Seventh Japan-Canada
Microscopy Societies Joint Symposium
2026

第 7 回 日本-カナダ顕微鏡学会交流シンポジウム
2026

Current status of quantum microscopic imaging
and
its application to materials development

量子ビーム顕微イメージングの現状と材料開発

May 25 - 26, 2026
Sendai International Center, Exhibition Building
Sendai, Miyagi, Japan

The Japanese Society of Microscopy (JSM)
Microscopy Society of Canada (MSC)

This symposium is held with the 82nd Annual Meeting of the Japanese Society of Microscopy.

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Seventh Japan-Canada Microscopy Societies Joint Symposium 2026

	Time (Tokyo)	Speakers	Time (Montréal)
Session 1	**May 25, Monday**	**Sendai International Center**	**May 24, Sunday**
	9:15 ～ 9:30	Connecting	8:15 pm ～ 8:30 pm
	9:30 ～ 9:55	**J-1**: Daisuke Urushihara (Nagoya Institute of Technology)	8:30 pm ～ 8:55 pm
	9:55 ～ 10:20	**C-1**: John L. Rubinstein (University of Toronto)	8:55 pm ～ 9:20 pm
	10:20 ～ 10:45	**C-2**: Israt Ali (INRS)	9:20 pm ～ 9:45 pm
	10:45 ～ 11:10	**J-2**: Yuya Morimoto (RIKEN)	9:45 pm ～ 10:10 pm
	11:10 ～ 11:35	**C-3**: German Sciaini (University of Waterloo)	10:10 pm ～ 10:35 pm
	11:35 ～ 12:00		
	12:00 ～ 12:50	(Luncheon Seminar in JSM Meeting)	
Session 2	**May 26, Tuesday**	**Sendai International Center**	**May 25, Monday**
	9:15 ～ 9:30	Connecting	8:15 pm ～ 8:30 pm
	9:30 ～ 9:55	**J-3**: Hideto Yuasa (Osaka Metropolitan University)	8:30 pm ～ 8:55 pm
	9:55 ～ 10:20	**J-4**: Simone N. T. Kurial (Kawasaki Medical School)	8:55 pm ～ 9:20 pm
	10:20 ～ 10:45	**C-4**: Paul Finnie (NRC Canada)	9:20 pm ～ 9:45 pm
	10:45 ～ 11:10	**C-5**: Jason Tam (University of Alberta)	9:45 pm ～ 10:10 pm
	11:10 ～ 11:35	**J-5**: Yasukazu Murakami (Kyushu University)	10:10 pm ～ 10:35 pm
	11:35 ～ 12:00		
	12:00 ～ 13:30	(JSM Annual General Meeting)	

Official site: https://www.omu.ac.jp/eng/japan-canada-microscopy-seminar/english/index.html

Contact: gr-eng-JapanCanadaSeminar@omu.ac.jp

URL of web-site connection for hybrid meeting

Session 1 May 25, 2026 9:30 – 11:35 am Tokyo time

Sendai International Center, Exhibition Building, Sendai, Miyagi, Japan
https://us06web.zoom.us/j/88378706970

Webinar ID: 88378706970 ⇨

Session 2 May 26, 2026 09:30 – 11:35 am Tokyo time

Sendai International Center, Exhibition Building, Sendai, Miyagi, Japan
https://us06web.zoom.us/j/85313808074

Webinar ID: 85313808074 ⇨

【Preface】

Dear Participants,

It is our great pleasure to welcome you to the 7th Japan–Canada Microscopy Societies Joint Symposium.

Since its launch in 2020, this symposium has served as an important platform for scientific collaboration between the Japanese Society of Microscopy (JSM) and the Microscopy Society of Canada (MSC), bridging communities across materials and life sciences. We are pleased that this year’s symposium continues to be held in a hybrid format fostering broader international engagement.

The theme of this year’s symposium, “Current status of quantum microscopic imaging and its application to materials development,” highlights recent advances in quantum-level observation techniques and their expanding roles in understanding and designing advanced materials. We hope that this symposium will stimulate active discussion, inspire new research directions, and further strengthen collaboration between Japan and Canada in the field of microscopy.

Following the success of previous symposia, this year’s program features excellent presentations from both early-career and established researchers, reflecting the dynamic progress of microscopy research in both countries. We believe that the exchange of ideas through these presentations will contribute to deepening scientific understanding and reinforcing academic connections between our communities.

We would like to express our sincere appreciation to all those who made this event possible, especially Professor Hiroshi Jinnai of President of JSM, and Professor Kenji Tsuda of the chairperson of the 82nd Meeting of JSM

We sincerely hope that this symposium will provide a valuable opportunity for scientific exchange and will further promote friendship and collaboration between the microscopy communities of Japan and Canada.

Sincerely,

Organizers,
Shigeo Mori, (Osaka Metropolitan University)
Kodai Niitsu, (NIMS)
Ken Harada, (Osaka Metropolitan University, and NIMS)
Marek Malac, (NRC-NANO, and University of Alberta)
Makoto T. Schreiber, (University of Alberta)

【Greetings】

Dear Esteemed Colleagues,

On behalf of the Japanese Society of Microscopy (JSM), it is my great pleasure and honor to welcome you to the 7th Japan-Canada Microscopy Joint Symposium, held during our 82nd Annual Meeting at the Sendai International Center in Sendai, the historic and beautiful "City of Trees.”

This year marks the seventh edition of the symposium. What began as a collaborative initiative has steadily grown into a hallmark and an indispensable international feature of our annual meeting. The event’s continued success is a testament to the enduring partnership and mutual respect between the microscopy communities of Japan and Canada.

Canadian microscopy research consistently upholds world-leading standards, and we are privileged to host leading Canadian scientists in Sendai. This year’s program features a diverse focus on cutting-edge topics, including energy materials, bio-imaging, and advanced analytical techniques, reflecting the synergistic strengths of both nations. For Japanese researchers, direct exposure to such high-level research is a vital catalyst for new scientific insights and innovations.

Furthermore, this symposium serves as an exceptional platform for young researchers and students to broaden their international perspectives. I am confident that the ties between our two countries will be further strengthened through the discussions held here in Sendai.

In closing, I would like to express my sincere gratitude to the organizers and volunteers from both Japan and Canada for their dedicated efforts. I look forward to a fruitful exchange of ideas and to the continued flourishing of our international partnership.

Yours sincerely,

Hiroshi Jinnai, (Tohoku University)
President of The Japanese Society of Microscopy

【Greetings】

Esteemed Colleagues,

It is my honor and distinct pleasure to offer a few words to welcome you to the seventh joint workshop between the Japanese Society of Microscopy (JSM) and the Microscopy Society of Canada (MSC), held in conjunction with the 2026 Annual Conference of the JSM in Sendai, Japan, and the 2026 MSC Annual Meeting in Montreal, Canada.

I want to congratulate the organizing scientific committee who have put together a very exciting program. The symposium features a slate of high caliber speakers that represents the cutting edge of microscopy being developed in Japan and Canada. From determining the nanoscale structure of ferroelectrics to mapping tissues at the nanoscale or from imaging electron dynamics at ultra short time scales to observing the native conformations of proteins in their native cellular environment, the program offers a rich diversity of topics that is representative of the power of advanced microscopy techniques to reveal the fundamental inner workings of nature. It is sure to be a truly enriching workshop.

This workshop continues a collaborative tradition between our societies that started seven years ago with the vision and efforts of colleagues who are with us today and some that have departed. This edition of the JSM-MSC workshop honors the leadership of our colleague Misa Hayashida, who was instrumental in establishing the workshop, and whose legacy continues through a scholarship established in Misa's name to support the participation of early career microscopists. I want to encourage all attendees to enjoy this workshop and contribute to the continued success of these events by celebrating the successes of our colleagues, being curious of new possibilities, engaging in constructive scientific discussions, and fostering the spirit of collaboration in discovery. I hope you find this workshop inspiring and stimulating.

I want to end by recognizing the organizing committee who have brought this workshop together through careful planning and selfless work. I want to sincerely thank our esteemed Japanese colleagues Shigeo Mori (Osaka Metropolitan University), Kodai Niitsu (National Institute for Materials Science), and Ken Harada (Osaka Metropolitan University), and their Canadian counterparts Marek Malac (National Research Council) and Makoto Schreiber (University of Alberta, Canada) for their commitment to organize this excellent workshop. This event is an exemplar of sustained international cooperation and one that we wish to continue to foster to the benefit of JSM, MSC and their members.

Thank you and I wish you the best for this workshop!

Jose Moran-Mirabal, (McMaster University)
President of the Microscopy Society of Canada

【Scientific Program】

Session 1 (Tokyo time: Monday, May 25, 2026)
Web connecting 09:15 – 09:30

J-1 09:30 – 09:55
Daisuke Urushihara (Nagoya Institute of Technology)
Observation of charged domain wall structure in niobium-based ferroelectrics (Na, K)NbO_3

C-1 09:55 – 10:20
John L. Rubinstein (University of Toronto)
Cryo-EM of endogenous membrane proteins in their native lipid bilayer

C-2 10:20 – 10:45
Israt Ali (INRS)
Fast and efficient reduction of electron-beam-treated graphene oxide by an infrared laser pulse

J-2 10:45 – 11:10
Yuya Morimoto (RIKEN)
Experimental and theoretical efforts towards attosecond diffractive imaging of electronic dynamics

C-3 11:10 – 11:35
German Sciaini (University of Waterloo)
The Ultrafast Electron Imaging Lab: From Time-Resolved Electron Diffraction to Liquid-Phase Electron Microscopy

Session 2 (Tokyo time: Tuesday, May 26, 2026)

Web connecting 09:15 – 09:30

J-3 09:30 – 09:55
Hideto Yuasa (Osaka Metropolitan University)
Hepatic Sinusoidal Microstructural Alterations Underlying Liver Pathology Revealed by Volume Electron Microscopy

J-4 09:55 – 10:20
Simone N. T. Kurial (Kawasaki Medical School)
Mapping liver zonation at nanoscale

C-4 10:20 – 10:45
Paul Finnie (NRC Canada)
Another Dimension of Hyperspectroscopic Optical Microscopy: Excitation Raman Scattering of Chirality-Pure Carbon Nanotubes

C-5 10:45 – 11:10
Jason Tam (University of Alberta)
Visualizing the early stages of ceramic sintering at the atomic scale

J-5 11:10 – 11:35
Yasukazu Murakami (Kyushu University)
High-Sensitivity Electron Holography and Its Applications

Observation of charged domain wall structure in niobium-based ferroelectrics (Na, K)NbO_3

Daisuke Urushihara[1*] (漆原大典), Toru Asaka[1], Koichiro Fukuda[1]

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Ferroelectric materials exhibit domain structures composed of regions with different orientations of spontaneous polarization. The configuration and reorientation of these domains have been widely utilized in functional applications.[1] In domain engineering for electronic property control, not only domain size and morphology but also domain walls play a crucial role. Among various types of domain walls, charged domain walls are particularly intriguing because they possess non-zero bound charges. A head-to-head polarization configuration results in positively charged domain walls, whereas a tail-to-tail configuration produces negatively charged ones. In $ErMnO_3$, for example, enhanced conductivity has been observed at tail-to-tail walls, while suppressed conductivity appears at head-to-head walls.[2] (Na,K)NbO_3 is a promising lead-free ferroelectric material due to its high Curie temperature and excellent electromechanical properties. Because (Na,K)NbO_3 can form 180°, 90°, 60°, and 120° domains, complex domain configurations, including charged domain walls, are expected to emerge, particularly in the presence of *A*-site vacancies. In this study, we investigated the relationship between domain structures and *A*-site vacancies in (Na,K)NbO_3 using multiple microscopic techniques to clarify the formation mechanism of charged domain walls.[3]

Microstructural observations were conducted using confocal laser microscopy. Piezoelectric force microscopy (PFM) measurements were performed in both vertical and lateral modes. For transmission electron microscopy (TEM) analysis, polycrystalline specimens were thinned by mechanical grinding and Ar^+ ion milling. Selected area electron diffraction (SAED) and convergent beam electron diffraction (CBED) were carried out at accelerating voltages of 200 kV and 80 kV, respectively. The domain structures were examined using bright-field (BF) and dark-field (DF) TEM imaging.

Samples sintered under low oxygen partial pressure (10^{-15} atm) exhibited stoichiometric composition and uniform grains approximately 2 μm in size. In contrast, samples sintered in air contained large grains (~40 μm) and showed alkali-metal deficiency, indicating the presence of *A*-site vacancies. PFM observations of air-sintered samples revealed wide stripe domains, attributed to 90°, 60°, or 120° ferroelastic domains in the orthorhombic phase, as shown in Fig. 1. In large grains, complex domain structures were frequently observed, likely associated with *A*-site vacancy formation. BF-imaging revealed both flat stripe and curved domain walls, consistent with PFM results. SAED analysis was used to determine the polarization directions within individual domains. As shown in Fig. 2, the domain configuration was found to consist of ferroelectric 180° domains coexisting with ferroelastic 90° domains. In regions where 180° domains were separated by bent domain walls, locally charged domain walls were identified, possibly associated with planar defects. These findings provide new insights into the formation of charged domain walls in (Na,K)NbO_3 and contribute to the understanding of domain-wall functionality for future nanoelectronic applications in ferroelectric materials.

Acknowledgment:
This work was partially supported by JSPS KAKENHI under Grant No. 19KK0124. The author would like to express sincere appreciation to Mr. R. Kobayashi, Dr. A. Martin, Prof. K. G. Webber, and Prof. K. Kakimoto for their generous support and valuable contributions.

References:
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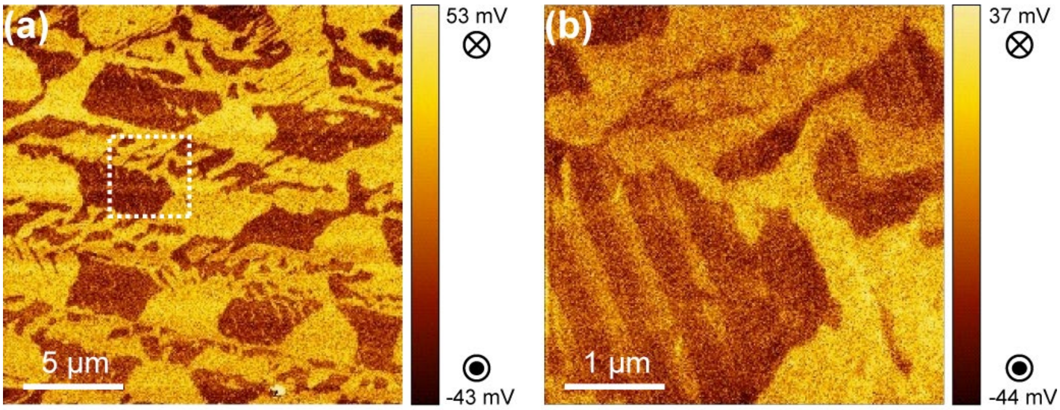

Fig. 1 (a) The vertical PFM image of (Na,K)NbO_3 and (b) magnified image of the dashed square region in (a).

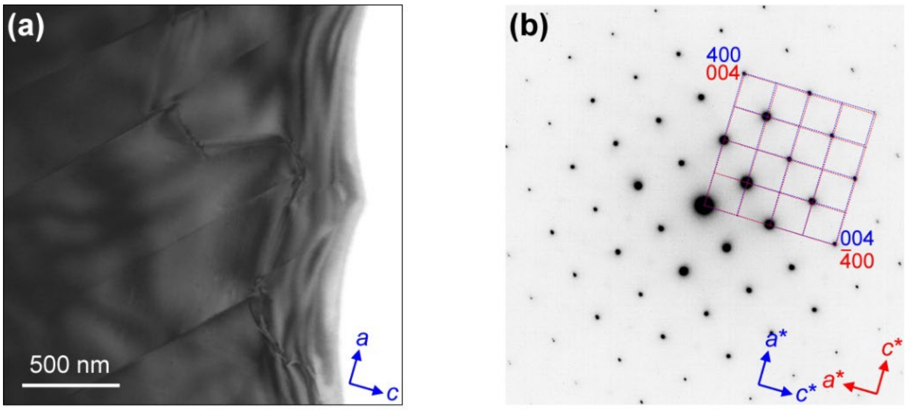

Fig. 2 (a) BF image and (b) SAED pattern of (Na,K)NbO_3.

Session 1 C-1

Cryo-EM of endogenous membrane proteins in their native lipid bilayer

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Single particle electron cryomicroscopy (cryo-EM) of membrane proteins is often performed with recombinant proteins extracted from the membrane with detergents. However, numerous experiments have now shown that cryo-EM of endogenous protein complexes can reveal component proteins that were not known from prior analysis to be part of the assembly. Further, relaxing assumptions about the state of the membrane protein allows structures to be determined in the context of native membrane vesicles. This analysis has allowed detection of component proteins and interactions that are lost when membranes are dissolved with detergents (**Fig. 1**). I discuss the current approaches for preparing specimens of endogenous membrane proteins in native lipid bilayers, including limitations and methodological advances that are needed for future progress.

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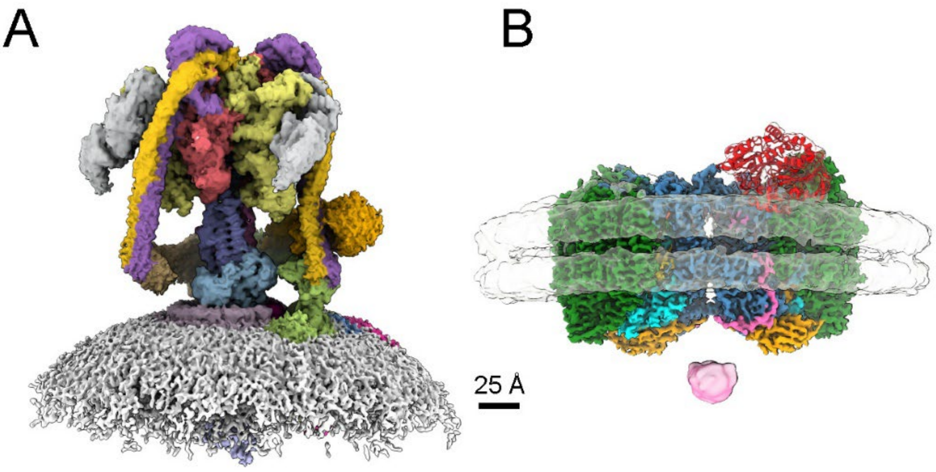

Fig. 1 Cryo-EM of endogenous membrane proteins in native lipid bilayers. **A,** Structure of the mammalian V-ATPase in native synaptic vesicle membranes [1]. **B,** Structure of the mycobacterial respiratory supercomplex with bound malate:quinone oxidoreductase (*red*) in native lipid bilayers from *Mycobacterium smegmatis* [2].

Session 1 C-2

Fast and efficient reduction of electron-beam-treated graphene oxide by an infrared laser pulse

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Fast and energy-efficient reduction of graphene oxide (GO) remains challenging under single-pulse irradiation. Here, we will present a dual-beam strategy enabling complete reduction of GO via electron-beam preconditioning followed by 1064-nm near-infrared (NIR) laser pulse irradiation, investigated in-situ using a dynamic transmission electron microscope (DTEM). We find that while pristine GO does not undergo reduction under NIR irradiation, prior electron-beam exposure activates the material, enabling rapid and complete oxygen removal within one laser shot.

We use time-resolved electron energy-loss spectroscopy (TREELS) of the oxygen K-edge to capture and quantify the deoxygenation dynamics. The 46-nm-thick GO film is shown to undergo complete reduction within 940 ns, corresponding to an effective oxygen diffusivity of ~1.6×10^{-8} m^2s^{-1}. Complementary COMSOL simulations elucidate the transient thermodynamic response, indicating that the oxygen reduction occurs at temperatures as low as ~206 °C.

In this talk, we will also present structural evidence of localized restoration of sp^2 bonding accompanied by turbostatic disorder, confirmed by selected-area electron diffraction (SAED) and high-resolution transmission electron microscopy (HRTEM). These findings highlight how electron-beam preconditioning can improve the efficiency of laser-driven transformations and demonstrate the use of a DTEM to uncover new photo-induced chemical and structural dynamics in low-dimensional materials.

Session 1 J-2

Experimental and theoretical efforts towards attosecond diffractive imaging of electronic dynamics

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Electrons within matter can move on the attosecond timescale. In order to image electron motion as a snapshot, we are developing a time-resolved diffraction technique with attosecond electron beams. In this presentation, we will show our recent results on the attosecond electron diffraction from a laser-excited silicon crystal. Moreover, it is not fully comprehended how to retrieve microscopic information of a sample by attosecond electron or X-ray diffraction. Here, we will present the S-matrix theory for the scattering of attosecond electron beams and show numerical results elucidating target characteristics as well as the coherent properties of the ultrashort electron beams.

Time-resolved electron microscopy has recently been advanced to the attosecond resolution based on the novel technologies of laser-based temporal modulation [1,2], interferometry with optically-induced coherence [3,4], or sub-optical-cycle gating [5]. However, the atomic-resolution attosecond electron microscopy or diffraction has not been achieved yet. A promising approach for achieving both the atomic and attosecond resolution is the time-resolved diffraction using attosecond electron pulses [7,8].

Here we report our recent results of the attosecond transmission electron diffraction from a silicon crystal [6]. The schematic of the experiment is shown in Fig. 1(a). A single-crystal silicon membrane was excited by the electric field of laser light (red, 1030 nm). The ultrafast dynamics was probed with the train of attosecond electron pulses (blue). When the light-electron delay was scanned on the attosecond time scale, we observed periodic oscillations of the Bragg-spot intensities as shown in Fig. 1(b). We attributed the effect to the field-induced rocking-curve effect [6]. The excitation field induces not only the electron dynamics in the sample but also the quiver motion of the attosecond electron beam. Accordingly, the incidence angle of the beam to the crystal is modulated on the sub-optical timescale, causing the decrease or increase of the Bragg-spot intensities. We will discuss how to suppress the field-induced rocking curve effect [6]. The field-induced rocking curve effect observed in this work needs to be considered in future attosecond electron microscopy and diffraction experiments.

Theoretical research is as important as experimental research for the realization of attosecond diffractive imaging of electron dynamics. Pioneering theoretical studies on the attosecond X-ray and electron diffraction showed that the retrieval of the microscopic structural information of a sample in a transient state is challenging due to the coherent and broad energy distribution of the attosecond beam [9,10]. Moreover, comprehensive understanding of the collision of electron pulses shaped in time and space is lacking.

We here present time-dependent S-matrix theory for the scattering of attosecond electron wave packets by an atomic target [11]. Electron-atom scattering is considered in a non-perturbative way. The interference between the transmitted and scattered waves in the forward direction is included. As an example, we studied the scattering of a sub-relativistic (10-keV) ultrashort electron wave packet with a 1 Å (rms) spot size. The target is a hydrogen atom, which is fixed in space. We considered two types of ultrashort Gaussian electron wave packets. Figures. 2(a) and (b) show the total elastic scattering probabilities, see [12] for details. We found that dependence on the pulse widths can be controlled by the spatio-temporal property of the ultrashort electron wave packet [12].

In addition to the results shown in Fig. 2, we will also present results of the time-resolved electron diffraction patterns from a hydrogen atom in a transient state. We will discuss the origin of ultrafast changes of diffraction patterns as well as their connection to the instantaneous states of the target.

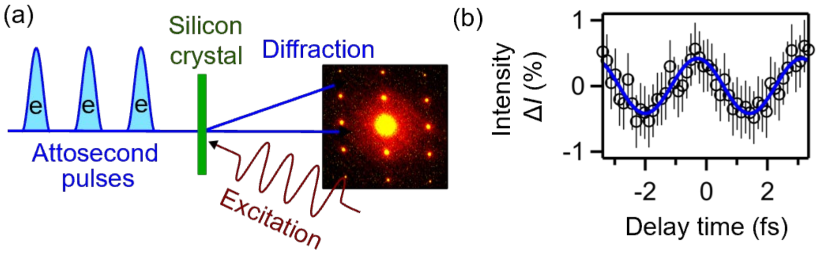

Fig. 1 Proof-of-principle attosecond electron diffraction experiment and the field-induced rocking curve effect [6]. (a) Schematic of the experiment. Attosecond electron pulses at 70 keV are diffracted by a single-crystal silicon membrane. The relative delay between the excitation field and the attosecond electron beam is scanned. (b) Observed changes of the diffraction spot intensity. Circles: measurement results. Blue curve: result of a sinusoidal fit.

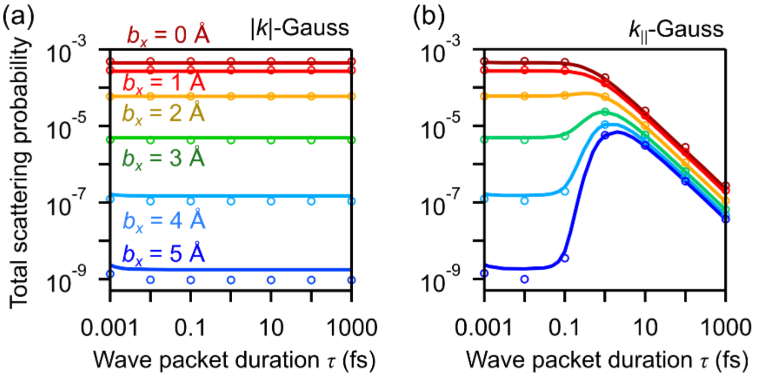

Fig. 2 Simulated total elastic scattering probabilities of ultrashort electron wave packets by a hydrogen atom [12]. Two types of Gaussian wave packets are considered. See [12] for details. Curves: total elastic scattering probabilities. Circles: normalized electron flux passing through the position of the target. b_x represents the impact parameter.

References:
[1] Y. Morimoto and P. Baum, *Nat. Phys.* **14**, 252–256 (2018).
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Session 1 C-3

The Ultrafast Electron Imaging Lab: From Time-Resolved Electron Diffraction to Liquid-Phase Electron Microscopy

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In our Ultrafast Electron Imaging Lab (UeIL), we are dedicated to capturing the "atomic movie"—moving beyond static structural snapshots to witness the fundamental dance of atoms in real time. We specialize in developing homemade instrumentation because the growing demand for accessible, laboratory-scale instruments highlights a critical need for compact solutions that large-scale MeV ultrafast electron diffraction (UED) facilities cannot always provide [1]. By engineering our own compact electrostatic UED instruments, we bridge the gap between sub-angström spatial resolution and femtosecond temporal precision. Our current laboratory-scale platform (Fig. 1A, 1B) operates at a maximum cathode voltage of 150 kV and produces electron pulses of approximately 200 fs (full-width-at-half-maximum, FWHM), with the potential to approach the 50-fs instrument response threshold through enhanced high-voltage conditioning and ultrashort laser excitation [1]. Representative results are shown in Fig. 1C-1F.

The core of our research infrastructure is built upon the synergy between UED and Liquid Phase Electron Microscopy (LPEM) [2]. While UED has become a cornerstone for resolving structural dynamics at the atomic scale, achieving these insights depends critically on producing ever-shorter electron pulses that can overcome broadening from space-charge effects [1]. To extend these capabilities to chemical and biological systems in their natural environments, we have developed proprietary nanocontainers and an "air-free, solvent-vapour-saturated" sample loading method (Fig. 2A-2C). By using straightforward drop-casting and silicon nitride window membranes as thin as 5 nm, our LPEM approach eliminates common issues like window bulging and liquid overflow that plague commercial systems. This allows us to maintain a stable, controlled environment for imaging low-contrast specimens, such as vesicles (Fig. 2D) and plasmid DNA, with high throughput and reproducibility [2].

The relevance of our work spans the frontiers of condensed matter physics, chemistry, and materials science. By building our own instruments and proprietary devices, we gain the unique ability to directly observe photoinduced transformations and phase transitions in non-equilibrium systems using a balance of high pulse brightness and multi-kilohertz repetition rates. Furthermore, our focus on liquid-phase dynamics will provide unprecedented insights into catalysis and protein function—processes essential for developing next-generation technologies. We do not simply use technology; we redefine it to ensure our discoveries are guided by ambitious hypotheses rather than the limitations of off-the-shelf equipment. Through this integrated approach to instrumentation development, we provide the structural foundation for understanding how matter evolves in real time.

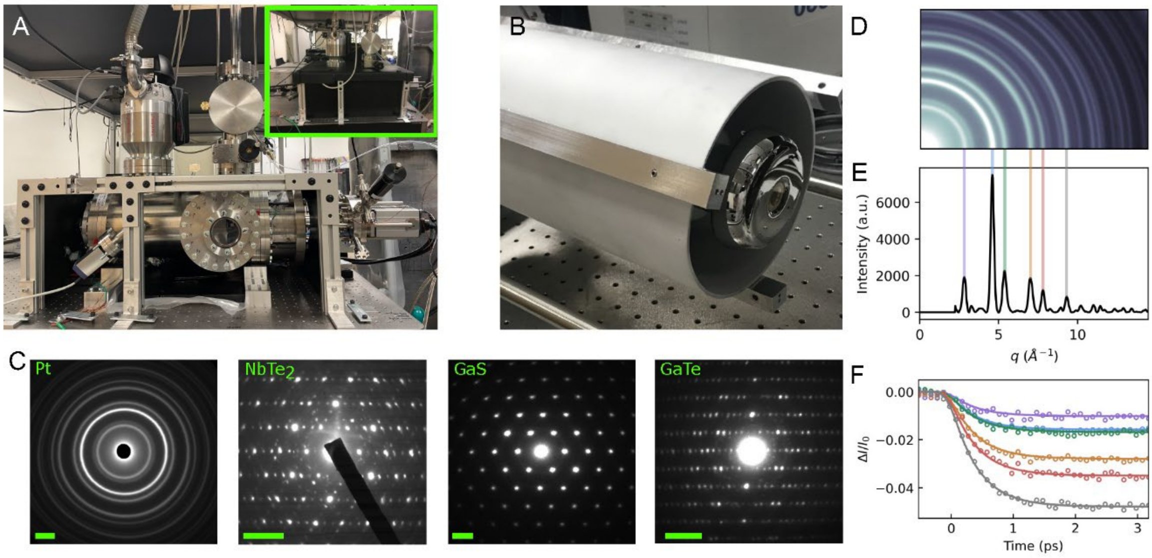

Fig. 1: A. Photograph of the electron diffractometer on the optical table at the University of Waterloo. The inset shows the chamber inside of its lead enclosure. **B.** Photograph of the electron gun head surrounded by an aluminum shield. **C.** UED images of different samples. The scale bars represent 2 Å^{-1}. **D.** Top-right sector of a raw diffraction image obtained from the Pt sample plotted on a log-intensity scale. **E.** Single line profile extracted after background subtraction. Vertical lines indicate the positions of selected Bragg reflections. **F.** Relative intensity changes as a function of time delay (colour-coded as in F). Figure adapted from [1].

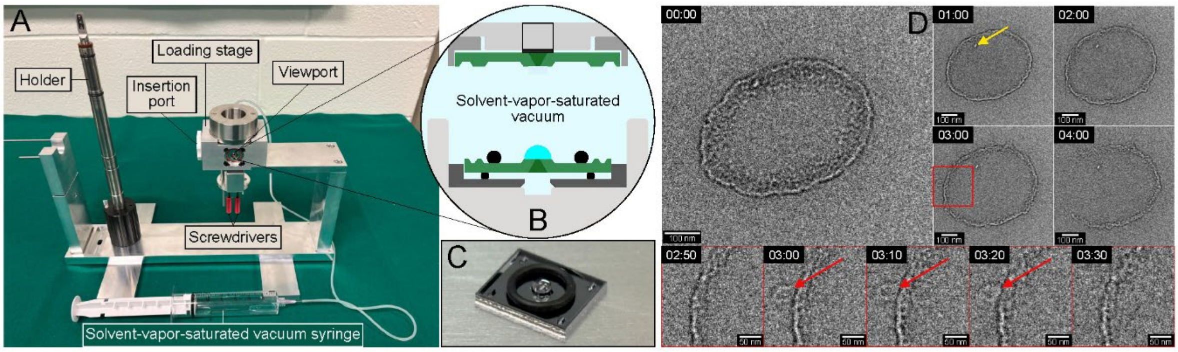

Fig. 2: A. Photograph of the latest sample loading station and JEOL LPEM holder. The syringe is used to create a solvent-vapor-saturated vacuum, enabling the removal of air. **B.** Illustration of the cross-section of the NFC in position before closure and sealing. **C.** Close-up view of the NFC carrier, showing the dispensed liquid droplet and the internal O-ring. **D.** Beam-induced rupture of an unstained vesicular structure. Two apoferritin molecules are indicated by the yellow arrow. The formation of a small liposome during ruptire is indicated by red arrows. Images were obtained with 300-keV electrons at a magnification of 11,000× with a dose rate of approximately 5 electrons Å^{-2} s^{-1}, utilizing an NFC with a nominal spacer of ~200 nm and chips combining 10-nm and 5-nm thick SiN$_x$ membranes. Figure adapted from [2].

References:

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Session 2 J-3

Microstructural Changes of Hepatic Sinusoids with Liver Injury Revealed by Volume Electron Microscopy

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In recent years, treatment outcomes for liver diseases have improved remarkably owing to the development of effective therapies for hepatitis viruses. However, with the westernization of lifestyles and the aging of society, the incidence of alcoholic and metabolic dysfunction–associated steatohepatitis has been increasing, which induce liver fibrosis. Progression of liver fibrosis caused by chronic hepatitis leads to the development of liver cirrhosis and hepatocellular carcinoma. Effective therapies for liver fibrosis have not yet been established. Therefore, liver diseases remain a significant health concern.

The liver is composed of structural units called hepatic lobules. Each hepatic lobule consists of hepatic cords formed by hepatocytes, the parenchymal cells of the liver, and hepatic sinusoids, which are hepatic capillaries. Around the hepatic sinusoids, hepatic stellate cells (HSCs) are located. Because the liver contains relatively little extracellular matrix compared with other organs, hepatic cells are closely associated with one another, forming a unique microenvironment [1]. Since cell–cell contact is an important factor regulating cellular biology and function, this microenvironment is thought to play a critical role in maintaining liver homeostasis. We therefore investigated microstructural changes of hepatic sinusoids that occur during the transition from normal to pathological states using volume electron microscopy, and examined how changes in the sinusoidal microenvironment contribute to liver disease progression.

Figure 1 shows the structure of hepatic sinusoids in the normal liver and the morphological changes of HSCs during liver injury. In the normal liver, HSCs exist in a quiescent state, whereas upon liver injury they transform into an activated phenotype and produce collagen fibers that cause liver fibrosis. Therefore, activation of HSCs is a major cause of liver cirrhosis and is considered a therapeutic target. Quiescent HSCs exhibit a characteristic stellate morphology, whereas activated cells undergo marked morphological changes. However, these changes have largely been observed *in vitro* [2], and the morphological changes occurring *in vivo* have remained unclear. We investigated the morphological changes of HSCs *in vivo* and further identified regulatory factors controlling these changes and their impact on liver pathology [3,4].

Figure 2 shows metastatic cancer cells invading the liver from the bloodstream. Unlike capillaries of other organs, hepatic sinusoids contain numerous fenestrae in the endothelia. We found by scanning electron microscopy that some of these fenestrae become enlarged after liver injury. When cancer cells were injected into the spleen under these conditions, the cells were able to pass through these enlarged gaps and invade the hepatic parenchyma. These findings reveal a novel mechanism of intrahepatic metastasis of cancer cells [5].

In this presentation, we will present these findings based on morphological analyses together with molecular biology data.

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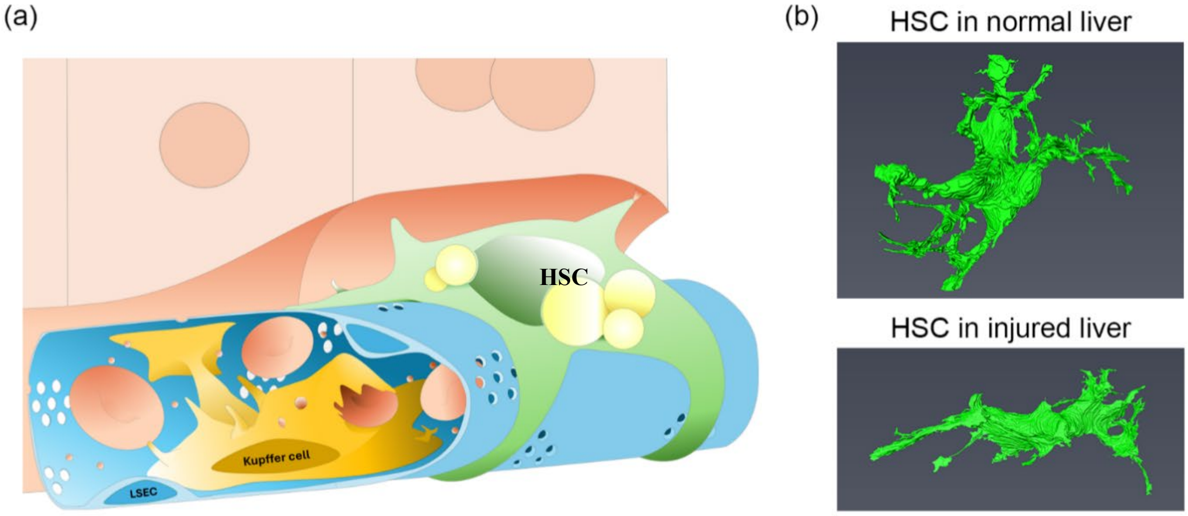

Figure 1. (a) Schematic illustration of the sinusoidal structure of the liver. (b) Volume electron microscopy images of HSCs in normal and injured liver.

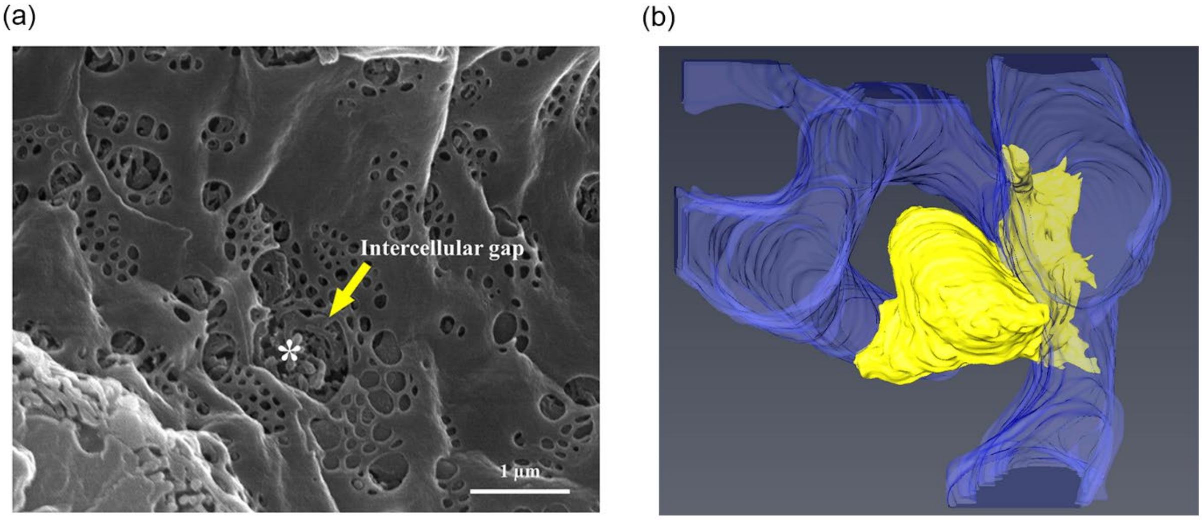

Figure 2. (a) Scanning electron microscopy image of the sinusoid. (b) Volume electron microscopy image of cancer cell invasion from bloodstream into the hepatic parenchyma. Yellow: Cancer cell, Blue: Sinusoid.

Session 2 J-4

Mapping liver zonation at nanoscale

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The liver is organized into hexagonal functional units called lobules, composed of radial chords of hepatocytes spanning the distance between the portal triad and central vein (Figure 1A). Oxygen-rich blood entering from the hepatic artery and oxygen-poor blood exiting from the central vein create a gradient along the portal-central axis which dictates the division of metabolic labor among hepatocytes in a phenomenon known as "zonation". Each "zone" can be identified by unique protein expression detectable by immunofluorescence staining (Figure 1A). Despite their homogenous histological appearance, hepatocytes in zone 1, closest to the portal vein, zone 3, closest to the central vein, and zone 2, the mid-lobule, differ not only in their metabolic functions, but also gene expression, DNA methylation, regenerative capacity, ploidy [1] and adeno-associated virus capsid transduction [2]. This level of specialization translates into zone-specific vulnerabilities, rendering hepatocytes differentially susceptible and responsive to disease. For example, in cholestatic liver disease, periportal hepatocytes contribute to the initial expansion of ductular reactions through a process known as metaplasia, where a 20-30 µm diameter hepatocyte transforms into a 7-9 µm diameter cholangiocyte-like cell through an unknown physical mechanism. Hepatocytes are also capable of permanently converting into mature cholangiocytes and rebuilding missing bile ducts in a mouse model of the human cholestatic liver disease Alagille syndrome [3]. To address the significant physical transformation that accompanies the hepatocyte's zonation-dependent disease response, we visualized zone-specific subcellular composition and morphology in healthy and cholestatic liver tissue using transmission electron microscopy and ultra-high voltage electron microscopy (UHVEM) (Figure 1B). This approach facilitates the tracking of individual zonated hepatocytes from their location in the liver lobe (peripheral, mid-lobe, hilar) to their position in the lobule (zones 1-3), to their intracellular contents using correlative light and electron microscopy (Figure 2).

Acknowledgement: This research is supported by a JSPS-KAKENHI grant to S.N.T.K.

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Fig. 1A

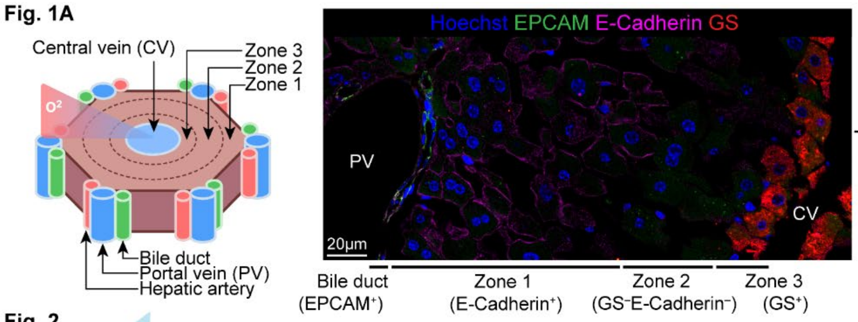

Fig. 1B Zone-specific analysis

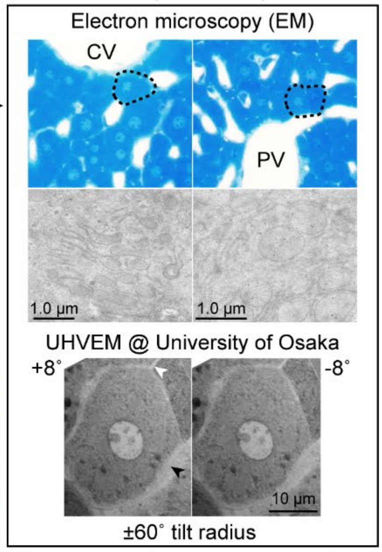

Fig. 2

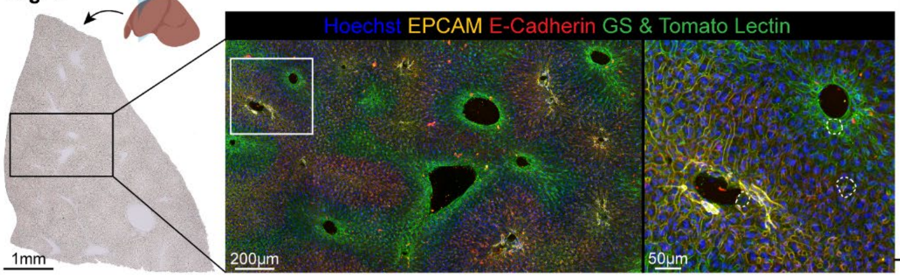

Fig. 1. A) Schematic of liver lobule zonation (left) and visualization by immunofluorescence (right). **B**) Zone-specific ultrastructural analyses are possible by identifying portal and central veins in semi-thin (~500 nm) toluidine blue-stained serial sections correlating to ultrathin (70 nm) or thick (4 µm) sections. Upper panel shows mitochondria and endoplasmic reticulum in different zones observed by transmission electron microscopy of ultrathin sections. Lower panel shows stereo images of a hepatocyte at +8˚ and -8˚ rotation visualized using ultra-high voltage electron microscopy (UHVEM) of thick sections. Black and white arrows show bile canaliculus and sinusoid, respectively.

Fig. 2. Plan for mapping liver zonation from the solid organ to millimeter to nanometer scale using correlative light and electron microscopy. 50 µm tissue sections are stained with zonation-specific antibodies and individual hepatocytes (dashed lines) are chosen for further ultrastructural analysis by electron microscopy. Maximum projection image is shown.

Session 2 **C-4**

Another Dimension of Hyperspectroscopic Optical Microscopy: Excitation Raman Scattering of Chirality-Pure Carbon Nanotubes

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Hyperspectroscopy is the combination of spatial and spectral data. Progress in digital imaging, data processing and photonic components is driving progress in hyperspectroscopic optical microscopy. An important optical micro-spectroscopy technique, Raman scattering (RS) spectroscopy, reveals vibrational modes of a sample, and is often spatially mapped to produce a hyperspectral dataset of vibrational mode intensities as a function of position. RS and optical absorption (OA) spectroscopy are important analytical spectroscopies for the single-walled carbon nanotube (SWCNT) material system. In optical absorption (OA) SWCNTs have various excitonic and electronic resonances in ultraviolet, visible and near-infrared (NIR). As a result, SWCNTs show resonant RS (RRS), meaning the peak intensity depends strongly on ingoing light wavelength. In fact, a RRS-derived plot, the Kataura plot, is a standard tool for the characterization of SWCNTs. Importantly, today's SWCNTs are highly pure and are sorted into specific molecular structures of fixed diameter and chiral angles. So, it is possible to have essentially the same material but with various electronic structures which are broadly similar, but not the same.

Usually in RRS, spectra are obtained serially in time with different lasers, or a tunable laser. This works well, but can be time consuming and costly. We have been developing an expedient technique using all wavelengths at once which we call Full Spectrum Raman Excitation Mapping (REM) Spectroscopy [1]. The full REM provides very detailed information as it combines vibrational and OA data. This allows us to see vibrational and electronic features over a broad band [2] and even track changes in real time [3]. Now we can see not just phonon emission, as is most common in RS spectroscopy, but also phonon absorption (Anti-Stokes RS) [4]. This provides some experimental insight into the form of the RS matrix element, which can be connected to simple quantum theory, potentially revealing quantum coherent phenomena. We believe multidimensional hyperspectroscopic optical microscopy like this has great potential not just for SWCNTS but for many types of samples.

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Session 2 C-5

Visualizing the early stages of ceramic sintering at the atomic scale

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Sintering is a foundational process to fabricate ceramic objects from powder compacts. The early stages of sintering are commonly described by well-established models such as the two-particle model, where two spherical particles are joined together, forming a neck at the particle-particle interface [1]. The driving force for sintering is the reduction of surface energy through neck formation, which is dictated largely by curvature under isotropic continuum approximations [1]. However, while classical models provide a robust macroscopic description, they fail to account for the discrete nature of crystalline materials at the atomic scale.

This study bridges the gap by providing direct, atomic resolution observations of the initial and intermediate stages of ceramic via *in situ* scanning transmission electron microscopy (STEM). Using a novel sample preparation technique designed to replicate the geometry of the two-particle model, we demonstrate that the initial stage of sintering is more complex than predicted by the curvature-driven neck growth alone. These findings offer a refined fundamental understanding of sintering kinetics and provide guiding principles for the optimization of ceramic sintering parameters in advanced manufacturing.

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Session 2 J-5

High-Sensitivity Electron Holography and Its Applications

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In this lecture, we present recent advances achieved over the past decade in improving the precision of phase analysis in electron holography, together with representative applications of this technique to materials science.

The precision of phase measurement in electron holography depends strongly on the image quality of digitally recorded holograms, specifically on the fringe contrast and the number of electrons per pixel [1]. From this relationship, it would appear that securing a sufficiently high electron dose is the primary requirement for improving phase-analysis precision. In practice, however, excessive electron irradiation often induces specimen damage and contamination, and consequently, holograms with suboptimal image quality must be analyzed. To address this issue through data processing, we have developed key technologies for noise reduction and extraction of weak signals from holograms and reconstructed phase images.

Under the support of the JST-CREST program, we developed a statistical image-processing approach based on the Wavelet Hidden Markov Model (WHMM), which enables reliable discrimination between weak signals and noise in image data [2,3]. By combining optimized data-acquisition conditions for holograms with post-acquisition weak-signal extraction techniques, the precision of phase analysis has been improved to approximately $2\pi/1000$ rad [3,4]. Recently, it has also been demonstrated that WHMM-based noise reduction is highly effective for electron holography applied to beam-sensitive materials. Even under extremely low-dose conditions—corresponding to an average of approximately one electron per pixel—it has been experimentally verified that appropriate noise processing allows visualization of the electrostatic potential distribution of charged nanoparticles [5].

As an example of the application of high-sensitivity electron holography, we analyzed the weak charging states of catalytic materials [2,6]. For instance, Pt nanoparticles supported on TiO_2 were found to exhibit either positive or negative charging depending on the interfacial structure, including the crystallographic orientation relationship between Pt and TiO_2. Furthermore, the amount of charge on Pt nanoparticles was shown to be influenced by multiple factors, including lattice distortion within the Pt crystals. In contrast to spectroscopic techniques that provide accurate averaged information over many nanoparticles [7], electron holography enables simultaneous evaluation of the charging state and crystal structure on a particle-by-particle basis.

As a further recent development, in situ hologram acquisition and phase analysis under gas environments such as oxygen and hydrogen (Fig. 1) have enabled evaluation of the charging states of catalysts under working conditions [6].

This work was carried out in collaboration with numerous colleagues, including Prof. R. Aso, Mr. H. Sano, Ms. A. Sato, Prof. H. Hojo, Prof. H. Einaga, Dr. Y. Tomita, and Prof. T. Yamamoto at Kyushu University; Prof. Y. Midoh, Prof. H. Yoshida, and Dr. H. Nakajima at Osaka University; and Dr. T. Tanigaki, Dr. F. Ichihashi, Dr. Y. Takahashi, Dr. T. Akashi, and Dr. H. Shinada at Hitachi, Ltd. This research was supported by JST-CREST (JPMJCR1664) and JSPS-KAKENHI (21H04623, 22K18904, 25H0080).

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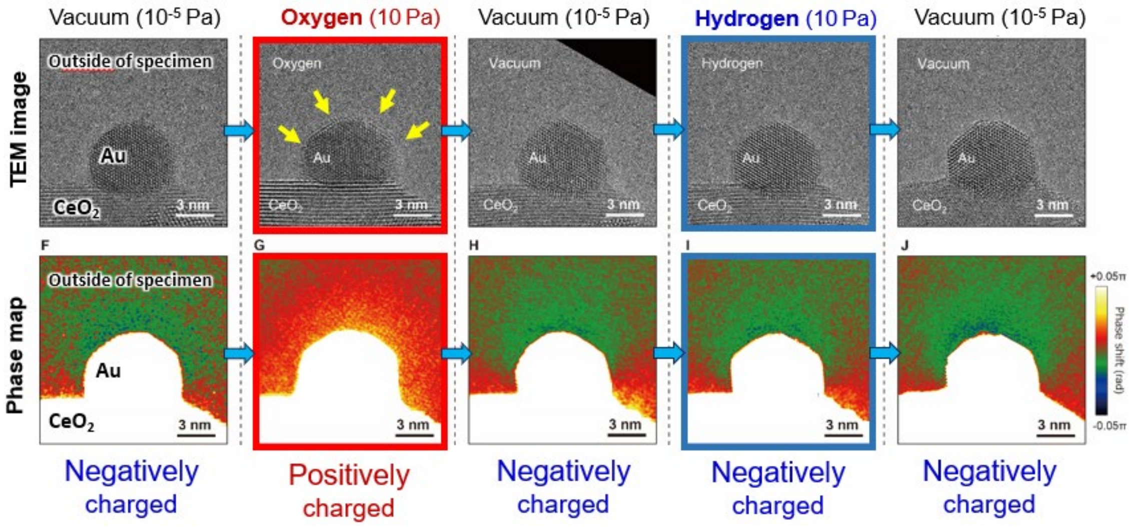

Fig. 1 Structure and charge state of Au/CeO$_2$ catalysts observed in various conditions of data acquisition [6].

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【Misa Hayashida student scholarship】（林田美咲記念 研究奨励金 制度）

The scholarship has been established in memory of Dr. Misa Hayashida, a talented researcher who made important contributions to development and applications of electron microscopy. Misa’s contributions to science were stopped by her passing at an early age. The scholarship aims to preserve her curious spirit and her love for scientific discovery.

Thanks to generous support of Misa's family and friends, the scholarship welcomes young microscopy researchers from both Canada and Japan with the aim of fostering relations between the Microscopy Society of Canada (MSC) and the Japanese Society of Microscopy (JSM).

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https://microscopy.or.jp/jp-ca_symposium/2025/hayashida.html ⇩