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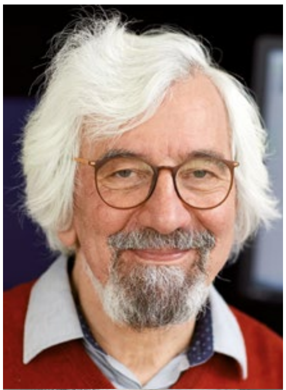

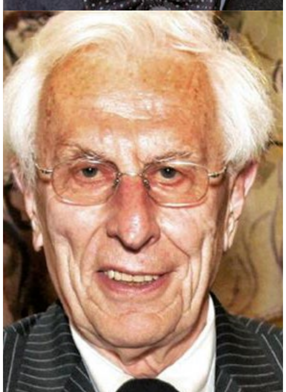

European Microscopy Society

Yearbook 2020

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thermo scientific

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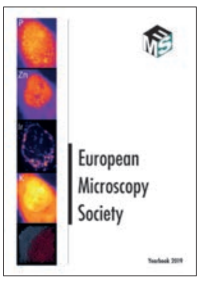

This bottom image was chosen as the cover of the Yearbook 2019.
Thanks to Serhii Kostrikov, MD, PhD, Postdoctoral researcher.
Affiliation: Technical University of Denmark, Department of Health Technology, Colloids and Biological Interfaces group.
Information about the image:
On the image one can see vasculature of both tumor-free mouse brain (gray pseudo color) and orthotropic patient-derived glioblastoma xenograft (red pseudo color) in the optically cleared tissue sample. Vasculature was labelled by intravenous injection of Alex Fluor 647-conjugated wheat germ agglutinin. The dataset was acquired with confocal laser scanning microscope – LSM780 (Zeiss Microscopy), 10x objective with NA 0.3. 3D rendering was done in Amira software (Thermo Fisher Scientific).

PREFACE

Dear EMS members,

It is our great pleasure to send you the EMS yearbook of 2020.

What a very strange year!

Despite the unusual worldwide health context, our community continued its strong activity, inventing new ways of communicating, working, exchanging, and constantly renewing. This yearbook, which contains many information, which will for sure convince you about the good health and dynamism of our society. In particular look for the two EMS award papers from Sara Bals and Emmanuel Beaurepaire, and additionally a very nice paper about the KAVLI price, who was awarded this year to four very important personalities of our community.

In early April this year, the EMS Executive Board met virtually to set the future of EMC2020 and 2024, the conditions of the next General Council, General Assembly as well as the candidacies for the new board.

As you had already know, EMC2020 conference was to be chaired by conference chair Prof. Klaus Qvortrup and his efficient local team and RMS-as PCO, before it was post-poned. Instead, we had a very successful virtual early career European Microscopy Congress in November 2020. Looking ahead to EMC2024, despite the huge work of the applicants and of the Executive board, the four applications (Barcelone, Brno, Budapest and Maastricht) the General Council unanimously voted to reconvene in Copenhagen. We look forward to attending this future event that EMS is going to spare big effort over the next 4 years.

Early in 2020, the jury of the EMS Outstanding Paper Award came to a decision on the round of 2019. 24 papers of very high quality were nominated, more precisely: 6 Instrumentation and Technique Development papers, 9 Life Sciences papers and 9 Materials Sciences papers. The following papers were selected as award winners: Hage et al. (Instrumentation), Cserep et al (Life Sciences), and Barroo et al (Materials Sciences). Congratulations to all the authors of these outstanding papers! We also warmly thank the nominators of all other exceptional papers and look forward to a new round by next January 2021 for the 2020 papers. The EMS expresses gratitude to the brilliant jury and chair Peter Nellist, who worked for the last time in this quadrennial.

In 2020, 4 events where sponsored by the EMS, and motivating reports are available in this yearbook.

This 2020 EMS yearbook is printed and distributed by ERI company, free of charge for the Society. Special thanks to the firms who have advertised in its pages to support us.

Thanks also to all our colleagues who have contributed to and helped proof-read this yearbook.

We look forward to new developments, announcements, and a fascinating time at EMC2024 - hope to see you all at the end of August 2024 in Copenhagen!

Virginie Serin
EMS Secretary


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LETTER FROM THE PRESIDENT

Dear EMS members,

You are now browsing the EMS yearbook 2020, which is yet more proof of the resilience of our Society. We have responded to the COVID-19 pandemic by maintaining all our normal activities, most of which you are found within these pages, while adapting others to the new circumstances. The best example of the latter is the successful virtual early career European Microscopy Congress from November 2020, which partly replaced the cancelled EMC2020. The meeting gathered several hundred young attendees, and was wonderfully organised by the Nordic Microscopy Society and the RMS as PCO. Thanks to all of those who led the efforts, in particular their head, Prof. Klaus Qvortrup. Other meetings and workshops went virtual, some of them sponsored by the EMS.

When the decision to cancel EMC2020 was made at the virtual General Assembly meeting in August, it was also decided to transfer responsibility for EMC2024 to the same organising committee, the Nordic Microscopy Society, and it will be held in Copenhagen. This was a difficult decision because it involved the cancellation of excellent bids for EMC2024 from four cities: Barcelona, Brno, Budapest and Maastricht. Let us hope that these bids and others can also be present in Copenhagen in 2024 for the organisation of EMC2028.

As with other EMS yearbooks, this one covers a variety of topics from our multifaceted society, giving full coverage of all the EMS-supported activities. Regarding awards, you can read the papers from our two most recent awardees, Dr. Sara Bals (EMAT-University of Antwerp; JEOL-European Microscopy award for the Physical/Materials Sciences and Optics category), and Dr. Emmanuel Beaurepaire (Ecole Polytechnique/CNRS/INSERM Paris; FEI-European Microscopy award for the Life Sciences category). Other awards such as the EMS Outstanding Paper Awards in Instrumentation, Life Sciences and Material Sciences, and others received by EMS members in different forums are also mentioned. A comprehensive description of most of the EMS-related activities that took place during 2020 can also be found in these pages, in particular those organised by the national societies.

An essential aspect of the EMS activities is the support given to meetings and workshops organised by EMS members, including scholarships for young attendees. The readers will find a comprehensive report of these events, which are supported by the money received from our members and from corporate sponsors, in an account of the EMS finances for 2020 by our Treasurer, Prof. Christian Schöfer.

Going back to the virtual General Assembly meeting from last August, one of the important decisions made was the renovation of the Executive Board, some of whose members were confirmed in their posts. The members of this new Executive Board include me, the President (José María Valpuesta; Madrid, Spain), the Secretary (Virginie Serin; Toulouse, France), the Treasurer (Christian Schöfer; Vienna, Austria), and the members Cristiano Albonetti (Bologna, Italy), Lucy Collinson (London, UK), Randi Holmestad (Trondheim, Norway), Agnes Kittel (Budapest, Hungary), Saso Sturm (Ljubljana, Slovenia), Servet Turan (Eskişehir, Turkey) and Igor Weber (Zagreb, Croatia). The Executive Board includes the *ex officio* members Josef Zweck (Past President; Regensburg, Germany) and Klaus Qvortrup (EMC Chair; Copenhagen; Denmark), and the ECMA representative, Kornelia Weidemann.

The Executive Board's renewal meant the sad departure of Serap Arbak (Istanbul; Turkey), Thierry Epicier (Past EMC representative; Lyon, France), Peter Nellist (Oxford, UK), Roger Wepf (former Past President) and the ex-ECMA representatives Stefan Kuypers and Rod Shipley. Their work on the Executive Board is greatly appreciated and their personal figures will be missed.

There is a Spanish saying that can be roughly translated to "gratitude is the sign of noble souls", thus we are deeply grateful to all the members of the Executive Board who have coordinated all the activities described above. A special thanks goes out to all the sponsoring companies, which are not only active in assisting the scientific activities of EMS members, but also support each meeting and workshop, and who have made possible the free printing and distribution of this yearbook.

Another special thanks goes to the EMS Secretary, Prof. Virginie Serin, and the EMS PCO liaison, Marina Vita, for putting so much effort into coordinating this yearbook, which condenses the work of a very active community, with more than 6500 members belonging to 24 national societies.

The COVID-19 pandemic is still with us, but has not greatly affected our doings; most of the upcoming 2021 EMS activities have gone virtual and will be described in the next EMS yearbook.

José M. Valpuesta
EMS President

TESTING INSTRUMENTATION IN THE NANO AND MICRO SCALE BY SCHAEFER-TEC

schaefer
www.schaefer-tec.com

The Schaefer-Tec group with offices in Germany, Switzerland, France, Italy and Romania is a European distributor and service provider for a number of scientific testing instruments. Schaefer-Tec has been founded over 50 years ago, originally with vacuum technology, and has evolved over time to include instruments for nano- and microtechnology respectively surface analysis. The following interview has been made with the CEO, Martin Bossard.

Which are today your main product lines?

We see a strong demand for advanced **optical and mechanical 3D profilometry** which we cover with products from our partners KLA (Zeta), GBS and Sensofar. Optical 3D profilers allow the form and roughness measurement of surfaces with features down to sub-micrometer lateral dimensions and structure heights down to nanometres. The Zeta-300 optical profiler for example has the possibility of automatic wafer handling while other models offer five-axis sample handling for 360° stitching, or fast analysis for in-line inspection.

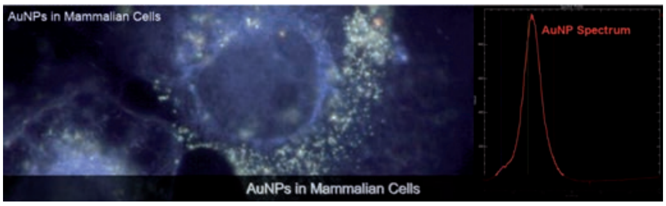
Another important line are the **Nanoindenters** respectively **Nanomechanical testers** from KLA. They provide reliable measurements of hardness, Young's modulus, and other mechanical properties at the surface to explore new materials and reduce product failures. The large range of models include frequency-specific testing, quantitative scratch and wear testing, integrated probe-based imaging, high-temperature testing, in-SEM use and many more.

Are you also selling high resolution microscopes?

We are representing **AFM's** (RHK, for UHV AFM/STM as well as CSI which is particularly strong in electrical measurements) as well as **SEM's** (Phenom desktop SEM's).

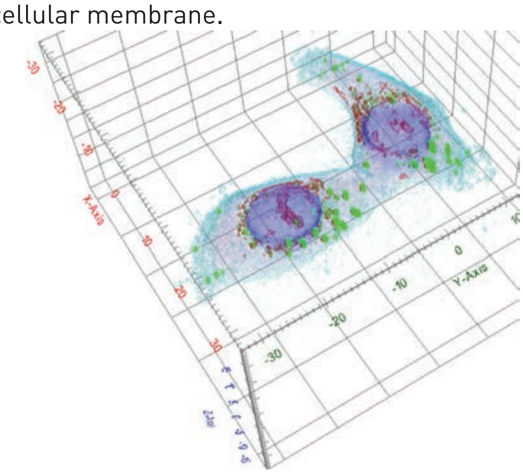
You mentioned nanotechnology, which products do you have in that field?

Besides the AFM's which were already mentioned we offer instruments for the detection and qualification of **nanoparticles**. For example the CytoViva label-free detection and identification of nanoparticles in cells or tissue by the patented **Enhanced Darkfield Hyperspectral Microscopy.**
For precise size distribution measurement of nanoparticles, we propose the LS Instruments laser light scattering instruments.



That means you are also working in biological systems?

Yes, besides CytoViva we also represent a new **Holotomographic (3D holographic) microscopy** technology from Tomocube which enables the quantitative and noninvasive investigation of biological cells and thin tissues. The Tomocube microscope reconstructs the 3D refractive index distribution of live cells and by doing so, provides structural and chemical information about the cell including dry mass, morphology and dynamics of the cellular membrane.



Is there a "last but not least" field we have not covered yet?

There are a few, but I would like to mention the **Micro- and Nano-Probing Robots** (Imina) for Nano-probing and -manipulation inside a SEM, FIB or under an optical Microscope with unsurpassed precision, as well as **Cryostats** (ARS Cryo).

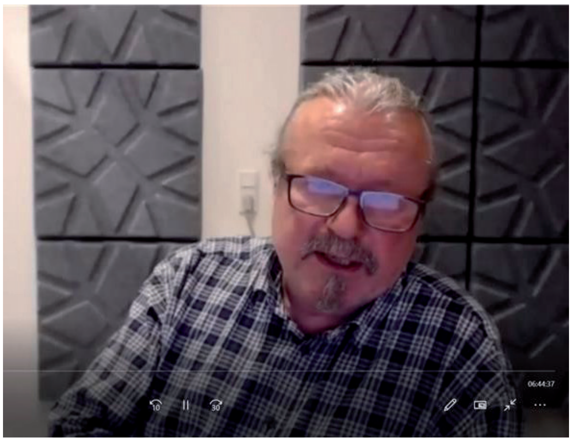
REPORT ON EMC2020

EMC2020 - VIRTUAL EARLY CAREER EUROPEAN MICROSCOPY CONGRESS 2020
24 – 26 November 2020 | Online

During the first months of 2020, many of our friends and colleagues will have been greatly looking forward to the year's biggest event in microscopy – emc2020, scheduled to take place in August in Copenhagen. Undertaking and planning an event of this size and complexity is always a huge challenge, and an immensely exciting business. I am sure that everyone involved on the organising committees – SCANDEM, the EMS, RMS and others – would agree that we were well on the way to delivering a fantastic Congress, sure to live long in the memory for those attending.

Needless to say, no one could have foreseen the intervention of a global pandemic. Still, as the potential implications of Covid-19 became clear in March, and many European countries began to lock down, we continued our preparations. The hope was that by late August, restrictions relating to public gatherings might have eased sufficiently for the event to go ahead. Sadly, it was not to be. In April the Danish Government announced that public events for more than 500 people could not take place until 1 September, which meant emc2020 was cancelled as a force majeure. Of course, the safety of congress delegates, visitors, and exhibitors must always be our highest priority, and in the context of the damage wrought by Covid-19 across the world, the cancellation of public events seems like rather small change. But the loss of emc2020 was still a huge disappointment for everyone who had put so much time and effort into its planning – and, I am sure, for everyone looking forward to attending.

Allison Winton, Chief Executive RMS, PCO EMC2020



Klaus Qvortrup, University Copenhagen, Denmark, SCANDEM, president of EMC2020,

We are especially grateful for the understanding and goodwill of our many exhibitors, sponsors and other partners, who had fully committed to the event. Many of our exhibitors even donated a proportion of their refunded booking fee to the appointed PCO of the congress, the RMS – a fantastic gesture which helped to offset some of the Society's losses.

But that wasn't quite the end of the story for emc2020, because one major element of the Congress did eventually go ahead – albeit in a virtual format. Among the key elements of the original programme was the eagerly-awaited Early Career meeting, which a huge number of young researchers had been planning to attend. Their desire to provide an opportunity for early career scientists to present their work at an international meeting – despite the circumstances – led to the planning of a huge, online conference, which took place over three days in November. Titled 'Virtual Early Career emc2020', the event was a great success, with more than 150 speakers presenting recent PhD and postdoctoral research to an audience of several hundred more.

Despite being virtual, the conference provided ample opportunity for scientists to network with experts in the field on an international stage. The online format also allowed those who may not have otherwise been able to attend an in-person meeting to engage with the European microscopy community.

I would like to thank the RMS for hosting this important meeting, thereby ensuring that we were able to salvage something of huge value from the ashes of emc2020. The feedback we have received from those who took part has been really heart-warming.

Looking ahead to 2021 and beyond, my immediate hope is - unsurprisingly - for us to meet again in person, and for the pandemic to subside as quickly as possible. We have already seen some fantastic progress in terms of vaccine development, and I would like to pay tribute to the tireless dedication of scientists and medical professionals in tackling the crisis around the world.

I am also very excited about working with my colleagues at SCANDEM, the EMS, RMS, and others, as we prepare to stage emc2024! Because of course, emc2020 was not strictly cancelled; it was merely postponed for four years, to take place at the same venue – Copenhagen's fantastic Bella Centre – with the same, unparalleled range of conference sessions, meetings and other features – including the all-important opportunities for networking and socialising.

In fact, we're aiming to put on a Congress that is even better than emc2020 was shaping up to be, and can't wait to see you there in a few years' time! ■

Klaus Qvortrup
Chair of EMC2020,
University of Copenhagen

EARLY CAREER EMC2020 MEETING – MY PERSONAL IMPRESSIONS

After the emc2020 meeting in Copenhagen had to be cancelled due to the pandemia caused by the Covid-19 outbreak, the question that quite obviously arose was how to handle the abstracts for the congress which were already received. For the EMS executive board it was no question that EMS had to offer an alternative to the regular congress, especially for young scientists. We all enjoy the open exchange of ideas, when they can be presented in a congress to co-scientists and be subject of critical discussions. Many of us experienced this already many times and know about the enormous importance of listening to talks about recent developments and results, being presented with the researcher's interpretation, and about the networking possibilities. By listening to various presentations – which do not have to completely agree on the message involved – we get a rich menu of "brain food", topped with "desserts" in poster sessions. It is this invaluable input of many facettes of a certain topic, which enables us to penetrate a scientific problem to the smallest details, expertly presented by our fellow colleagues from many different viewpoints. In the end, this enables every one to come to his or her own conclusion by judging the pro's and con's laid out in the presentations.

While for senior scientists the cancellation of a congress may be a nuisance, although a rather grave one, they already experienced the merit of numerous congresses and they already have their network established. For a young scientist who is just at the brink of his or her early career, missing this important opportunity is very unfavourable. Even more important is the experience to have one's own results presented to an expert audience and to receive and answer questions.

I had the chance to follow most of the time the "Early Career emc2020 Meeting", jointly organized by the EMS and RMS. For me – as probably most of us – it was the first time to attend a large meeting from the distance, and I have to state that I found it extremely useful. My thank goes to the session chairpersons (who did an incredible job!), RMS who did a perfect job in organizing the virtual meeting, and to all contributors. I really enjoyed to listen to the talks, and was even more positively surprised as I found that many topics of my current interests have been extensively covered by excellent presentations. I used the chance to ask questions, as many others did so, too, and I was contacted during the meeting by several persons directly.

Although I still hope that we can meet in person again in the (near) future, I have to state that this "Early Career emc2020 Meeting" was a very worthy place to visit for me, well organized and maintained and crowded by many young scientists with excellent presentations. Thanks to the commendable discipline of all involved persons in the discussion, these have also been very fruitful and as lively as in a regular conference.

In summary, the "Early Career emc2020 Meeting" was not what the EMS aimed for when planning the emc2020 congress, but it turned out to be an extremely successful possibility to bring together young scientists from all over the world and enable scientific exchange even in these complicated times. Thank you to all persons who helped to make this a success!

Under the few things I missed, though, was the opportunity to be able to ask someone to join me on a remote table for an in-depth discussion or to meet in the evening for a nice dinner and drink with friends and colleagues – maybe the organizers will find ways to provide even that in the future if the necessity should arise ;-)

Wishing everyone all the best – I am looking forward to meeting you in person again! ■

from Josef Zweck,
EMS Past President

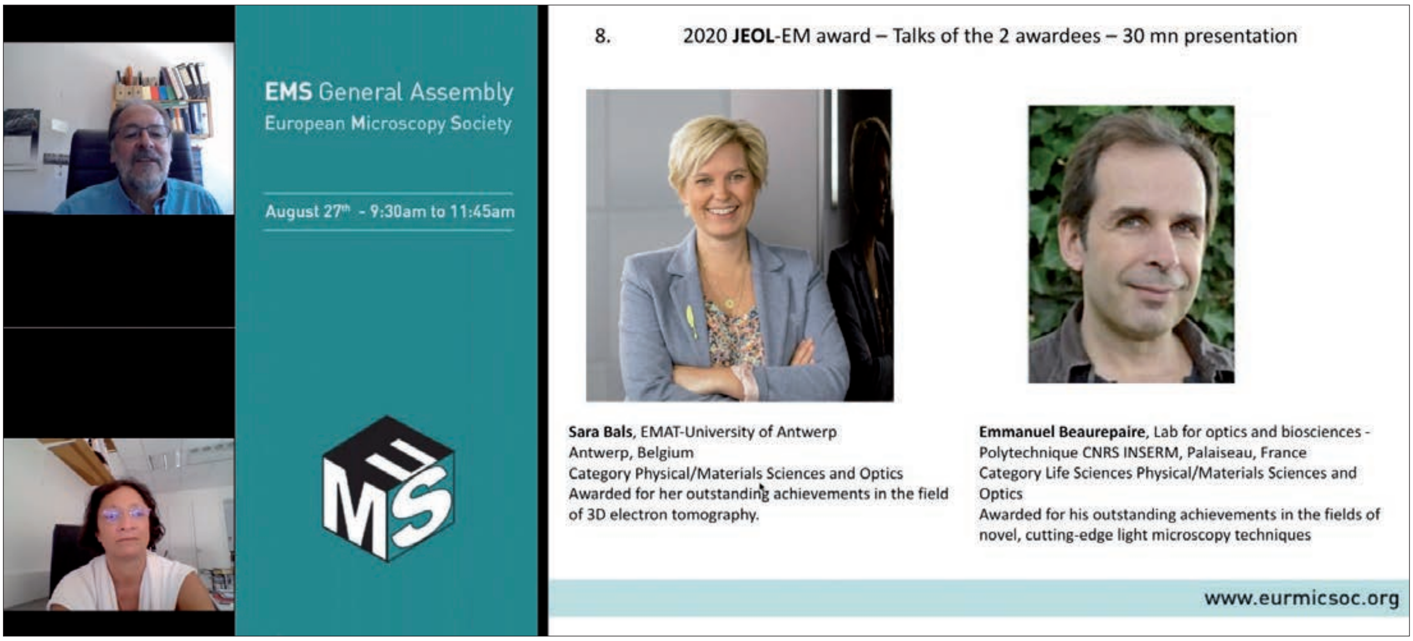
EM AWARDS

2020 JEOL-EUROPEAN MICROSCOPY AWARDS

The 2020 JEOL-European Microscopy award for the category Physical/Materials Sciences and Optics goes to Dr. Sara BALS from EMAT-University of Antwerp, Belgium, for her outstanding achievements in the field of 3D electron tomography by combining state-of-the-art electron microscopy with advanced reconstruction algorithms.

The Life Sciences award was delivered to Dr. Emmanuel BEAUREPAIRE from the laboratory for optics and biosciences CNRS-INSERM-Polytechnique, Palaiseau, France for his outstanding achievements in the fields of developmental biology and neurobiology by development of novel, cutting-edge light microscopy techniques. The winners of this prestigious quadrennial award founded in 2004 receive the amount of 3.000 euro and a glass plaque for display.

We congratulate our winners once more and look forward to a new round in 4 years. ■



Pictures of presentation of the awardees by Joseph Zweck and Virginie Serin during the virtual EMS general assembly, August 2020.

MULTIPHOTON MICROSCOPY OF BRAIN AND DEVELOPING TISSUES

www.lob.polytechnique.edu

This short article is related to the 2020 EM life sciences award from the European Microscopy Society.

Introduction

Since its introduction in the early 90s at Cornell University, multiphoton microscopy[1,2] has become a reference technique for fluorescence imaging of intact biological tissues in fields ranging from neuroscience to developmental biology and physiology. Multiphoton (or nonlinear optical) microscopy is an application of femtosecond lasers and provides a unique combination of imaging depth (~3 scattering lengths, or ~500 microns in brain tissue), 3D resolution (approximately 0.5 × 0.5 × 2 μm^3) and sensitivity (taking advantage of fluorescence contrast). In multiphoton microscopy, a femtosecond near-infrared laser (750-1300 nm) is focused and raster-scanned in the sample. A nonlinear optical effect such as two-photon-excited fluorescence, which is intrinsically confined to the vicinity of the focus of the objective, is used as contrast mechanism. This 3D confinement is maintained until imaging depths of several hundreds of microns, which makes the technique uniquely suited for tissue-scale morphological and functional studies.

Over the past three decades, the field of multiphoton microscopy has seen multiple technical and applicative developments. Technology was pushed to image deeper, faster, and to provide more contrast modalities. Novel applications were developed in synergy with the methods.

The "advanced microscopies and tissue physiology" team at the Optics and Biosciences Laboratory (LOB) at Ecole Polytechnique, Palaiseau and its collaborators have been since 2002 active in the field of tissue multiphoton microscopy. Collectively, our contributions include two types of studies: (i) methodological innovations for the observation of developing tissues (multicolor two-photon excitation, third-harmonic generation imaging, adaptive optics, pulse shaping, etc), and (ii) pioneering applicative studies with biologist colleagues such as the quantitative description of cell divisions during the first three hours of zebrafish development using multiharmonic microscopy[3], the first demonstration of a mechanical-genetic feedback loop during Drosophila early embryo development using laser ablation[4,5], or the first brain-wide high-resolution imaging of brainbow-labeled tissue[6]. Some of these advances and results are summarized in the next sections.

Multicolor nonlinear microscopy for the study of neurodevelopment. To study the development of complex tissues such as those of the central nervous system, it is necessary to simultaneously monitor many parameters, and for example to map the distribution of several fluorescent proteins with micron-scale resolution over large volumes (several cubic millimeters). With the objective of imaging large volumes of multicolor-labeled 'brainbow' tissues, our group has introduced in 2012 a new approach to two-photon trichromatic excitation by frequency mixing[7]. Together with our collaborators at Institut de la Vision (J. Livet et al), we then developed an original imaging system integrating this approach of multicolor multiphoton excitation with automated serial sectioning (chromatic multiphoton serial (ChroMS) microscopy[6], Figure 1). This system enabled for the first time to record 3D maps of ex vivo mouse brains labelled with the multicolor 'brainbow' method, at arbitrary depth with cellular resolution. Within 1-2 days of acquisition it is possible either to map a mouse brain with one plane every 100 µm, or to image a continuous volume of several cubic millimeters. A first application using this technique to reveal the clonal development of cortical astrocytes was published in 2019 [8].

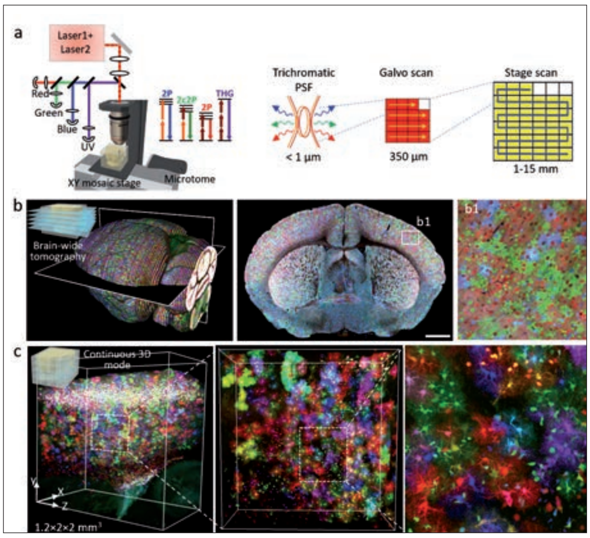


Figure 1. Multicolor multiscale brain tissue imaging with chromatic multiphoton serial (ChroMS) microscopy. (a) Principles of the instrument. (b) Brain-wide serial-2D mode, in which one plane is recorded every 50 µm. (c) Continuous 3D mode, where a volume of several mm^3 is imaged without data loss. Collab J. Livet, Institut de la Vision. Adapted from Abdeladim, Nat Comm 2019.

Using the wavelength mixing approach, we also developed methods for (i) multicolor two-photon fluorescence lifetime imaging (FLIM)[9], (ii) long-term imaging of adult neural stem cells in the live adult fish brain (collab N. Dray & L. Bally-Cuif, Institut Pasteur)[10], or (iii) ex-vivo brain-wide zebrafish imaging[11].

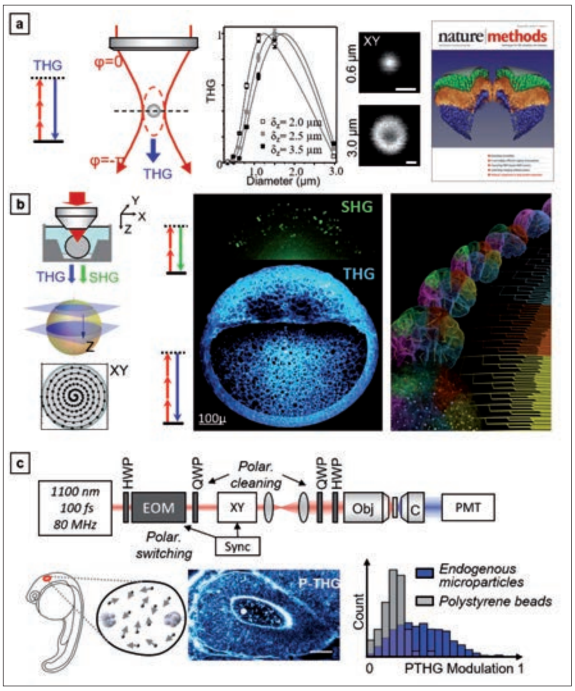


Figure 2. THG microscopy: principles and applications. (a) Effect of the phase distribution of the excitation beam on image contrast. THG imaging highlights heterogeneities and interfaces such as lipid droplets. Adapted from Debarre, Nat Meth 2006. (b) Reconstruction of the zebrafish embryo early development using label-free THG-SHG microscopy. THG reveals morphology and SHG highlights mitotics spindles in dividing cells. Collab N. Peyriéras, CNRS. Adapted from Olivier, Science 2010. (c) Extension to fast polarization THG imaging and detection of flowing biocrystals in vivo. Adapted from Morizet, Optica 2019.

Novel contrasts: third harmonic generation microscopy (THG) for imaging non-fluorescent biological tissues. One specificity of multiphoton microscopy is that it gives access to complementary contrast mechanisms in addition to fluorescence. The same imaging platform can be used to obtain 3D images based on processes such as second-harmonic generation (SHG), third-harmonic generation (THG), coherent anti-Stokes Raman scattering (CARS), fluorescence lifetime (FLIM), and their polarization-resolved extensions. All these signals provide additional information on cells and samples, provided one can relate them to their biological origin. Our group has published a fair number of contributions on harmonic generation imaging. In particular, THG microscopy (first demonstrated by Barad et al[12]) provides an image of non-fluorescent media based on third order nonlinear susceptibility. At LOB, we have pioneered the use of this approach for biological imaging by elucidating its contrast mechanisms. We have identified that lipidic structures are a major source of THG contrast in cells and tissues[13].

We also showed that polarized THG imaging is a probe of molecular order in ordered lipids and biocrystals[14,15]. We have optimized the combination of THG with second-harmonic generation (SHG) contrasts revealing fibrillary collagen, myosin or tubulin, and we published several applicative studies using THG-SHG for analyzing embryo development[3], human corneas[17], bone tissue[18], etc. See Figure 2.

Deeper: towards multicolor deep-tissue live imaging with 3-photon excitation. Despite the good performance of two-photon microscopy in live biological tissues, its imaging depth is limited by scattering. At large imaging depths (>500 µm in densely labelled brain tissue), the confinement of two-photon excitation and the signal-to-noise ratio are strongly degraded. Recent work at Cornell University (C. Xu's group[19,20]) showed that a way to bypass this limitation is to implement three-photon excitation shifted in the near infrared (1.3 or 1.7 µm). This strategy can provide fluorescence microscopy images at depths exceeding 1 mm. In collaboration with the Lab Charles Fabry (LCF) at IOGS Palaiseau, we extended this concept by building the first dual-color 3-photon microscope, allowing simultaneous excitation of red and green fluorescent proteins deep in living brain tissue, with a higher signal-to-noise ratio than two-photon microscopy ([21], Figure 3).

Faster: rapid multiphoton imaging with light-sheet excitation. A general limitation of multiphoton microscopies is that they usually rely on point-scanning acquisitions.

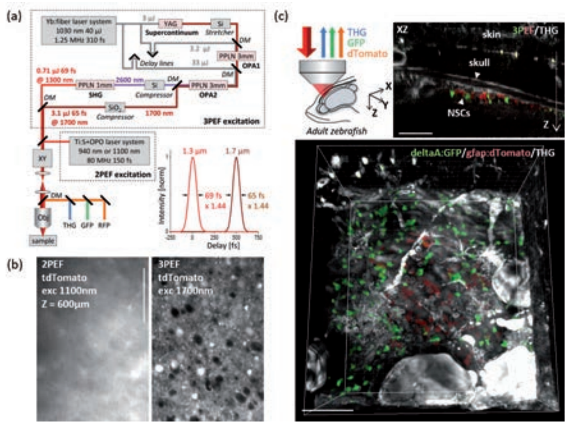


Figure 3. Dual-color deep-tissue three-photon (3P) microscopy. (a) New OPA laser source design providing simultaneous excitation at 1.3 µm and 1.7 µm. (b) 3P excitation improves SNR compared to 2P excitation deep inside mouse brain. (c) Simultaneous dual-color 3P and THG imaging of two cell populations labelled in green and red in the adult fish brain. Scale bars 100 µm. Collab. F. Druon, IOGS. Adapted from Guesmi et al, Light Sci App 2018.

Fluorophores photo-physics limit the pixel rate to few microseconds in standard microscopes, resulting typical acquisitioning times of ~0.5-1 s for a 512-512 image. Increasing the imaging speed is an active area of research, and one interesting strategy is to use light-sheet (or line-scan) excitation.
At LOB, we have combined our multicolor two-photon approach with the light-sheet geometry, resulting in trichromatic imaging of zebrafish embryo heart 100 times faster than with conventional multiphoton geometry ([22], Figure 4), at the expense of a somehow reduced imaging depth. Ongoing developments of this technology open interesting perspectives for fast tissue imaging[23].

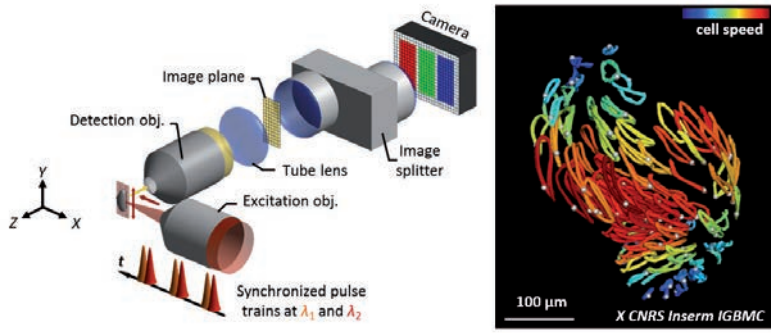


Figure 4. Two-photon light-sheet microscopy. Fast multicolor imaging and 3D reconstruction of a zebrafish embryo beating heart with 50Hz resolution. Collab W. Supatto. Adapted from Mahou, Nat Methods 2014.

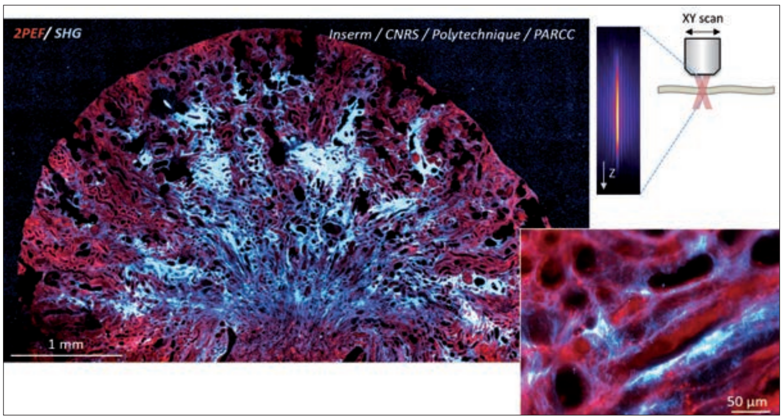


Figure 5. Beam shaping for multiphoton imaging. Programmable Bessel beam excitation provides extended-depth label-free 2-photon / SHG imaging. Application to the rapid screening of collagen in a histological section of fibrotic mouse kidney tissue. Collab PL Tharaux, HEGP Hospital. Adapted from Vuillemin, Sci Rep 2016.

Beam shaping for multiphoton imaging: wavefront control and Bessel beams. The signals observed in nonlinear microscopy depend primarily on the spatial distribution of the focused field (amplitude, phase, polarization). In turn, this distribution can be controlled by means of a spatial light modulator placed before the microscope to allow the improvement of contrast, depth, and imaging speed. Our group have explored the use of adaptive optics for multiphoton imaging of live embryos some years ago[24,25], and more recently introduced theoretically and experimentally the use of Bessel beams in harmonic generation- based microscopy and histology. We showed that it is possible to perform SHG imaging with extended depth of field (a "thick slice") by combining Bessel excitation and off-axis signal detection. This approach is potentially interesting for characterizing the distribution of collagen in histological slides, which are generally non-planar. In this context, Bessel excitation allows replacing a 3D scan by a 2D scan([26], Figure 5).

In conclusion, these developments now make it possible to image large volumes of brain tissue with cellular resolution and to analyze brain formation in terms of connectivity and cell lineage with a precision that could not be obtained 10-15 years ago. Other applications are currently being explored, in fundamental biology (embryonic morphogenesis, biomechanics, early cardiac development) or for projects with a more biomedical scope. Indeed, these advances in technology and fundamental biology are important steps towards a better understanding of cancerous or neurological pathologies. In the coming years, ongoing progress in multiphoton microscopes performance and miniaturization will without any doubt open additional application fields. ■

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ELECTRON TOMOGRAPHY: A 3D VIEW INTO THE WORLD OF ATOMS

This short article is related to the 2020 EM Physical/Materials Sciences and Optics award from the European Microscopy Society.

Introduction

Nanomaterials are of crucial importance in a broad range of applications including nanomedicine, catalysis, sensing or plasmonics. The functional properties of these materials are mostly determined by their three-dimensional (3D) structure and composition. Therefore, if one is able to measure the positions of the atoms, their chemical nature and the bonding between them, the properties of the nanomaterials can be predicted, which might even trigger the development of novel nanostructures. Therefore, the rational design of nanomaterials with desired functional properties strongly depends on the availability of quantitative 3D characterization techniques that yield information even down to the atomic scale.

After completing my PhD under the supervision of Professor Gustaaf (Staf) Van Tendeloo at EMAT (University of Antwerp, Belgium), I had the opportunity to join the National Center for Electron Microscopy at the Lawrence Berkeley National Laboratory, where I worked with Professor Christian Kisielowski. During our first meeting, Christian told me about a technique that was already popular in the field of biology and which was gaining increasing interest in materials science as well: electron tomography. I started reading papers on the topic and there was one paper published in Ultramicroscopy that really sparked my interest: "3D electron microscopy in the physical sciences: the development of Z-contrast and EFTEM tomography" by Paul Midgley and Matthew Weyland[1]. For me, this paper was the start of the rest of my career in electron microscopy. More than 17 years later, I received the quadrennial JEOL-EM award organized by the EMS. This is an incredible honour and the result of the work done by a large team of co-workers, including the entire EMAT group and colleagues across the world with whom I collaborate on electron microscopy techniques but also on materials- and nanoscience. Being able to explore the 3D world of nanomaterials and being able to visualize their structures and compositions is extremely fascinating. With the present text, I would like to share this fascination with the reader. It is not my intention to provide an actual review on electron tomography since excellent overview papers exist[2-6].

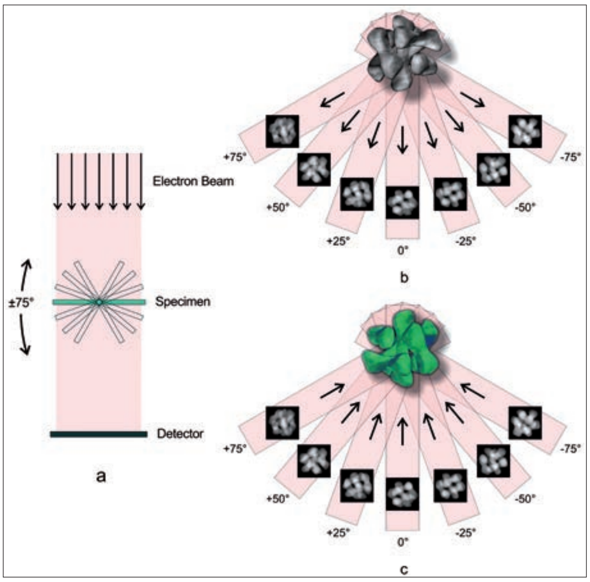

Figure 1. Illustration of a continuous electron tomography experiment, including the acquisition of a tilt series (a,b) and back-projection of the images along their original acquisition directions (c).

This paper is a subjective description of how I have experienced my journey in the 3D world of atoms.

From 2D to 3D

Aberration corrected transmission electron microscopy (TEM) allows one to characterize materials with a spatial resolution of the order of 50 pm[7]. Not only structural, but also chemical and electronic information can be obtained. However, one should never forget that TEM images are only 2D projections of 3D (nano)-objects. Electron tomography can overcome this limitation and has been used as a powerful tool to investigate the morphology, 3D structure and composition of a broad range of materials. When applying conventional electron tomography, a series of projection images is acquired by tilting the sample in the TEM over a large tilt angle range, with a tilt increment of typically 1º or 2º. Next, this tilt series of projection images is aligned, using e.g. cross-correlation. Finally, through a mathematical algorithm, the tilt series is combined into a 3D reconstruction of the original object. **Figure 1** illustrates the workflow of the technique for a 3D reconstruction of an assembly of Au nanodumbbells[8].

Different electron microscopy techniques such as bright field (BF) TEM, high angle annular dark field scanning TEM (HAADF-STEM), electron holography, energy dispersive X-ray spectroscopy (EDX) and energy filtered TEM (EFTEM) have all been extended to 3D[2,3,9-11] providing a variety of novel insights on a broad range of samples. The extension of electron energy loss spectroscopy (EELS) from 2D to 3D furthermore enables one to investigate valence in 3D. This approach was used to reveal a core-shell structure in ceria and in iron oxide[12,13]. Moreover, also the low-loss regime has been proven to be of great interest, e.g. to visualize surface plasmons in 3D or to map the 3D distribution of a polymer-fullerene blend in organic photovoltaics[14,15].

Seeing atoms in 3D

For many years, the ultimate dream was to achieve electron tomography with atomic resolution. First reports in which the 3D atomic structure of a nanoparticle was visualized, were based on a single 2D projection image. Through a quantitative analysis of the projected intensities in atomically resolved high angle annular dark field (HAADF) scanning transmission electron microscopy (STEM) images, acquired from a Au nanocluster, Li et al. were able to extract a thickness profile and a 3D model was proposed[16].

In 2011, a real breakthrough was performed when Van Aert and coworkers obtained a more unique 3D reconstruction at the atomic scale for a Ag nanoparticle embedded in an Al matrix[17]. This was achieved by a combination of counting atoms from 2 different directions and discrete tomography. It was hereby assumed that all of the atoms were positioned on a pre-defined fixed grid and that the particle was connected without the presence of vacancies. The same approach was used in a follow-up study in which the core-shell structure of a PbSe-CdSe nanorod was investigated[18]. Although discrete tomography provides an excellent start, deviations from a fixed grid may be present because of defects, strain or lattice relaxation.

Such deviation are of great importance as they determine the physical properties of nanomaterials. It was therefore clear that further progress was required. One may therefore wonder if continuous tomography can lead to visualisation of individual atoms in case the projection images yield atomic resolution. Fullerene-like nanostructures were investigated with a sub-nanometer spatial resolution by Bar Sadan and co-workers[19]. In 2012, Scott et al. reported a 3D reconstruction at a resolution of 0.24 nm based on so-called "equally-sloped tomography"[20]. The main difference in comparison to conventional electron tomography is that the tilt series is not acquired with a constant increment of the tilt angle between two successive projection images, but with a constant increment of the slope. Although not all atoms in the multiple twinned Au nanoparticle could be located in the reconstruction, individual atoms could be observed in some parts of the nanoparticle.

After these initial studies, different methodologies were proposed to obtain 3D reconstructions using a limited number of projection images or using continuous tilt series[21-23]. In this manner, 3D strain measurements became possible and also disordered structures could be unraveled[24-26].

Being able to measure lattice strain in 3D has indeed been an important goal in the field of (high resolution) electron microscopy. A well-known example of strained nanoparticles are the so-called "nanodecahedra" or "pentagonal bipyramids" (See **Figure 2**). To investigate their 3D structure, a continuous tilt series of 2D projection images was acquired in HAADF-STEM mode and a dedicated alignment procedure was applied[24]. During a conventional alignment, the angles at which the images in the tilt series are acquired are mostly fixed according to their nominal values. Here, the angles were estimated during the reconstruction in an iterative manner. In addition, we assumed that the 3D atomic potential can be modeled by 3D Gaussian functions.

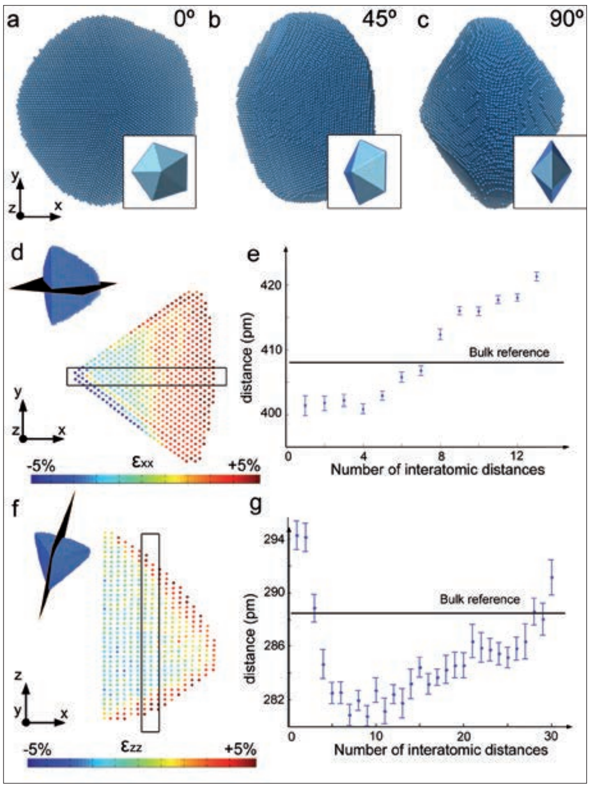

Figure 2. (a-c) 3D visualizations of the reconstruction showing the atomic lattice of a Au nanodecahedron. (d,f) xx and zz strain field showing a surface relaxation in both directions. (e,g) This surface relaxation is confirmed by measuring the lattice parameter on slices through the reconstructions.

Although this is a moderate hypothesis, it significantly simplifies the reconstruction problem to a sparse inverse problem, yielding the coordinates of the individual atoms as a direct outcome of the reconstruction.

Visualizations of the final 3D reconstruction, obtained for the Au nanodecahedron containing more than 90,000 atoms, are presented in **Figure 2.a-c** along different viewing directions. The inset displays the 3D model of the morphology. Since the coordinates of the atoms are a direct outcome of the reconstruction technique, it becomes straightforward to calculate the 3D displacement map. The displacements were calculated with respect to a reference region in the middle of the segment. Both along the x and z direction, a systematic outward expansion of the lattice can be observed. The expansion along z is limited to a few of the outer atomic layers and shows an asymmetry (**Figure 2.f-g**) that is likely to be related to the fact that the decahedron is deposited on a carbon support.

In situ 3D characterization

Despite the progress in the field of 3D imaging and the ability to see atoms in 3D, several open questions remain. The reason is that 3D characterization by TEM is typically performed using the conventional conditions of a TEM: ultra-high vacuum and room temperature. Since it is known that the morphology and consequently the properties of nanomaterials will change at higher temperatures or pressures, it is not surprising that a lot of effort has been devoted to the development of *in situ* TEM. In addition to the use of "Environmental TEM" (ETEM), dedicated *in situ* holders became very popular. Currently, a wide variety of holders is available, ranging from the application of strain, heat and light to electric biasing. Furthermore, different environments such as liquids and gasses can now be created in a TEM using environmental cells. All of these exciting opportunities have transformed the TEM from a *post mortem* technique into a true nano laboratory, enabling the investigation of transformations of nanomaterials, *in situ* and at the highest possible resolution. However, understanding the complex changes for anisotropic nanosystems in 3D rather than in 2D remains very challenging.

Combining *in situ* holders and advanced 3D characterization is indeed far from straightforward. There are technical limitations, such as the narrow tilt range of some holders, but also more fundamental aspects such as the time required to collect the tilt series of images. Even a trained user needs at least 1 hour to acquire a tilt series for conventional electron tomography. When combined with spectroscopic techniques, additional data need to be taken at every tilt angle, which increases the acquisition time to several hours. First attempts to accelerate the acquisition process of an electron tomography tilt series were done using BF-TEM[27]. In this manner, experiments at high temperature have been performed using a dedicated ETEM[28]. However, when investigating highly scattering nano-objects, which is often the case in materials science, diffraction contrast will violate the projection requirement for tomography[1]. We therefore recently developed fast HAADF-STEM tomography[29]. The main idea is that the holder is tilted uninterruptedly, while simultaneously acquiring a fast image sequence. The acquisition time achieved in this manner has been shown to be of the order of a few minutes for TEM and STEM imaging[30]. By combining the approach with a Micro-ElectroMechanical Systems (MEMS) heating holder, which can tilt over a range of ±80º, we were able to measure transformations of morphology and composition in nanoparticles as a function of temperature[29,31,32].

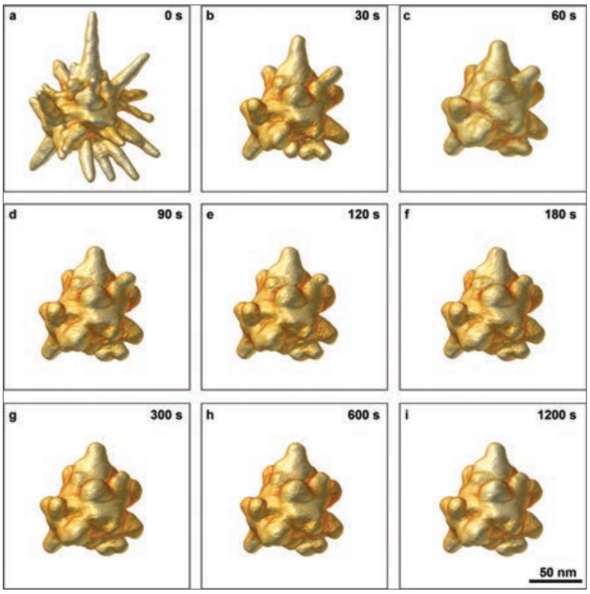

Figure 3. Reshaping of a Au nanostar as a function of heating time at a temperature of 300 °C. In between the heating steps, the sample is quenched in the TEM and a fast HAADF-STEM series is acquired. It is clear that the sharp branches of the nanostar disappear, which will influence the physical properties of the sample.

As a proof of concept, we recently studied the transformation of highly anisotropic Au nanostars at 200 °C, 300 °C and 400 °C *in situ* using heating tomography (**Figure 3**)[29]. Such studies are of great interest since anisotropic metal nanoparticles are known to reshape at temperatures hundreds of degrees below their bulk melting temperature. 3D heating experiments were carried out in a stop-and-go manner, where heating cycles were interrupted to acquire fast tomography tilt series.

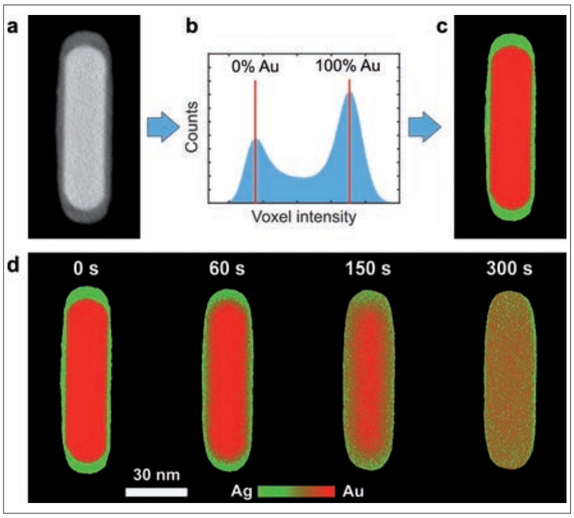

Figure 4. Illustration of the approach used to reconstruct the 3D elemental distribution inside nanoparticles upon heating. (a) Slice through the HAADF-STEM reconstruction of the Au@Ag core– shell nanorod. (b) Histogram of voxel intensities inside the particle; estimated intensity values for pure Ag and pure Au are indicated by red vertical bars. (c) Color map of the elemental distribution inside the slice of the nanorod before heating, where red corresponds to pure Au and green to pure Ag. (d) Slices through 3D compositional distributions inside the same particle at different stages of alloying.

Our results demonstrate an obvious reshaping behaviour for the Au nanostars and we also observed a morphology transformation for AuPd octopods in 3D[31]. By having the complete 3D information at every reshaping step, we could unambiguously demonstrate for the nanostars and octopods that indeed volume got redistributed from areas of higher curvature (tips/branches) to areas of lower curvature (sides) resulting in an overall decrease of the nanoparticle curvature. Next to monitoring surface diffusion, heating electron tomography can also be used to quantify internal nanoparticle elemental diffusion of e.g. alloying materials[32]. We hereby use the Z contrast in HAADF-STEM imaging. For core-shell geometries of materials with different Z contrast, each voxel intensity in the 3D reconstruction can consequently be attributed to an element and when the imaging conditions are not changed, the evolving voxel intensities can be used to quantify elemental diffusion inside the nanoparticle. In the specific work, we heated the initial Au-Ag core-shell particles at 450 °C to induce alloying (**Figure 4**). We quantified the progress of alloying and by fitting the experimental results to the outcome of diffusion simulations based on a discretization of Fick's law over the experimental voxel grid, we could calculate diffusion constants on a single nanoparticle level.

Unfortunately, fast tomography is not always applicable, e.g. the tilt range of most gas cell holders does not allow one to obtain a high quality 3D visualisation using conventional reconstruction algorithms. Estimation of 3D models from single 2D projection images is therefore gaining renewed interest. Using atom counting procedures, which is the field of expertise of Sandra Van Aert and her team at EMAT, it was shown that the number of atoms in a given atomic column can be counted with single atom sensitivity from HAADF-STEM images[17]. For example, this approach was used to investigate the dynamical behaviour of ultra-small Ge clusters[33].

To extend the 2D images into 3D, ab initio calculations were performed. Also for larger nanoparticles, counting results can be applied to build a 3D model when combined with molecular dynamics (MD) simulations. In this manner, the approach can be considered as an alternative path for those experiments where in situ holders simply do not yield sufficient tilt ranges for tomography. This is e.g. the case for gas flow holders enabling pressures up to 1 bar and temperatures up to 1000°C. Such holders clearly transform the TEM into a true nanoreactor, but unfortunately such system cannot be used for conventional tilt tomography experiments.

To measure variations of the 3D atomic structure of Pt nanoparticles, a model catalyst for numerous gas phase reactions, under the flow of H_2 and O_2, we applied atom counting combined with energy minimization[34]. **Figure 5** shows a Pt nanoparticle, in vacuum at 300°C (**Figure 5.a**), in 1 bar of 5% H_2 in Ar flow (**Figure 5.b**), and in a 1 bar O_2 environment (**Figure 5.c**). To investigate the transformation during cycling, the switch from H_2 to O_2 was repeated several times using the same particle.

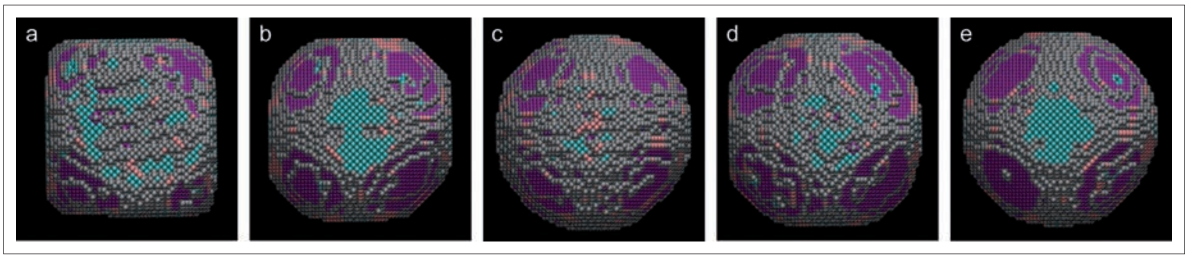

Figure 5. 3D structure of a Pt NP in vacuum (a) and in different gaseous environments, that is, (b,d) in 5% H_2 in Ar; (c,e) in O_2, all at 300 °C. The atoms are shown using different colours, according to the type of facet: blue={100}, pink={110}, purple={111}, grey=higher index.

The results for the second cycle are presented in **Figure 5.d** (in a H_2 flow) and **Figure 5.e** (in a O_2 flow). We clearly observed morphology changes with a more faceted appearance of the particle in H_2 and a significant increase of higher order facets, corresponding to a more rounded morphology in O_2. This quantitative methodology to measure transformations of nanoparticles in a relevant environment is highly relevant toward understanding e.g. catalytic activity, stability and selectivity.

Outlook

Obviously, the field of electron tomography for materials science has evolved tremendously since the start of the century. Nowadays, not only structure, but also composition and valence can be investigated in 3D. The addition of additional triggers, such as heat or a gaseous environment resulted in the ability to better understand the structure-property connection. In this overview, the focus is on metallic nanoparticles. These are relatively stable under the electron beam and expanding such detailed 3D characterization to more sensitive materials remains a challenge. Although the use of the fast tomography approach is a first step, additional effort will be required to also investigate these systems at atomic resolution or during in situ experiments. Such further development will especially be important to investigate e.g. degradation mechanisms of nanomaterials, leading to better stability during their application. Another important development will be to enable the observation of dynamic processes in a more continuous manner than the current stop-and-go approach. To achieve this goal, prior information concerning expected transformations that occur during the (possibly even faster) acquisition of a tilt series could be incorporated in more advanced reconstruction algorithms.

Acknowledgements

I am extremely grateful to be part of the EMAT laboratory since the start of my PhD. It is a true blessing to work in such an inspiring environment and to collaborate with people that became friends or almost family over the years. A special "thank you" goes out to all the students and postdocs that have worked with me during part of my journey. It has been an honour to work with many of my role models in the field of electron microscopy. Moreover, I want to thank all of my collaborators in the field of materials science, for continuously challenging me and my co-workers with more beautiful, but increasingly complex (nano)structures. Finally, this work has been funded by different institutions, but I want to especially thank the Research Foundation - Flanders (FWO) and the European Research Council (ERC). ■

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REPORTS ON EMS SPONSORED EVENTS

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COILED COILS, MYOSIN, TITIN AND STRIATED MUSCLE: A REFLECTION ON THE CONTRIBUTIONS OF JOHN TRINICK AND GERALD OFFER

January 10, 2020; University of Leeds

GORDON RESEARCH CONFERENCE ON LIQUID PHASE ELECTRON MICROSCOPY

January 26-31, 2020; Lucca (Barga), Italy

XVII^TH INTERNATIONAL CONFERENCE ON ELECTRON MICROSCOPY (EM'2020)

June 14 to 17, 2020; Wisla, Poland

SYMPOSIUM ON RECENT ADVANCES IN MICROSCOPY CHARACTERIZATION OF PHOTONIC AND OPTOELECTRONIC MATERIALS

June 23-24, 2020; London, UK

COILED COILS, MYOSIN, TITIN AND STRIATED MUSCLE: A REFLECTION ON THE CONTRIBUTIONS OF JOHN TRINICK AND GERALD OFFER

January 10, 2020; University of Leeds

This one-day meeting, held at the University of Leeds on the 10th January 2020, celebrated the life and work of John Trinick and Gerald Offer. All the speakers presented work that build on the development of research ideas and understanding into specific muscle proteins: titin, myosin and myosin-binding protein C (C-protein), in recognition of the contributions of John Trinick and Gerald offer to this field of research. John (a trained physicist) was a world leading expert in titin, and Gerald discovered C-protein. Each of the speakers gave a brief overview of their interactions with either John, Gerald or both researchers, and how they worked alongside them, and how this developed into their current research. Exciting new research was presented on the role of C-protein in regulating myosin activity, particularly in cardiac muscle (from Howard White (East Virginia Medical School, USA) and Charlie Scarff, University of Leeds). Dek Woolfson (University of Bristol) presented his innovative new work on the development of novel synthetic coiled coils based on a meticulous understanding and ability to model these structures. He introduced new software CCBuilder 2.0, originally based on modelling coiled coils using the Crick equations, which he started with Gerald Offer. Mathias Gautel (King's College London) reflected back on the first attempts to sequence titin at EMBL, with encouragement from John Trinick, a subject also reflected on by Belinda Bullard, as she explained her work on proteins in insect flight muscle that share similarities with titin. Mathias highlighted that titin was now acknowledged as a key disease gene in many cardiac and skeletal muscle diseases and presented his new work in this area. Annalisa Pastore reflected on John's influence on her own work while he was on sabbatical at EMBL, initiating her research into the structure of individual titin domains. Pauline Bennett revealed her new work on how titin and C-protein are localised to think filaments in muscle. Michelle Peckham and Roger Craig both presented their new work on smooth and non-muscle myosin, and regulation of their activity. Peter Knight finished the meeting with an excellent overview on how John and Gerald's work led the way in the field. The key takeaway from the meeting was that new developments and approaches are providing us with new insight into how these proteins function, building on years of work that began with key findings from John and Gerald. The meeting was attended by about 50 people from the UK, Europe, the USA and Hong Kong.

We'd like to thank the EMS, Biochemical Society, Royal Microscopical Society and the IOP, which helped to bring in speakers and to encourage junior scientists to join the meeting. ■

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GORDON RESEARCH CONFERENCE ON LIQUID PHASE ELECTRON MICROSCOPY, *January 26-31, 2020; Lucca (Barga), Italy*

View of the Lucca (Barga) valley, Italy, 27 January, 2020.

The first Gordon Research Conference on the topic of Liquid Phase Electron Microscopy (LP-EM) took place at the venue Renaissance Tuscany Il Ciocco, Lucca (Barga), Italy, 26-31 Jan. 2020. This conference presents a mile stone in the development of the LP-EM research field. LP-EM refers to a class of methods for imaging specimens in liquid with nanometer spatial resolution using electron microscopy. LP-EM overcomes the key limitation of electron microscopy: since the electron optics requires a high vacuum, the sample must be stable in a vacuum environment. However, many types of specimens – in particular liquids - relevant to biology, materials science, chemistry, geology, and physics, change their properties when placed in a vacuum. This Gordon Research Conference discussed the latest research results, advances in method, and future directions of LP-EM. It presented an international forum for scientists from multiple disciplines and at different stages in their career. Oral and poster presentations focused on the usage and development of this new *in situ* technology to study fundamental aspects involving the structure and dynamics of organic and inorganic materials, and biological specimens.

Topics both theoretical and experimental aspects were discussed of:

- innovation in liquid cells and holder designs; microscopy and spectroscopy,
- beam-sample interactions and the use of low dose LP-EM,
- nucleation and growth of nanoparticles and crystals,
- electrochemistry,
- imaging in ionic liquids,
- the self-assembly and structure of soft matter,
- studying biological samples, for example, protein function,

- advanced image acquisition, analysis and data interpretation.

The number of attended amounted to 120 of which 22% were graduate students, and 20% were post-docs. Most attendance was from academia (91%) but industry (6%) and governmental organizations (3%) were also represented. The gender balance reflected 62%/38% male/female. Most attendees were from Europe (60%), while North American (20%) and Asian (20%) scientist were also present.

Chair: Niels de Jonge
Co-chair: Nico Sommerdijk

Keynote speaker was Armand Alivisatos (University of California, Berkeley, USA).

The GRC contained the following program:

- **Studying Materials Processes During Electron Beam Exposure** with invited speakers Frances Ross (Massachusetts Institute of Technology, USA) and Taylor Woehl (University of Maryland, USA). Discussion leader was Patricia Abellan (Institut des Matériaux Jean Rouxel (IMN), CNRS, France).
- **Innovations in Liquid Enclosures: MEMS, Environmental Systems and Graphene** with invited speakers Kristian Mølhave (Technical University of Denmark, Denmark), and Armand Alivisatos. Discussion leader was Dwayne Miller (Max Planck Institute for the Structure and Dynamics of Matter, Germany).
- **In Situ Microscopy of Liquid Ion Battery Materials** with invited speakers B. Layla Mehdi (University of Liverpool, United Kingdom), and Nigel Browning (University of Liverpool, United Kingdom). Discussion leader was Nigel Browning (University of Liverpool, United Kingdom).
- **Dynamic Nanoparticle Interactions** with invited speakers Qian Chen (University of Illinois at Urbana-Champaign, USA), and Haimei Zheng (Lawrence Berkeley National Laboratory, USA). Discussion leader was Marijn van Huis (Utrecht University, The Netherlands).
- **Towards Quantitative and Time-Resolved LP-EM** with invited speakers Heiner Friedrich (Eindhoven University of Technology, The Netherlands), and Tim Dahmen (German Center for Artificial Intelligence (DFKI) GmbH, Germany). Discussion leader was Rafal Dunin-Borkowski (Forschungszentrum Jülich, Germany).
- **Nanomaterial Growth Viewed in Liquid at Atomic Resolution** with invited speakers Ute Kaiser (University of Ulm, Germany), Utkur Mirsaidov (National University of Singapore, Singapore), and Damien Alloyeau (Laboratoire Matériaux et Phénomènes Quantiques, University of Paris / CNRS, France). Discussion leader was Eva Olsson (Chalmers University of Technology, Sweden).
- **Studying Cells at Single Molecule Level in Liquid** with invited speakers Diana Peckys (Saarland University, Germany), and Chikara Sato (National Institute of Advanced Industrial Science and Technology (AIST), Japan). Discussion leader was Niels de Jonge (INM-Leibniz Institute for New Materials, Germany).
- **Soft Matter and Biominerals** with invited speakers Nathan Gianneschi (Northwestern University, USA), Radostin Danev (The University of Tokyo, Japan), and Joseph Patterson (University of California, Irvine, USA). Discussion leader was Jim De Yoreo (Pacific Northwest National Laboratory, USA).
- **Self-Assembly Processes in Materials Science and Biology** with invited speakers Jungwon Park (Seoul National University, South Korea), and Alfons Van Blaaderen (Utrecht University, The Netherlands). Discussion leader was Deb Kelly (Pennsylvania State University, USA).

Website: https://www.grc.org/liquid-phase-electron-microscopy-conference/2020/

The next Gordon Research Conference on LP-EM will take place January 30 - February 4, 2022, at the Four Points Sheraton / Holiday Inn Express, Ventura, CA, USA.

Chairs: Nigel Browning and Deb F. Kelly ■

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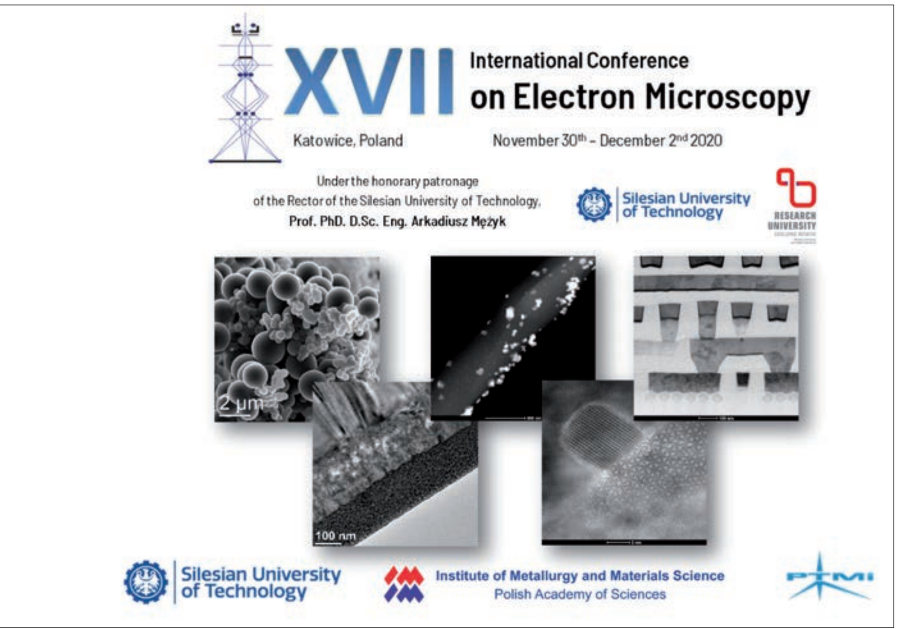
XVIITH INTERNATIONAL CONFERENCE ON ELECTRON MICROSCOPY (EM'2020)

November 30-December 2, 2020; Katowice, Poland



The XVIIth **International Conference on Electron Microscopy (EM'2020)** organized jointly by Silesian University of Technology, Association of Graduates of the Metallurgy and Material Science of SUT, and the Polish Society for Microscopy (PTMi) was held on **November 30th-December 2nd, 2020** in Katowice, Poland. Due to the COVID-19, for the first time the conference was entirely in *online* form.

The Conference provided a platform for electron microscopists, crystallographers, materials scientists, and solid state physicists to discuss methods and techniques used in electron microscopy. The scope of the EM'2020 was to provide a broad overview of the recent achievements in electron microscopy in the three major areas of instruments, methods, and application.

During the conference almost 170 participants, from 13 countries (i.a. Japan, France, Great Britain, Italy, Switzerland, Norway, Poland, Slovakia, Czech Republic, USA), listened to 123 presentations (including: 11 invited lectures, 37 plenary lectures, 29 in the session for young scientists and 46 in the poster session). There were also two meetings in the "Round Table" convention, with the following topics: "Electron microscopy in biological and medical research" and "Advanced techniques in scanning electron microscopy and related sciences" which became a platform for the experience exchange among scientists. Traditionally, three competitions were conducted during the conference: Young Scientists Best Presentation, Best Poster Award, and Best Picture Award.

Abstracts of given speeches and posters have been published in Book of Abstracts and Book of Posters. Conference participants have the opportunity to publish their research results in high-rated journals, such as Microscopy and Microanalysis (IF = 3.414) and Archives of Metallurgy and Materials (IF = 0.586).

Moreover, the EM'2020 conference was sponsored by the following companies: Platinum Sponsor - COMEF, Gold Sponsor - PIK Instruments, Silver sponsor - LABSOFT and other sponsors - TESCAN, Uni-Export. Media support for the conference was offered by the Polish Radio Symphony Orchestra (NOSPR) in Katowice and the Silesian Museum. ■

Hanna Myalska

SYMPOSIUM ON RECENT ADVANCES IN MICROSCOPY CHARACTERIZATION OF PHOTONIC AND OPTOELECTRONIC MATERIALS

June 23-24, 2020; London, UK

*in partnership with the Royal Microscopical Society (RMS) and the European Microscopy Society (EMS)

Chair: Prof Anna Baldycheva (University of Exeter)

This 2 day symposium focus on an emerging field of microscopy; the *in-situ* characterization of novel nanophotonic and optoelectronic systems and devices. Internationally known experts in the field of novel photonic and optoelectronic material development will join the symposium to discuss the most critical technological insights, discoveries and new practical applications in microscopy and micro-spectroscopy characterization of metamaterials, plasmonic and photonic crystal materials.

The symposium covered fundamental techniques such as optical microscopy, TEM, SEM, AFM, Raman, and FTIR for a wide range of possible applications, from chemistry and material fabrication to nanophotonic and optoelectronic systems engineering. The conference will also include workshop with hands-on demonstrations and possibility to test participant's samples on-site.

The symposium topics included:

- 2D materials
- IV element-based photonic materials and devices
- Chalcogenide materials
- Quantum Dots and Nanowires
- Organic materials
- Liquid Crystals and Fluid Nanocomposites ■

Prof Anna Baldycheva

REPORT ON SPECIAL EVENTS

2020 KAVLI PRIZE IN NANOSCIENCE

AWARDED TO HARALD ROSE, MAXIMILIAN HAIDER, KNUT URBAN, AND ONDREJ KRIVANEK "FOR SUB-ÅNGSTRÖM RESOLUTION IMAGING AND CHEMICAL ANALYSIS USING ELECTRON BEAMS" A TRIBUTE TO THE LAUREATES

Ute Kaiser, Helmut Kohl, Dagmar Gerthsen, Joachim Zach, Joachim Mayer, and Wolfgang Jäger

Aberration correction of electron optics is in the focus of the 2020 Kavli Prize in Nanoscience for its profound impact on electron microscopy and nanoscience.

The German Society for Electron Microscopy (DGE) is excited to celebrate their members Harald Rose (Professor at the Technical University of Darmstadt and Senior Professor at Ulm University, Germany), Maximilian Haider (Co-founder and Senior Adviser of CEOS GmbH, Heidelberg, Germany, and Honorary Professor of the Physics Department, Karlsruhe Institute of Technology, Germany), Knut Urban (one of the former Directors at the Ernst Ruska Centre for Microscopy and Spectroscopy with Electrons at the Forschungszentrum Jülich, Germany, and Senior Professor at RWTH Aachen University), together with Ondrej Krivanek (Co-founder and President of Nion Co., Kirkland WA USA, and Affiliate Professor of the Physics Department, Arizona State University, Tempe AZ USA), who are awarded the prestigious 2020 Kavli Prize in Nanoscience "*for sub-ångström resolution imaging and chemical analysis using electron beams*". In order to correct the unavoidable aberrations in electron optics they developed 'glasses' consisting of magnetic multipoles. Since then, over 900 aberration corrected electron microscopes have been installed worldwide.

The Kavli Prize honors scientists for breakthroughs in astrophysics, nanoscience and neuroscience – " transforming our understanding of the very big, the very small and the very complex". The Kavli Prize consists of USD $ 1,000,000 in each of the scientific fields. The prizes will be presented to the Laureates during a ceremony in Oslo in 2022 by the Norwegian Academy of Science, the Norwegian Ministry of Science and Education and the Kavli Foundation. From the award citation:

"The Norwegian Academy of Science and Letters has decided to award the Kavli Prize in Nanoscience for 2020 to ...

Harald Rose, for proposing a novel lens design, the Rose corrector, enabling aberration correction in transmission electron microscopy that can be applied to both conventional and scanning microscopes.

Maximilian Haider, for the realization of the first sextupole corrector, based on Rose's design, and for his role in the implementation of the first aberration corrected conventional transmission electron microscope.

Knut Urban, for his role in the implementation of the first aberration corrected conventional transmission electron microscope.

Ondrej L. Krivanek, for the realization of the first aberration corrected scanning transmission electron microscope with sub-ångström resolution, well suited for spatially resolved chemical analysis. This was obtained using a quadrupole-octupole corrector."

On May 27, 2020, headlines of many regional newspapers and press releases of research institutions announced the exciting news. Among others: 'Darmstädter TU-Professor erhält Kavli-Preis' (Darmstädter Echo), 'How we learned to see atoms precisely' (TU Darmstadt), 'Das Unsichtbare sichtbar gemacht – Kavli-Preis für Wegbereiter der Elektronenmikroskopie' (Universität Ulm), 'Kavli Prize for Pioneers of Electron Microscopy' (KIT Karlsruhe), 'Kavli Preis für Wegbereiter der modernen Elektronenmikroskopie' (Forschungszentrum Jülich), 'Kirkland wizard honored with Kavli Award' (Seattle Times USA, May 28, 2020). Press releases were also issued by scientific societies, for instance, by the German Society for Electron Microscopy (DGE), the European Microscopy Society (EMS), the German Physical Society (DPG), the MSA Microscopy Society of America, and by popular journals. Examples are 'Scientific American' and the 'Forbes' magazine.

With some biographical notes the authors congratulate most sincerely all Laureates on their prestigious awards, also on behalf of the members of the DGE, honoring their outstanding inventions and developments in aberration correction which have revolutionized the field of electron microscopy.

Harald ROSE


© private

Harald Rose was born in 1935 in Bremen, Germany. He studied physics at the Technische Hochschule (TH, now Technical University) in Darmstadt. In his Doctorate (PhD) thesis, written under the auspices of Otto Scherzer, he investigated the possibilities to correct the spherical and chromatic aberrations of round lenses by use of multipole lenses. In his "Habilitation" thesis he proposed a correcting system consisting of five quadrupole and octupole lenses, which was built later on and proved experimentally that correcting aberrations of electron lenses is indeed possible.

In the seventies he began to investigate imaging energy filters, which, theoretically speaking, are a generalization of his previous research to "curved axes". This resulted in the Omega and the Mandoline filters for transmission electron microscopes as well as a project called SMART for energy-filtered photoemission electron microscopy at the Berlin Electron Storage Ring for Synchrotron Radiation (BESSY).

In 1972/1973 Harald Rose spent a sabbatical year in Albert Crewe's group in Chicago which he used to advance imaging theory for the conventional as well as the scanning transmission electron microscope. He proposed several new imaging modes, e.g. the differential phase contrast mode, which has seen a great revival in recent years. Furthermore he laid the foundations for the description of imaging with inelastically scattered electrons. From 1976 to 1978 he worked at the research center of the New York State Department of Health, primarily dealing with methods to image biological structures.

Returning to Darmstadt he extended his research to low-voltage scanning microscopes, electron beam lithography and the description of the Boersch effect. An example is the development of an electrostatic detector objective lens (EDOL) and a multipole corrector for low-voltage scanning microscopes.

Harald Rose strongly objected any formal authorities, regardless of whether it was himself or somebody else. Students were particularly impressed by his enthusiasm. Usually the group went jointly to lunch in the "Mensa" (the university restaurant) and afterwards there was a "Teerunde" (tea circle) with vivid discussions on anything and everything including politics and physics.

These lively discussions in the daily "Teerunde" as well as in the weekly group seminars every Thursday during the lecturing period were an important inspiration. External visitors - in particular foreigners - were often surprised or sometimes even shocked about the very direct style of these discussions and the bluntly stated objections. Even though this might seem strange for any outsider – and very tough for a young student giving his first presentation of the state of his thesis work – it was always clear that any criticism was focused on the subject and had nothing to do with the person. This very direct style was extremely helpful to understand flaws in derivations or other delicate points. Also, he always encouraged his students to attend electron microscopy conferences.

Harald Rose's enthusiasm has always been a strong stimulus for his students. He preferred deriving analytical expressions instead of numerical calculations wherever possible. The two copies of the Gradstein-Ryshik "Tables" were moving quickly from desk to desk. His own "Computation book", meticulously describing his derivations of lengthy equations, was an inexhaustible source of knowledge.

The spirit of the group was always very impressive. For years the group members went out bowling once a week. Some were also playing football once a week. Every summer Harald Rose would invite his group members to a garden party at his house at the Mathildenhöhe, the Art Nouveau quarter in Darmstadt close to the institute.

A further turning point was the announcement of the purchase of a MeV electron microscope at the Salzburg meeting in 1989 by the Max-Planck-Society for 15 million DM (7.5 MEUR) to obtain a resolution of about 1.2 Ångström. Harald Rose claimed, that this could be achieved much more easily and with less cost by using aberration correction. This raised his competitive spirit and in less than 6 weeks he laid out the basic setup for such a system. Based on his earlier investigations he proposed to use two sextupoles to correct for the spherical aberration. This idea was realized in a joint project with Max Haider and Knut Urban funded by the Volkswagen Foundation and laid the foundation for a very fruitful collaboration in the years to come. Nowadays such correctors are standard components of modern transmission electron microscopes, yielding a point-to-point resolution of less than 1 Ångström. In the 2000s the idea came up to develop a microscope with an additional correction of the chromatic aberration to obtain a resolution of 0.5 Ångström. Based on Rose's ideas, the TEAM project in Berkeley and later the PICO project in Jülich were initiated.

After Harald Rose's retirement, in 2000, the Institute of Applied Physics, the Department of Physics, and the President of the Technical University of Darmstadt decided to discontinue electron optics, despite numerous memorandums from science and industry to continue this extremely successful research field for Nanotechnology. This decision was harmful especially because Darmstadt was the only place in Germany at which courses on electron optics had been given. As consequence, Harald Rose accepted a one-year invitation as a research fellow from the electron microscopy group at Oak Ridge National Laboratory. He worked on the theory of electron holography and on image formation in STEM. Afterwards he was invited by Murray Gibson to join the Argonne National Laboratory, Argonne USA, to design an electron-optical system for high-resolution in-situ electron microscopy, in the context of Murray Gibson's DOE-funded project. This project was taken over by Uli Dahmen from Lawrence Berkeley National Laboratory (LBNL) in Berkeley USA after Murray Gibson left the electron microscopy field. As consequence, Rose followed the invitation of the Berkeley lab to become a research fellow at the Advanced Light Source and an advisor for the TEAM project from 2003 to 2005. The outcome of his stay was the design of the spherical and chromatic aberration corrector for the TEAM project. This corrector design became also the basis for the PICO project, realized later at the FZ Jülich. Both projects were successful in demonstrating for the first time a resolution of 50 picometer (0.5 Ångström). In addition, Harald Rose taught an extended course on charged-particle optics, that formed the basis of his book "Geometrical Charged-Particle Optics ", which was published by Springer in 2009. Meanwhile, this book is regarded as the "bible" for charged-particle optics.

In 2005, Ute Kaiser at Ulm University bought one of the first commercial aberration-corrected transmission electron microscope, and in 2007, she asked Harald Rose to teach her group and herself the principles of aberration correction. The lectures were the start of an extremely fruitful cooperation, which lasts until now. One intention of her SALVE project, funded in 2008, was to continue electron optics in Germany with a Carl Zeiss Professorship on Electron Optics at Ulm University. In 2011 Harald Rose became Carl Zeiss Senior Endowed Professor at Ulm University. After Zeiss stopped the development of transmission electron microscopes, Harald Rose continued in Ulm as a guest scientist and became a Senior Professor at Ulm University in 2015. He acted as strong and inspiring supporter and associate member of the SALVE project. The heart of the successful SALVE instrument, the low-voltage spherical and chromatic aberration corrector, bears his signature.

Harald Rose is an active and much valued member of Ute Kaiser's group of Materials Science Electron Microscopy at Ulm University. His passionate and science-oriented way of thinking and discussing are an invaluable experience for all group members. His lectures on charged-particle optics are always well-received by the students at Ulm University but also by the students of Chongqing University, Chongqing, China, where he is giving a compact course every year. The seminars and lecture courses on Fourier Optics and on structure physics in Ulm are embossed by his crystallized knowledge. During the annual "Kleinwalsertal SALVE Seminars", the attendees experience his tough-minded search for correct answers but also his precise knowledge of the paths in nature, which he shows with big steps that many members of the group could hardly match.

Since more than 20 years, Harald Rose is working intensively on his novel theory on the structure of elementary particles, which he already introduced to the public in Ulm's Physical Colloquium in December 2019. The scientific community may expect a novel way of explaining the mass and the internal structure of elementary particles.

Three apt quotes by Harald Rose characterize not only his clear thinking but also his humor: (1) "But this I published already in 1976" ! (Annotation: this is always true !), (2) "100 times zero is still zero" ! (3) "The product of competence and arrogance is a constant" !

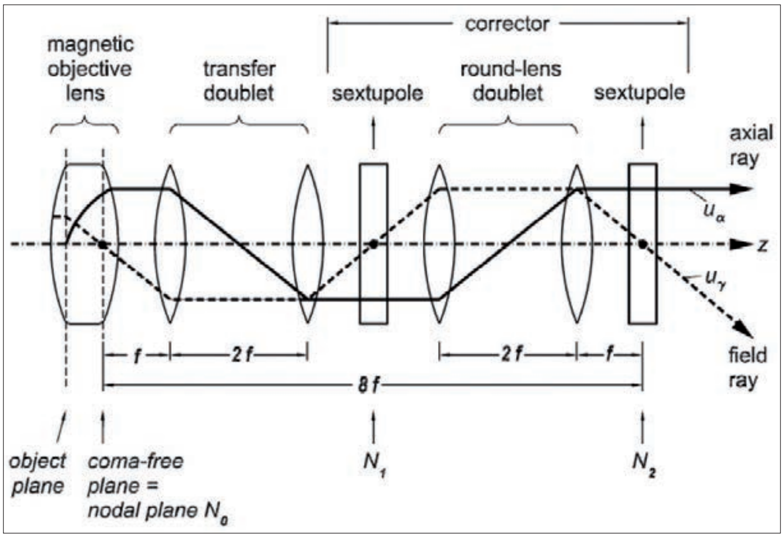
Harald Rose has received numerous further prestigious awards, among those the 2009 Robert Wichard Pohl Prize of the DPG German Physical Society, and, jointly with Haider and Urban, the 2011 Wolf Prize in Physics and the 2013 BBVA Foundation Frontiers of Knowledge Award in Basic Sciences. Harald Rose is Honorary Fellow of the Royal Microscopical Society, and he is an Honorary Member of the DGE.

As Senior Professor at Ulm University, Harald Rose is very active. He continues to teach, he collaborates with young and with older scientists, and he is highly appreciated as speaker and as discussion partner at numerous international workshops and conferences.

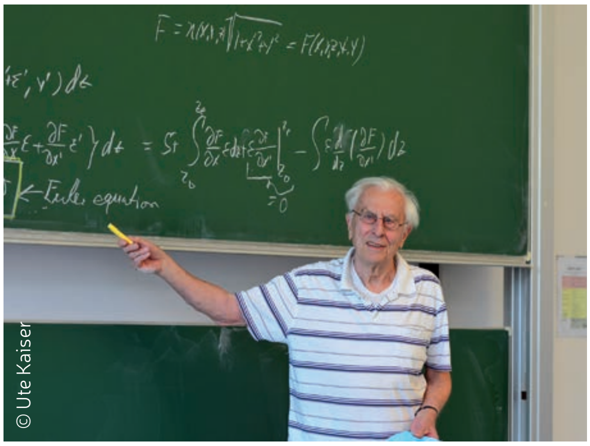
"You see that everybody said you will fail. But there was no physical reason for it. Because it was just a matter of lack of necessary technology. So my opinion was: I have to wait until technology will be available, and then it will work."

"Real advancement in science needs good ideas, endurance, devotion and - perhaps nowadays - team work." Harald Rose

From the interview with Harald Rose:
https://www.youtube.com/watch?v=p9z4QvoUzGs



The schematic for an aberration corrector in the 1990 paper by Harald Rose. Optik 85, 19-24 (1990) Elsevier GmbH
Reprint of Figure 1 from: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

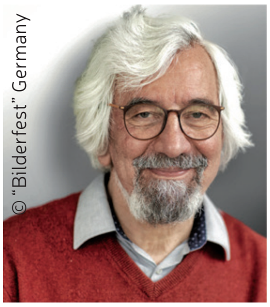


Harald Rose - teaching electron optics at the Ulm University in 2020.

Harald Rose and Max Haider with Ute Kaiser and the participants of the 'Kleinwalsertal' SALVE School 2014.

Harald Rose - discussing at the Microscopy Conference MC 2011 Kiel.

Maximilian HAIDER



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Max Haider was born in 1950 in Freistadt, Austria. He started his career in optics already at an age of 14, when he began an education as ophthalmic optician close to his place of birth in Linz. He finally received a degree of a German/ Austrian "Meister" (master craftsman). This title gave him a high reputation amongst the craftsmen in the mechanical workshops, when he later was discussing manufacturing issues of his electron optical designs. He was considered to be a "man from the real world", not an "escapist scientist" from the ivory tower.

But he felt that only handcraft was not enough for him, he wanted to understand, what is behind it. So he decided to study physics at the universities of Kiel and Darmstadt so "That I may understand whatever binds the world's innermost core together (Goethe, Faust)". In Darmstadt he submitted his diploma thesis entitled "Design and test of an electric and magnetic dodecapole lens" in Harald Rose's group, where at this time a small experimental niche existed dating back to Otto Scherzer's times. So he got into contact with aberration correction in electron optics by working at the famous Darmstadt Cc/Cs-corrector. Looking today at the control panel of the corrector it becomes clear, why the technology was not yet ready for a widespread application of this technique: dozens of control knobs, no computer support, evaluation just 'by eye'. Consequently they could only show the correction of the aberrations, but no improvement of resolution. It took another 15 years before aberration correction became a success.

Since the budget for experimental work was very limited in Darmstadt he went to a more wealthy place: the European Molecular Biology Laboratory (EMBL) in Heidelberg, which had a strong physical instrumentation group in those days. There he finished his Doctorate thesis (PhD) about "Design, construction and testing of a corrected electron energy loss spectrometer with large dispersion and a large acceptance angle", still under the supervision by Harald Rose. Following his PhD he started various development projects for corrected electron optics as a group leader at the EMBL. One of them was the development of a hexapole corrector for a TEM with Harald Rose and Knut Urban as partners, financed by the Volkswagen Foundation.

In 1996 it became clear that there was no future for instrumentation development inside EMBL. The focus of the EMBL had changed. So Max Haider decided to start up a company called CEOS, Corrected Electron Optical Systems GmbH, together with Joachim Zach to be able to bring the most recent developments in electron optics to the scientific and industrial community within commercial electron microscopes.

But the project funded by the Volkswagen Foundation had not yet achieved the goal to improve the resolution significantly. Some mysterious blur and jitter was found. So while CEOS was already running and concentrating on Cc/Cs-correction for a scanning electron microscope, Max Haider, being still part of his time at the EMBL, continued to search for the problem in the TEM together with Stephan Uhlemann. They tried to find the problem, but were initially without success. Some people, who had always known that aberration correction would never "fly", felt validated. With only a few weeks left, before the project would definitely end, Max showed his characteristics, which is one of the main reasons for his success: Don't trust the scientists, whatever arguments from theory or their "experience" they will bring up. If you feel that something should work, try it and fight for it. He could not believe that the corrector was the source of the problem. So within days he designed and built a new projective lens together with the CEOS team and inserted it in the microscope below the corrector. This should reduce the influence of all downstream optics via an increased intermediate magnification.

And indeed: this brought the success. The additional damping by the projective was suppressed. The corrector worked as it should and for the first time aberration correction improved the resolution of a TEM. This success was achieved less than four weeks before the instrument had to be shut down and shipped to the institute led by Knut Urban at the Forschungszentrum Jülich.

This success was the starting point for the further rapid development of aberration corrected electron microscopy. At an early stage CEOS decided to enable scientists around the world the broadest access to this technology. So they did not bind themselves to just one microscope manufacturer but offered to supply the correctors to all of them. As a result they all were able to report to have broken the 1 Å resolution barrier within the next few years. The number of installations grew rapidly, and aberration correction has today become a standard technology in high-end electron microscopy.

In the first years of corrected electron microscopy with commercial instruments the focus of the scientists was concentrating on the visibility of individual atom columns. Whereas this was already possible in regular undisturbed crystals without aberration correction, now the atom positions could be tracked right to the edges of interfaces and deviations from the ideal positions could be visualized. With further improvements of the instruments it became possible to detect atom column positions with a precision of only a few picometers, far below the point resolution of the instrument. This gave access to investigations of local stress and local chemical bonding. But not only atom columns could be imaged. Individual atoms in 2D materials and even the movement of such individual atoms could be observed.

In life sciences the situation is a bit different. Up to now, the best structural data of biomolecules with a precision of only around 1.2 Å have been achieved with corrected and uncorrected microscopes. There are ongoing discussions in the community, whether life science will benefit from the correction of Cs. However, corrected electron microscopes also give a much better control of lower order parasitic aberrations. This could also be a reason for the better biological data, which might not have been taken without the corrector.

Since 2008, Max Haider has also been an Honorary Professor in the Physics Department at Karlsruhe Institute of Technology. He and his assistant Roland Janzen took responsibility of the electron optics education by starting a lecture course on theoretical electron optics.

Max Haider also vividly demonstrates not only excellence in science but also, being co-founder of CEOS GmbH, he serves to young scientists as an outstanding example of a successful entrepreneur.

Max Haider is not only a dedicated scientist but is engaged also in societal matters, for instance, as member of the town council and of the Board of the Friends of the voluntary Fire Brigade in his home town.

CEOS GmbH in Heidelberg, the company he co-founded together with Joachim Zach in 1996, also initiated and sponsors the "Harald Rose Distinguished Lecture" which is awarded every two years since 2013. The award is dedicated to honor scientists, who are actively working on electron microscopy methods, in the field of particle and wave optics, image formation, and/or energy filtering in research and teaching.

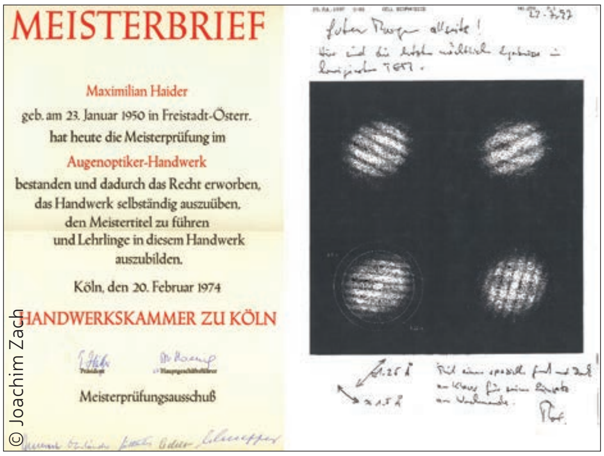
Maximilian Haider has been awarded numerous further prestigious prizes for his work, including the 2011 Wolf Prize in Physics and the 2013 BBVA Foundation Frontiers of Knowledge Award in Basic Sciences, jointly with Rose and Urban. CEOS GmbH was awarded the 2005 Innovation Prize of the State of Baden-Württemberg, Germany, for "exemplary achievements". He is Honorary Fellow of the Royal Microscopical Society, and he is Honorary Member of the DGE.

Max Haider continues to be actively involved in the development of new electron optical systems as Senior Advisor for CEOS GmbH in Heidelberg. He also continues to collaborate with scientists, and he is a highly appreciated speaker at international workshops and conferences.

"I think that close cooperation between research and industry is beneficial for all, but what counts much more is the collaboration and understanding of the needs of researchers and respect for each other."

"For me, the most exciting developments are those that help us to carry out research against climate change. Our development of these new instruments supports this research by helping researchers to have a look inside nanomaterials, and to understand the structure and function of such tiny objects. For example, electron microscopy can be used to understand the mode of action of solar cells and to optimize their efficiency, as well as to find the best way to store the produced power in batteries. In both cases, it is essential to understand the processes at the atomic level." Maximilian Haider

From the interview with Maximilian Haider:
https://www.forbes.com/sites/sujatakundu/2020/05/27/meet-the-winners-of-the-2020-kavli-prize-for-nanoscience/


MEISTERBRIEF

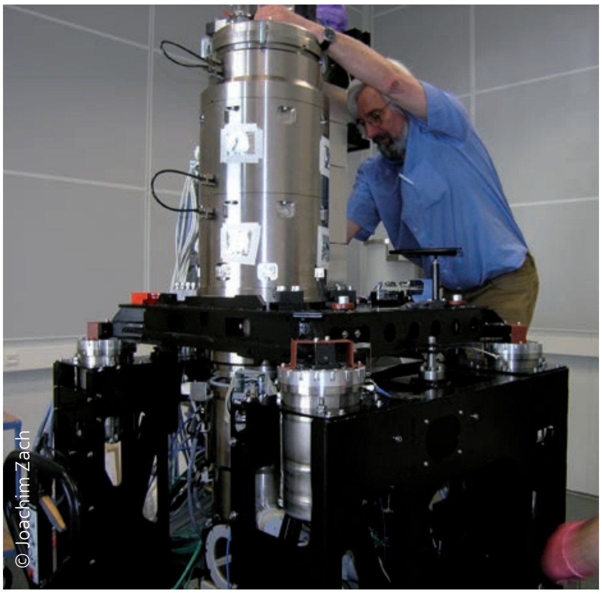
Maximilian Haider
geb. am 23. Januar 1950 in Freistadt-Österr.
hat heute die Meisterprüfung im
Augenoptiker-Handwerk
bestanden und dadurch das Recht erworben,
das Handwerk selbständig auszuüben,
den Meistertitel zu führen
und Lehrlinge in diesem Handwerk
auszubilden.

Köln, den 20. Februar 1974

HANDWERKSKAMMER ZU KÖLN

Meisterprüfungsausschuß

From the ‘Meisterbrief’ as optician to the ‘Master of aberration correction’ for electron microscopes: Max Haider’s Meisterbrief (1974) as optician and his FAX message as of July 23, 1997, reporting that aberration correction is successfully improving the electron microscope resolution.



Maximilian Haider, the ‘craftsman’, installing the TEAM-1 Cc/Cs corrector at the NCEM in Berkeley USA (2008).

Maximilian Haider, Honorary Professor at Karlsruhe Institute of Technology (KIT), with Dagmar Gerthsen and the members of her group.

Serious discussions between Max. Haider and Harald Rose even on-stage – symptomatic for their collaboration ! (2010).

Knut URBAN


© Research Center Juelich

Knut Urban was born 1941 in Stuttgart. He studied physics at the University of Stuttgart and carried out his PhD thesis work under the supervision of Prof. Alfred Seeger and Prof. Manfred Wilkens at the Max-Planck-Institut (MPI) für Metallforschung, Stuttgart. He was awarded the doctoral degree in natural sciences from the University of Stuttgart in 1972. It was this school in which he developed his deep scientific interest in solid state physics and characterization methodology, which guided his activities throughout his entire career. The breadth of his scientific interests and his ambitions to solve the unsolvable by constant improvement of both experiments and instrumentation has driven him from these early times up to the present day.

In 1975, he received a permanent staff position at the Max-Planck-Institut für Metallforschung, Stuttgart. He spent 1980 and 1981 as a Guest Scientist at the Metallurgy Section, Centre d'Études Nucléaires de Saclay (CEA), Paris, and 1982 as a Guest Scientist with a grant of the Alexander von Humboldt-Foundation at the Physical Metallurgy Division at the Bhabha Atomic Research Centre Bombay/India.

In his early work, Knut Urban employed the electrons to introduce radiation-induced effects in metals and alloys and to study the kinetics and thermodynamics of the defect agglomeration and annealing *in situ* in the TEM. In that respect, he was also a pioneer in the field of *in-situ* experiments, for which he employed the first 650 kV high voltage TEM at the MPI at Stuttgart and later the AEI EM 7 instrument with accelerating voltages up to 1.2 MeV. When Knut Urban realized that temperatures of 10 K are needed to freeze-in thermally-induced effects, he went to Ernst Ruska's laboratory at Berlin, where he constructed and built the first He-cooled goniometer and collaborated with Ernst Ruska in many instances.

In the early eighties, Knut Urban turned his attention to an entirely new field, order-disorder transformations in alloys. He employed his experience with radiation-induced phenomena to investigate spinodal ordering in these alloys, a phenomenon which cannot be explained by conventional thermodynamics. His interest was triggered by the Landau-theory of spinodal ordering developed by D. de Fontaine, and his activities can be considered as an early example of developments in theory going hand-in-hand with novel experiments. Triggered by his interest for new phenomena and by his broad international network, it was no surprise that he immediately turned his attention to the observation of quasicrystals reported to him by his colleague and friend Dan Shechtman. As a pioneer in the field, he was able to use the unique experimental setup which he developed for cryo- and high-temperature experiments to study the order-disorder phenomena in quasicrystal-forming alloys. He was able to verify that this crystallographically forbidden state is actually not just a frozen-in state of an undercooled liquid, but can be thermodynamically stable, if e.g. produced by annealing of the radiation-amorphized alloy.

In 1986, Knut Urban received his first academic appointment and took a position as Professor at the University of Erlangen-Nürnberg and then immediately accepted an appointment as Director at the Institute of Solid State Research, Research Center Jülich, in combination with the position of a Chair for Experimental Physics at RWTH Aachen University.

Defect physics and plasticity in quasicrystals remained one of his main fields of activities and he was always fascinated by the fact that novel experimental techniques and theoretical concepts beyond the classical limit are needed to understand the phenomena. This was also specifically recognized in the laudatio for the Von-Hippel-Award, which he received in 2006 from the American Materials Research Society (MRS). Extending his quasi-crystal activities to related crystal-systems, he pioneered the field of complex metallic alloys, materials with unit cell sizes of more than thousand atoms. Knut Urban and his co-workers managed to grow phase-pure single crystals and to study their properties extensively. He successfully initiated and coordinated an EC Network of Excellence "Complex Metallic Alloys" (2005 to 2014), and he was also the Scientific Coordinator of the DFG Priority Program on "Physical Properties of Complex Metallic Alloys" (2006 to 2015).

During his time at the MPI für Metallforschung at Stuttgart, led by Alfred Seeger he got also introduced to superconductivity.

Shortly after Bednorz and Müller (Nobel Prize in 1987) had discovered high-temperature superconductivity, Knut Urban and his group at Jülich established a major research effort on Josephson-junctions in $YBa_2Cu_3O_7$. These activities also triggered his interest in high-resolution TEM characterisation of oxides, an endeavour which was seriously hampered by the limitations imposed by the aberrations and, e.g., made it impossible to image all sublattices individually.

Driven by his ambition to push the resolution of high-resolution TEM to the limits imposed by quantum mechanics, he teamed up with Harald Rose and Max Haider, from 1989 to 2001, to develop the world's first aberration-corrected electron microscope. Fascinated by the idea to achieve the "impossible" – at the time when the three got together a committee of the National Science Foundation of the USA declared that aberration correction cannot be realized – this was just the right team to tackle the change of paradigm. Since none of the established funding sources promised support, it was the Volkswagen Foundation which finally committed to fund the development. Knut Urban's contributions have specifically addressed the development of new experimental methods and a new imaging theory which form the basis of direct atomic structure imaging with the new aberration correctors. Knut Urban and his team were able to demonstrate that it is not ideal to just compensate the spherical aberration of the objective lens, but rather to slightly overcompensate it. Taking into account the quantum-mechanical nature of the scattering process in the sample, the negative-spherical-aberration-imaging (NCSI) technique was developed and later became the reference for the commercial development and many laboratories which purchased aberration-corrected high-resolution TEMs. Some of the major breakthroughs of Knut Urban and his co-workers were realized in ferroelectrics, high-Tc superconductors and other oxide materials and were based on the fact that now light-element columns consisting of oxygen, nitrogen or boron anion sublattices can also be directly imaged.

Based on the funding which he received from the DFG for a 'Sub-Ångström TEM', in 2004 he initiated the foundation of the Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C) as a joint centre of FZ Jülich and RWTH Aachen University and as first German national user facility for atomic resolution electron microscopy. Based on numerous contacts with the Ruska family, the name was chosen and it was a special honour for all scientists involved that Ernst Ruska's widow and their two sons were able to attend the opening ceremony. Further support by the DFG made it possible to install the next major development by Harald Rose and Max Haider, an instrument with a corrector for chromatic aberration, at the ER-C. Being second after the TEAM-instrument at the National Center for Electron Microscopy at LBL Berkeley, the Jülich PICO instrument got equipped with the newest version of the Cc-corrector and has demonstrated the huge potential of compensating both, the spherical and the chromatic aberration in many high-resolution techniques.

Over the years, Knut Urban published many articles in the 'Frankfurter Allgemeine Zeitung', one of the most recognized newspapers in Germany. In particular he was invited to write a key article devoted to the development of the natural sciences at the turn of the millennium. In the years 2003-2005, he was also president of the German Physical Society (DPG), with 54.000 members the largest physical society of the world, where he initiated many future-oriented changes and established many new contacts to the political legislation in Germany.

After his retirement Knut Urban took positions as Guest Professor at the Tsinghua University, Beijing, China (till 2014), and as Adjunct Professor at Xi'an Jiaotong University, Xi'an, China (till 2018). He is member and chairman of the International Advisory Council of the Minister of Science and Education of the State of Bavaria, Germany, for the Bavarian Elite University program and since 2017 Chairman of this Council. Since 2016 he is also Head of Materials Science Advisory Board of a major manufacturer of electron microscopes.

Knut Urban has been awarded numerous further prestigious honors, including the 2006 Von Hippel Award of the US Materials Research Society, and, jointly with Rose and Haider, the 2011 Wolf Prize in Physics and the 2013 BBVA Foundation Frontiers of Knowledge Award in Basic Sciences. He is honorary member of many national and international scientific bodies, and he is Honorary Member of the DGE.

Knut Urban maintains an active role at the ER-C and is Professor Emeritus at RWTH Aachen University and, since 2010, he received the recognition as JARA (Jülich Aachen Research Alliance) Senior Distinguished Professor of RWTH Aachen University and Forschungszentrum Jülich.

"Seventy-five years after its invention, transmission electron microscopy has taken a great step forward with the introduction of aberration-corrected electron optics."

"The study of materials and even of devices in atomic dimensions is an old dream of materials research. Measuring parameters at atomic dimensions that determine macroscopic behavior is perhaps the most comprehensive change that this new electron microscopy has made possible." Knut Urban

From: http://www.ceos-gmbh.de/en
From the interview with Knut Urban:
https://www.forbes.com/sites/sujatakundu/2020/05/27/meet-the-winners-of-the-2020-kavli-prize-for-nanoscience/

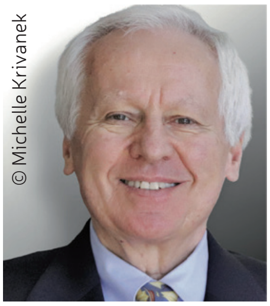
The first aberration-corrected transmission electron microscope at the Research Center Jülich.

Knut Urban at work with fellow scientists at an aberration corrected TEM of the ER-C: (from left to right) Karsten Tillmann, Andreas Thust, Knut Urban, Chunlin Jia, and Lothar Houben who is now at the Weizmann Institute of Science, Rehovot, Israel.

Inauguration of the Ernst Ruska Centrum (ER-C) in 2006: (front row) Irmela Ruska, Ernst Ruska's widow, Knut Urban, the initiator and former ER-C director, and Joachim Mayer, director of the ER-C; (back row) Jürgen Ruska, Ernst Ruska's son, Burkhart Rauhut, Rector of RWTH Aachen University, Ulrich-Ernst Ruska, Ernst Ruska's son, and Joachim Treusch, Chairman of the Board of Directors, FZ Jülich.

Knut Urban, Harald Rose and Maximilian Haider at the PICO 2015 conference in Kasteel Vaalsbroek NL.

Ondrej KRIVANEK


© Michelle Krivanek

Ondrej Krivanek is a physicist of Czech and British nationality and is resident in the United States. He was born in Prague, Czechoslovakia (now Czech Republic) and growing up at a time when the Soviet Union and other socialist countries took pride in their science and technology accomplishments, and in their educational systems. His favourite subjects in high school were math and physics, and as a student in his senior high school year, he competed in the national rounds in math and physics, earning prizes in both. Another major influence was his hobby of building model airplanes using balsa wood and translucent lightweight paper.

Choosing a field for university studies, he took the entrance exam for the Mathematical-Physical Faculty of Charles University in Prague. While enjoying a summer vacation in London in 1968, he had planned to come back to Prague in time for the start of the university school year when the Soviets and their satellites invaded Czechoslovakia in August 1968, to stop the push towards democracy led by Alexander Dubček. He decided to stay and suddenly found himself to be an immigrant in a country whose language he had to learn and understand.

Being awarded a scholarship, Ondrej Krivanek studied physics at the University of Leeds where he obtained a degree before moving to Cambridge to work on his PhD thesis in electron microscopy with Archie Howie at the Cavendish Laboratory. His research focused on characterizing the structure of amorphous materials using electron microscopes, the latest versions of which were then just able to resolve atomic planes in various materials. He obtained 0.3 nm resolution images from "amorphous" carbon, and used them to show that the carbon contained small graphitic nanocrystals. "The work made me realize that a clear view of the structure of matter on the atomic scale would only become possible with electron microscopes with better resolving power".

Following his time in Cambridge, Ondrej Krivanek held postdoctoral positions at the Kyoto University in Japan where at that time in the laboratory of Professor Kobayashi was the world's highest resolution electron microscope. After the stay in Kyoto, he started a postdoc stay at Bell Labs in Murray Hill, New Jersey, USA. There, he performed investigations, using the electron microscopes at Cornell University, on the important silicon-silicon dioxide interface of electronic MOSFET semiconductor devices.

Ondrej Krivanek became interested in electron energy loss spectroscopy (EELS) during a subsequent postdoc stay in Professor Gareth Thomas' group at the University of California in Berkeley. " I was more interested in advancing techniques and instruments than materials", and the technique he thought was especially interesting was electron energy loss spectroscopy. There were no commercial spectrometers in those days. With major help from Peter Rez, a physicist at Arizona State University, who wrote the software, he was building a complete instrument. The principal limitation of this first spectrometer was that it had no aberration correction beyond first order.

In close collaboration with Peter Swann of Gatan, a revised design of the spectrometer was produced, that had full second-order aberration correction. The spectrometer became known as Gatan serial EELS model 607, and it was a commercial success. The design was completed after he moved to a full-time position as Assistant Professor and Associate Director of the HREM facility at Arizona State University.

At the same time he started collaborating with Gatan Inc., first as a consultant, before moving permanently to the company in 1985 and becoming its R&D director. A number of successful instruments were introduced, including parallel-detection EELS, post-column imaging filters, CCD cameras, scanned image acquisition systems, as well as software. "I learned that making instruments commercially can be a great way to fund instrumentation research, especially when working with like-minded researchers and lean administrations that understand the value of good science". The imaging filter they built used quadrupole optics and corrected second-order aberrations and distortions using sextupoles.

In 1995 he went back to the Cavendish Lab in Cambridge to work with Mick Brown and Andrew Bleloch on aberration correction of electron lenses. As Ondrej Krivanek mentions in his autobiography: “We had two key insights. One, aberration correction brings its strongest benefits to STEM, … for which the benefits of correction are double: better spatial resolution and more intense beam current in a small probe, giving a major improvement in the STEM’s spectroscopic capabilities. This was the reason we focused our efforts on STEM aberration correction right from the beginning … Two, the correction of spherical aberration requires a complicated piece of electron optics, which is bound to introduce many kinds of “parasitic” aberrations”. And: “… our Cambridge corrector did not improve on the performance of the best uncorrected STEMs of the time but our ‘mark II corrector’ did.

Niklas Dellby and I designed and built this corrector as a next project, after I became a Research Professor at the University of Washington in Seattle, and we founded Nion Co. in late 1997.” The photo shows the Nion founders together with Nion’s first employee, George Corbin in front of the Nion I building. The project led to the “first STEM of any kind able to focus an electron beam to < 1 Å (0.1 nm) diameter at 120 keV”. The advances with their new corrector were documented by first images with sub-ångström resolution obtained with a quadrupole-octupole STEM corrector, published in 2002 by Krivanek, Dellby and their colleague Phil Batson from IBM. Soon afterwards, a similar corrector was built into a 300 keV STEM at Oak Ridge National Laboratory, achieving resolved atom columns 0.78 Å apart.

Aberration correction had become the new frontier in electron microscopy. CEOS GmbH in Germany invented correctors that are supplied to established manufacturers of electron microscopes, both for conventional transmission electron microscopes and for scanning transmission electron microscopes. Nion Co. concentrated on designing correctors for STEM, supplying at first correctors for VG STEMs. The next “big idea” was ambitious and led to developing a whole new electron microscope, the Nion UltraSTEM™.

The applications of the new STEM led to “spectaculary clear images”. “The popular wisdom back then was that the imaging technique of high-angle annular-dark field imaging could not usefully image light atoms such as carbon. The signal was supposed to be too weak to make imaging of single atoms possible”. Examples were images of 2D materials such as graphene and of 1D materials such as nanotubes. Imaging of a boron nitride monolayer with atomic substitutions was successful, being also featured on the cover of an issue of Nature. A research group at the University of Vienna was successful in ‘driving’ a single Si atom in chosen directions in a graphene sheet by the electron beam. The increase in the available beam current allowed the elemental composition of materials to be efficiently mapped at atomic resolution both by EELS and by energy-dispersive X-ray spectroscopy (EDXS). As well mappings of bonding information were obtained, using chemical shifts in EEL spectra of different elements. The optical properties and stabilities of these instruments have brought “the energy resolution of EELS to 5 meV, attainable on a routine basis. This resolution level allows vibrational spectroscopy to be performed in the electron microscope“.

There are now over 20 of these instruments in the world, and about 700 aberration-corrected (S) TEMs made by other manufacturers.

The following apt quotes, taken from Ondrej Krivanek’s autobiography and from an interview following the Kavli Prize announcement, describe in some way his characteristics and his achievement: “When I decided to go into aberration correction, full professors would tell me you are burying your career. This is never going to work! One had to have a healthy dose of self-confidence to disregard it. “

Ondrej Krivanek has received numerous further prestigious awards, including the Duddell Medal and Prize of the British Institute of Physics, and the Cosslett Medal from the International Federation of Microscopy Societies. He was awarded the Fellowship of the American Physical Society and the Distinguished Scientist Award of the Microscopy Society of America, and he is Honorary Fellow of the Royal Microscopical Society.

Ondrej Krivanek is president of Nion Company as well as Affiliate Professor at Arizona State University. He enjoys applying the instruments in collaborations with their users, and he is a highly appreciated speaker at international workshops and conferences.

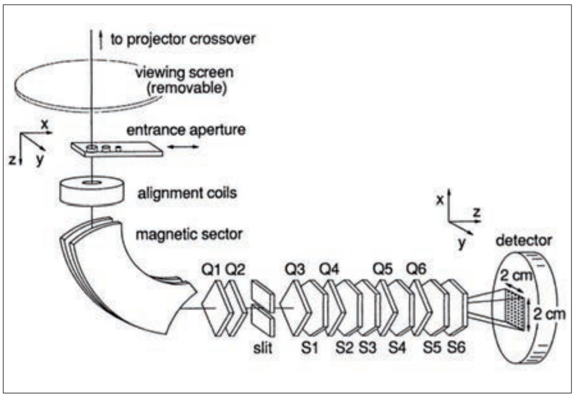
Contents and quotes of this section are based on the autobiography of Ondrej Krivanek.

http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

"This was a project where I went into it thinking: most people expect me to fail – I can only exceed expectations."

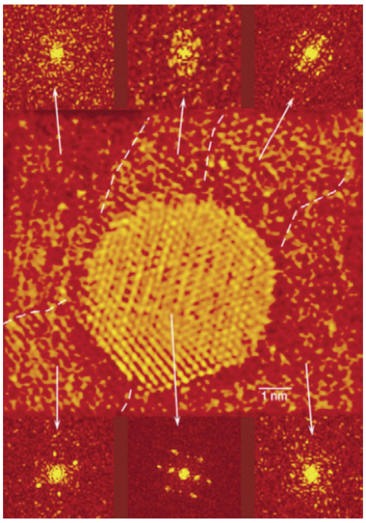
"You can see atoms. You can put an electron beam pretty much on a single atom, and you can ask the atom: what kind of an atom are you? And it will respond, it will give you an energy loss spectrum in which it identifies itself. And not only that, it also tells you how it's bonded to its neighbors." Ondrej Krivanek

From the interview with Ondrej Krivanek:
https://www.youtube.com/watch?v=p9z4QvoUzGs



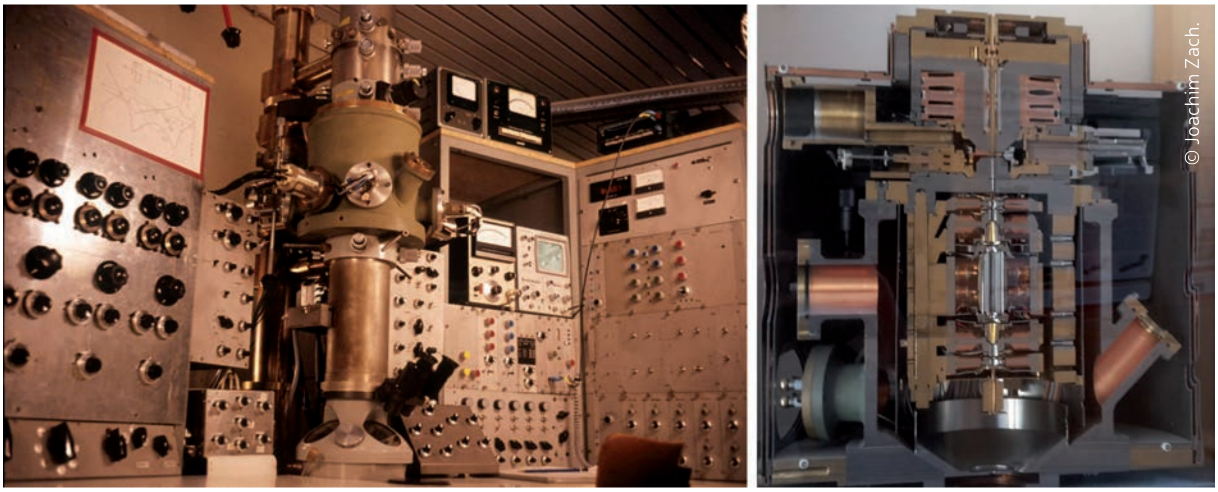
'An imaging filter that used quadrupoles (Q) and sextupoles (S) to correct second-order aberrations and distortions (schematic).' - Reprint of Figure 1 from Ondrej Krivanek's autobiography: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

Ondrej Krivanek, George Corbin and Niklas Dellby "in front of Nion I building, which featured a large garage that we later converted into a mechanical assembly room. Nion can therefore partly claim that its origins were in the proverbial garage." - Reprint of Figure 3 from Ondrej Krivanek's autobiography in: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience



"Atomic resolution image of an island of Au on an amorphous carbon substrate. The island is surrounded by monoatomic clusters of Au. Diffraction patterns from different regions sur-rounding the island show that these clusters are ordered in various structures adjacent to the built-up islands. Nature 418, 617-620 (2002) © Springer Nature Ltd." - Reprint of Figure 3 from: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

Ondrej Krivanek, co-founder and president of Nion, with one of the Kirkland company's electron microscopes. - Reprint from 'The Seattle Times' (on-line article), May 29, 2020. Photo: Courtesy Ken Lambert. https://www.seattletimes.com/seattle-news/science/kirkland-microscope-wizard-honored-with-kavli-award-norways-nobel-prize/



The famous Darmstadt corrector (late 1970ies/ early 1980ies): control panel and a cross-sectional view.

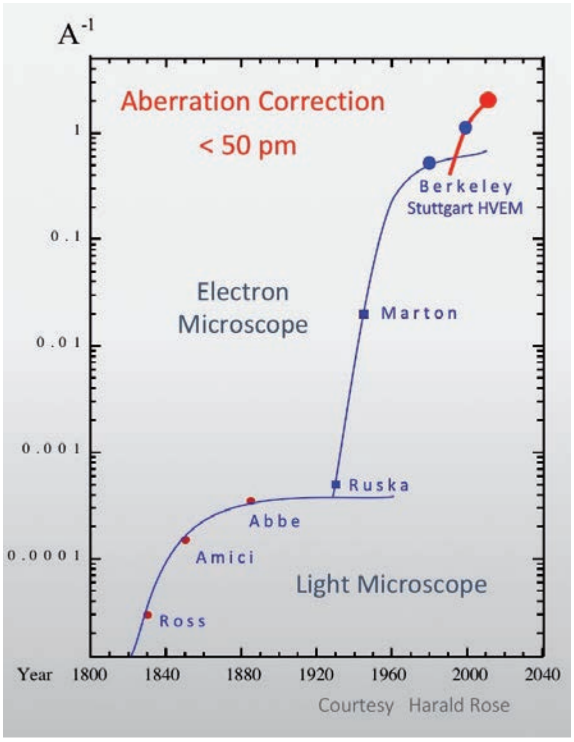
The pioneering work of the Laureates has led to TEM and scanning (S)TEM instruments that enable imaging and quantitative analyses of the atomic structure, of local elemental composition, and of electronic properties. These instruments are routinely used in many laboratories worldwide in research, synthesis of materials and in monitoring quality and fabrication of devices in industrial technology.

Transmission electron microscopy and its advanced characterization methods belong to the most important techniques in science and research on materials to understand their structural and physical properties. Starting with the construction of a transmission electron microscope in 1932, the methods of electron microscopy continue to make substantial contributions to key areas of materials science, physics, chemistry, life science, nanoscience, and to the development of device technologies.

The invention of aberration-corrected electron optics and the efforts taken to realize the first aberration-corrected advanced instrumentation for high-resolution TEM and STEM led to improvements in electron microscopy that were never anticipated before, reaching resolutions better than 50 picometer. The early prototypes of correctors were milestones on the way to modern correctors that are used nowadays in the many instruments worldwide.

"The central part of the first STEM Cs corrector that improved the resolution of the microscope it was built into, with multipole stages containing strong quadrupoles and octupoles, and 96 auxiliary coils for nulling parasitic aberrations. Corrector Ø~12 cm." - Reprint of Figure 2 from Ondrej Krivanek's autobiography: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

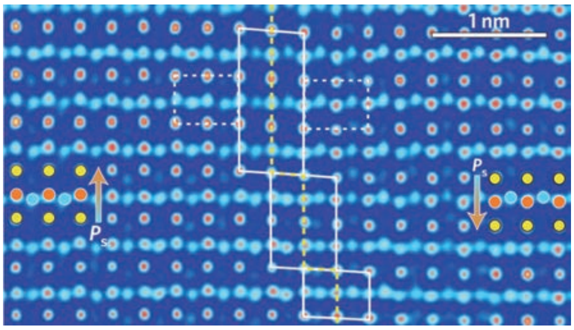
The progress in imaging resolution of aberration-corrected transmission electron microscopes is best illustrated by the famous graph, designed initially by Harald Rose and meanwhile shown in various modifications during numerous presentations worldwide. Aberration correction improved also the precision of analyses dramatically, thus enabling to not only separate closely spaced objects, "making visible the invisible", but to also determine the distances between imaged objects on the atomic scale with a picometer precision.



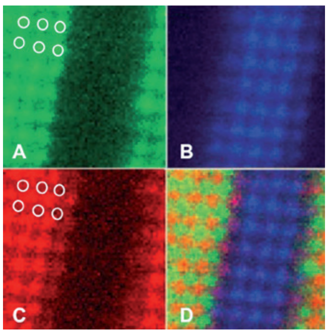
The famous 'Rose' graph: increase of microscope resolution over years. – Adapted from Fig. 11 in: H. Rose, J. Electron Microscopy 58(3), 77–85 (2009)

TEM and STEM instruments can now be used to take novel experimental approaches that, for instance, utilize fast and highly sensitive electron detectors, fast data acquisition, processing and evaluation routines, specialized electron beam sources and energy monochromators for high-resolution spectroscopy, advanced electron energy loss spectrometers, or large area detectors for improved x-ray spectroscopy. Selected-area electron diffraction from micrometer-size regions or nano-beam electron diffraction provide crystallographic information. Electron holography and differential phase contrast imaging enable measuring magnetic properties and probing electric field structures of materials on the nanometer scale. Dedicated low-voltage high-resolution instruments allowing to operate the electron microscope at electron energies as low as 20 keV, have been used for the characterization of low dimensional materials, particularly graphene, and also succeeded in imaging molecules.

High precision mapping of atom positions, determining atom site occupancies and atom shifts, atomic-scale imaging and bonding analyses, or *sensitive atomic-level characterization* of very delicate samples at low electron energy and with minimal electron beam exposures, including, for instance, graphene and other two-dimensional materials, are now among the topics in structure research of materials. Two examples may serve as illustration. The aberration-corrected TEM has been used to directly correlate the positions of atoms in a ferroelectric material with changes in the electric polarization. STEM in combination with EELS has been used to obtain atomic-scale information on the chemical composition of materials.



"Atomic structure of different ferroelectric domains in the material PZT obtained by aberration-corrected TEM. The positions of the atoms (O, blue; Pb, yellow; Zr/Ti, red) in the two phases can be directly linked to the direction of electric polarization (PS). Adapted from C.-L. Jia et al. Atomic-scale study of electric dipoles near charged and uncharged domain walls in ferroelectric films. Nature Mater. 7, 57-61 (2008) © Springer Nature Ltd." - Reprint of Figure 2 from: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

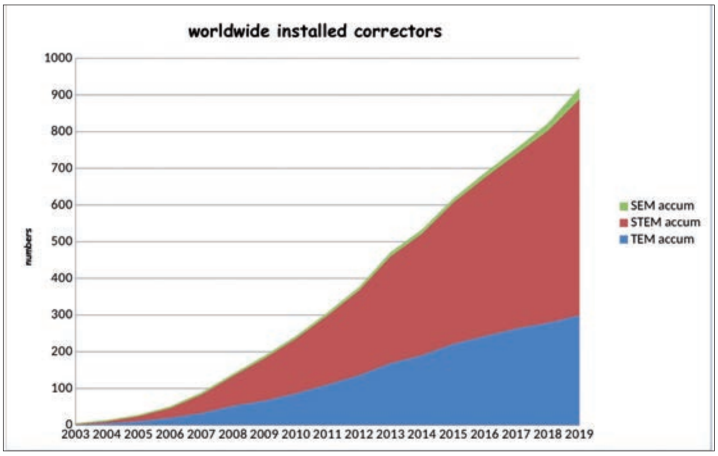


"Atomic-resolution chemical map, obtained using EELS on a STEM, of a (La,Sr)MnO3/SrTiO3 multilayer showing the La (green), Ti (blue) and Mn (red) atoms; the white circles indicate the position of the La columns; field of view 3.1 nm. From D. A. Muller et al. Atomic-scale chemical imaging of composition and bonding by aberration-corrected microscopy. Science 319, 1073-1076 (2008)." - Reprint of Figure 4 from: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

Some centers provide unique environments for materials research with electrons by operating *electron microscopes* as a *mini-laboratory*, similar to synchrotrons with beam lines for materials research. High-resolution (S)TEM instruments are at the core of a system, providing an electron beam of controlled properties, electron optics for imaging, and advanced detection systems for scattered electrons, for energy loss electrons or for further secondary effects of beam-sample interaction.

Integrated are mini-laboratories that provide controlled sample environments for *in situ* experiments or enable sample manipulation and property measurement for investigations of materials with electrons. Thus, for instance, chemical reactions between materials in controlled gaseous or liquid environments are studied *in-situ* under direct atomic-resolution observation, either with specialized sample holder configurations or in an environmental (S)TEM instrument utilizing different gases. Tomography experiments aim at elucidating the 3D structure and surface morphology of nano-objects, pursuing fundamental research on materials for catalysis. Manipulating single atoms and atomic-scale dynamical processes in materials can be studied in response to external stimuli, for instance, mechanical stress, temperature and electric and magnetic fields. Deducing macroscopic properties of materials from their microscopic properties has become possible with these instruments. Their application is often the only successful way for obtaining information on the nanoscale, thus being especially important in nanoscience.

The modern field of transmission electron microscopy uses now sophisticated *characterization platforms* that combine specialized computer-controlled instruments with various types of advanced detector systems and of sample stages. *Current instrument* developments are often performed in collaborations between research centers and instrument manufacturers, with the focus on creating novel methodological possibilities for materials characterization, that again will support a substantial industry of manufacturers.



Accumulated corrector installations containing CEOS correctors and about 20 NION correctors. Copyright © Joachim Zach CEOS GmbH

Aberration-corrected electron microscopy enables scientists to image and analyze materials and investigate scientific questions with unprecedented methodology. The number of aberration correctors and aberration-corrected instruments sold reflects the need for this technology. At the end of 2019, the number of electron corrector systems installed worldwide has reached more than 900. In parallel, the number of scientific publications in materials science and in life science carrying 'aberration correction' in their titles has increased enormously.

Aberration correction has propelled electron microscopy and nanoscience into a new era. As Professor Bodil Holst of the University of Bergen, chair of the Kavli Prize in Nanoscience Committee, said: "Behind this year's Kavli Prize lies more than 60 years of theoretical and experimental struggle. It is a beautiful example of scientific ingenuity, dedication and persistence. We honour four laureates who have enabled humanity to see where we could not see before."

"I always felt strongly that I wanted to do something of value for mankind." – Fred Kavli

From: http://kavliprize.org/about

Our sincere congratulations on your achievements,

Harald Rose, Max Haider, Knut Urban, and Ondrej Krivanek !

SOURCES AND FURTHER READING

Kavli Foundation and Kavli Prize

https://www.kavlifoundation.org
https://www.kavlifoundation.org/kavli-prize
http://kavliprize.org/about

2020 Kavli Prize announcement

https://www.youtube.com/watch?v=E_DVSdjE-JY
https://www.worldsciencefestival.com/kavliprize2020/

2020 Kavli Prize in Nanoscience

http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

Biographies of the Laureates

http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

Interviews with the Laureates

Harald Rose and Ondrej Krivanek:
https://www.youtube.com/watch?v=p9z4QvoUzGs

Maximilian Haider and Knut Urban:
https://www.forbes.com/sites/sujatakundu/2020/05/27/meet-the-winners-of-the-2020-kavli-prize-for-nanoscience/

Company web pages

CEOS GmbH Heidelberg, Germany
http://www.ceos-gmbh.de/en/

Nion Co. Kirkland, USA
http://nion.com

"Three of the laureates co-founded two companies and commercialized their lenses contributing further to the major impact of their scientific work. Since then their microscopes have played an enormous role both in fundamental science and technology, where they are used, among others, by semiconductor, chemical and automotive industries."

From: http://kavliprize.org/prizes-and-laureates/prizes/2020-kavli-prize-nanoscience

Further reading

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M. Bosman, G. Kothleitner (Guest Editors). Ondrej Krivanek: A Research Life in EELS and Aberration-Corrected STEM. Special Volume - honoring Ondrej Krivanek's scientific career, Ultramicroscopy 180, 1-196 (2017).

ALBERT CREWE AWARD 2020

Dr Andrew Yankovich received the prestigious Albert Crewe Award in the year of 2020 from the Microscopy Society of America (MSA). The award recognizes distinguished contributions to the fields of microscopy and microanalysis in the physical sciences of a single early career scientist. Dr. Andrew B. Yankovich is a research scientist and faculty member in the Department of Physics, Eva Olsson Group, at Chalmers University of Technology in Gothenburg, Sweden.

His recent work includes precise measurements of atomic site-specific strain in nanocatalysts and the influence of these strain patterns on catalytic properties, the discovery of fundamental interactions between surface plasmons in coupled metallic nanostructures and the establishment of STEM EELS as a crucial technique for understanding and visualizing strong light-matter interactions at the nanoscale.

Albert Crewe (1927 - 2009), a physics professor at the University of Chicago and director of Argonne National Laboratory, developed the high-resolution electron microscope that was able to capture the first images of individual atoms in motion. His discoveries helped establish and expand the field of modern scanning transmission electron microscopy, as well as its use for atomic-scale research . ■

Andrew Yankovitch

VIRTUAL CHRISTMAS GET-TOGETHER: 1ST SINO-EUROPEAN EARLY CAREER RESEARCHERS WORKSHOP ON EMERGING TECHNIQUES AND APPLICATIONS IN ELECTRON MICROSCOPY

27-28 December 2020

The formidable year of 2020 has greatly affected the extent of academic exchange and driven us towards a new culture of online discussions. Despite many virtual events successfully held throughout the year, few of them served as a platform for early career researchers and brought a broader community beyond Europe. In view of this, three Europe-based young microscopists, Dr. Pei Liu (University of Antwerp, BE & Technical University of Denmark, DK), Penghan Lu (Research Center Juelich, DE), and Dr. Mingjian Wu (University of Erlangen-Nuremberg, DE) initiated and organized the 1st Sino-European Early Career Researchers Virtual Workshop on Emerging Techniques and Applications in Electron Microscopy on 27 and 28 December 2020.

The program consisted of 18 invited talks given by early career researchers and young PIs from 8 European countries as well as China. Those high-quality presentations were focused on 4 topical sessions, including 1) Imaging and diffraction of radiation sensitive specimen, 2) Quantification and data mining in electron microscopy, 3) *In situ*/environmental/ultrafast electron microscopy and 4) Advances in electron spectroscopy. At the end of each session, a panel discussion following the format of the Gordon Research Conference lead by senior experts turned out to be very stimulating and sparked the audience to a plethora of insightful comments. Furthermore, during the workshop, a career forum and Christmas quiz rounds added more joyful moments to the virtual get-together.

The workshop has attracted more than 360 registrants from 21 countries and 123 organizations. Around 210 colleagues eventually participated in the workshop and contributed about 120 questions in the Q&A sessions after the talks, as well as many more comments during the panel discussions. Thanks to the online platform, excessive questions could be answered offline and shared with all participants.

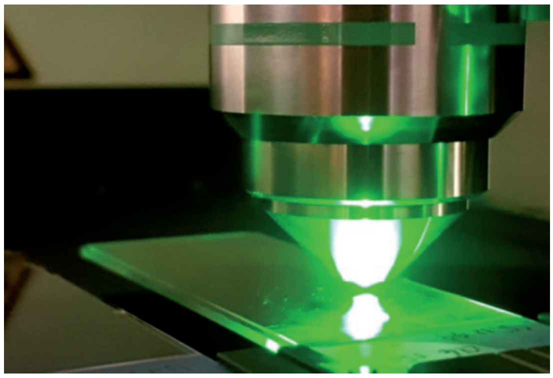
After the workshop, the organizers received a lot of positive feedback from the attendees about the outstanding quality of the invited talks, the deep insight from the panel discussions, as well as the smooth organization and the welcoming atmosphere. This greatly encouraged the organizers to extend this virtual event to an annual series and continue organizing the 2nd workshop in December 2021. We are looking forward to meeting more colleagues next time! ■

Mingjian Wu

MAX PLANCK BIOIMAGING CORE UNIT NETWORK ESTABLISHED

First formalized in spring 2020, the Max Planck Bioimaging Core Unit Network (MaxBI) supports service groups and core facilities within the Max Planck Society (MPG) in the fields of light microscopy, electron microscopy, medical imaging, flow cytometry, and image analysis. To date, MaxBI has 53 individual members and represents 23 core units or service groups at 17 Max Planck Institutes (MPIs). The MaxBI recently received funding for 5 years and was inaugurated on November 9th in a virtual kick-off meeting that was opened by MaxBI's Deputy Spokesperson Dr. Wiebke Möbius (MPI of Experimental Medicine): "An important aspect of science is sharing knowledge and learning from experts. Building networks that make this possible is the basis for scientific progress. And it is also more fun!". Prof. Tobias Moser, Spokesperson of the Cluster of Excellence in Multiscale BioImaging of the University of Göttingen, Germany, emphasized how essential collaborative efforts are to enable imaging across multiple length scales, due to the broad spectrum of different methods required. Next, MaxBI's Spokesperson Dr. Tobias Rasse (MPI for Heart and Lung Research) gave a tour through the history of the network: "Establishing a network in the middle of a pandemic was a huge challenge that forced us to learn how to collaborate and overcome obstacles working 'isolated' toward our common goals. It was a rewarding journey." He highlighted that the network is open for new members and welcomes fresh ideas on how to empower people, science, and innovation. The kick-off meeting was concluded by Dr. Douglas Richardson (Harvard Center for Biological Imaging, Cambridge, MA, US), who presented pioneering strategies on how to keep up with the ever-increasing speed of technology to offer first-class service as prerequisite for groundbreaking research.

The meeting was the first of many steps on the path of establishing MaxBI as comprehensive hub for exchange on bioimaging technology, image acquisition, and analysis. "We will provide



technical training for staff and users, promote career development of facility personnel, and offer actions aimed at equipping future and recently recruited core facility heads with the necessary management skills" explains Dr. Gabriele Malengo (MPI for Terrestrial Microbiology), who leads the workgroup 'Staff and User Training'. The first courses will start in January 2021 in collaboration with the Planck Academy, with an initial focus on image analysis. By introducing the Spotlight Lectures "we want to empower young scientists, giving them the possibility to present their research to a broad audience" says Dr. Elisa D'Este, MPI for Medical Research, head of the workgroup 'Communications and Public Relations'. A recording of the kick-off meeting, as well as information on the Spotlight Lectures, the training courses, job offers, and further activities are available on the MaxBI webpage http://www.bioimagingnet.mpg.de, Twitter @MPBioImagingNet, and LinkedIn. The Max Planck Society warmly welcomes MaxBI to the "Max Planck Network family" and is looking forward to further news. ■

Christian Kubat

COVID DROVE THE DEVELOPMENT OF THE FIRST FULLY ONLINE EDITION OF THE SCHOOL

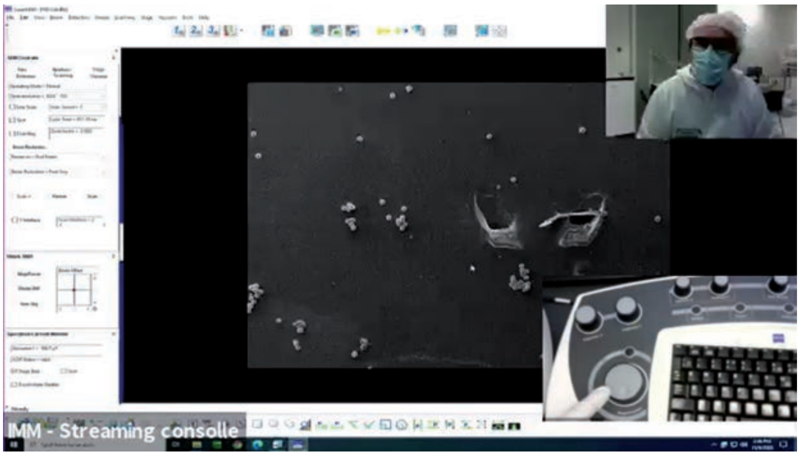
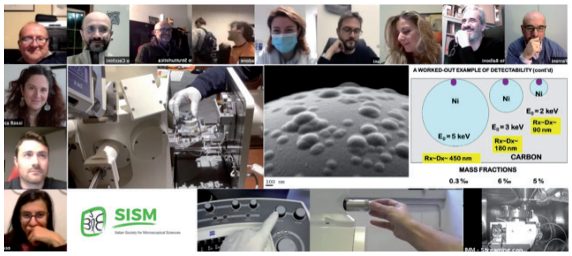


Image of a frame extracted from the video recorded during a practical session of the School introducing the use of the FIB. The main image is from the instrument control screen while the insets show the speaker and a portion of the microscope console.



Mosaic photo of some of the participants, lectures and demonstrations at the Aldo Armigliato SEM School in Materials Science organized by SISM in November 2020. The Italian SISM Society is committed to support young researchers and students of the Microscopical Sciences during the Covid pandemic.

Even in this troublesome 2020, the Italian Society of Microscopical Sciences (SISM) organized the 3rd edition of one of its established training events: the theoretical and practical SEM School in Materials Science. The event was directed by Dr. Vittorio Morandi (CNR – IMM, Bologna) and Dr. Regina Ciancio (CNR – IOM, Trieste) and took place from 9 to 13 November 2020 in Bologna (Italy) at the microscopy facility of the Microelectronics and Microsystems Institute (IMM) of the Italian National Research Council (CNR), where Aldo Armigliato served for most of his research activity.

In the effort to maintain the microscopy community against the limitations from the Covid pandemics and to support the young researches, the school was for the first time entirely delivered online but maintained its traditional formula consisting of lectures and practical demonstrations.

During five days, participants were introduced to the basic concepts and physical phenomena underlying imaging, spectroscopy, and microfabrication in the SEM and FIB platforms for a wide spectrum of SEM applications ranging from Secondary, BackScattering, Transmission, Environmental- SEM imaging to X-Ray Spectroscopy, Cathodo-Luminescence, Electron BackScattered Diffraction, and Electron-Beam-induced-Current techniques.

Theoretical lectures by key-note experts as well as commercial presentations by representatives of the main companies operating in the field of electron microscopy were held online through the ZOOM platform in a continuous live interaction with the attendees.

Thanks to a live-streaming system implemented and optimized by Prof. Matteo Ferroni (University of Brescia and CNR – IMM) in the console of the SEM and FIB microscopes of the IMM laboratory, demonstrations were broadcasted with negligible latency and High-Definition video quality during the practical sessions, so to allow participants to have a realistic experience with the microscope operation. It was possible to combine in a single frame different video signals, such as the microscope main screen or other detectors screens as well as those from cameras framing the speaker or the microscope console or external videos too, and send them to the participants using the broadcasting platform.

The functioning and optimization of the SEM were presented in combination with FIB-SEM systems for application in materials science, functional characterization and device diagnostics. With the same technology, a practical session dedicated to EBSD and STEM imaging was also organized at the CNR laboratory in Lecco (Italy).

The school involved 60 participants of different nationalities, coming from different academic institutions and industries. A satisfaction questionnaire as well as an evaluation survey were sent to all the participants whose great level of interest and appreciation demonstrated the high potential of online laboratories in promoting science education.

The school was supported/sponsored by Emme3, 2M Strumenti, Zeiss Italy, Bruker, Assing, Tescan, Jeol Italy, Thermo Fisher Scientific, Quantum Design Italy. ■

Aldo Armigliato, Matteo Ferroni, Regina Ciancio, Vittorio Morandi and Roberto Balboni.
SEM School in Materials Science

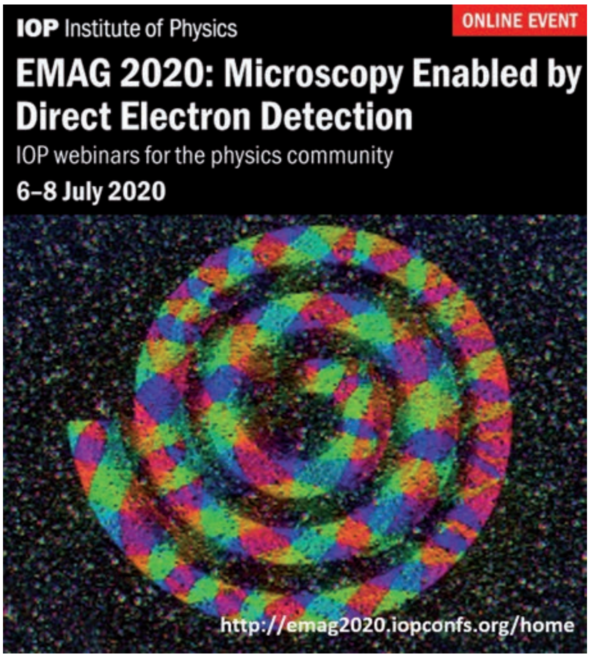
EMAG2020: MICROSCOPY ENABLED BY DIRECT ELECTRON DETECTION

The Electron Microscopy and Analysis Group of the UK Institute of Physics (IOP) held their national conference on 6-8th July (http://emag2020.iopconfs.org/home). It was originally planned to be held in Glasgow, but was moved to become the IoP's first multi-day online meeting, spread over the course of 3 afternoons, with an evening social event. The conference attracted over 280 registered delegates - more than double the expected numbers - and individual sessions attracted around 200 attendees, many international.

A compressed format was adopted to accommodate the pressures of home-working; and each session comprised an invited talk and a series of contributed 'flash' talks, sponsor presentations and virtual posters from academia and industry.

The theme of the conference was 'Microscopy Enabled by Direct Electron Detection' and the ambition was to capture the tremendous science now being enabled by modern detector technologies. It was fitting that a conference focused on improved technologies and methodologies for seeing the world should be timed for the year 2020, a number that is synonymous with perfect vision.

The conference truly show-cased the 'state of the art' in modelling, development, use and analysis of direct electron detectors within electron microscopy. Distinguished international speakers spanned the breadth of the field, including: ptychography of beam-sensitive materials (Pete Nellist, University of Oxford, UK); 4D-STEM (Colin Ophus, Lawrence Berkeley National Laboratory, USA); EELS (Mitra Taheri, Johns Hopkins University, USA); Lorentz imaging (Stephen McVitie, University of Glasgow, UK), Momentum-resolved STEM (Knut Muller Caspary, Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Germany) and



SEM-based diffraction (Carol Trager-Cowan, University of Strathclyde, UK). Each session was lively, engaging and enthusiastically embraced by the online audience, with the online format affording greater opportunity for questions. Student contributions were particularly strong and the eventual prizes, to Thomas Danz of the University of Göttingen and Kirsty Paton of the University of Glasgow, were very well deserved.

As the first such online event run by the IOP on this scale, the meeting and was judged a great success by all who attended. At the time, we had envisaged the online format being a one-off event; but the success of the conference indicates that the most successful online aspects are here to stay. ■

Donald MacLaren

ELECTRON MICROSCOPY WORKSHOP: JOURNEY TO THE MYSTERIOUS WORLD OF LIFE SCIENCES BY ELECTRON MICROSCOPY: "SEE BOTH; THE FOREST AND THE TREES"

One-day workshop with international participation entitled as ''ELECTRON MICROSCOPY WORKSHOP: JOURNEY TO THE MYSTERIOUS WORLD OF LIFE SCIENCES BY ELECTRON MICROSCOPY:''SEE BOTH; THE FOREST AND THE TREES'' has been organized by Prof. Dr. Serap Arbak, Assist. Prof. Dr. Deniz Yucel and Assist. Prof. Dr. Merve Elmas in March 5, 2020 at Acıbadem Mehmet Ali Aydınlar University, School of Medicine, Department of Histology and Embryology, Istanbul Turkey.

The objective of the meeting was to demonstrate the possibilities of different electron microscopical tools and inform the participants how to use these techniques in their own researches and in their own laboratories. There was an attendance of 110 microscopists. 5 lectures from invited speakers: Dr. E. Korkmaz (Thermofisher Scientific Eindhoven , The Netherlands) - Dr. R. Sougrat (King Abdullah Univ. of Science and Technology Saudi Arabia) - Prof. Dr. V. Hasırcı (Acıbadem Mehmet Ali Aydınlar Univ. Faculty of Engineering, Turkey) - Prof. M. Kutlu (Anadolu Univ. Faculty of Science, Eskisehir Turkey) and Assoc. Prof. Dr. A. Sendemir (Ege University, Faculty of Engineering, İzmir Turkey) provided up-to-date information about various sample preparation for transmission and scanning electron microscopy. Prof. E. Falcieri (Bologna, Italy) could not attend unfortunately the workshop due to the pandemics. A vivid discussion took place at the end the session.

In the second part of the workshop, 6 short talks as case studies from Acıbadem Mehmet Ali Aydınlar University were given and hands-on sessions were organized in Electron Microscopy Laboratory. 6 groups of 12 participants were informed by electron microscopy manufacturer company representatives from THERMOSCIENTIFIC FISHER-The Netherlands and ANATEK-Turkey. They informed the participants about the recent developments in electron microscopy. A quite satisfactory exchange of knowledge took place about ***THERMOFISHER SCIENTIFIC QUATTRO S ESEM & TALOS L120C TEM*** electron microscopes. The training also included the info about the variety of specimens to be studied under those microscopes. There was an ample opportunity for the participants to discuss their specific problems with the faculty. This event provided the opportunity to bring together researchers from diverse backgrounds to present the state-of-the-art in cutting edge electron microscopy tools and related applications. Participation was free. An attendance certificate has been presented to the participants. ■

On behalf of the Organizing Committee, I would like to extend my gratitude to COST Action CA 15214 EUROCELLNET for their generous support to organize this workshop.

Electron Microscopy Workshop - March 5, 2020, Istanbul, Turkey.

Serap Arbak

2020 DUNCUMB AWARD WINNER

EMS has been notified that N. Zaluzek received the 2020 Duncumb award from MAS. EMS is very happy to inform our community.

Nestor J. Zaluzec received his BS in Physics from the Illinois Institute of Technology in Chicago, and his PhD from the University of Illinois at Urbana-Champaign with Prof. H. L. Fraser. He was awarded the prestigious Eugene P. Wigner Fellowship at Oak Ridge National Laboratory, after which he joined Argonne National Laboratory, established the Electron Microscopy Center, and became its first Director. Nestor is a Fellow of the MicroAnalysis Society and received the Presidential Science award in 2017. He is also a Fellow of the Microscopy Society of America, Northwestern University (NAISE) and the University of Chicago (CASE) and holds Adjunct appointments at Northern Illinois University and the University of Illinois at Chicago.

Nestor's microanalytical origins trace back the early 70's, where as an undergraduate working part-time at the Sherwin Williams Research Center, he designed and built his first instrument, the Spectrogoniophotometer. In graduate school, he switched from light to electrons where his research included designing hardware and software for quantitative x-ray microanalysis and an early form of scanning diffraction for TEM/STEM. At ORNL, he interfaced one of the first EDS systems to an HVEM as well as built an aberration-corrected electron spectrometer and associated software. At Argonne, he continued his R&D in both XEDS and EELS, where he built the first CCD detector system for parallel EELS. The now-ubiquitous Plasma Cleaner for EM's was another of his inventions as well as the Scanning Confocal Electron Microscope and the Pi steradian XEDS detector. Position Resolved Diffraction (now called 4D STEM) using 2D detector arrays, and the TelePresence Microscopy Collaboratory for remote instrument operation is also part of his repertoire.

Nestor is presently a Senior Scientist in the Photon Sciences Directorate at ANL where he continues to work on multi-modal, multi-dimensional hyperspectral imaging and analysis of hard and soft matter applied to both the physical and biological sciences. ■

Nestor J. Zaluzec

esteem3

ESTEEM3: ENABLING SCIENCE AND TECHNOLOGY THROUGH EUROPEAN ELECTRON MICROSCOPY

ESTEEM3 is an integrated infrastructure network of **European Electron Microscopy Facilities** providing **Transnational Access** for academic and industrial research communities in materials, physical, chemical and life sciences to the most powerful electron microscopy instrumentation and techniques available at the nanoscale.

Coordinated by **Prof. Dr. Peter A. van Aken**, from the Max Planck Institute for Solid State Research in Stuttgart, Germany, the project has a term of four and a half years, from January 2019 to the end of June 2023, and is a follow-on-project of ESTEEM and ESTEEM2.

The project offers researchers in the private or public sector worldwide free **Transnational Access** to the best facilities and expertise in electron microscopy for the study of materials. Applications can be submitted online to https://www.esteem3.eu for one of the 15 laboratories in Europe, where applicants can request access to laboratories located in a different country than the applicant institution.

In 2020, ESTEEM3 has submitted its **first Periodic Report** (covering the first 18 months of the project) to the European Commission. After the Midterm Review Meeting, the reviewers deemed the results and progress of the project excellent. ESTEEM3 has so far provided access to more than 200 projects, which shows the interest towards access to TEM infrastructures in Europe, and proves that ESTEEM3 is a very solid network to support the European electron microscopy community.

ESTEEM3 member laboratories **and especially SMEs** (Attolight, CEOS, DENS solutions and Nanomegas) also develop **Joint Research Activities, with so far more than a hundred published manuscripts:**

- one axis is to develop *new techniques* in electron microscopy,
- a second axis is devoted to the study of *materials for ICT, energy, health and transport,*
- and a third axis concerns *automation* and *big data.*

Additionally, ESTEEM3 deploys an **education and training** component by organizing schools, workshops and webinars as **Networking Activities,** where upcoming events are announced at the ESTEEM3 webpages https://www.esteem3.eu/news and https://www.esteem3.eu/Upcoming-events. ■

Antoine Kieffer

OUTSTANDING PAPER AWARDS FOR 2019

2019 EUROPEAN MICROSCOPY OUTSTANDING PAPER AWARDS – WINNERS

The winners of the European Microscopy Outstanding Paper Awards for papers published in 2019 are:

Life Sciences: Cs. Cserép, B. Pósfai, Ni. Lénárt, R. Fekete, Zs. I. László, Zso.Lele, B. Orsolits, Gá. Molnár, St. Heindl, A. D. Schwarcz, K. Ujvári, Zs. Környei, K. Tóth, E. Szabadits, B. Sperlágh, M. Baranyi, L. Csiba, T. Hortobágyi, Zs. Maglóczky, Be. Martinecz, G. Szabó, F. Erdélyi, R. Szipőcs, Mi. M. Tamkun, Be. Gesierich, Ma. Duering, I. Katona, A. Liesz, G. Tamás, Á. Dénes, Science 367, 528-537 (2020), "Microglia monitor and protect neuronal function via specialized somatic purinergic junctions".

The jury noted that this is truly impressive and really exciting science. The authors combine a whole panel of electron and photonic microscopies with all sort of correlative and combination possible. Very original approach.

Instrumentation and Technique Development: F. S. Hage, D. M. Kepaptsoglou, Q. M. Ramasse, and L. J. Allen, Physical Review Letters, 122, 016103 (2019), "Phonon Spectroscopy at Atomic Resolution".

The jury felt that this was high quality work showing the possibility to obtain phonon spectra with atomic resolution. This development allows for analysing vibrations in crystalline material at higher resolutions.

Materials Science: C. Barroo, Z-J Wang, R. Schlögl and M-G Willinger, Nature Catalysis 3, 30–39 (2020) [published online 2019]. "Imaging the dynamics of catalysed surface reactions by in situ scanning electron microscopy"

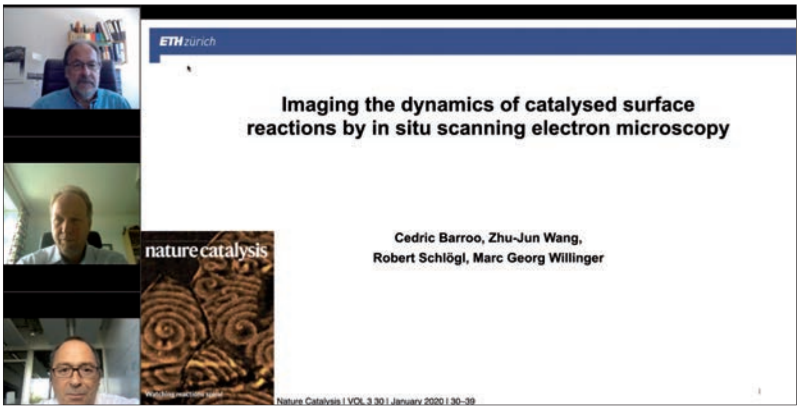
The jury was very impressed how catalytic reactions on metal surfaces and their complex dynamics can be directly revealed and analyzed under relevant working conditions using *in situ* environmental SEM. Regarding innovation and novelty they felt that this paper is outstanding.

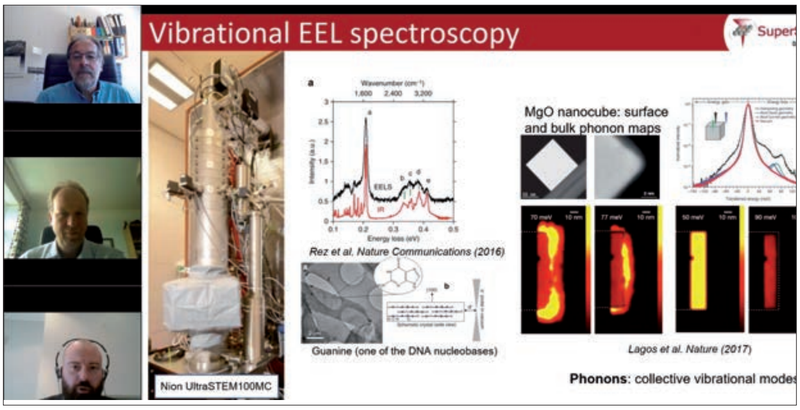
EMS extends its warmest congratulations to all winners.

OutPA 2017 – 2019 Jury Members (judging on papers in 2016 - 2017 – 2018 - 2019)

- Erdmann Spieker (Institute for Micro- and Nanostructure Research, Erlangen, Germany)
- Francesco Priolo (Università di Catania, Catane, Italy)
- Paul Midgley (University of Cambridge, Cambridge, UK)
- Bruno M. Humbel (University of Lausanne, Lausanne, Switzerland)
- Catherine Venien- Bryan (Université Paris 6, Paris, France)
- Jose-Maria Carazo (Universidad Autonoma, Madrid, Spain)
- Peter Nellist, Oxford U. , UK, Chair of the OPA jury

EMS presents its deepest thanks to this outstanding jury. ■





Screen shots taken during the virtual EMS general assembly, August 2020

EMS

SCHOLARSHIPS 2020

EMS STUDENT REPORTS 2020:
EMC2020; Virtual meeting

Last Name	First Name	Institution & Country	
Vrca	Ivana	University of Zagreb	Croatia
Sousa	Mario	Laboratory of cell Biology	University of Porto, Portugal
Gavhane	Dnyaneshwar	Debye Institute for Nanomaterials Science	Utrecht University, Netherlands
Bucinska	Lenka	Center Algatech	Czech Academy of Sciences in Trebon, Czech Republic
Mukherjee	Saptarshi	IIT (BHU)	Varanasi, India
Sharna	Sharmin	IFP Energies nouvelles- R06	Catalysis, Biocatalysis and Separation Division Etablissement de Lyon, France

SHORT REPORTS

IVANA VRCA

I'm Ivana Vrca, PhD student at the University of Zagreb, Faculty of Food Technology and Biotechnology, and I'm working at Faculty of Chemistry and Technology, University of Split, Croatia. European Microscopy Congress 2020 in Copenhagen was cancelled due to COVID-19 pandemia, so this year, Virtual Early Career European Microscopy Congress was held online on November 24 – 26, 2020.

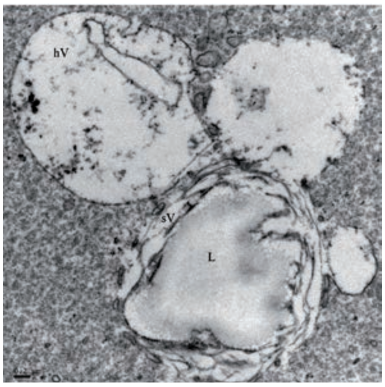
First, I would like to thank you scientific organisers: Klaus Qvortrup, Marco Beleggia, Jakob Birkedal Wagner, Eija Jokitalo and Julia Fernandez-Rodriguez on the opportunity they provided to young researchers to present their results obtained so far.

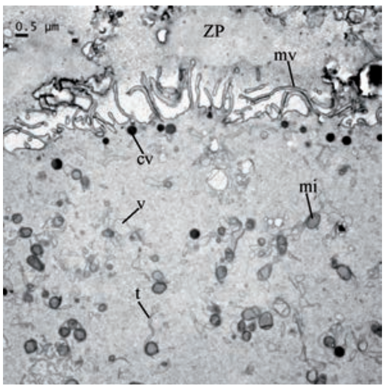
During this congress, I had the opportunity to present as a mini oral poster presentation on four presentation slides titled "Ultrastructure analysis of plant tissue leaves of Brassica juncea L. and Tropaeolum majus L. by TEM". The aim of this research was ultrastructure analysis of plant tissue leaves of *Brassica juncea* L. and *Tropaeolum majus* L. and try to locate the components of the glucosinolate-myrosinase system because it is different between plant organs and changes during a plant's growth cycle.

Finally, I would like to end with a sentence that stands on the official EMC 2020 website:

Thank you to everyone that took part in the virtual event.

MARIO SOUSA





1-Pavani K C, Rocha A, Oliveira E, Moreira da Silva F, Sousa M. Novel ultrastructural findings in bovine oocytes matured in-vitro. ***Theriogenology.* 2020**; 143(Feb):88-97.

Doi: https://doi.org/10.1016/j.theriogenology.2019.12.003

Author affiliations: PKC: Faculty of Veterinary Medicine, Ghent University, Belgium; AR, EO, MS: ICBAS-UP (Institute of Biomedical Sciences Abel Salazar, University of Porto, Portugal); MSF: Faculty of Agrarian Sciences and Environment, University of Açores, Portugal.

Main finding: Previous studies evaluated the ultrastructural morphology of bovine oocytes at different stages of maturation. As there was no detailed study regarding the mature stage, we here first described the detailed ultrastructural morphology of MII bovine oocytes. Oocytes came from Bos taurus ovaries (Holstein-Friesian) of Azores Islands cows. The main and novel ultrastrutural finding is related to the observation of a lipid factory, where lipid droplets were shown to evolve from striated vesicles and heterogeneous vesicles.

A lipid factory is firstly described in bovine MII oocytes. Lipid droplets (L) developed from heterogeneous (hV) and striated (sV) vesicles.

2-Sofia Coelho, Ana Sílvia Pires-Luís, Elsa Oliveira, Ângela Alves, Carla Leal, Mariana Cunha, Márcia Barreiro, Alberto Barros, Rosália Sá, Mário Sousa. Stereological study of organelle distribution in human oocytes at metaphase I.

***Zygote.* 2020**; 28(4):308-317.

DOI: https://doi.org/10.1017/S0967199420000131

Author affiliations: SC, ASP-L, EO, AA, RS, MS: ICBAS-UP (Institute of Biomedical Sciences Abel Salazar, University of Porto); CL, MB: CMIN/CHUP (Maternal Child Centre of the North-Hospital/University Center of Porto); MC, AB: CGR (Center for Reproductive Genetics A. Barros)

Main finding: The ultrastructure of immature human oocytes at the metaphase-I stage (MI) has been rarely reported, and the location of organelles and their frequency has not yet been described. In this work, we described qualitatively and quantitatively the ultrastructure of human immature MI oocytes. For the quantitative analysis, we performed a stereological evaluation of the relative volumes (Vv) and determined the spatial distribution of organelles. We observed significant differences in organelle volume and distribution inside the MI oocyte and between immature MI oocytes and prophase-I arrested oocytes (GV), crossing with data from our previous work on GV oocytes. These findings may contribute to an improvement of stimulation protocols and methods of in-vitro maturation.

The relative volumes and the spatial distribution of organelles was quantified by stereological methods in human immature MI oocytes. ZP: zona pellucida; mv: microvilli; cv: cortical vesicles; mi: mitochondria; v: smooth endoplasmic reticulum vesicles; t: smooth endoplasmic reticulum tubules.

DNYANESHWAR GAVHANE

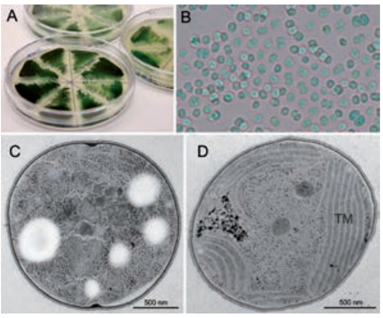
I work as a Ph.D. student in the Soft Condensed Matter group in Debye Institute for Nanomaterials Science at Utrecht University, Netherlands. It was really a pleasure to participate in my first 'Virtual Early Career European Microscopy Congress 2020' which was held during 24 – 26, November 2020. It was very interesting and full of excellent speakers and works.

I presented a talk titled, 'Insights into the Growth of Two Dimensional WS_2 form *in-situ* TEM investigations'. In brief, our work presented *in-situ* Transmission Electron Microscopic (TEM) observations of the dynamics during the growth of two-dimensional tungsten disulfide.

Despite the ongoing pandemic, we got the great opportunity through this virtual meeting to present our work to the expertise in the field of microscopy along with the vast audience from various fields from the comfort of our homes. Along with the talks I have enjoyed the poster contributions as well where we had the opportunity to get in touch with the current research work in the field of microscopy.

I would like to thank the organizers of emc2020 to conduct it in these difficult times and for recognizing the importance of scientific information among young researchers and enabling them to get in touch with the current research works and for the opportunity to present my work in emc2020.

LENKA BUCINSKA

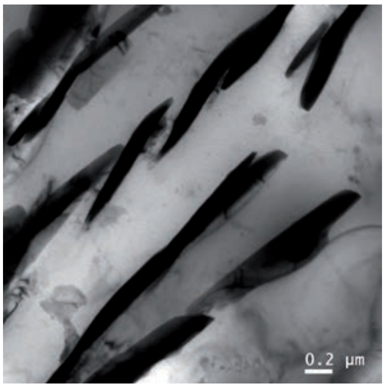


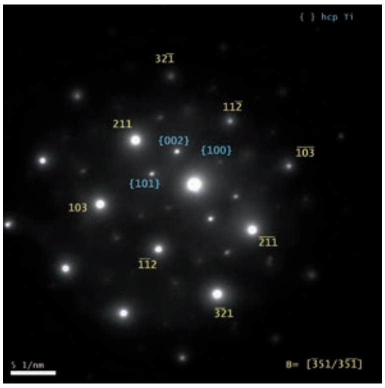
My name is Lenka Bucinska and I am a postdoc in laboratory of the Photosynthesis, Center Algatech of the Institute of Microbiology of the Czech Academy of Sciences in Trebon, Czech Republic. I thank organizers (the European Microscopy Society (EMS), SCANDEM and Royal Microscopical Society) for organizing the Early Career emc2020 Meeting that I could attend. I have joined the meeting on very last decision a week before the meeting and finally could attend only for a part of the talks due to the busy schedule with the experiments. Even though my short participation, I believe that now it is even more important to stay in touch, show and discuss your research in scientific community.

And we must endure the inconvenience during this Covid pandemic. For that I like the online platform of the meeting. For the future I hope I will have another opportunity to join similar concept of meeting also with a presentation or poster of my research topic, which is focused dominantly on photosynthesis in cyanobacterium Synechocystis PCC 6803. I combine electron microscopy techniques with molecular biology and biochemistry to study the biogenesis of photosynthetic membrane in this cyanobacterium.

The attached picture shows the cyanobacterium Synechocystis PCC 6803 A) growing on agar plate. B) In liquid culture –light microscopy. C) and D) electron microscopic pictures of the ultrastructure of stressed cell that losses the thylakoid membrane (TM) and control cell with normal TM formation (published in Klotz et al 2016, Curr Biol).

SAPTARSHI MUKHERJEE





Probing phase separation and omega transformation in Vanadium-Titanium alloys at fine length scales

Continuously diminishing fossil fuel resources, environmental concerns and changing geo-political scenario have incentivised the search of alternative energy resources and technologies. In this changing scenario, hydrogen may evolve as a new energy currency. It has been realised that single point solution to this energy problem is not quite achievable due to the limitation arising out of resources, climatic conditions etc. Judicious selection of energy technologies and its exploitation in its most efficient form is the way forward. Vanadium alloys have attracted attention in the recent past due to its high-temperature strength, low activation, fast decay characteristics, non-magnetic properties. In addition to that vanadium alloys may be used in metal hydride batteries due to its ability to absorb hydrogen. However, very little is known about its phase transformation behaviour and microstructural evolution. Last decade has observed an upsurge in research activities in development, processing and characterization of vanadium alloys with a view to apply this material in fusion reactors and in metal- hydride batteries. However, limited creep properties, He-embrittlement coupled with processing difficulties of these alloys serves as the motivation to better understand the physical metallurgy of such V-alloys at the atomic scale.

Elemental V and Ti (both >99.7% purity) in the form of rods were procured and routine X-Ray Diffraction (XRD) patterns were recorded from them for cross-verification. Three Ten gram buttons of binary V-Ti alloy were prepared through vacuum arc melting in an argon back-filled chamber, composition being: V-10%Ti, V-15%Ti and V-30%Ti (expressed by weight). The buttons were re-melted 5-7 times each so as to attain uniform chemical composition throughout its volume. Moreover, pure vanadium pellets (>99.9% purity) were heated by pulsed laser in a controlled oxygen atmosphere to obtain V-O solid solution alloy. Cross-section microscopy (XTEM) were performed on the specimen. Due to oxygen incorporation a new phase is nucleated at the surface which is plate like in morphology. The diffraction pattern from the plate like phase indicates that it is related to the cubic phase. However, there is elongation along the c- axis and contraction along the a- and b-axes. Our First principles DFT calculation also indicates that oxygen incorporation introduces strain in the lattice and in order to accommodate the strain the BCC structure transforms to Tetragonal structure. Similar tetragonal phase in the shape of whiskers can be seen in the as-cast V-Ti alloys. Thus, both systematic introduction as well as accidental pick up of oxygen during processing leads to a bcc to bct polymorphic transformation. Apart from that, V-10Ti alloy showed initial stages of phase separation with mottled contrast in the matrix phase along with precipitation of α-Ti nano-particles. V-15Ti specimen revealed matured form of phase separation resulting in lamellar microstructure of alternating V-rich and V-lean domains. Omega transformation was predominantly seen in the V- 30Ti specimen with diffuse scattering in the diffraction patterns and athermal domains of 5-7 nm in size.

SHARMIN SHARNA

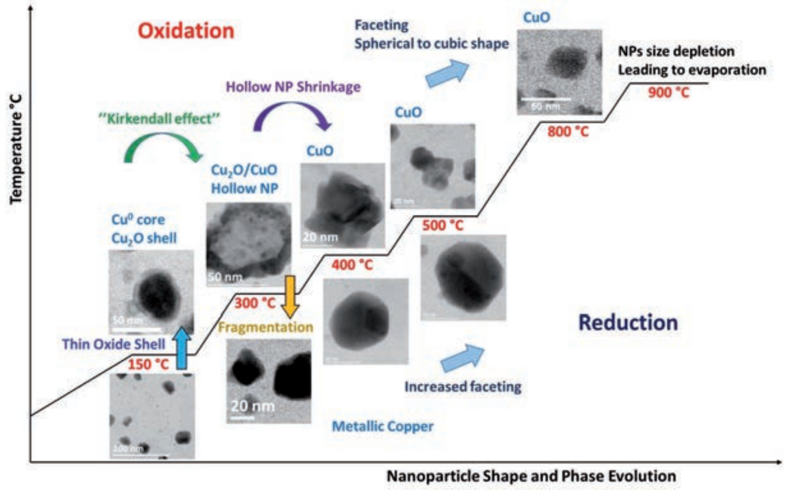


Figure 1: Summary of the key observations on the evolution of copper based nanoparticles morphology and phase as a function of temperature and oxidation-reduction atmosphere, illustrated using STEM-BF images extracted from in-situ STEM observations during the reactions.

In-situ STEM study to understand the morphology and phase evolution of model copper based oxygen carrier during high temperature redox cycling

Sharmin Sharna[1,2 *], Mounib Bahri1, David Chiche[2], Anne-Sophie Gay[2], Arnold Lambert[2], Virgile Rouchon[2], Ersen Ovidiu[1]

1-Institut de Physique et de Chimie des Matériaux de Strasbourg, UMR 7504 CNRS – Université de Strasbourg, 67034 Strasbourg, France.

2-IFP Energies nouvelles, Rond-point de l'échangeur de Solaize, BP 3, 69360 Solaize, France

Copper nanoparticles (NPs) are used in many industrial applications including catalysis and in microelectronics devices. Recently, supported Cu based NPs has found interest as oxygen carrier material for Chemical Looing Combustion or CLC, an alternative combustion process with inherent carbon dioxide capture solution[1]. The material sustains successive high temperature (800-900°C) reduction (combustion) and oxidation (regeneration of oxide phase) reaction cycles which leads to chemical, structural and morphological changes in the material leading to degradation in the oxygen carrying properties[2]. Thus, understanding the oxidation mechanism of copper NPs, their subsequent reduction as well as their deactivation through sintering under reaction conditions is of special interest to optimize oxygen carrier design.

We have dedicated our first study to achieve nanoscale understanding of oxidation-reduction mechanism of model Cu-based NPs (2-80 nm) deposited on SiNx substrate at CLC operating conditions, using in-situ STEM based on enclosed membrane. The sample was heated from 150°C to 900 °C, at atmospheric pressure with H_2/Ar (1:1) as reducing gas and O_2/Ar (1:1) as oxidizing media.

The experimental results elucidate the evolution of nanoparticles morphology, phase, as well as particle size distribution and sintering mechanism. A summary of the key observations concerning the changes in shape and phase of the copper based NPs is presented in figure 1. At low temperature, the oxidation proceeds via formation of a thin Cu_2O layer. The subsequent step of oxidation is followed by hollow nanoparticles formation due to oxide phase growth mechanism governed by outward diffusion of copper atoms. The initial nanoparticles are composed of a mixture of Cu_2O and CuO, which eventually lead to CuO phase. A further increase in temperature results in the collapse of the hollow shells. Finally, at 700-800 °C, the copper oxide phase starts to form cubic shaped particles. Reduction of the copper oxide under hydrogen causes fragmentation of the nanoparticles at 300 °C. The fragmentation is less prominent with increasing temperature, presumably due to rapid sintering induced at high temperature. Under both oxidizing and reducing atmosphere, rapid heating to 900 °C promotes a range of sintering events including Ostwald ripening, Particle Migration and Coalescence (PMC), and attractive migration and coalescence. Moreover, the copper phase starts to deplete in size eventually disappearing at a temperature between 800°C and 900°C, depending on particle size and duration of the heating step. A range of events are taking place simultaneously; the mechanisms involved for the various observations will be expounded during the communication.

In summary, in-situ STEM at CLC operating conditions (atmospheric pressure and high temperature) has provided valuable insights into the morphological and phase evolutions of copper based NPs as well as their sintering mechanism...

REFERENCES:

1. Adanez et al., Progress in Energy and Combustion Science., 38, (2012), 215-282,
2. Lambert et al. Fuel., 216 (2018), 71–82.

FINANCIAL REPORT OF EMS BUDGET

EUROPEAN MICROSCOPY SOCIETIES

REPORTS FROM NATIONAL AND REGIONAL SOCIETIES

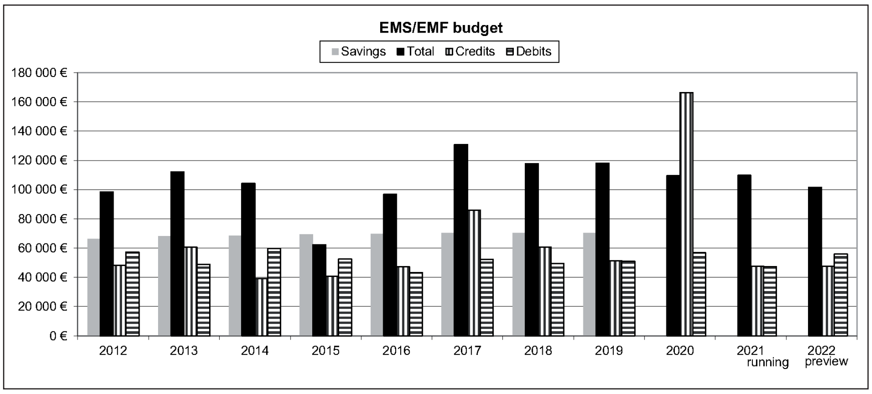
EUROPEAN CORPORATE MEMBER ASSEMBLY (ECMA)

EMS CALENDAR 2021

APPLICATION FOR MEMBERSHIP

FINANCIAL REPORT OF EMS BUDGET

TO BE PRESENTED AT THE VIRTUAL EMS BOARD MEETING, APRIL 22, 2021. BUDGET 2020 FINAL, OVERVIEW BUDGET 2021 AND PROPOSAL BUDGET 2022



Budget 2020, final

Incomings

The majority of incomings came from contributions of the national societies and the ECMA members with further incomings from individual members, interest rates and from job postings for non-EMS members. Furthermore. In summary, an amount of **€ 48 151.87** was accrued.

Expenses

EMS supported the virtual EMC with € 18 000 to reduce fees for young scientists (replacing scholarships). Only one supported meeting took place in presence mode (€ 750). Two board meetings, one GA and one GC took place. Costs for organization of virtual meetings, for professional secretarial support and for three Outstanding Paper Awards added up to € 35 516.58. Together with further costs (banking, web hosting, flyers, etc.) EMS had total expenses of **€ 56 769.67.** Thus, the annual balance for 2020 ended with a minus of **€ 8 617.80.**

As a matter of fact, our bank closed our deposit account of **€ 70 258.44** and the amount was transferred to the giro account. As of December 31st, 2020, EMS had total assets of **€ 109 446.03.**

Budget 2021, running; (as of February 22, 2021)

Incomings

The major revenues will again be accrued by the annual contributions of EMS members of the national societies and of ECMA members. Invoices to national societies, ECMA members and individual members will be sent out after this board meeting, reminders in June. Further incomings will be accrued by individual member fees and job postings for non-EMS members.

Together, incomings are expected to amount to **€ 47 700.**

Expenses

EMS can support one extension meeting (MC2021) and sponsor up to 10 supported meetings (together € 9 000). Assuming that meetings will predominately be online rather than presence mode, EMS will not distribute scholarships but reserves € 4 800 to lower online fees for young colleagues. Further expenses will include the Outstanding Paper Awards (€ 3 000), two board meetings (this one and one embedded in the MC2021), one General Assembly (MC2021), professional secretarial support and bank costs.

Expenses are estimated to amount to **€ 47 700**. It is thus calculated to end the year 2021 with a balanced budget.

Budget 2022, proposal

The proposal is based on the assumption that meetings will take place in presence mode.

Incomings

Major incomings will be accrued by the annual fees of EMS members of the national societies and of ECMA members. Together with interest rates of the savings account and advertising for non-EMS members, we can expect incomings of **€ 47 800.**

Expenses

Due to IMC20 there will be no EMS extension meeting. EMS can support 4 sponsored meetings (in total € 3 000) and can issue 24 scholarships (á € 800) as travel support to attend IMC20 (€ 19 200). Further expenses will include the Outstanding Paper Awards, costs for professional secretary, two board meetings (one extra, one included in EMC) and bank costs, amounting to a total of estimated **€ 55 800**.

It is thus calculated to end the year 2022 with a **minus of € 8 000.**

Annotations: the risen Credits bar in 2020 is due to transfer of all savings to the giro account; note that Credits and Debits exclusively depict annual budget figures without overflows; Total includes overflows and shows figures at the end of the year; Savings in previous years depicts the part of the Total that was on the savings account. ■

Christian Schöfer, m.p.
Treasurer EMS/EMF
Vienna, April 22, 2021

EUROPEAN MICROSCOPY SOCIETIES

Number of EMS Members by Societies (2020)

National and regional societies			# of members
Armenian Electron Microscopy Society	(AEMS)	Armenia	8
Austrian Society for Electron Microscopy	(ASEM)	Austria	185
Belgian Society for Microscopy	(BSM)	Belgium	321
Croatian Microscopy Society	(CMS)	Croatia	115
Czechoslovak Microscopy Society	(CSMS)	Czech Republic	253
Dutch Society for Microscopy	(NVvM)	Netherlands	224
Electron Microscopy and Analysis Group (Institute of Physics)	(EMAG)	United Kingdom	314
French Microscopy Society	(SFμ)	France	400
German Society for Electron Microscopy	(DGE)	Germany	436
Hellenic Microscopy Society	(HMS)	Greece	36
Hungarian Society for Microscopy	(HSM)	Hungary	85
Israel Society for Microscopy	(ISM)	Israel	179
Italian Society of Microscopical Sciences	(SISM)	Italy	191
Microscopical Society of Ireland	(MSI)	Ireland	119
Nordic Microscopy Society	(SCANDEM)	Scandinavia	199
Polish Society for Microscopy	(PTMi)	Poland	149
Portuguese Society for Microscopy	(SPMicros)	Portugal	30
Romanian Electron Microscopy Society	(REMS)	Romania	49
Royal Microscopical Society	(RMS)	United Kingdom	1534
Serbian Society for Microscopy	(SSM)	Serbia	92
Slovene Society for Microscopy	(SDM)	Slovenia	114
Spanish Society for Microscopy	(SME)	Spain	296
Swiss Society for Optics and Microscopy	(SSOM)	Switzerland	78
Turkish Society for Electron Microscopy	(TEMD)	Turkey	79
Russian Society of Electron Microscopy	RSEM	Russia	20
Total			**5375**
Corporate members EMS (43 companies)	(ECMA)		36
Individual members	IND		15

REPORTS FROM NATIONAL AND REGIONAL SOCIETIES

HUNGARIAN SOCIETY (HSM)

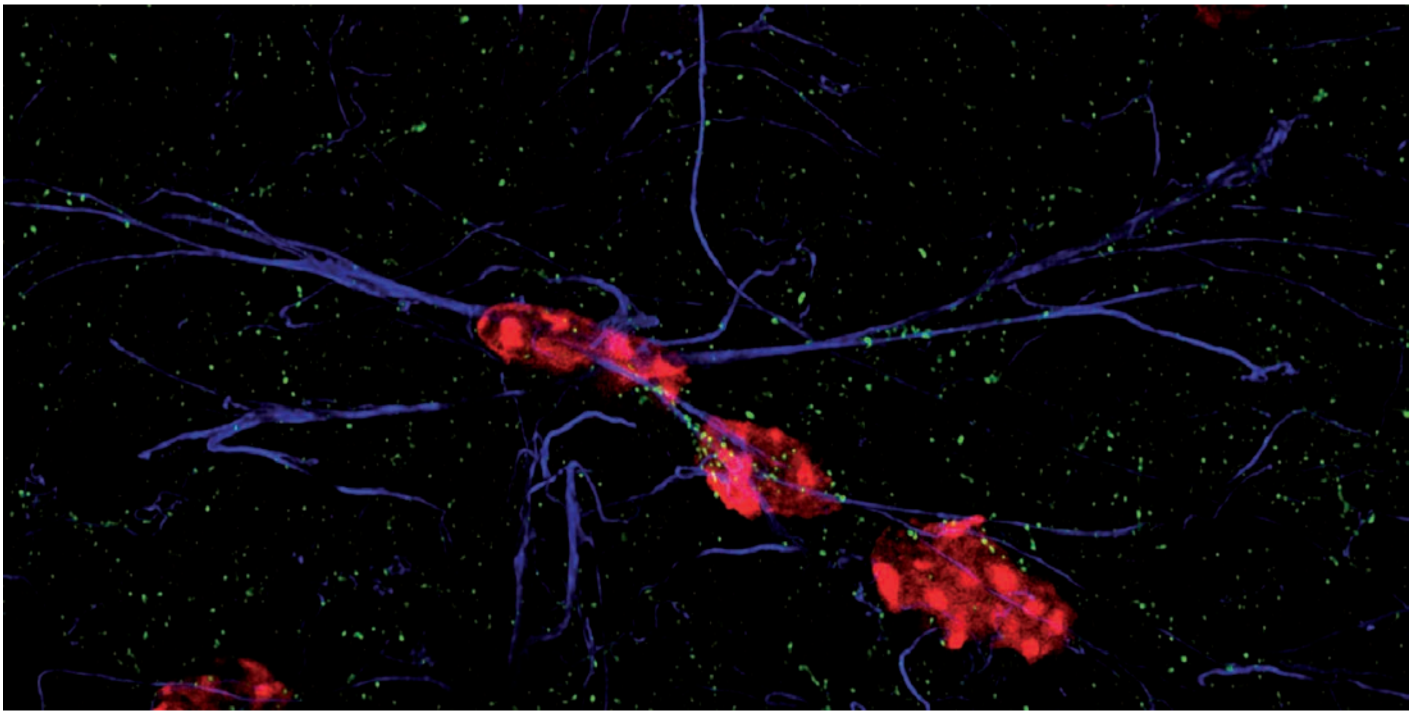
FRENCH MICROSCOPY SOCIETY (SFμ)

SPANISH MICROSCOPY SOCIETY (SME)

THE ROYAL MICROSCOPICAL SOCIETY (RMS)

TURKISH SOCIETY FOR ELECTRON MICROSCOPY (TEMD)

YEAR OF ANNIVERSARIES (HSM)



Chain (http://netrix.koki.mta.hu/data/galeria/NCOE/Chain.png) to the anniversary of the Microscopic Center of the Institute of Experimental Medicine

2020: it was a too special year with difficulties everywhere, but we have to concentrate on the brighter part of our life and to go on. Let's mention the most memorable events for Hungarian microscopists of this special year.

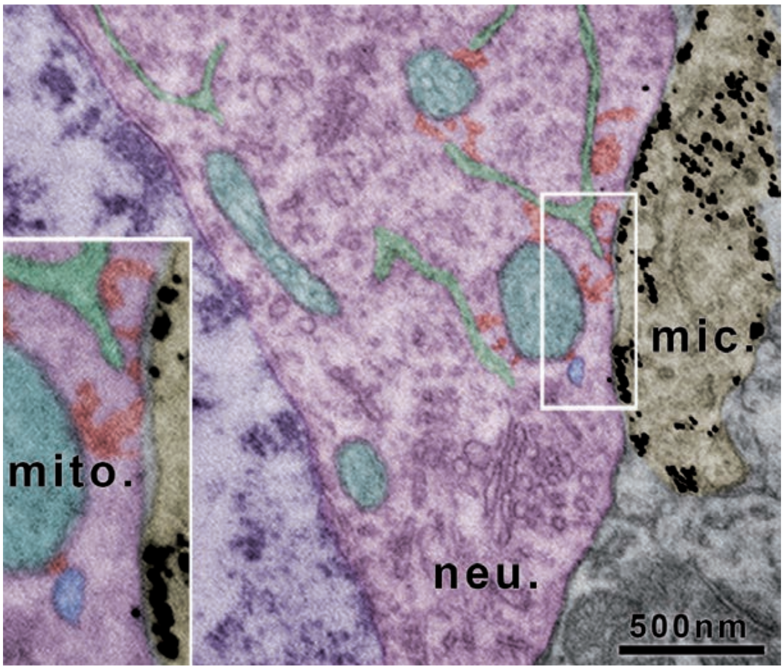
In April, Femtonics Research and Development Ltd. the spinoff company of the Institute of Experimental Medicine, ELRN, received the 2019 Innovation Award of the Hungarian Association for Innovation "From Basic Research to the Market" for their world-class microscope developed for cutting-edge neuroscience research. Thanks to the many years work on their Femto3D ATLAS laser scanning 3D microscopes, they are real "Hungarikum", designed and manufactured in Hungary, based on more than 40 patents and operating with the most advanced state-of-the-art imaging technology.

Although we had to cancel the annual meeting of HSM in May, we had an anniversary.

Dr Dezső Szabó and his JEOL

The Microscopic Center of the Institute of Experimental Medicine celebrated the 10th anniversary of its foundation on May 18. More exactly, it would have been celebrated, but the festive was postponed due to the world known corona virus that otherwise is so spectacular under electron microscope.

Csaba Cserép and Balázs Pósfai



Mitochondrion in a neuron and microglia contact

In July we had a really exceptional anniversary. Dr. Dezső Szabó, one of the founders of our society, had his 95th birthday on July 12th!

Although we could not organize even a little birthday party either, but the epidemic could not stop everything. Since the cancellation of our conference was predictable, not too many submitted their abstracts, however, based on those we had and by the help of Laci Barna and Kata Solymosi, we "published" the very first online abstract book of our society which is dedicated to Dr. Dezső Szabó. And this little present made him at least as happy as a big birthday cake.

The last month of this summer gave another reason for celebration. We did not have the emc2020 in Copenhagen, but the General Assembly of EMS was broadcasted – and was attended by more EMS members than ever before! This broadcasting will be very memorable for us, Hungarian microscopists, because of the OPA lectures. Exactly ten years ago Zsolt Czigány was OPA winner in Material Sciences, and now we had winners Csaba Cserép and Balázs Pósfai in the Life Science category. The talk was given by Csaba Cserép. Those who read their last year's published award-winning Science article easily agree that there weren't many chances of submitting too many articles last year that were similarly outstanding, using so state-of-the-art microscopic techniques to achieve similarly significant scientific results.

EMS YEARBOOK REPORT (Sfµ)

As the coronavirus spread across the world, many preventive measures are being taken, we, at the Sfµ have not escaped them. Some events, which are supported by the Sfµ, have simply been postponed; others have been transformed into virtual conferences, with a great deal of videoconferencing.

An example to illustrate the latter case is the Sfµ junior congress. Initially scheduled at the CEMES lab in Toulouse in May 2020, the congress was eventually held as an online webinar from 18th to 20th November 2020. Despite the unexpected last-minute rush for the reorganization of the conference, only weeks before the starting date, almost all of the 50+ originally registered speakers and participants attended. This congress is very important for the youngest of us at a crucial moment in their career. Indeed, this congress offers them not only the opportunity to present their work but also gives them the chance to meet and interact with professionals from the field of research and development from various companies. Six invited speakers presented the latest news on "imaging of sensitive samples", "time resolved microscopy", "diffraction" and "3D imaging". In addition, representatives from six different companies from various fields, including Safran tech, Yves Rocher and Merck, presented the role of microscopy in their respective companies and fields. This was followed by interesting questions from young researchers about job-hunting within R&D in the private sector. We thank again all of them for their enthusiast participation to the meeting. 20 PhD students and postdoctoral researchers contributed by presenting their work through impressive live streamed oral presentations and various (and for some of them, very creative) pre-recorded elevator pitches. The Sfµ is very grateful to Mia Andersen (PhD, CEMES), Ségolène Combettes (PhD, CEMES) and Laura Plassart (PhD, LBME, Univ. Toulouse III) for the amazing organization of the meeting.

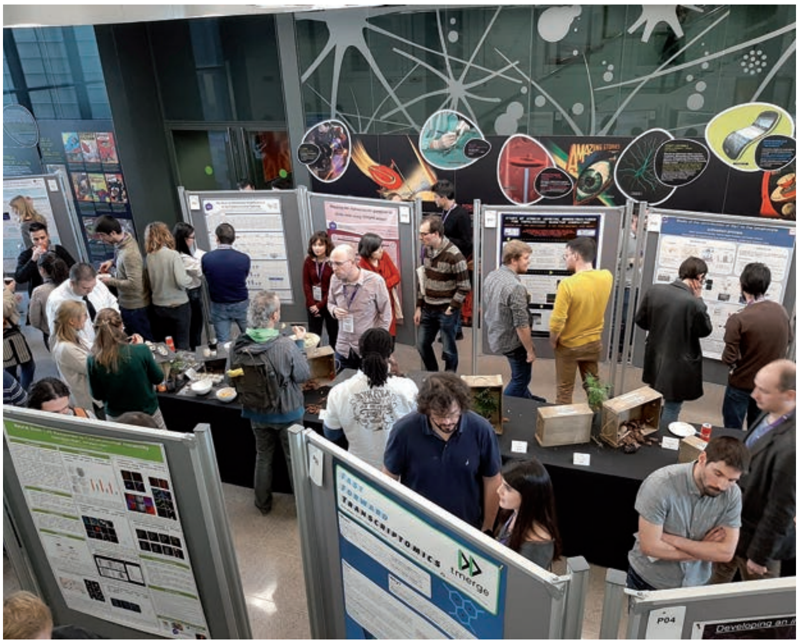
The organizers of the Sfµ junior congress standing in front of CEMES, Toulouse. Mia Andersen, Ségolène Combettes and Laura Plassart (from right to left), with a nice bunch of flowers as proof of deep gratitude from the Sfµ.

Sfµ will hold the Seventeenth congress of the Society from 5th to 9th July 2021 (https://sfmu.fr/fr/colloque_formations/next/). The city of Reims will host this event, which is organized by Jean Michel and colleagues. As for the previous congresses, Materials Sciences, Life Sciences and Common Symposia will be proposed. Hopefully this event will be "in person". During this meeting, we will award the Raimond Castaing prize (dedicated to advanced researchers) for the two categories: Life sciences and physical/material sciences. The Pierre Favard award (dedicated to the best PhD work) will be also celebrated.

Finally, we would like to remind you that, among its various activities focused on training young researchers and supporting scientific events involving microscopy, the Sfµ funds many types of travel grants to attend national and international conferences. Although the past year saw some restraints due to the sanitary conditions, we hope that we will be back on track for the coming year. In addition, for the past three years, Sfµ has been very pleased to offer bursary to laboratory research internships to Master students in the field of microscopy. ■

Catherine Vénien-Bryan
President of the French Society of Microscopies

ANNUAL REPORT ON THE SPANISH MICROSCOPY SOCIETY (SME)

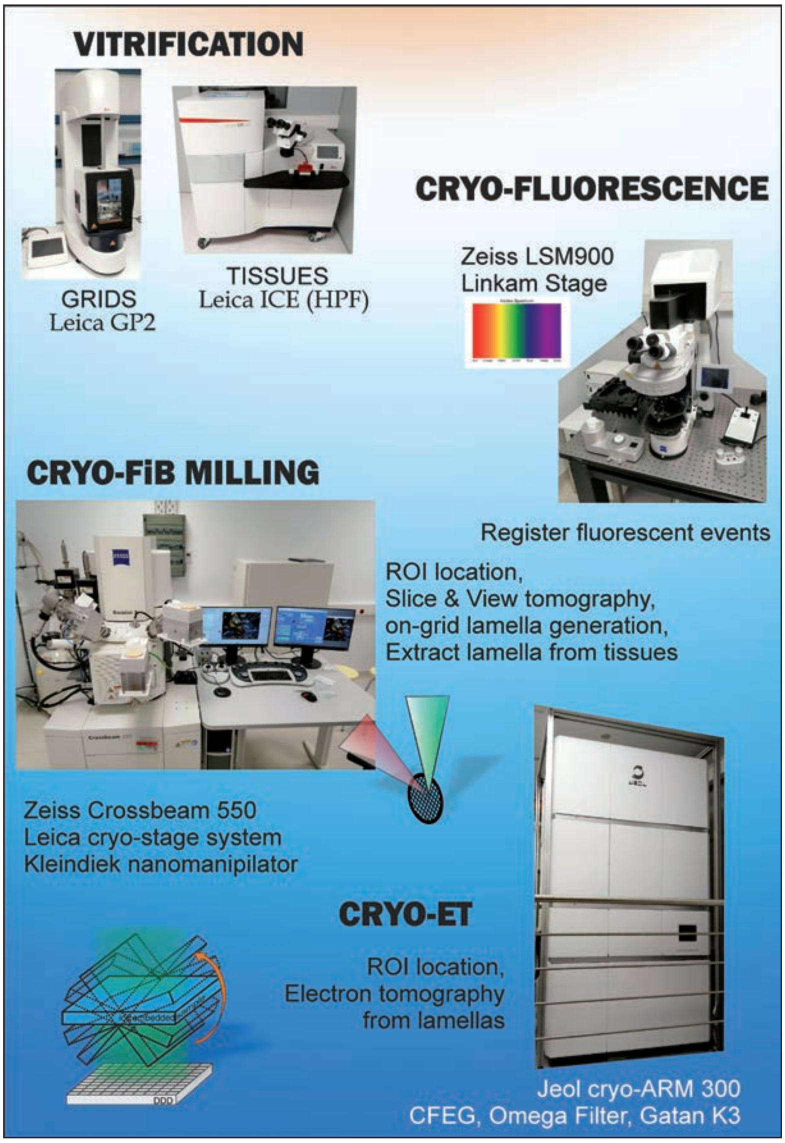


2020 has been a strange and weird year due to the known COVID-19. Despite the pandemics, the SME has remained active preparing together with our Portuguese colleagues our next joint meeting, the Microscopy at the Frontiers of Science (MFS2021), that will take in September 2021 in Braga (Portugal), https://mfs2021.com/. From here we would like to invite you all to participate.

This year SME could only sponsorship 1 event. The rest had to be cancelled due to the COVID. Fortunately, the 3rd edition of the BIST Symposium on Microscopy, Nanoscopy and Imaging Sciences was organized successfully in January, before COVID stroke us. https://bist.eu/events/event/2020-bist-symposium-on-microscopy-nanoscopy-and-imaging-sciences/. A great list of keynote speakers, including EM, SPM, OM and correlative microscopies and techniques participated and made a wonderful event once again.

Things are also moving, and several microscopy-related projects received the green light during 2020. Several new microscopes will be purchased during 2021. Of special notice are the new ALBA Synchrotron EM facilities which will receive high-end Materials and Life Sciences microscopes in 2021. Stay tuned for news from Barcelona where several research institutions, including ALBA-CELLS, ICN2, CSIC (ICMAB and IBMB), IRB, BIST and UAB among others, have joined together to make it possible.

This is just the first seeding step for ASTIP (ALBA Science, Technology and Innovation Park), where microscopes, especially those correlatives with Synchrotron beam lines, will represent one of its main strengths. Other funded projects include also an aberration corrected microscope with in-situ liquid capabilities to be placed at UB, which joint together with CRG, IRB, IBEC and BIST for this new and exciting adventure.



NEW EQUIPMENT FOR THE CRYOELECTRONMICROSCOPY FACILITY AT THE NATIONAL CENTRE FOR BIOTECHNOLOGY IN MADRID

The cryo-electron microscopy facility at the National Centre for Biotechnology (Centro Nacional de Biotecnología; CNB-CSIC) has recently had installed a 300 kV JEOL CryoARM300 equipped with an autoloader, a Gatan K3 direct electron detector and an Omega energy filter.

This state-of-the-art cryo-electron microscope is suited for the collection of large amounts of high-resolution data that can be used for high-resolution studies using single-particle methodology, or for the reconstruction of pleiotropic structures such as cells and subcellular structures, using cryo-electron tomography.

In addition, the facility has had installed all the necessary equipment for cryo-correlative microscopy, which includes two vitrification devices, a Leica EM CP) for thin specimens and Leica EM GP2 high-pressure freezer, suited for the fast-freezing of cellular samples.

Samples can be first visualised using a cryo-optical microscopy (Zeiss LS900 AiryScan cryo-confocal microscope) and the samples prepared for cryo-electron tomography with a Zeiss CrossBeam 550 cryo-FIB-SEM microscope. This infrastructure will increase the microscopy capabilities of the facility and will allow direct visualization of cells for tissue-cell resolution or for preparation of thin lamellas in cells for molecular resolution. ■

THE ROYAL MICROSCOPICAL SOCIETY (RMS)

Grace Burke,
President of RMS

Needless to say, 2020 did not pan out as expected and posed a huge challenge for the Society's programme of events, outreach work and other regular activities. However, picking over the ups and downs of the last 12 months, it is clear that the challenge of operating through a pandemic has opened up new and exciting possibilities, particularly in the development of online facilities to promote scientific discussion and – perhaps ironically – bring the microscopy community closer together.

Early meetings and Science Heritage collection of microscopes

Though it now seems an impossibly long time ago, the early months of 2020 did see plenty of business as usual, with the Society's regular, January events a particular success. The Flow Cytometry Facilities meeting in Newcastle attracted 101 attendees, while EM-UK in Plymouth saw 76 participants. The UK Light Microscopy Facility Meeting 2020 was a big success, with 165 people in attendance, and the RMS helped organise a meeting in memory of Gerald Offer and John Trinick at the University of Leeds which attracted 29 people.

The new year also saw the generous donation to the RMS of a set of replica antique microscopes, selected from the Replica Rara series of instruments commissioned by Dr & Mrs James B McCormick to illustrate the development of optical microscopes through the 17th and 18th centuries. The project was the result of close collaboration between Dr McCormick and former RMS President Dr Gerard Turner in the 1970s.

Figure 1. Compound microscope of ~ 1750, attributed to John Cuff

Figure 2. The complete collection

The collection of instruments consists of eight microscopes, ranging from a tiny, silver copy of a Leeuwenhoek microscope, an "Olde English" tripod microscope in a leather-bound tube of the 17th C, to several elegant brass instruments of 18th C. An example is shown in Figure 1.

The microscopes are all in perfect working order and demonstrate the superb technical skills of the original makers. The complete collection is on display in the RMS Office Library in Oxford and it is planned to show some of the instruments at future events. Figure 2 shows the collection in place.

Coronavirus and shift to 'virtual'

As the implications of Government restrictions to tackle the new Coronavirus became clear in late March, a number of immediate challenges were posed – not least the need to establish new, remote-working arrangements for our office staff, and a new-found reliance on virtual communication with members, partners and volunteers. As Professional Congress Organiser for emc2020, we continued to plan in earnest for the major event of the year. The hope was that by late August, when the conference was due to be held, restrictions relating to the pandemic might have eased sufficiently for it to go ahead.

Preparations continued to gather pace, but in April the Danish Government announced that public events for more than 500 people could not take place until 1 September, which meant the event was cancelled as a *force majeur*. Of course, the safety of congress delegates, visitors and exhibitors must always be our highest priority, but the cancellation of emc2020 was obviously a huge blow for Professor Klaus Qvortrup and the organising committees, SCANDEM, the EMS, the RMS and everyone else involved in its planning.

We are hugely grateful to the many exhibitors who donated a proportion of their refunded booking fee to the RMS – a gesture which helped to offset some of the Society's associated losses. We now look forward to resuming our role as PCO for emc2024 in Copenhagen, on behalf of SCANDEM and the EMS.

Despite the disruption to our usual calendar of face-to-face meetings, courses and other events, our shift to virtual events had become fully established by the summer months. Among the first RMS-hosted virtual events was a series of excellent meetings focused on the question of how microscopy facilities across the globe could safely return in a post-Covid environment. Separate meetings were held for LM, EM and Flow Cytometry, each attracting around 300 participants. These meetings – and follow-up events in the late summer - provided a really important platform for scientists to share their concerns and build a consensus around the best working practices to take forward.

Online advances

The experience gained from such meetings now means our staff can offer practical support for other organisations, groups and academics planning virtual events. From simple use of the RMS Zoom account and help with registration, through to fully planning and hosting large-scale online meetings and conferences, we are now able to provide a whole new package of support to our partners and colleagues, ensuring they can get the best out of their online interactions. We have now hosted several successful events on behalf of other groups and partners – a particular success being the Light Sheet Microscopy Meeting in September which attracted more than 800 registrations. Alongside this, we have also pulled together an extensive online resource of microscopy talks, webinars and other virtual training opportunities to assist our community in the absence of face-to-face contact.

Alongside the development of the Society's online meeting capabilities, the RMS made some important changes to its website in 2020. We now have an exciting Discussion Groups feature enabling website visitors to access more of the information, conversations and networking opportunities that interest them most. There are 14 groups - covering the whole spectrum of microscopy – where people can create forums and upload documentation for discussion with the wider community. It means the Society has a better means of sharing information and facilitating scientific conversations than ever before. We have also improved the online experience of our members, who can now create and manage their own account, sign up for events, and keep track of announcements – all at the touch of a button.

Awards, Outreach and Publications

Thankfully, some of the Society's regular activities and areas of business did continue unaffected during 2020. This year saw a raft of RMS Awards handed out to leading scientists across all areas of microscopy. The Society announced the winners of its Science Section medals, Mid-Career Awards, The President's Medal and Vice Presidents' Medal. A brand-new award for Outreach and Education, in honour of the late Professor Chris Hawes, was also given out for the first time. Details of all the winners can be found on our website at www.rms.org.uk

In November the Society was very proud to announce the appointment of four new Honorary Fellows, who will receive the title next year. Joining the distinguished ranks of the RMS Hon Fellowship are: Professor Peter Nellist (Oxford University), Professor George Smith (Oxford University), Professor Knut Urban (Ernst Ruska Centre) and Dr Anne Carpenter (The Broad Centre). The achievements of each of these pre-eminent scientists are truly deserving of the Society's highest accolade.

Although some of the Society's Outreach and Education work was interrupted by the pandemic, we are very pleased to report that our annual Summer Studentship scheme was able to go ahead in 2020, with students largely working from home and projects adjusted to take account of issues around access to laboratories during lockdown. This year four undergraduates received Studentships of £2,000 each to assist their summer project, and their completed reports have already appeared in print.

We are also very proud to have been able to continue publishing our quarterly membership magazine, infocus, and the monthly Journal of Microscopy throughout the pandemic. These publications continue to be an essential cornerstone of our communication with members and the wider scientific community.

Final thoughts

As we look ahead to 2021, there obviously remains much uncertainty around the viability of 'in-person' meetings, conferences and courses. Naturally, we are hugely looking forward to a return to something like business as usual, and very much hope that our normal programme of face-to-face meetings will resume as soon as possible. Clearly nothing can be taken for granted in these times, and while we are planning on the basis that 'in-person' will be possible, we also know the experience we have gained in hosting virtual events holds the Society in good stead, should there be a need to revert to online interactions. 2021 is of course an mmc year, and discussions are ongoing about what form the Congress will take. We'd really like this to be an in-person event, though at this stage it is looking more likely that it will be virtual. Further detail will be available in the coming weeks. ■

Allison Winton,
RMS Chief Executive.

REPORT FOR TURKISH SOCIETY FOR ELECTRON MICROSCOPY (TEMD)

In 2020, monthly scientific meetings of the Turkish Society for Electron Microscopy have been regularly organized. Due to Corona Virus pandemics the scientific meetings were organized as 7 online webinars. Three of these webinars have been co-organized by ZEISS, Leica and ThermoFisher Scientific companies.

The preparations for next **25th National Congress of Electron Microscopy-EMK 2021** (with international participation) which will be organized in September 2021 by Izmir Institute of Technology, Department of Material Sciences are going on.

Turkish Society for Electron Microscopy is one of the Organizer Societies of 15th Multinational **Congress on Microscopy-MCM 2021** which will be held in August 22-26, 2021 in Vienna, Austria. Turkish Society contributes to the organization of MCM 2021 by the representatives as 'Chairs' and 'Members of Organizing Committee'. ■

CORPORATE MEMBERS 2020

Platinum members

- Diatome Ltd
- JEOL Europe
- TESCAN

Gold members

- Andor Technology
- DELONG INSTRUMENTS a.s
- Hitachi High-Technologies
- Leica Microsystems
- Thermo Fisher Scientific

Silver members

- Akadémiai Kiadó
- AMETEK B.V.
- Bruker Nano GmbH
- Carl Zeiss Microscopy GmbH
- CEOS
- DENSsolutions
- Electron Microscopy Sciences
- Intelligent Imaging Innovations GmbH
- NanoMEGAS
- Quorum technologies
- SPI Supplies
- Ted Pella, Inc.
- TVIPS - Tietz Video and Image Processing Systems
- XEI Scientific Inc.

Bronze members

- Advanced Microscopy Techniques
- Deben UK Ltd
- Digital Surf
- EMSIS GmbH
- Eumex Instrumentebau GmbH
- Fischione Instruments
- FemtoTools AG
- Gammadata Instrument AB
- Gatan
- ISS Group Services Ltd
- JSC Nanopromimport
- Klocke Nanotechnik
- LAB PROTECT – Electron Microscope Protection
- MICROS Austria Produktions- und Handelsges.m.b.H
- Micro to Nano
- NANOVIZZ
- NenoVision
- Protochips
- Safematic GmbH
- Science Services GmbH
- SmarAct GmbH
- Systron EMV GmbH

EMS CALENDAR 2021

High Content Imaging 2021
23 to 25 March 2021
Virtual meeting - United Kingdom

Focus on Microscopy 2021
28 to 31 March 2021
Virtual meeting

Electron Backscatter Diffraction - EBSD 2021
20 and 21 April 2021
Sheffield - United Kingdom

PICO 2021 - Sixth Conference on Frontiers of Aberration Corrected Electron Microscopy
02 to 06 May 2021
Ernst Ruska Centre in Jülich -
Kasteel Vaalsbroek - Netherlands

Quantitative Electron Microscopy 2021 (EMS Sponsored Events)
09 to 21 May 2021
Port Barcarès - France

Advanced Workshop on Cryo-Electron Tomography (EMS Sponsored Events)
15 to 21 May 2021
Biocenter – Vienna - Austria

EMAS 2021 - 17th European Workshop on Modern Developments and applications in Microbeam Analysis
16 to 20 May 2021
Krakow - Poland

European Light Microscopy Initiative 2021
22 to 25 June 2021
Online - United Kingdom

Microscience Microscopy Congress 2021
05 to 09 July 2021
Manchester Central - United Kingdom

Microscopy Conference 2021 Joint Meeting of Dreiländertagung & Multinational Congress on Microscopy (EMS Extension)
22 to 26 August 2021
Digital

CINEMAX VI PhD Summer School in Denmark
23 to 27 August 2021
Fuglsang Manor on Lolland - Denmark

16th European Molecular Imaging Meeting - EMIM 2021
24 to 27 August 2021
Lokhalle Goettingen - Goettingen - Germany

EUROMAT 2021 - European Congress and Exhibition on advanced Materials and Processes
12 to 16 September 2021
Graz - Austria

Microscopy at the Frontiers of Science (EMS Sponsored Events)
27 to 30 September 2021
Braga - Portugal

One Day flowcytometry UK Meeting 2021
18 November 2021
Babraham Institute - Cambridge - United Kingdom

APPLICATION FOR MEMBERSHIP

EUROPEAN MICROSCOPY SOCIETY (EMS)

Individual Member Subscription form

Individual membership of the European Microscopy Society is open to all microscopists for €25 per year. Note that the membership fee is €7 for members of European national microscopy societies. Please complete and return the following form* to:

Virginie Serin, Secretary EMS, CEMES - CNRS
Centre d'Élaboration de Matériaux et d'Etudes Structurales (UPR 8011)
29, rue Jeanne Marvig, BP 94347, 31055 Toulouse Cedex 4, France
email: sec@eurmicsoc.org , Fax: +33 (0)5 62 25 79 99

Prof./Dr./Mr./Ms.: ______________________ Last Name: ______________________

First Name: ____

Institute: ____

Department: ____

Address: ____

Zip code: ____________________ City: ______________________________

Country: ____

Tel.: ______________________ Fax.: ______________________________

E-mail address: ____

Website: ____

I will transfer 25 € to EMS, in favour of account:

Freunde

IBAN AT812011130003104790

BIC/SWIFT: GIBAATWWXXX

Erste Bank, Austria

Please mail or fax a copy of your bank transfer statement to:

Prof. C. Schöfer, EMS Treasurer, Medical University of Vienna, Austria,
Tel: (+43)14 0160 37713 Fax: (+43)14 0160 937799,
email: christian.schoefer@meduniwien.ac.at

Date / Signature: ____

* please print for clarity

APPLICATION FOR MEMBERSHIP

EUROPEAN CORPORATE MICROSCOPY ASSEMBLY (ECMA)

https://www.eurmicsoc.org/en/organisation/corporate-members-ecma/concept-constitution-fees/

Subscription form

To subscribe to the ECMA, please complete this form* and mail or fax to:
Virginie Serin, Secretary EMS, CEMES - CNRS
Centre d'Élaboration de Matériaux et d'Etudes Structurales (UPR 8011)
29, rue Jeanne Marvig, BP 94347, 31055 Toulouse Cedex 4, France
email: sec@eurmicsoc.org , Fax: +33 (0)5 62 25 79 99

Prof./Dr./Mr./Ms.: Last Name:

First Name:

Representing the Company:

Address:

Zip code: City: ______________________________

Country:

Tel.: Fax.: ______________________________

E-mail address:

Website:

We select the following category (thick one)

- ○ Platinum minimum 2.000 €
- ○ Gold 1.000 €
- ○ Silver 500 €
- ○ Bronze 200 €

and will transfer the corresponding amount in favour of account:

Freunde, IBAN AT812011130003104790, BIC/SWIFT: GIBAATWWXXX
Erste Bank, Austria

Please mail or fax a copy of your bank transfer statement to christian.schoefer@meduniwien.ac.at , EMS Treasurer, Prof. C. Schöfer, Medical University of Vienna, +43 14 0160 937799

Date / Signature: ____

* please print for clarity

Notes

Notes

LIST OF ADVERTISERS

LIST OF ADVERTISERS

Scientific / Metrology Instruments

Multi-purpose Electron Microscope

CRYO ARM™

Ultimate instrument for Protein/Virus structure study

Cold FEG
Omega energy filter
Phase plate
Single Particle Analysis

www.jeol.com