



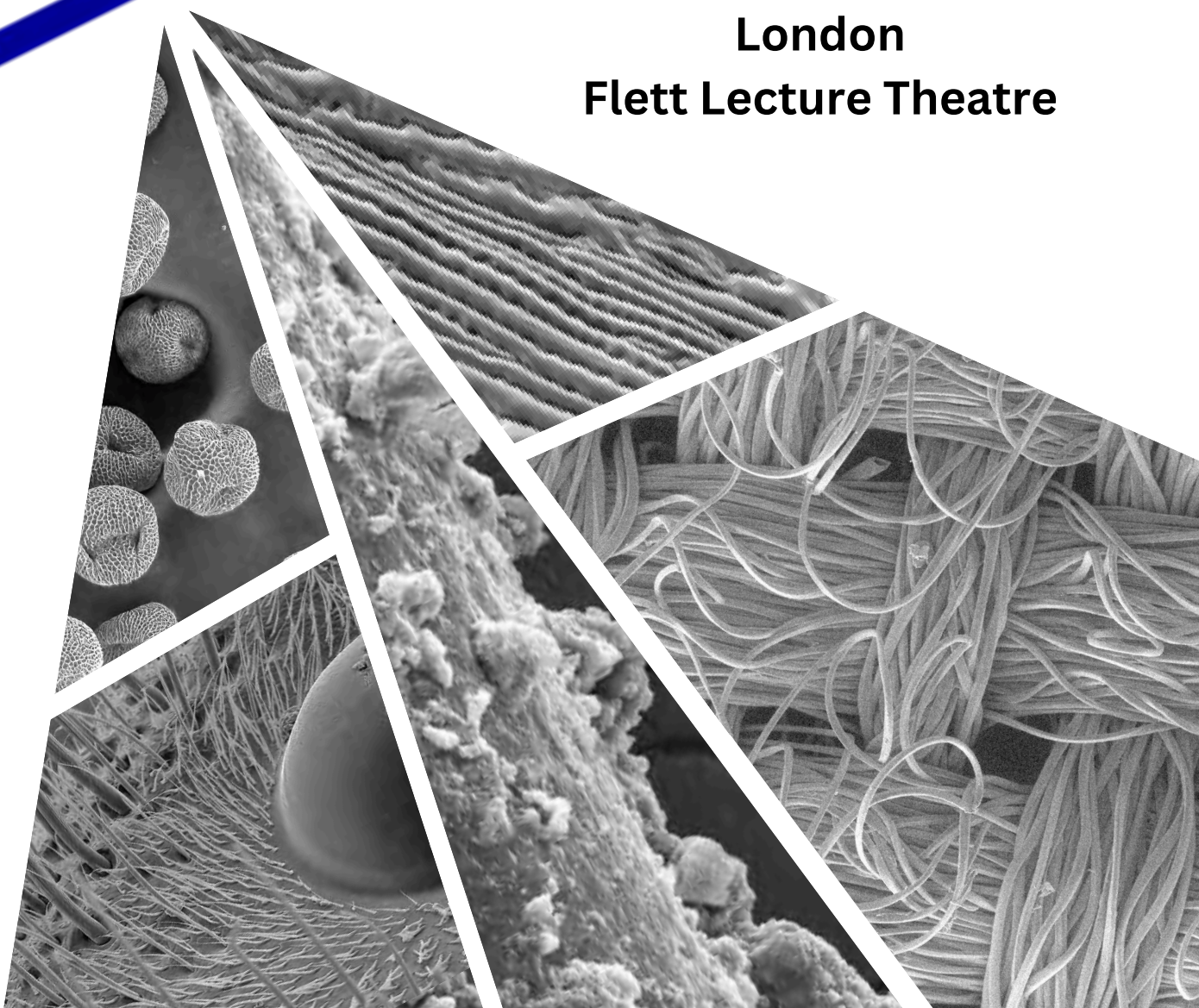
Society of Electron
Microscope Technology

One Day Meeting

Monday 8th December 2025



Natural History Museum,
London
Flett Lecture Theatre



Programme

09:15 - Registration: Flett Theatre foyer (1st floor, Earth Galleries Building)

09:50 - Welcome and Introduction - Alex Ball, SEMT Chair

09:55 - Introduction to The Natural History Museum - Alejandro Cortes

Morning Session

10:00 - 10:25 - **Ali Gholinia**, Henry Royce Institute and Department of Materials, The University of Manchester, **Automation in SEM; 3D materials characterisation, Correlative microscopy, and in situ studies**

10:25 - 10:50 - **Alex Strachan**, Plymouth Electron Microscopy Centre, **Building a commercial orientated facility from start to.....**

10:50 - 11:25 - **Coffee and trade exhibition**

11:25 - 11:50 - **Bart Wagner**, Histopathology Department, Royal Hallamshire Hospital, **A new edition of an old textbook, how and why we did it and what's next?**

11:50 - 12:50 - RMS Beginners' Competition



1. **Emilie Smith**, Cardiff University, Key Challenges in In Situ Gas Phase Electron Microscopy Catalysis Studies
2. **Nagu Sathappan**, Brunel University, High-Temperature Magnetic Imaging Using Quantum Well Hall Effect (QWHE) Sensors Integrated into Magnetic Flux Leakage (MFL) Systems for Advanced Non-Destructive Testing
3. **Krijn van der Steen**, UMC Utrecht, AIDED: AI-Driven, Expert-Decided Acquisition for Real-Time Microscopy
4. **Charlie Butterworth**, University of Strathclyde, Refractive Index Manipulation of 3D Printed Lenses Using ZrO₂ Nanoparticle Doping
5. **Fintan Hardy**, Imperial College London, Accelerating Identification of Polar Domains From 4D-STEM Datasets Using Machine Learning
6. **Darcy Gabriel**, Imperial College London, Age-dependent changes of alpha-Synuclein in the motor cortex

12:50 - 14:30 - **Lunch and trade exhibition** (+ judging of RMS Beginners' Competition). **Kindly sponsored by Deben and Quorum.**

14:10 - 14:30 - SEMT AGM, Flett Theatre (including SEMT committee membership/ changes of officers and committee members)

Programme

Afternoon Session

14:30 - 14:55 - Peter O'Toole, University of York, **The Importance of Enabling New Technologies**

14:55 - 15:20 - Sara Russell, The Natural History Museum, **An SEM investigation of asteroid (101955) Bennu, returned by the OSIRIS-REx mission**

15:20 - 16:00 - Coffee and trade exhibition

16:00 - 16:25 - Sally Schofield, Nanoscale and Microscale Research Centre, University of Nottingham, **Public Engagement and Outreach at the nmRC**

16:25 - 16:50 - Agnese Benzonelli, University of Cambridge, **Revealing the Black: Plasmonic Effects in Shakudo Sword Fittings**

16:50 - 17:15 - Katie Beirns, University of Oxford, **Graphene Windows: Innovating Liquid-Phase Electron Microscopy Methods for Mitochondrial Research**

17:15 - 17:40 - Anna Heinrich and Leon Palmer, **Beyond Appearance**

18:00 - 20:00 - Wine reception and finger buffet + announcement of winners of the RMS Beginners' Competition. **Kindly sponsored by JEOL UK.**



SEMT Annual General Meeting Agenda

1. Apologies
2. Minutes of the previous AGM
3. Matters arising
4. Chairman's report
5. Secretary's report
6. Treasurer's report and accounts
7. Revision to the SEMT Constitution
8. Election of Officers and committee for 2026
9. Any other business

Officers of the SEMT

Chair

Alex Ball



Secretary

Ken Mingard



Treasurer

Steve Furzeland

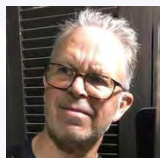


Committee

Pedro Machado



Neil Wilkinson



Emily Woodcock



Committee

Russell Bailey



Paola Ciselli



Patricia Goggin



Paul Gunning



Sarah Hall



Matthew Hannah



Louise Hughes



Jennifer Pearson-Farr



Acknowledgements

SEMT would like to thank:

The Natural History Museum for kindly hosting the SEMT meeting 2025.

JEOL for sponsoring the evening drinks reception and buffet.

Deben and **Quorum** for sponsoring the lunch.

RMS for facilitating the ticketing, registration desk and awarding the RMS beginners' competition prize

And **all our trade partners** for their ongoing support!

Proposed Revised Society of Electron Microscope Technology Constitution

- 1.** The title of the Society shall be the Society of Electron Microscope Technology – “The Society”. The Constitution is available on the website.
- 2.** The aims of The Society shall be to encourage interest in electron microscope technology and associated fields and to promote the interests of those engaged in these areas.
- 3.** Membership shall be open to any person connected with or interested in electron microscopy. The membership of The Society for each year is defined by the mailing database.
- 4.** A Committee consisting of no more than sixteen persons, including the Officers, shall be elected at the Annual General Meeting. and shall hold office for one year. Retiring Committee members shall be eligible for re-election.
- 5.** The Officers of The Society shall be the Chair, Secretary and Treasurer. The Chair and the Secretary shall be elected at the Annual General Meeting. The Treasurer shall be elected by the Committee. All shall take office on election and shall hold office until the next Annual General Meeting. Those retiring shall be eligible for re-election.
- 6.** Two people, not being Officers or members of the Committee, shall be appointed at the Annual General Meeting to examine and report on the annual accounts.
- 7.** Vacancies amongst Officers or Committee members may be filled by the Committee at their discretion, and any person so appointed shall hold office or serve on the Committee until the next Annual General Meeting or until the next Extra-ordinary General Meeting, whichever is the earlier. The Committee can co-opt members for a one-year term.
- 8.** The election of Officers and Committee members shall be by a show of hands at the AGM. Nominations (proposed and seconded) can be volunteered at the AGM and voted on at the same meeting.
- 9.** An Annual General Meeting shall be held no later than December 31st in each year, for which members shall receive 4 weeks notice including the agenda of the meeting. At the Annual General Meeting the Treasurer shall submit for approval the accounts showing the financial state of the Society.
- 10.** Only resolutions received by the Secretary at least six weeks before the Annual General Meeting shall be included in the agenda.
- 11.** An Extra-ordinary General Meeting may be called by the Committee or on receipt of a written requisition signed by at least six members of the Society. Members shall receive at least seven days notice of such a meeting. No business shall be transacted at any Extra-ordinary General Meeting except that which appears on the notice calling the meeting, other than the filling of vacancies, if any.
- 12.** A quorum for the Annual General Meeting and any Extra-ordinary General Meeting shall be 25% of the membership of the Society present on the day of the meeting.
- 13.** A quorum for a Committee meeting shall be four members, two of whom must be Officers.
- 14.** Should a resolution be passed at an Annual General Meeting that an annual membership fee is required; members shall pay an annual subscription. Duly paid-up members shall have the right to vote at any meeting. Should a member’s subscription be twelve months or more in arrears the member’s name may be removed from the Society’s register at the Treasurer’s discretion.
- 15.** Amendments to this Constitution may be made at the Annual General Meeting or at any Extra-ordinary General Meeting by a simple majority of those present, provided that notification of the proposed amendments has been made in the notice concerning the meeting.

SEMT would like to thank the following
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Seeing beyond

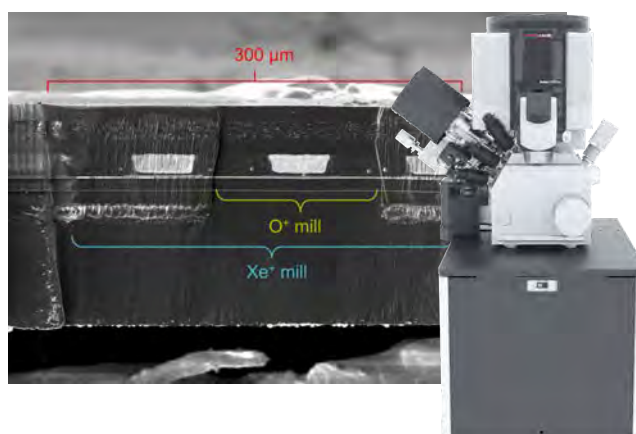
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Automation in SEM; 3D materials characterisation, Correlative microscopy, and *in situ* studies

Ali Gholinia

Henry Royce Institute and Department of Materials, The University of Manchester, Manchester.

Three dimensional (3D) data unlocks the hidden information in two dimensional (2D) analysis, such as the investigation of crack paths, grain boundary planes and much more [1]. Automation in scanning electron microscopy (SEM) has become more reliable for 3D serial sectioning techniques (SST) to acquire large volume 3D datasets over long periods without interruption. There are various ion species and photon available to cater for different applications in high resolution (in nanometers) with Ar^+ broad ion beam (BIB) and Ga^+ focused ion beam (FIB) and more rapid and large volumes investigation by milling using Xe^+ plasma-PFIB and by ablation using femto second (fs) laser ($\sim 1\text{mm}^3$). Figure 1 shows the respective volumes and resolutions possible with the various 3D SST techniques, where the large volumes achievable with fs-laser overlap with X-ray computed tomography (XCT) techniques for practical correlative microscopy investigations [2]. The in situ tribeam fs-laser PFIB enables simultaneous multi-modal investigation using electron back scatter diffraction (EBSD) and energy dispersive spectroscopy (EDS) with flexibility to use both ablation and milling.

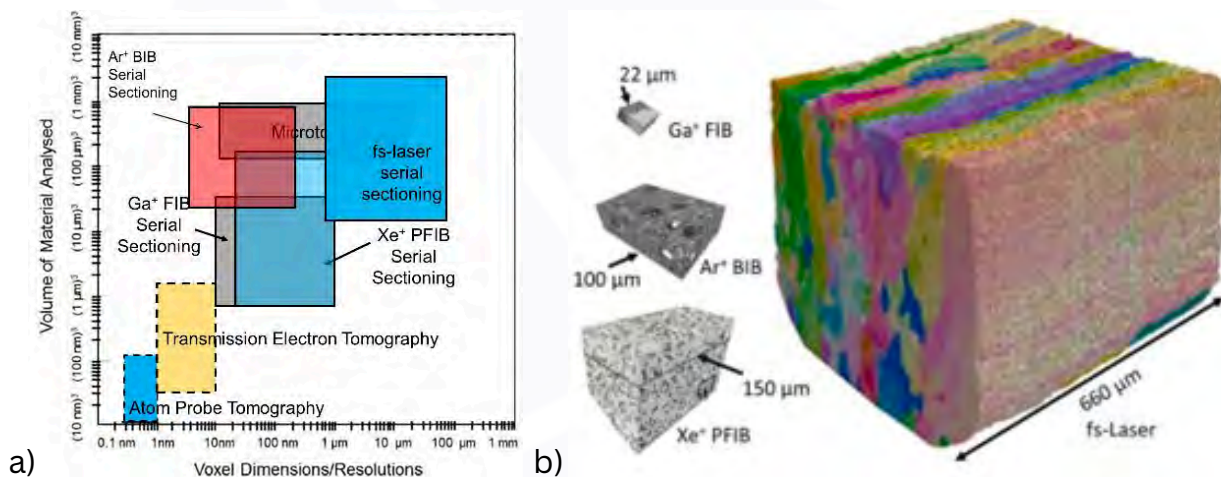


Figure 1- a) Comparison of resolution and volume between 3D techniques, b) representative volumes analysed during a similar time scales by various 3D techniques [1, 2].

In recent years automation in SEM has also helped to develop new in situ techniques for deformation and heating too. In situ deformation and heating experiments present a new insight into phenomena such as dislocation activity during deformation, phase transformation, recrystallization and grain growth during heating. The conventional post-mortem, ex situ techniques are limited to a snap shot of the events, which limit our full understanding of these events. The conventional manual in situ techniques are limited to few data points and relocation of the area of interest is not precise between data points. We have developed an automated in situ deformation and heating integrated system, which can run autonomously over a long time to acquire data with exceptionally high temporal resolution and high stability in automated site location and focus using a fiducial. The SEM, EBSD and High Resolution Digital Image Correlation (HR-DIC), have improved dramatically with the development of a fully integrated systems enabling fully automated scans over long durations. Figure 2 shows the high GND density and high local strain near a twin boundary for a Ni Inconel 690 alloy after 10% deformation, which are calculated from EBSD and HR-DIC maps, respectively [3].

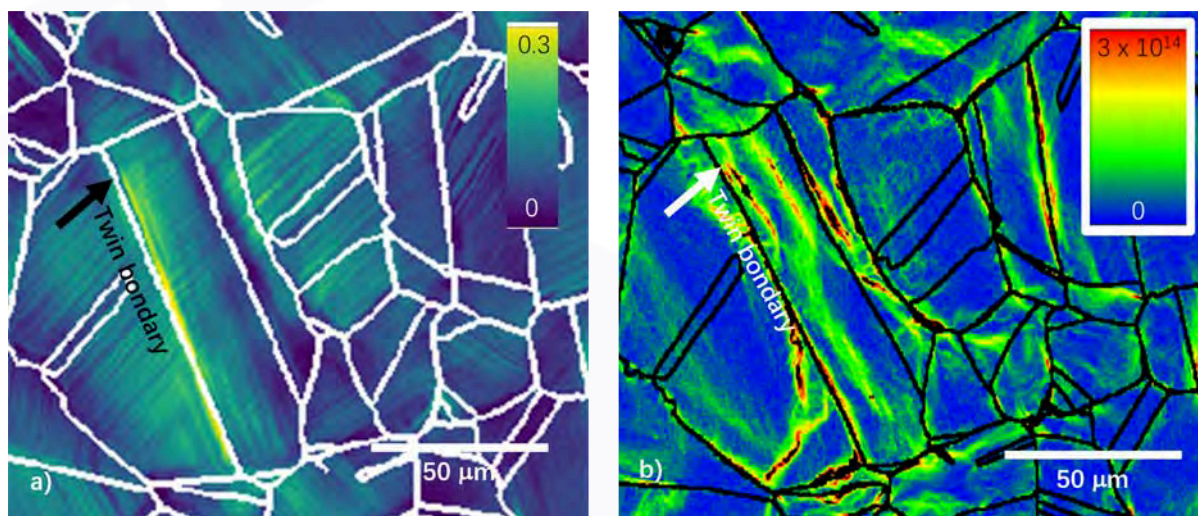


Figure 2- a) Effective shear strain from HR-DIC and b) GND density per m2 from EBSD in IN690 deformed to 10% tensile strain at room temperature [3].

References

- [1] A. Gholinia, J. Donoghue, A. Garner, M. Curd, M.J. Lawson, B. Winiarski, R. Geurts, P.J. Withers, T.L. Burnett, Exploration of fs-laser ablation parameter space for 2D/3D imaging of soft and hard materials by tri-beam microscopy, *Ultramicroscopy*, 257 (2024) 113903.
- [2] T.L. Burnett, R. Kelley, B. Winiarski, L. Contreras, M. Daly, A. Gholinia, M.G. Burke, P.J. Withers, Large volume serial section tomography by Xe Plasma FIB dual beam microscopy, *Ultramicroscopy*, 161 (2016) 119-129.
- [3] Z. Yang, R. Thomas, J. Donoghue, A. Smith, M. Preuss, A. Gholinia, In situ and correlative study of dislocation density and deformation mechanisms in Inconel 690, Submitted to *Materials Characterization* (2025).

Building a commercial orientated facility from start to.....

Alex Strachan

Plymouth Electron Microscopy Centre, Plymouth Science Park, Plymouth

As academic institutions face financial challenges and the landscape of higher education continues to change, some technical facilities are being asked to shift their focus towards attracting commercial engagement.

Plymouth Electron Microscopy Centre (PEMC) is a core facility within the University of Plymouth. With the building in which PEMC was located having reached the end of life, PEMC arrived at a crossroads in its future requiring a redefinition of its function and purpose. As a core facility PEMC has always been involved in three key areas; teaching, research and commercial interactions. To facilitate and justify a new PEMC facility, the hierarchy of these key areas would need to be re-evaluated with a stern focus towards commercial engagement and the generation of income. To this end a new strategy was formed to secure the future of PEMC for all its users.

In the last 18 months PEMC has endeavoured to reposition itself to attract local, national and international businesses. This has required a strategy incorporating the design of a new facility, marketing, recruitment, branding, social media and certification amongst many other aspects. This has by no means been a smooth process, so learn from my mistakes and save yourself the pain and stress!



PEMC in 2023



UNIVERSITY OF
PLYMOUTH

Plymouth Electron Microscopy Centre

PEMC logo in 2023



PEMC in 2024



PEMC
PLYMOUTH ELECTRON MICROSCOPY CENTRE

PEMC logo in 2024

A new edition of an old textbook, how and why we did it and what's next?

Bart Wagner¹ and Lucy Collinson²

1. Histopathology Department, Royal Hallamshire Hospital, Sheffield.

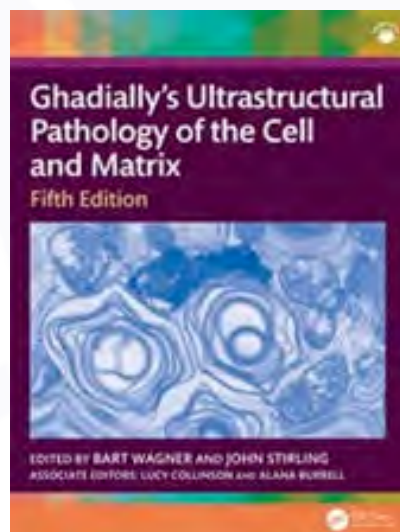
2. Electron Microscopy Science Technology Platform, The Francis Crick Institute

The 5th edition of 'Ghadially's Ultrastructural Pathology of the Cell and Matrix' (2025) is a large text and TEM image atlas of mainly diseased human tissue studied one organelle at a time. The text has gone on the first step of transition from a single to multi-author book, mainly using Ghadially's original images.

We contend that professional biological electron microscopists should initially read the book from cover to cover and then, as the need arises, dip into it as a reference textbook. To encourage this: reading the book won't take as long as you think, you will find it interesting, and you will be more able to look at EM images with understanding.

We will outline the journey of bringing this edition to reality and our plans for the next edition. We feel that this should include many more EM images of rarely encountered structures – and a suitably amended text.

We will also update on a new effort to bring together the research and clinical electron microscopy communities to address challenges in using EM in clinical research and in porting new technologies available in research settings to the diagnostic field. We are hoping to build collaborations which will lead to translation of cutting-edge research techniques and tools to real world clinical challenges, ensuring early and maximum impact of discoveries and developments.



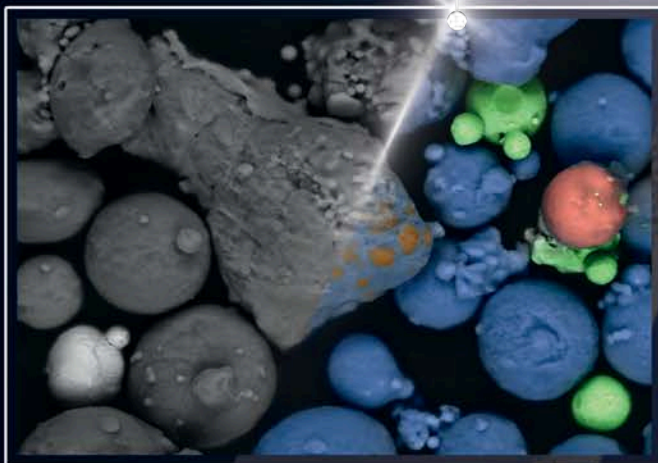
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Observation Preparation

Insert the specimen holder and click the **Start Button**.

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Click anywhere on a Map

The stage moves to the clicked position automatically.



Double-click



Image Capture

Click the Capture Button

Butler mode assists data acquisition. Even a beginner can capture data easily.

Automatic alignment



Observation Completed

Click the **Sample Exchange Button**

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Learn more

Key Challenges in In Situ Gas Phase Electron Microscopy Catalysis Studies

Emilie Smith¹ and Thomas A. Slater¹

1. Translational Research Hub, Cardiff University, Cardiff

In situ electron microscopy is an emerging technique that allows researchers to observe catalysts working in real time during gas-phase reactions. Unlike traditional methods that examine catalysts before and after reactions, this approach provides direct observation of structural changes as they happen. While offering unique insights, several factors can affect the quality and interpretation of results.

Through a literature review, this presentation will introduce four challenges:

1. Electron beam damage: How the imaging beam itself can alter catalyst particles, creating artificial changes that are not part of the real reaction.
2. Carbon contamination: Unwanted carbon deposits that build up during imaging and can interfere with the catalytic process (Figure 1).
3. Degraded spatial resolution: How the gas environment reduces image sharpness compared to traditional electron microscopy.
4. Limited temporal resolution: The inability to capture very fast processes that occur during catalysis.

The presentation will cover what causes each challenge, how to identify it in practice, and practical approaches to minimise problems. Understanding these limitations enables researchers to design better experiments and interpret results more accurately.

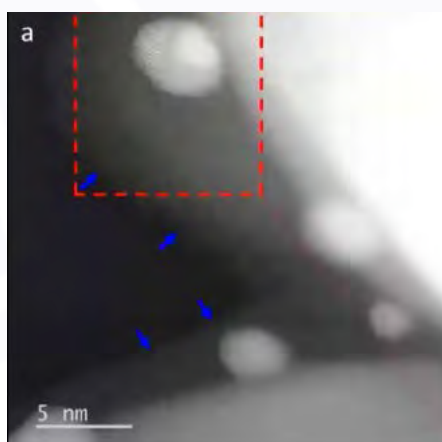


Figure 1: An example of contamination during imaging (indicated by blue arrows) (adapted from Hu, 2023).

RMS Beginners' Competition



High-Temperature Magnetic Imaging Using Quantum Well Hall Effect (QWHE) Sensors Integrated into Magnetic Flux Leakage (MFL) Systems for Advanced Non-Destructive Testing

Nagu Sathappan^{1*}, Mohamed Missous², and James Sexton²

1. Brunel University, Uxbridge. 2. University of Manchester, Manchester

This research focuses on the development and integration of Quantum Well Hall Effect (QWHE) sensors into Magnetic Flux Leakage (MFL) scanning systems for real-time magnetic imaging in high-temperature environments. The primary objective is to enhance non-destructive testing (NDT) techniques for the precise detection of surface and subsurface defects in ferromagnetic materials, particularly under extreme thermal conditions.

QWHE sensors offer significant advantages over conventional Hall sensors, including higher magnetic sensitivity, superior spatial resolution, and robust thermal stability. These properties are critical for maintaining sensor performance and reliability in demanding industrial settings such as aerospace, nuclear power, and petrochemical infrastructure, where components are often exposed to elevated temperatures and harsh environments.

The integration of QWHE sensors into MFL systems enables the development of a next-generation magnetic imaging platform capable of providing accurate, high-resolution defect characterization in real time. This advancement represents a substantial improvement in structural health monitoring technologies, ensuring the early detection of flaws that could lead to catastrophic failures if left unaddressed.

By extending the boundaries of magnetic sensor technology and applying it to practical NDT imaging systems, this research contributes to the wider field of smart diagnostics and predictive maintenance. Ultimately, the impact of this research work lies in its potential to prevent pipeline accidents and related environmental hazards, thereby making the environment a better and safe place to live.

RMS Beginners' Competition



AIDED: AI-Driven, Expert-Decided Acquisition for Real-Time Microscopy

Krijn van der Steen

Lab Cellular Disease Models, Regenerative Medicine Center, UMC Utrecht, the Netherlands.

A gap often exists between the technical expertise required to engineer AI models for image analysis and the biological knowledge needed for their effective application. Well-informed parameter choices depend on both technical skill and a clear understanding of the desired outcomes and the behaviour of the underlying system. Moreover, some patterns cannot be uncovered by generating more labels; they require a precise, human-defined interpretation of their meaning [8]. This disconnect may manifest as data drift, where training data diverges from real-world conditions. Alternatively, it may appear as overly permissive predictions where models prioritise inclusivity over precision. Such issues are not always revealed by standard performance assessments at deployment.

After deployment, models are often considered correct based on initial validation metrics and researcher-developer trust. Arbitrary or non-representative test data can inflate perceived performance, leaving weaknesses unnoticed until they cause significant issues. Without continuous monitoring, both trust and performance degrade over time [7, 4]. Undetected drops in performance can propagate through systems, causing data cascades [6]. Such cascades can amplify small errors into costly large-scale refactors.

The root cause of these pitfalls is the absence of integrated human feedback in currently deployed systems. We therefore propose a Human-Alongside-The-Loop (HATL) approach [3], in which the system suggests regions of interest (ROIs) using predefined yet real-time adjustable parameters. ROIs with aggregated prediction confidence scores are generated by the prediction model. Real-time parameter adjustments allow users to refine ROI selections dynamically. This feature subsequently enables reviewing and augmenting ROIs before inclusion in subsequent experiment steps. An example is shown in Figure 1.

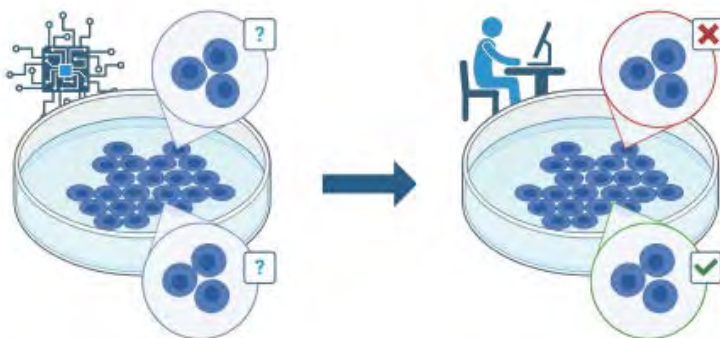


Figure 1: Schematic illustration showing AI-highlighted ROIs with final selection by an expert. Highlighting the conceptual working of the AIDED framework. Created with biorender.com

The system can operate automatically or with a human alongside the loop to maintain a balance between throughput and quality. Users may step back once trust is established in the system, and later reinsert themselves as needed. This design keeps users critical, engaged, and informed, helping to preserve human expertise in the laboratory—a concern highlighted in similar systems [2].

HATL approaches have proven successful in both the medical and natural domains, achieving significant reductions in data volume and processing time. More importantly, they outperform approaches relying solely on AI or human evaluation. In the medical domain, combining AI guidance with expert evaluation of lesions has been shown to improve diagnostic accuracy [5]. In the natural domain, AI-assisted seal classification has enabled human researchers to efficiently identify harbor seals by selecting the correct individual from the system's top- k suggestions [1].

Whereas the concept is applicable to the entire domain of microscopy, our concrete implementation has been done by leveraging the ZEN Blue API on our Zeiss Celldiscover7 system, a screenshot is visible in Figure 2. An example use-case would be real-time prediction of where ciliated cells exist in an image, selecting areas with the highest average predicted ciliation, and capturing videos of these regions at higher magnification. This yields highly enriched data to help identify patterns of cilia movement within the well.

Adding a feedback loop further strengthens the approach—building trust, increasing robustness, and expanding its scope to capture events not immediately recognised as important. While this interactive process may reduce throughput compared to a fully automated pipeline, it outperforms a fully manual workflow. Once the user reaches a satisfactory confidence level in the system's performance, the learned weights can be applied automatically to future experiments, maintaining efficiency while preserving accuracy. This feedback loop can be further amplified by leveraging cloudserved models, such as those on Databricks, enabling multiple concurrent models to run and be trained for separate experiments and users. This ensures that up-to-date, real-time models are available for multi-user segmentations at all times, allowing each experiment to benefit from continuously refined predictions while maintaining expert oversight.

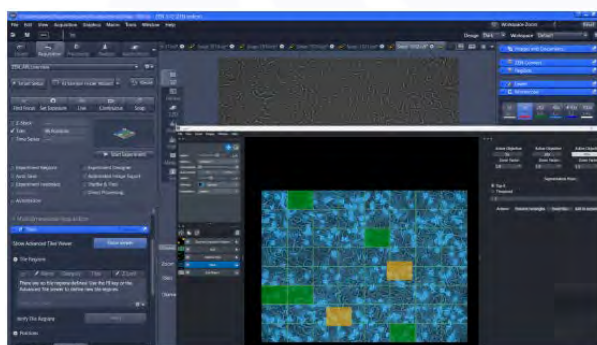


Figure 2: Example image where AIDED recommends ROIs of ciliated cells based on the top- k sorted regions (green), augmented by humansupplied ROIs (orange).

- [1] Zach Birenbaum et al. "SEALNET: Facial recognition software for ecological studies of harbor seals". In: Ecology and Evolution 12 (Apr. 2022). doi: 10.1002/ ece3.8851. [2] David Freeman Engstrom and Daniel E. Ho. "Algorithmic Accountability in the Administrative State". In: Yale journal on regulation 37.3 (Jan. 2020), pp. 1-. url: <https://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1563& context=yjreg>. [3] Masike Malatji. "Augmented Intelligence Framework for Human-Artificial Intelligence Teaming in Cybersecurity". In: Human-Centric Intelligent Systems 5.2 (2025), pp. 151-180. doi: 10.1007/s44230-025-00103-8. [4] Kurtis Pykes and Kurtis Pykes. "A Guide to Monitoring Machine Learning Models in Production". In: (June 2023). url: <https://developer.nvidia.com/blog/aguide-to-monitoring-machine-learning-models-in-production/>. [5] Carlo Reverberi et al. "Experimental evidence of effective human-AI collaboration in medical decision-making." In: Scientific reports 12.1 (2022), p. 14952. doi: 10.1038/s41598-022-18751-2. [6] Nithya Sambasivan et al. "“Everyone wants to do the model work, not the data work”: Data Cascades in High-Stakes AI". In: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. CHI '21. Yokohama, Japan: Association for Computing Machinery, 2021. isbn: 9781450380966. doi: 10.1145/ 3411764.3445518. url: <https://doi.org/10.1145/3411764.3445518>. [7] Jan B Schmutz et al. "AI-teaming: Redefining collaboration in the digital era". In: Current Opinion in Psychology 58 (2024), p. 101837. issn: 2352-250X. doi: 10.1016/j.copsyc.2024.101837. [8] Shreya Shankar et al. "“ We Have No Idea How Models will Behave in Production until Production”: How Engineers Operationalize Machine Learning". In: Proceedings of the ACM on Human-Computer Interaction 8.CSCW1 (2024), pp. 1-34.

Refractive Index Manipulation of 3D Printed Lenses Using ZrO₂ Nanoparticle Doping

Charlie Butterworth¹, Jay Christopher¹, Dickon Walker², Liam M. Rooney³, Margaret Cunningham⁴, Gail McConnell⁴, and Ralf Bauer¹

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2. National Manufacturing Institute Scotland, University of Strathclyde, Glasgow, UK

3. School of Infection & Immunity, University of Glasgow, UK

4. Strathclyde Institute of Pharmacy & Biomedical Sciences, University of Strathclyde, Glasgow, UK

We investigated the creation of optical elements with varying refractive index through low cost 3D printing. The refractive index of the elements was adjusted by adding ZrO₂ nanoparticles to off-the-shelf consumer grade resins, enabling the potential for designing more advanced additively manufactured optical components. Initial test elements with 10 wt% ZrO₂ loading were fabricated and trialled in a widefield imaging setup.

3D printing of optical elements has seen a significant interest in recent years, with comparably expensive two photon polymerisation (TPP) approaches demonstrating viable elements with high accuracy, e.g. on optical fibres [1], but requiring a complex laser and printer setup. Affordable consumer grade resin printers have also recently demonstrated print qualities sufficient for biological imaging [2]. These approaches in general use single materials, limiting elements to singlet lenses and lens arrays. To allow widening of the design space, multi refractive index solutions are desirable.

Nanoparticle doping of resins has been used for a variety of applications, including for the modification of refractive index (RI). TiO₂ was found to increase the RI of photocurable resin by 0.13 [3], while ZrO₂ doped resin has been used to create an achromatic Fraunhofer doublet lens using two photon direct writing [4]. Off-the-shelf resins/glues with different RIs have also been used to create doublet lenses using a consumer-grade Vat Photopolymerisation (VPP) printer [5]. However, there is still an unexplored opportunity to combine the high RI changes possible using nanoparticle doping and low-cost 3D printing, which can enable accessible custom optics with stable RIs. For example, increased design freedom is facilitated by tailoring the concentration of nanoparticles to the desired RI.

Consumer-grade resins, Siraya Tech and Anycubic Waterwash, were doped with 10 wt% ZrO₂ nanoparticles. A maximum RI increase of 0.06 was measured. Figure 1 shows a side-by-side comparison of the clarity of the nanoparticle enhanced resin and basic resin, indicating that the nanoparticles have been distributed in the resin without clouding or chemical changes affecting the transparency. The imaging performance was trialled by integrating the lenses into a basic widefield imaging set up with Köhler illumination. The images obtained using the moulded lens for each resin indicate the ZrO₂ nanoparticles do not significantly interfere with the light transmission or lens performance, and no additional artefacts or vignetting are observed. The minimum resolvable detail for the basic Siraya Tech resin moulded lens was 13.92µm, and 12.40µm for the 10 wt% doped Siraya Tech resin moulded lens, indicating a slight resolution increase.

It has been demonstrated that ZrO₂ doped consumer-grade 3D printing resins can be used for fabricating millimetre scale lenses using low-cost manufacturing techniques. Having validated the resin doping protocol, further work will include directly printing the lenses using VPP printing, and characterising lens performance. This will allow the creation of custom doublet lenses, fully 3D printed using low-cost techniques.

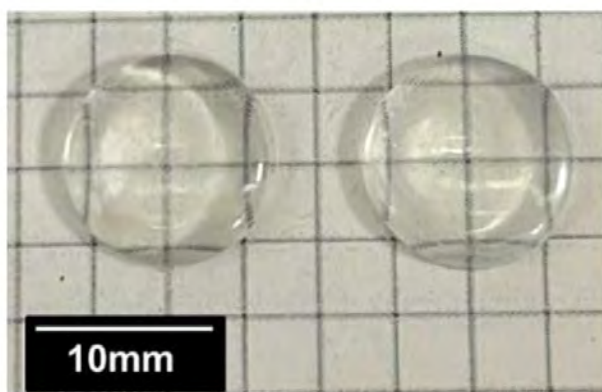


Fig. 1. Moulded lenses using undoped and doped consumer-grade 3D printing resins: Siraya Tech resin, left, and 10 wt% ZrO₂ Siraya Tech resin, right.

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Accelerating Identification of Polar Domains From 4D-STEM Datasets Using Machine Learning

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4D-STEM offers rich information across both real and reciprocal space, yet isolating meaningful features remains a computationally demanding and time-consuming challenge. Conventional approaches for detecting polar domains in 4D-STEM data sets typically involve manual inspection with tools like py4DSTEM [1]. While effective, these workflows are labour-intensive and susceptible to human error, which can compromise accuracy. More recently, convolutional neural networks (CNNs) have been applied to individual diffraction images from 4D-STEM, where autoencoders have been used to extract polarization domain information from latent space embeddings [2]. CNNs are naturally well-suited for diffraction analysis thanks to their translational equivariance, which reduces sensitivity to artifacts such as small misalignments.

In this study, we introduce a streamlined CNN model designed to identify polarization domains directly from reciprocal-space diffraction patterns in 4D-STEM. Trained on a set of 1,000 manually annotated images, the network successfully captures the underlying structural motifs of a ferroelectric test material, yielding strong performance in domain classification.

Traditionally, polarization mapping in ABO_3 ferroelectrics is achieved by tracking intensity variations in diffraction disks [3] or Kikuchi bands [4]. Here, we instead focus on the ferroelectric Boracite ($\text{M}_3\text{B}_7\text{O}_{13}\text{X}$), where symmetry breaking produces additional, offset diffraction disks that reflect polarization direction [5]. These “ghost” disks serve as signatures of local polarization. Boracite allows six distinct polarization orientations, and under applied bias, its domains and domain walls can readily reconfigure. Manual analysis of 4D-STEM images indicates that certain domain walls exhibit complex alternating polarization states. Because in situ 4D-STEM experiments generate enormous datasets (tens of terabytes) and polarization behaviour at moving walls is often non-trivial, automated methods are essential to accelerate analysis.

For this project, we constructed a CNN trained on ~1,000 labeled diffraction patterns randomly drawn from a ~40,000-image Boracite dataset. Images were classified into three categories: horizontal, vertical, or out-of-plane polarization, based on ghost disk offsets. Training required only ~10 minutes on a single GPU. During inference, each diffraction image was processed by the CNN, which output a categorical prediction that was then reconstructed into a polarisation domain map. The resulting maps, visualized using RGB coding, closely match those obtained through manual analysis, demonstrating that deep learning provides a fast and accurate alternative for polarization domain identification in complex ferroelectric systems.

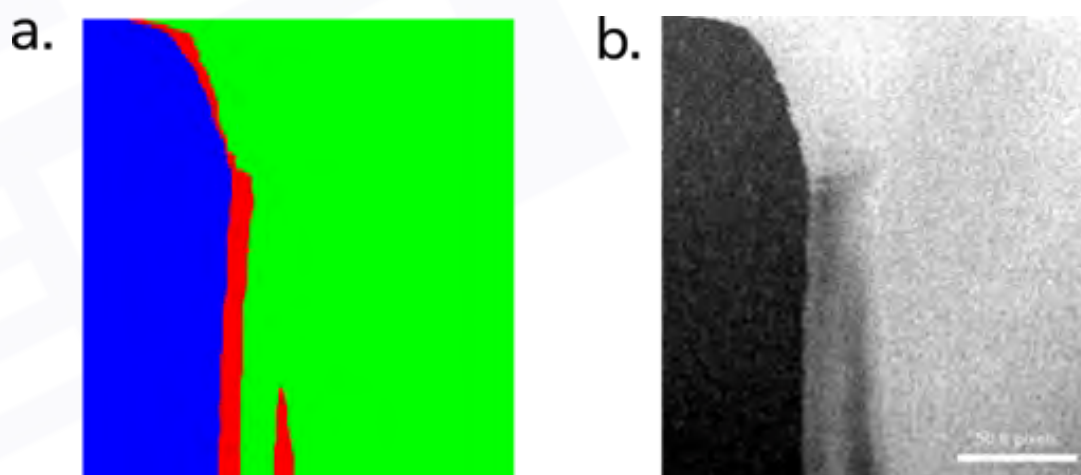


Figure 2. a) polarisation domain analysis the CNN mode (blue = vertically polarised, red = out-of-plane polarisation, green = horizontally polarised). b) polarisation domain analysis using py4DSTEM (Darker regions represent more vertically polarised image, lighter regions represent more horizontally polarised)

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Age-dependent changes of alpha-Synuclein in the motor cortex

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Alpha-Synuclein (aSyn) is a presynaptic protein that plays a significant role in neurotransmitter release, vesicular trafficking and the regulation of oxidative stress. The abnormal age-related accumulation of aSyn within neurones is thought to underly the pathophysiology of Parkinson's Disease (PD), most notably through the disruption and death of dopaminergic neurones within the substantia nigra. However, despite extensive research, the physiological role of aSyn remains poorly understood. aSyn interacts with multiple presynaptic binding partners, such as Synapsin-1 (Syn1) to facilitate vesicle clustering and recycling. Beyond its presynaptic roles, aSyn is functionally linked to postsynaptic scaffolds such as Homer1 (H1), which support synaptic signalling and structural plasticity. With ageing, the coordinated balance of these pre- and postsynaptic interactions may shift, providing insight into how synaptic architecture adapts over time and how changes influence neuronal function. To explore this, we focused on the motor cortex, a key region for synaptic integration and motor control.

We used young (3 months) and older (12 months) adult mice to evaluate and compare the expression of aSyn and its colocalization with Syn1 and H1 in the motor cortex. Immunofluorescent staining with confocal imaging was used to visualise protein expression in sagittal sections. FIJI ImageJ and MATLAB were used to analyse average molecular expressions by identifying peaks in fluorescent signal intensity.

Quantitative analysis of confocal images from the motor cortex revealed an increase in the mean density of aSyn expression in older compared to young brains. Syn1 expression did not differ significantly between age groups. In contrast, H1 expression was reduced in the motor cortex of older brains. Analysis of colocalisation between aSyn and its pre- and postsynaptic partners showed no significant age-related changes.

Collectively, our results suggest that age dependent mechanisms may contribute to aSyn increase at presynaptic sites without parallel changes in Syn1, suggesting subtle adjustments in presynaptic protein composition with age. This may influence vesicle dynamics and synaptic efficiency even in the absence of overt pathology. The reduction in H1 expression may contribute to reduced postsynaptic scaffolding, which may limit synaptic stability and plasticity in older animals. Together, these results highlight age-related shifts in the balance between pre- and postsynaptic proteins, offering a potential mechanism through which synaptic function gradually adapts during the ageing process.

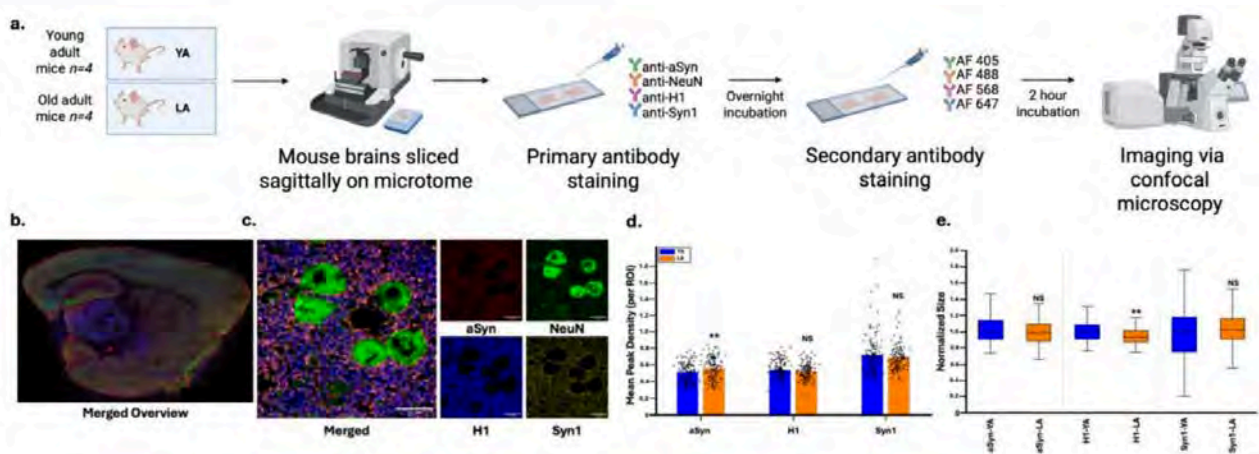


Figure 1. Experimental workflow, representative images and summary of findings. (a) Schematic illustration of experimental workflow. YA = young mice, 3 months old. LA = older mice, 12 months old. Primary antibodies: anti- α -Syn mouse, anti-NeuN guineapig, anti-Homer 1 rabbit, anti-Synapsin1 chicken Secondary antibodies: Goat anti-mouse ALEXA 405 fluorophore (AF 405), goat anti-guineapig ALEXA 488 fluorophore (AF 488), goat anti-rabbit ALEXA 568 fluorophore (AF 568), goat anti-chicken ALEXA 647 fluorophore (AF 647). Created in <https://BioRender.com> (b) Merged overview of a sagittal section showing the motor cortex. (c) Example of high-resolution images from the motor cortex, layer 2/3 expressing aSyn (red), H1 (blue), Syn1 (magenta) or NeuN (green). Merged image of all 4 channels. Scale bar: 15µm. (d) Mean density (per ROI) of aSyn, Homer-1, and Syn1. aSyn (YA vs LA, $P=0.0028$), Homer-1 (YA vs LA, $p=0.1920$), Syn1 (YA vs LA, $P=0.5316$). Two variable t-test was used to compare mean density of aSyn and Homer-1. Mann-Whitney U test was used to evaluate molecular expression of Syn1. (e) Box plot showing molecular expression of aSyn (YA vs LA, $P=0.1629$), Homer-1 (YA vs LA, $p=0.0016$), Syn1 (YA vs LA, $P=0.1182$). Mann-Whitney U test was used to evaluate molecular expression of aSyn and Homer-1. Two variable t-test was used to evaluate molecular expression of Syn1. All figures express results from analysis of the motor cortex, layer 2/3 in YA and LA cohorts. Expression is determined as ratio between ROI and background signal intensity. Data are presented as mean expression/normalised size $\pm$ s.e.m * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS not significant.



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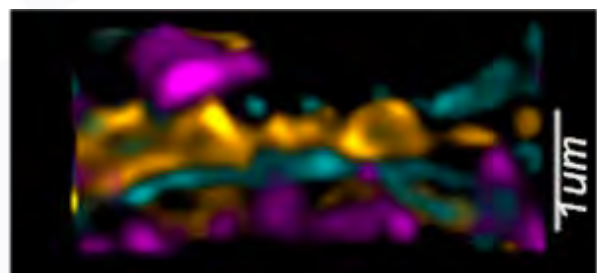
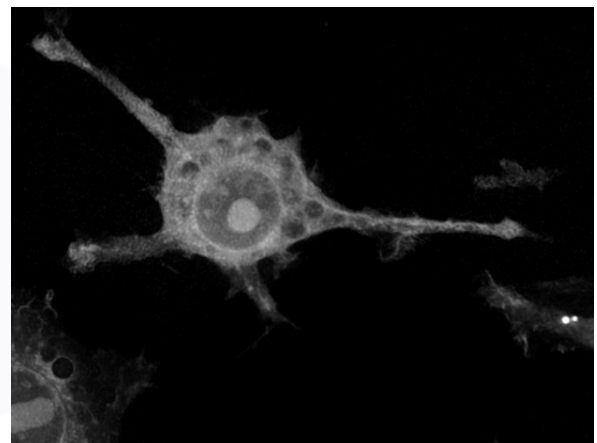
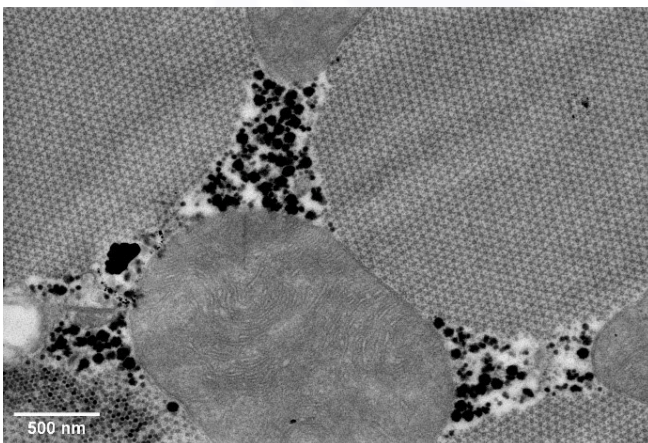
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The importance of enabling new technologies

Peter O'Toole

Director of the Bioscience Technology Facility and Head of Imaging and Cytometry, University of York and President of the Royal Microscopical Society

Core facilities are always evolving with new technologies and new applications/pipelines becoming available, adapting to new users and their new requirements. The role of the facilities is to ensure that we maximise the scientific impact of our instruments back to the academic users. The Imaging labs at York service over 400 users in any one year and cover a broad range of technologies from electron to a variety of light microscopes, from workhorse instruments to more bespoke and niche instruments. We have collaborations with large instrument manufacturers, e.g. Zeiss and Coulter, through to SME's such as Tomocube and historically Phasefocus. The talk will focus on the new technologies that we have helped develop, adapted and adopted and how we make access to these state-of-the-art facilities equitable across the internal and external user base. The critical importance of making the expertise and the equipment financially sustainable will also be discussed.



Mitochondria Tubulin ER

An SEM investigation of asteroid (101955) Bennu, returned by the OSIRIS-REx mission

Sara S. Russell, Tobias Salge, Ashley J. King, Natasha V. Almeida, Helena Bates, Paul F. Schofield, Harold C. Connolly Jr. and Dante S. Lauretta
The Natural History Museum, London, SW7 5BD

NASA's OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer) mission, which launched in 2016, mapped near-Earth asteroid (101955) Bennu, and returned ~122g of regolith samples to Earth in September 2023, with the aim of better understanding early Solar System processes. We investigated single ~mm sized particles using SEM imaging and EDX analyses.

Unprepared particles were initially analysed at 6kV at high vacuum using a FEI Quanta 650 field emission (FE)-SEM equipped with a Bruker QUANTAX EDX system, and an annular, high sensitivity XFlash FlatQUAD SDD. The particles were then mounted in epoxy, polished and carbon coated, and analysed using a ZEISS Ultra-Plus FE-SEM and Oxford instruments Aztec EDX system with a conventional, large area UltimMax 170 SDD. An intermediate accelerating voltage of 10kV was applied to limit the interaction volume of X-rays. Hyperspectral imaging data sets that provide complete spectra for each pixel of the SEM image were acquired from particles using automated stage control and pixel resolutions of 200-300 nm.

Both unprepared particles and polished sections yield information about the mineral constituents of Bennu and how it formed. All samples of Bennu are dominated by phyllosilicate (clay minerals), that make up typically ~80% of the rock. Carbonates, magnetite (Fe_3O_4) and sulphides are also major components, showing that Bennu consists of abundant minerals produced through the actions of water. We also found phosphates and halides, that may have formed during the evaporation of some of the last remaining fluid that was briny in nature. We also find some minerals, like olivine ($(\text{Mg,Fe})_2\text{SiO}_4$), that were present in the protoplanetary disk, and survived these asteroidal processes.

SEM/EDX analyses are able to determine the mineralogical and petrological properties of complex materials returned from asteroid Bennu, from which the history of the asteroid can be deduced; such asteroids may have been important in making our habitable planet. Analysis of unprepared particles is an effective technique for non-destructive analysis of precious space mission material.

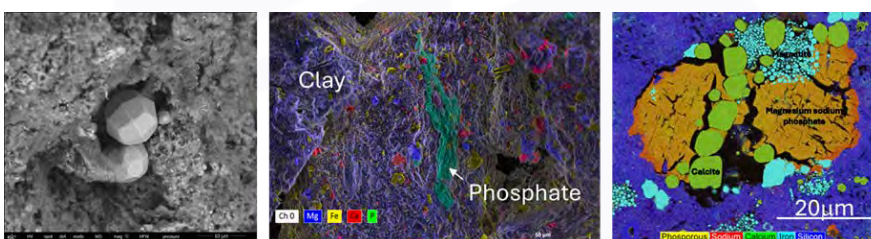


Figure 1-Left: SE image of magnetite crystals showing euhedral habit. Centre: EDX map of an unprepared Bennu particle, showing phosphate coating the phyllosilicate (clay) mass. Right: EDX image of carbonate and magnetite intergrown with phosphate in a polished particle.

Public Engagement and Outreach at the nmRC

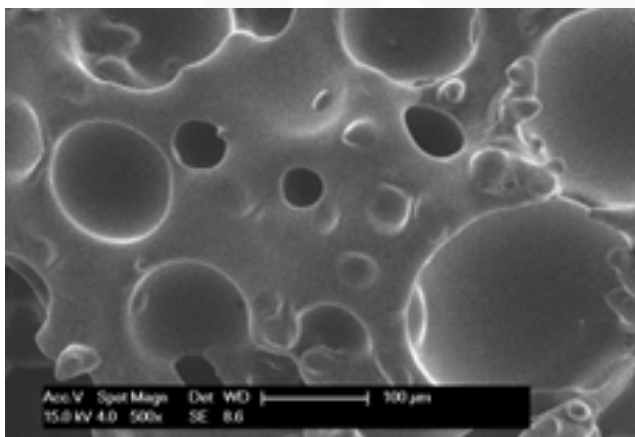
Sally Schofield

Nanoscale and Microscale Research Centre, University of Nottingham,
Nottingham

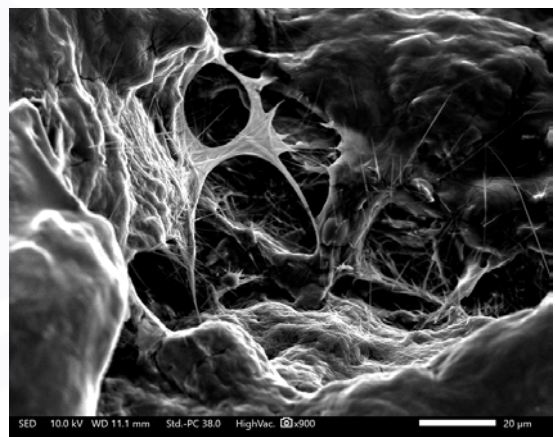
In March 2023 we launched an initiative called Under the Microscope, asking the public what everyday objects they would like to see imaged in microscopic detail. Following the success of this and with funding from the Royal Society of Chemistry, we then launched 'Under the Microscope LIVE!'.

Under the Microscope LIVE! Allowed us to introduce Scanning Electron Microscopy to secondary school students aged 14-17 years. In 6 months, we attended 12 schools, hosted 16 sessions and engaged with 285 students in total. We were also able to tailor our content to meet the needs of SEND (Special Educational Needs and Disabilities) students.

In this talk, we will share our approach to public engagement, discuss the challenges and successes of taking SEM on the road, and explore what we learned about making advanced science accessible and inspiring to diverse audiences.

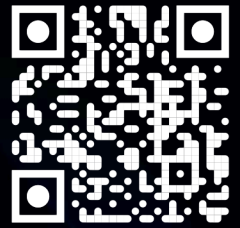


SEM Image of Honeycomb



SEM Image of Chewing Gum

Quorum



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Revealing the Black: Plasmonic Effects in Shakudo Sword Fittings

Agnese Benzonelli.^{1,2}, Pehlivan Z.S.³, Ringe, E.³, Martinon-Torres M.²

1. McDonald Institute for Archaeological Research, University of Cambridge

2. Department of Archaeology, University of Cambridge

3. Department of Materials Science and Metallurgy, University of Cambridge

This project investigates the physical mechanisms underlying the distinctive black coloration of Eastern artificially patinated copper–gold–silver alloys, particularly shakudo, historically used in Japan for sword fittings since the 13th century. While the addition of small amounts of gold and silver to copper has long been known to produce durable and visually striking patinas, the scientific explanation for this phenomenon has remained unknown.

Using a multidisciplinary approach combining archaeology, conservation science, and advanced materials analysis, we examined historical tsuba from the Fitzwilliam Museum, Cambridge, alongside experimental replicas. We investigated six historical tsuba selected to span different Au contents and prepared six FIB cross-sections; five lamellae were analysed alongside one experimental reference. Using FIB-prepared cross-sections and monochromated (S)TEM/EELS, we measured low-loss EELS spectra for plasmon analysis. The patinated surface comprises a cuprite-rich matrix containing nanoscale Au-enriched domains. Spectra show plasmonic features in the blue–near-UV region, data consistent with a plasmon-mediated mechanism, though further work is underway to identify the source of extinction.

By establishing a minimally invasive workflow for heritage metals we provide a replicable method to correlate nanoscale structure with macroscopic colour in historical alloys. The results refine current narratives about why Au is deliberately alloyed into shakudo and open new avenues for cross-disciplinary research on colour technologies and inadvertent nanostructuring in the past.

Graphene Windows: Innovating Liquid-Phase Electron Microscopy Methods for Mitochondrial Research

Katie Beirns^{1,2}, Brian Caffrey¹, Adrián Pedraza-Tardajos¹, Karl J. Morten², Angus I. Kirkland^{1,3} & Judy S. Kim^{1,3}

1. The Rosalind Franklin Institute, Harwell Campus, Oxfordshire UK. 2. Nuffield Department of Women's and Reproductive Health, University of Oxford, Oxford UK. 3. Department of Materials, University of Oxford, Oxford UK.

Mitochondria are vital organelles universally known as the powerhouses of the cell, though mitochondria regulate multiple cellular processes including calcium signalling and apoptosis. The regulation of broad cellular functions necessitates structural diversity and thus, mitochondria have a functionally significant ultrastructure that continuously adapts to meet changing cellular needs. Understanding the relationship between mitochondrial architecture and functional output is critical to recognising how mitochondrial perturbations drive cellular dysfunction and disease.

Electron microscopy (EM) imaging has greatly enhanced our knowledge of mitochondrial ultrastructure and structure-function relationships; however current mainstream EM techniques restrict studies to fixed or immobilised specimens. We aim to overcome this limitation by developing techniques to study functionally active mitochondria in graphene liquid cells (GLC) for liquid-phase electron microscopy (LP-EM). Strong attractive forces between graphene sheets form a hermetic seal that traps liquid around specimens, preserving them in an aqueous environment under the vacuum of the microscope, while simultaneously acting as electron-transparent viewing windows.

Using our developed GLC encapsulation technique, we have begun to explore the applications of LP-EM for investigations of mitochondrial functions in operando, examining the response of mitochondria to high calcium loads. Using fluorescence microscopy and scanning transmission electron microscopy (STEM), we have shown that the mitochondria retain their structural and functional integrity after graphene encapsulation, maintaining an intact transmembrane potential, and can take up calcium to form calcium phosphate granules. Our results demonstrate the potential of LP-EM to investigate the physical and functional changes mitochondria undergo in response to specific stimuli, enabling for the first time investigations of functionally active mitochondria using electron microscopy. With continued development, we envision broad applications of LP-EM that will improve our understanding of mitochondrial responses for biomedical research.

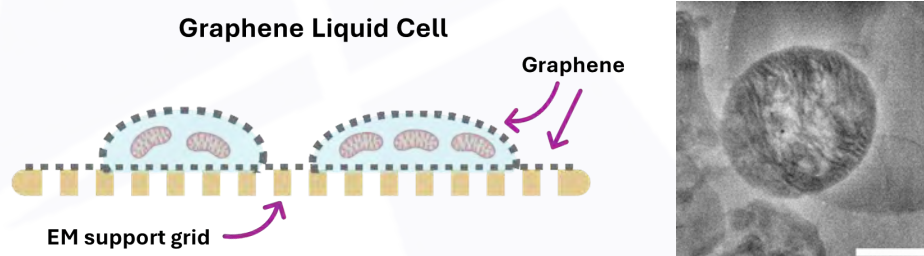


Figure 1. Mitochondria in Graphene Liquid Cells.

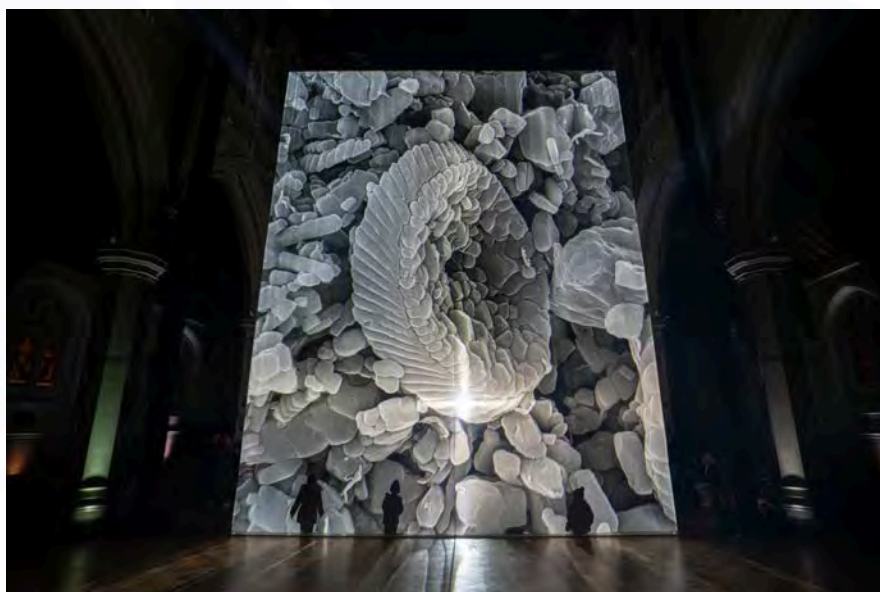
Left: schematic of a graphene liquid cell assembly. Right: Annular dark field STEM image of a mitochondrion encapsulated within a graphene liquid cell. Scale = 0.5 μm .

Beyond Appearance

Anna Heinrich and Leon Palmer

Anna Heinrich and Leon Palmer are two British artists who have worked in partnership for over 30 years. Anna and Leon will share some of their recent projects which include collaborations with scientists and show examples of how they have used different imaging techniques, such as scanning electron microscopy (SEM), in their work to look deeper into the nature of things beyond surface appearance. Their projection and installation work has developed from the multi-layered study of site and place with extensive uses of 3D lidar data, film and sound, combined with a fascination with the tension between the real and virtual.

Anna Heinrich and Leon Palmer have a cross-disciplinary approach and work with a wide range of media including large-scale projection, sound, light, optics, film, photography and digital imaging techniques. Their site specific work often evolves through a process of research, conversation and consultation. They have worked across the UK creating both temporary and permanent artworks, with residencies and commissions in diverse places such as Lindisfarne Castle, Aberdeen Spectra Light Festival, Chester Cathedral and Wakehurst, Royal Botanic Gardens Kew. In 2020 they undertook a year long residency at the University of Southampton where they were introduced to and trained to use a range of different imaging techniques including SEM, resulting in the work Inner Worlds. Since then they have used SEM in a number of recent projects including In Visible Light commissioned by Royal Botanic Gardens Kew for Meadowland at Wakehurst, and Once a Sea for We Shine Portsmouth.



Once A Sea Installation

Front cover images were produced by schoolchildren using a Hitachi benchtop SEM, loaned to schools over the past four years as part of the Hitachi STEM Education Outreach Programme kindly supported by:-
Hitachi HTA, Oxford Instruments, RMS, IRIS and the NHM.



Thank you for attending SEMT One-Day Meeting 2025