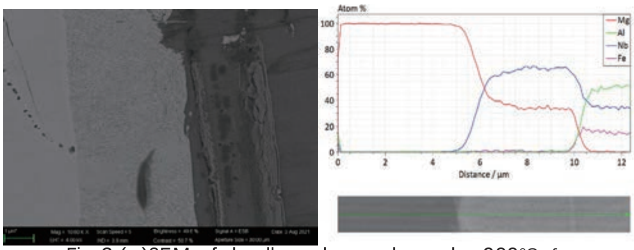

Fig.2 (a)SEM of dealloyed sample under 900℃ for 30min;(b)EDX line scanning of dealloyed sample under 900℃ for 30min

Fig.2 (b) shows the EDX line scanning result of sample dealloying at 900℃ for 30min. It reveals the porous area mainly contains Mg and Nb. It means Fe and Ni were dissolved into Mg melt.

From kinetics view, the reaction is slow comparing with previous work. After 30 minutes, only few microns of depth reacted. The kinetics behavior of this Nb-Fe-Al system is also worth to research.

In the future work, the reason why Fe dissolved into Mg should be clarified first. After that, find a way to make Fe reserved and form Nb-Fe intermetallic. Kinetics behavior during the dealloying will also be researched. Catalytic property of the dealloyed porous sample will also be evaluated.

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Keywords: Nanostructure, Catalytic
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Effect of Short-range Order on Mechanical Behavior in High Entropy Alloys

The short-range order (SRO) phenomenon in HEAs is one of the most important issues of concern. The characteristics and the formation kinetics of SRO in HEAs have not been clarified. In this research, Ir-Rh-Ru-Mo-W and Ir-Rh-W alloys was selected because of their single hcp structure. Till now, I held three different heat treatment on the two alloys: as-cast, homogenization and quenching state. Each of them shows single hcp phase.

High entropy alloys (HEAs) have attracted much academic interest due to their unprecedented microstructure and exceptional properties. The SRO phenomenon in the HEAs receives increasing attention from the year in 2019. In the HEAs, the spatial composition variation or undulation is appreciable and normal. There is a local preference of bonding among certain nearest-neighbor atom, leading to form SRO. Quite recently, the SRO in the CoCrNi[1] and VCoNi[2] alloy was successfully recognized by the energy-filtered TEM method, which provides an avenue for characterizing the local features of HEAs. Whereas, the characteristics and the formation kinetics as well as their influence on the multiscale mechanical behavior has not been clarified, particularly in the single hexagonal close packed (HCP) phase HEAs. The main purpose of the study is to investigate the SRO formation and its influence on mechanical behavior in HCP phase HEAs.

Alloy ingots with nominal compositions of $Ir_{25}Rh_{20}Ru_{25}Mo_{20}W_{10}$ and $Ir_{30}Rh_{35}W_{35}$(at%) alloys were prepared by arc-melting. Samples were annealed at 2100℃ for 1h to form the equilibrium phases. After the annealing, samples were heat treated at 1000 ℃ for 12h followed by water quenching.

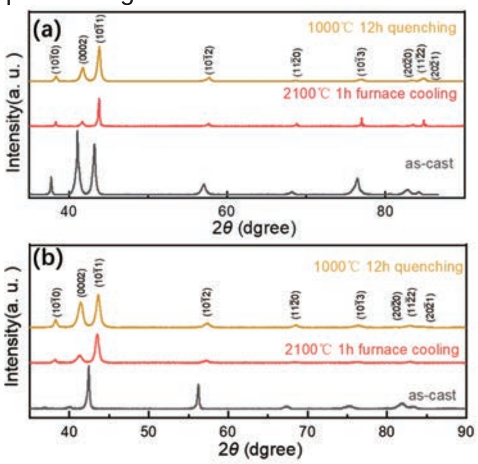

Fig. 1 XRD patterns of (a) $Ir_{25}Rh_{20}Ru_{25}Mo_{20}W_{10}$ and (b) $Ir_{30}Rh_{35}W_{35}$ alloys

Fig.1 shows XRD patterns of the $Ir_{25}Rh_{20}Ru_{25}Mo_{20}W_{10}$ and $Ir_{30}Rh_{35}W_{35}$ alloys prepared by arc melting, annealed at 2100 ℃ for 1h and water-quenched at 1000℃ for 12h. The annealing temperature of 2100℃ was determined by Takeuchi’s work[4]. These XRD patterns were identified as the reflections of the hcp structure.

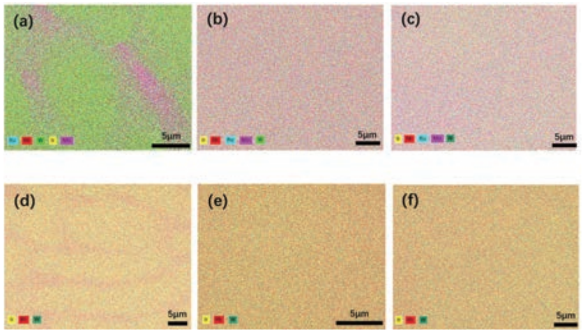

Fig. 2 element-mapping images of $Ir_{25}Rh_{20}Ru_{25}Mo_{20}W_{10}$ alloy (a-c) and $Ir_{30}Rh_{35}W_{35}$ alloy (d-f) prepared by arc melting, annealed at 2100℃ for 1 h and water-quenched at 1000℃ for 12h

Fig.2 shows element mapping images of $Ir_{25}Rh_{20}Ru_{25}Mo_{20}W_{10}$ and $Ir_{30}Rh_{35}W_{35}$ alloys in three different conditions. (a) and (d) demonstrate that elements in as-cast samples are heterogeneous, whereas, (b)(c) and (e)(f) demonstrate the constituent elements are homogeneously distributed. Considering phase transformation happened after water-quenched at 1000℃ for 24h(Not shown in this file), I believe that diffusing of atoms and formation of SRO happened in 1000℃ 12h water-quenched sample. Now, TEM testing is in progress

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ICC-IMR FY2020
Activity Report

Edited by ICC-IMR Office
Published in January, 2021

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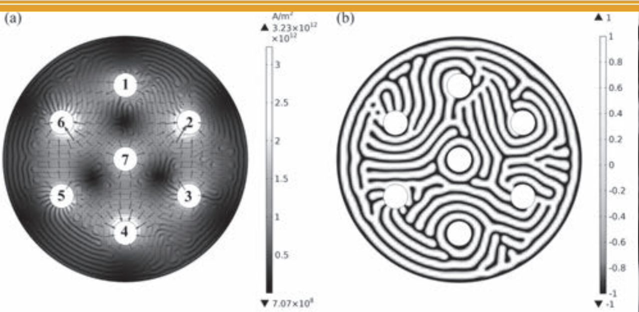
Printing: HOKUTO Corporation


(a)
A/m²
▲ 3.23×10¹²
×10¹²
▼ 7.07×10⁸
1
2
3
4
5
6
7
(b)
▲ 1
▼ -1