CINSaT

Center for
Interdisciplinary Nanostructure
Science and Technology

Newsletter No. 16 (July 2024)

UNIKASSEL
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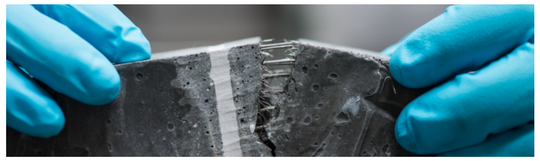
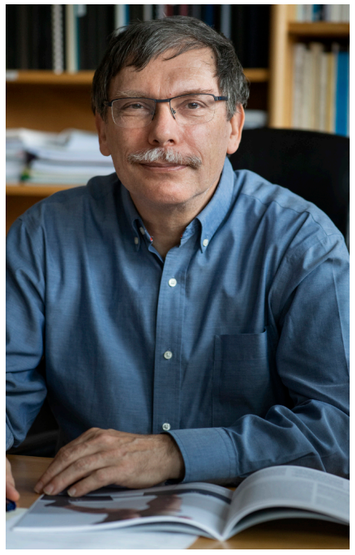


Cover Image

Fractal Au-Nanoparticle clusters and salt crystal flowers on HOPG measured by Nico Kubetschek and Dr. Stuart John Goldie with SEM.

Preface



Dear readers,

I welcome you to the first issue of the CINSaT newsletter in 2024. The first half of the year was dominated by the general assembly of the CINSaT members, which you can read more about in the General Information section. Several other meetings between the members of the CINSaT executive board and representatives of the university administration took place dealing with the further development of the structural organization of the coming installation of first key-labs, i.e., (i) **N**ano**T**echnology **L**aboratory (**NTL**) and **M**aterial **A**nalytic **L**aboratory (**MAL**). Both of them (MAL in part) will use in future the cleanroom infrastructure of the Nanotechnology Center (NTC), which is still in the planning phase. Please be not confused about the naming. We are now distinguishing between the organization of key-labs and the physical building, which will be used by two key labs. Before we used the name NTC for the new building and the key-lab organization. More details about the organizational development and the progress on the planning process will be reported in a future newsletter.

Another large event was the annual spring colloquium from March 7th to March 8th. This time the event was held in a new venue in Paderborn. You will find more information about the colloquium with a detailed report in the Latest Reports section. There you will also find short reports about the activities of the CINSaT during the “Campusfest” at the main campus of the University of Kassel on May 23rd and the “Hesse Day” (Hessentag) in Fritzlar on May 29th.

The main contribution to this newsletter is of course provided by our members. In the Research Highlights section Dana Bloß presents a new publication about her research to understand the mechanisms behind X-ray-induced radiation damage. Dana Bloß is a member of the research subgroup “Spectroscopy and Physics with Synchrotron Radiation” of our new member Dr. Andreas Hans, part of the research group of member Prof. Dr. Arno Ehresmann. CINSaT member Prof. Dr. Raffael Schaffrath presents a new publication about insights into the mechanism and structure of the Human Elongator Complex. Researchers from Krakow, Berlin and Kassel joined together to investigate this clinically important protein machinery which is related to the development of distinct forms of cancer and neurodevelopment disorders. Finally, our member Prof. Dr. Wenwen Song has released recently a book about the Nano-engineering of High Strength Steels to achieve enhanced mechanical properties. Prof. Song will also present her research in more detail in the New Members section.

In the Members section Dr. David Gallina is presenting the current research about the exploration of energy landscaped and magnetization dynamics of 2-D magnetic nanostructures in the research group “Theory of Low-Dimensional and Nanostructured Materials” headed by our member Prof. Dr. Gustavo M. Pastor.

Lastly, in the Announcement section you can find information about our newly launched Alumni-database. With this tool we are aiming to stay in touch with former members of CINSaT-related research groups and hoping to gather information about the career path of the nanoscience graduates.

I hope you will enjoy the reading of this issue!

General Informations

Latest information from the CINSaT management

Here we report briefly about key issues from the CINSaT committees, important discussions, and decisions from their meetings.

Member Meeting

The members met on 14th February 2024. In the following, main issues discussed, and decisions are briefly listed, which are of general interested:

- The financial report was presented by the management and the members released the management.
- The CINSaT memberships of Prof. Dr. Daqing Wang and Prof. Dr. Thomas Kusserow are terminated due to discontinuation of the membership requirements by simple majority vote. Prof. Wang and Prof. Kusserow receive alumni status.
- The changes from associated to full membership of Prof. Dr. Guido Falk von Rudorff and Prof. Dr. Mohamed Benyoucef were accepted with simple majority vote.
- The associated membership of Dr. Alexander Wetzel was extended with simple majority vote.

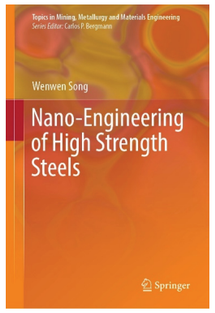
New Members

We welcome three new members to the CINSaT:

- Prof. Dr. Camilo Florian Baron has been at the University of Kassel since March 2023 and is developing the "Extreme Light for Nanostructures" department in FB 15. He submitted his application for full membership on 24th of January 2024, and gave his presentation on 7th of March 2024, as part of the CINSaT Spring Colloquium.
- Prof. Dr. Jost Adam has been at the University of Kassel since September 2023 and is developing the "Computational Materials and Photonics" department in FB 16. He submitted his application for full membership on 26th of January 2024, and gave his presentation on 8th of March 2024, as part of the CINSaT Spring Colloquium.
- Dr. Andreas Hans has been at the University of Kassel since 2006, with the start of his studies in Physics. He got his PhD in 2018. Since 2020 subgroup leader of the “Physics with Synchrotron Radiation” group in FB 10. He submitted his application for full membership on 26th of September 2023, and gave his presentation on 7th of March 2024, as part of the CINSaT Spring Colloquium.

Research Highlights

Highlight news - Announcing the book publication of ‘Nano-Engineering of High Strength Steels’



We are delighted to announce the book publication of “Nano-Engineering of High Strength Steels”, authored by our CINSaT full member, Prof. Dr.-Ing. habil. Wenwen Song, - now available at Nature Springer. This groundbreaking work explores the latest advancements in nano-engineering techniques for developing high-strength steels.

This book provides new insights into adjusting nanostructures in high-strength steels to achieve enhanced mechanical properties. It summarizes state-of-the-art nano-engineering approaches, such as precipitation engineering, interface engineering, and short-range ordering engineering. The nanostructure-process-property relationships in various high-strength steels, including TRIP/TWIP/MBIP in high-Mn steels (HMnS), medium-Mn steels (MMnS), bearing steels, tool steels, and more, are explored in detail. Covering detailed methodologies for nano-engineering high-strength steels, the book reports the impact of nanostructures on steel properties and explores practical applications and future directions in steel nano-engineering. By reviewing various case studies and experimental results, it provides a comprehensive guide for researchers, engineers, and students in the field of nanostructured metallic materials science.

By advancing nano-engineering techniques for sustainable applications, the current work explores the way to manipulate nanostructures through controlled methodologies, enhancing the mechanical performance of structured metallic materials. Integrating sustainability principles with nanotechnology research not only improves the mechanical properties of metallic materials but also aids in creating environmentally friendly materials.

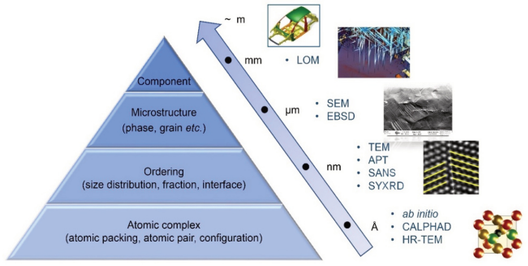


Figure 1 Multi-scale approaches in developing nanostructured high-strength steels [1].

Further Information

More information of the book can be found in this link: https://link.springer.com/book/10.1007/978-3-031-42967-5

ISBN: 978-3-031-42966-8/9, e-ISBN: 978-3-031-42967-5

[1] W. Song (2024). Nano-Engineering of high strength steels. Springer Nature.

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Towards a better understanding of X-ray-induced radiation damage

An international team of researchers led from Kassel investigated the production of low-energy electrons after X-ray ionization of inorganic ions

The macroscopic effects caused by the exposure of bio-organisms to ionizing radiation are quite well known and can be quantified in terms of increased risk as a function of the received dose. Prominent examples are increased cancer risk as a consequence of X-ray treatment or radioactive incidents, as well as sunburn caused by excessive UV-light exposure. The underlying physical and chemical mechanisms which happen on a molecular level following a single ionization event, caused by absorption of an X-ray or UV photon, are poorly understood to a large extent. The knowledge of all involved direct and indirect processes leading to the photoinduced formation of harmful species is far from complete. Most of the damage is typically attributed to low-energy electrons (LEEs) and molecular radicals. They are produced in a photoreaction and can then cause irreparable damage to biomolecules in their environment, for example double- or multi-strand breaks in DNA.

The experimental investigation of the fundamental formation mechanisms of LEEs is extremely challenging. Often, a basic requirement for the performance of state-of-the-art experiments on fundamental light-matter interactions is the spectroscopy of charged particles. In so-called coincidence experiments, kinematically complete reactions can be observed by measuring some or all of the resulting products from a single sample-photon interaction. Applying this scheme to real biological samples is practically impossible. Due to the large sample density, charged particles lose their initial properties through interactions with the environment or do not even escape from the sample. Moreover, the high-vacuum conditions typically necessary for electron or ion spectroscopy are lethal for living organisms.

A promising experimental compromise which combines high-vacuum charged particle spectroscopy with samples mimicking a realistic biological environment is the liquid microjet technique, which has been developed during the last decades. Here, a thin liquid sample of only few tens of micrometers diameter is injected into vacuum and soon after caught on cryogenic traps. It allows the combination of charged particle spectroscopy on liquid samples with modern tunable high-energy light sources like synchrotrons. In the presented work, we combined multi-electron coincidence spectroscopy with the ionization of fully solvated Mg2+ ions by soft X-rays. The Mg ions are of fundamental interest to study due to their relevance in the biosphere and furthermore serve as prototype systems for solvated inorganic ions. Through the coincidence method, we could observe and assign the emission of LEEs with specific kinetic energies to ionization of different orbitals of the Mg2+ ion. Comparison to a recent theoretical prediction allowed us to identify intermolecular autoionization mechanisms as the main origin of LEEs. Among those processes are intermolecular Coulombic decay (ICD) and electron-transfer-mediated decay (ETMD), both have been discussed intensely because of their potential relevance in biological photochemistry recently. It is evident, that in these processes each formation of a single LEE is accompanied by the production of at least one H2O+ radical. The LEE can then cause severe damage in the immediate environment, as illustrated in Fig. 1.

It is remarkable that the initially ionized ion undergoes a cascade of decay processes at the end of which it ends up in its initial charge state. This happens fast – within some hundreds of femtoseconds – and makes the ion ready for the absorption of another photon, starting the cycle over. Consequently, the damage introduced locally at the position of the ion can be multiplied by a large factor through continuous irradiation.

Further Information

JOURNALS: Dana Bloß, Florian Trinter, Isaak Unger, Christina Zindel, Carolin Honisch, Johannes Viehmann, Nils Kiefer, Lutz Marder, Catmarna Küstner-Wetekam, Emilia Heikura, Lorenz S. Cederbaum, Olle Björneholm, Uwe Hergenhahn, Arno Ehresmann & Andreas Hans, Nat. Commun. (2024), DOI:10.1038/s41467-024-48687-2

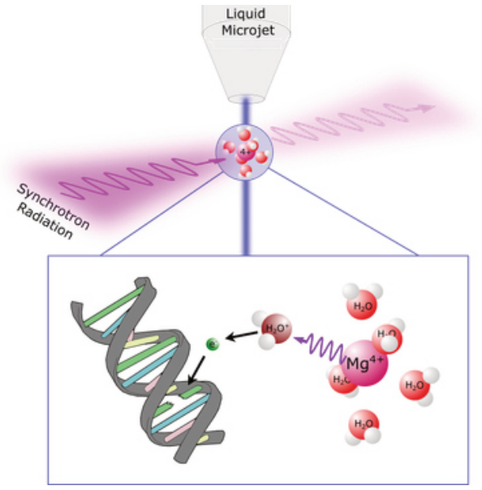

Figure 1: Illustration of the experimental scheme and scientific idea. A MgCl2 solution is injected into vacuum using the liquid microjet and irradiated by soft X-rays from a synchrotron. In single photon-atom interactions, the fully solvated Mg2+ ions are ionized. The main secondary products are low-energy electrons, which can act harmful to surrounding biomolecules.

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Structure and Mechanism of Human Elongator Complex Revealed

Genomic mutations and mis-regulation of the Elongator complex were found to be associated with distinct diseases in humans. The complex plays a vital role during protein biosynthesis of eukaryotic cells, supporting the decoding of messenger RNA into proteins by modifying transfer RNA. A collaboration of scientists from Krakow, Berlin and Kassel was now able to elucidate Elongator structure by cryo-electron microscopy (cryo-EM) and to suggest a reaction mechanism with which Elongator operates in the tRNA modification pathway. The study was recently published in Nature Communications (https://doi.org/10.1038/s41467-024-48251-y).

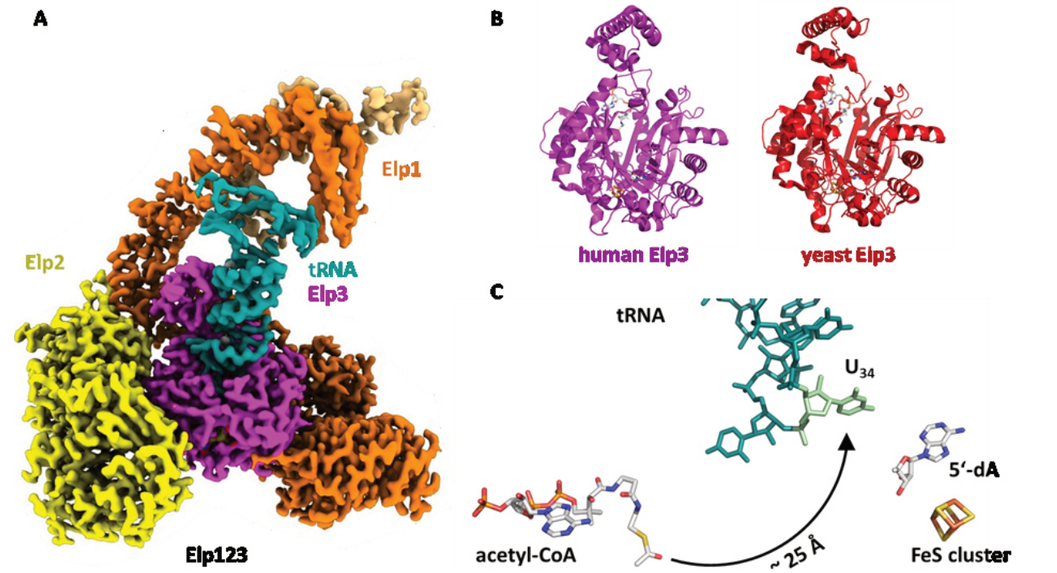

Fig. 1 The Elongator complex is conserved among eukaryotes. (A) Cryo-EM structure of the human Elp123 sub-complex with substrate tRNA bound. (B) The determined structure of human Elp3 (magenta), the catalytic active subunit of Elongator, is nearly indistinguishable from its yeast counterpart (red). (C) The elucidated structure supports a model, in which the acetyl moiety is relayed by conserved Elp3 amino acids over a distance of 25 Å to the anticodon wobble uridine (U34) of the tRNA thus enabling a carboxymethyl-modification reaction that requires iron-sulfur (FeS) cluster cofactor chemistry and a radical (5'-dA) formed by S-adenosyl-methionine cleavage.

In order to replace broken proteins and rejuvenate tissues, new proteins are steadily synthesized from our genetic code. This process was coined translation, since the information provided by the messenger ribonucleic acid (mRNA) is translated into another biomacromolecule known as protein. A type of RNA, the transfer RNA (tRNA), thereby decodes the mRNA and transfers a corresponding amino acid onto the newly synthesized protein. These tRNAs contain the bases uridine, cytidine, adenosine and guanosine and were found to be chemically modified by enzymes to ensure correct and high-fidelity mRNA decoding in the ribosome. One of these modifier enzymes is the so-called Elongator complex (Fig. 1A), a multi-subunit [Elp123]2•[Elp456]2 protein machinery that attaches carboxymethyl groups to uridine bases in the wobble position (U34) of tRNA anticodons. Since the modification actively partakes in anticodon-codon pairing, either mis-regulation or genetic mutations of Elongator were found to trigger translation defects that may be associated with human diseases such as distinct forms of cancers and neurodevelopmental disorders.

To better understand the elusive tRNA modification reaction mechanism, we aimed and reached at elucidating the structure of the human Elongator complex (Abbassi et al. 2024). Cryo-EM micrographs of Elongator were captured in the group of Prof Sebastian Glatt at the Malopolska Centre of Biotechnology, Jagiellonian University, Krakow, Poland, and the Elongator structures were further verified by crosslinking mass spectrometry in cooperation with Prof Juri Rappsilber at the Technical University Berlin, Germany. Historically, Elongator was discovered and characterized in the budding yeast Saccharomyces cerevisiae (Fig. 1B), which is commonly known as an ingredient for e.g. beer or pizza. In contrast to other models such as mouse or fruit-fly (i.e. Mus musculus or Drosophila melanogaster), yeast can survive without Elongator, which makes it a model quite suitable to study the protein complex in detail. The predictions by the above cryo-EM data were confirmed in the team of Prof Raffael Schaffrath at the University of Kassel, Germany, by mutagenesis of critical amino acids in yeast Elongator subunits and analysis of the functional consequences the alterations would have on the formation of Elongator dependent tRNA modifications.

The newly resolved structures of human Elongator closely matched cryo-EM data gathered from a previously published collaboration between the Krakow and Kassel teams on the yeast complex (Jaciuk et al. 2023), suggesting that Elongator and its reaction mechanism are highly conserved among lower and higher eukaryotic cells including our own (Fig. 1C). The overall resolution of 2.87 Å together with snapshots during the reaction cycle allowed to propose a hypothesis how Elongator chemically modifies the anticodon of tRNA. In conclusion, the reaction mechanism and structure of Elongator will help to further investigate human health and diseases that can associate with this clinically important protein machinery.

Research in this scientific cooperation and performed at the University of Kassel, Division of Microbiology, was made possible by DFG funds (SCHA750/20, SCHA750/25) to CINSaT member Prof Schaffrath, the GRK 2749/1 Multiscale Clocks (coordinator: Prof Stengl), a fast track stipend to Pauline Böhnert, and a PhD scholarship to David Scherf by the Otto Braun-Fonds Melsungen, Germany.

Further Information

This publication

Abbassi, N.-E.-H., M. Jaciuk, D. Scherf, P. Böhnert, A. Rau, A. Hammermeister, M. Rawski, P. Indyka, G. Wazny, A. Chramiec-Głąbik, D. Dobosz, B. Skupien-Rabian, U. Jankowska, J. Rappsilber, R. Schaffrath, T.-Y. Lin, and S. Glatt. 2024. Cryo-EM structures of the human Elongator complex at work. Nature Communications 15: 4094.
PMID: **38750017**
DOI: 10.1038/s41467-024-48251-y

Related publication ***NAR Breakthrough Article***

Jaciuk, M., D. Scherf, K. Kaszuba, M. Gaik, A. Rau, A. Kościelniak, R. Krutyhołowa, M. Rawski, P. Indyka, A. Graziadei, A. Chramiec-Głąbik, A. Biela, D. Dobosz, T.-Y. Lin, N.-E.-H. Abbassi, A. Hammermeister, J. Rappsilber, J. Kosinski, R. Schaffrath, and S. Glatt. 2023. Cryo-EM structure of the fully assembled Elongator complex. ***NAR Breakthrough Article***
Nucleic Acids Research 51: 2011-2032.
PMID: **36617428**
DOI: 10.1093/nar/gkac1232

Research – Prof GLATT

https://glatt-lab.pl/research-2/
https://www.researchgate.net/profile/Sebastian-Glatt

Research – Professor SCHAFFRATH

http://www.uni-kassel.de/fb10/de/institute/biologie/fachgebiete/mikrobiologie
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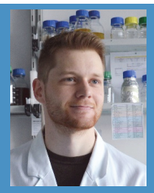

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New Members

New full member in CINSaT – Prof. Dr.-Ing. habil. Wenwen Song

In 2023, we welcomed a new full member, Prof. Dr.-Ing. habil. Wenwen Song, joining in the Center for Interdisciplinary Nanostructure Science and Technology (CINSaT) at the University of Kassel.

Prof. Dr.-Ing. habil. Wenwen Song completed her Ph.D. study with “summa cum laude” at Steel Institute (IEHK), RWTH Aachen University in 2014. During 2016-2022, Prof. Song worked as the group leader of Nanostructured Materials at RWTH Aachen. Prof. Song was a guest scientist at University of Cambridge, UK, during 2015-2016, and won Théodore von Kármán Fellowship at the University of Oxford in 2018. During 2017-2019, she served as a scientific leader of Cloud III, “Hydrogen Management”, within the Collaborative Research Centre SFB 761 ‘Steel - Ab initio: Quantum mechanics guided design of new Fe-based materials’ at RWTH Aachen. In January 2021, she completed her habilitation on the topic of “Nano-engineering of high strength steels” at RWTH Aachen University and was awarded with the Venia Legendi of “Nanoengineered Materials”. Prof. Song was awarded several prizes for innovative research and teaching, e.g. the Steel Innovation Prize 2018 in Berlin, the Junges Kolleg (young academy) prize in 2019 at NRW Academy of Sciences, Düsseldorf, and the “Distinguished RWTH Lecturer” prize 2020 at RWTH Aachen, etc. Since 2023, Prof. Song has been leading the department “Granularity of Structural Information in Materials Engineering” at the University of Kassel.

Prof. Song’s research expertise mainly specializes in developing nanostructured metallic materials using multi-scale correlative materials characterization and simulation techniques. Her research at CINSaT focuses on developing novel nanostructured metallic materials and processes for various sustainable applications in the Focal Point “Nanomaterials”.

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Latest Reports

Spring Colloquium 2024

The spring colloquium 2024 saw once again interdisciplinary scientific talks in a new venue.

Group photo of the CINSaT spring colloquium participants in front of the Welcome Hotel.

From 7th to 8th of March the CINSaT organized the annual spring colloquium. This time a new venue was chosen with the Welcome Hotel in Paderborn, around 80 km west from Kassel. In total 80 participants listened to over 25 scientific talks ranging from 10-minute general overviews of a focal point to 1-hour deep dives into the research of CINSaT applicants. The obligatory poster session showed around 50 posters and ensured lively discussions between the participants. We as organizers thank all participants and contributors to this event and hope to see ever-growing support from all members.

The first day started in the morning with CINSaT speaker Prof. Reithmaier giving his welcome speech, followed by some organizational remarks from CINSaT management. Prof. Backes – on behalf of focal point speaker Prof. Middendorf - chaired the first session of the focal point Nanomaterials with three presentations, followed by the related 1-hour talk entitled “Ultrashort laser pulses for materials processing applications” by CINSaT applicant Prof. Camilo Florian Baron. After lunch forcal point speaker Prof. Demekhin chaired the Chiral Systems session with two presentations which was followed by the next application talk entitled “From Molecules to Nanoparticles: Investigating the Photophysics of Quantum Systems by X-ray Induced Electron and Photon Spectroscopy” by CINSaT applicant Dr. Andreas Hans. With the Multiscale Bioimaging session chaired by focal point speaker Prof. Müller with two presentations the day ends at least in terms of talks. The participants yearned for some fresh air and movement which was provided by a guided tour of historic Paderborn. After dinner all participants met in the poster sessions which sparked successfully fruitful discussions which sometimes ended in the bar next to the hotel lobby.

The second day started with a continuation of the scientific talks, starting with the Photonics session chaired by focal point speaker Prof. Lehmann, which was followed by the appropriate talk given by CINSaT applicant Prof. Jost Adam entitled “Computational Materials and Photonics – Research Overview”. Focal point speaker Prof. Hillmer chaired the 3D Nanostructured session with three talks and after lunch the Quantum Technology session was chaired by focal point speaker Prof. Singer with two talks. With this all talks of the colloquium were given. Lastly the individual focal point sessions were held by the corresponding chairs to talk in more detail about future endeavors inside the focal point. After Prof. Reithmaier giving closing remarks, the spring colloquium 2024 ended and we hope that all participants had fun and learned something new!

Audience of the CINSaT spring colloquium listening to a lecture.

Focus session of the 3D Nanostructures focal point.

Focus session of the Nanomaterials focal point.

Prof. Dr. Camilo Florian Baron giving his CINSaT membership application talk.

Prof. Dr. Jost Adam giving his CINSaT membership application talk.

Campus Festival and Hesse Day 2024

The CINSaT presented its research on two events to the interested public with an information stand and demonstration experiments.

On May 23, the Campus Festival took place on the main campus of the University of Kassel. The entire campus was packed with activities ranging from food stalls, academic lectures and discussion panels for the public to concerts of various genres such as jazz and pop-rock. Over 8,000 people attended the campus festival, which began at 3 p.m. with an opening speech by University President Prof. Ute Clement. CINSaT was represented with an information stand about CINSaT, its research topics and the STEM degree programs offered at the university. Five experiments and demonstrations involved the audience and led to smiling children's faces and sometimes to serious discussions about the challenges of the world. CINSaT would like to thank all the volunteers who helped the management to organize this event.

CINSaT information stand at the Campusfest 2024.

PhD candidates Basma Elsaka and Philipp Kästner (both Technological Electronics department) explaining the demonstrator of micromirrors for light guidance.

One week after the Campus Festival, another event took place. From May 24 to June 2, the Hesse Day took place in Fritzlar, about 30 km from Kassel. A total of over 500,000 people visited the Hesse Day. CINSaT was asked by the Hessian Ministry of Science and Art to put together a program for 29 May to present CINSaT's research. Due to the limited space, only two CINSaT representatives shared the stand with two employees of the Ministry and presented ferrofluid and micromirrors as examples of CINSaT's diverse research activities. Nevertheless, interesting discussion ensued over the course of the whole day with the public.

PhD candidate Philipp Graßhoff (Technological Physics department) representing the CINSaT at the information stand of the Hessian Ministry of Higher Education, Research and Arts.

Announcements

CINSaT Alumni Database

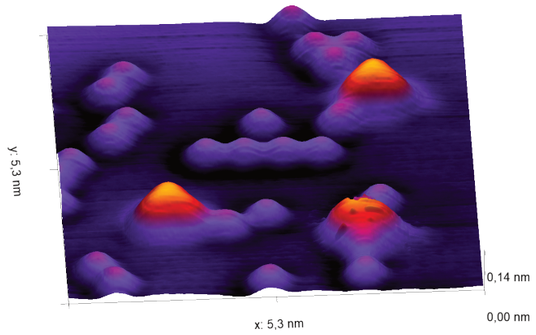
The CINSaT opens a database to stay in touch with former members of the CINSaT related research groups

For over 20 years, young researchers from CINSaT groups have been working to achieve their diplomas or PhDs. In the last issue, we reported on the meeting of the first cohort of nanoscience students, and it became clear that the former students are now established members of the scientific community in academic or commercial research. This first impression needs to be quantified and we are happy to announce the start of the new alumni database. With this, former students and group members can enter their contact information to stay in touch with the CINSaT. Later on, a questionnaire will be send out to gather more information about the career path of our graduates.

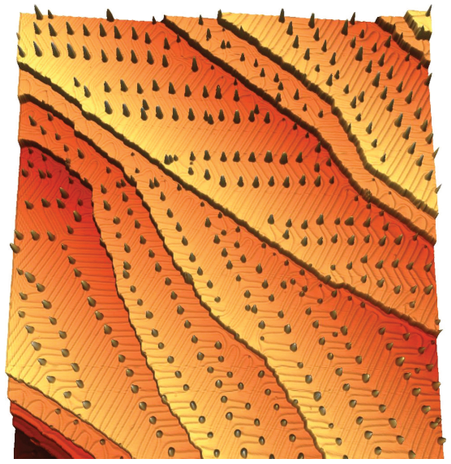
We therefore ask every member of the CINSaT or member of a CINSaT research group to forward this information to any known graduate from a CINSaT research group of the University of Kassel. Please share this information:

https://www.uni-kassel.de/forschung/cinsat/alumni

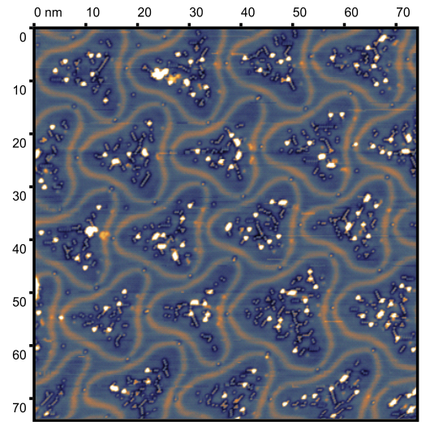
Nano Arts - STM Special



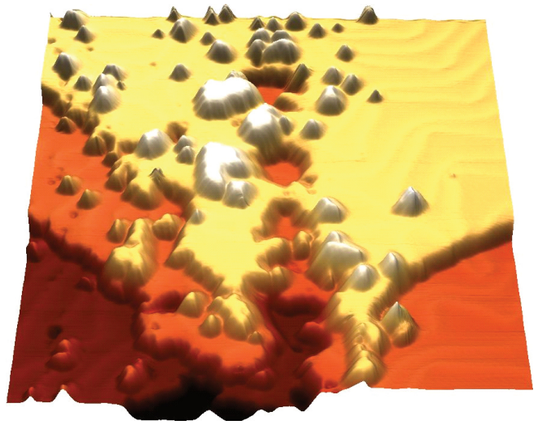
Sulphur dimers/trimers/chains on Au(111) measured by Nico Kubetschek with STM.



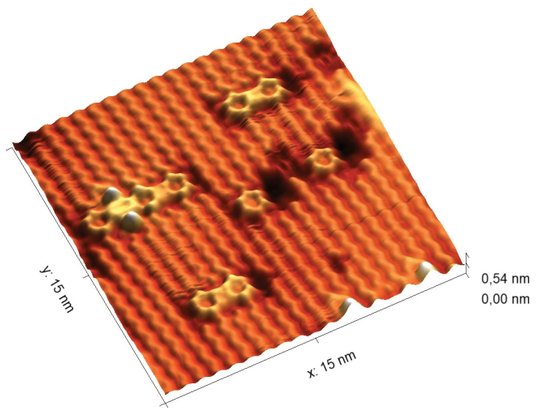
Cobalt quantum dots on Au(111) measured by Kamil Florian Cuppok and Nico Kubetschek with STM. The kinks of the Au(111) herringbone reconstruction act as nucleation template.



Au(111) reconstruction pattern due to sulphur adsorption measured by Nico Kubetschek with STM.



Au(111) Surface after STM tip crash. Measured by Yannic Mitja Altmann and Nico Kubetschek with STM.



Ebedded Cobalt nanostructures on the Ge(001) surface, measured by Nico Kubetschek with STM.

Photo: Campus Heinrich-Plett-Straße, Press and Public Relations Office University of Kassel, Studio Blåfield

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