DUTCH ASSOCIATION FOR CRYSTAL GROWTH

nederlandse vereniging voor kristalgroei

F A C E T

D A C G N e w s L e t t e r

November 2023
Issue 2/2023

FACET
Newsletter of the Dutch Association for Crystal Growth (DACG), section of the KNCV and the NNV.

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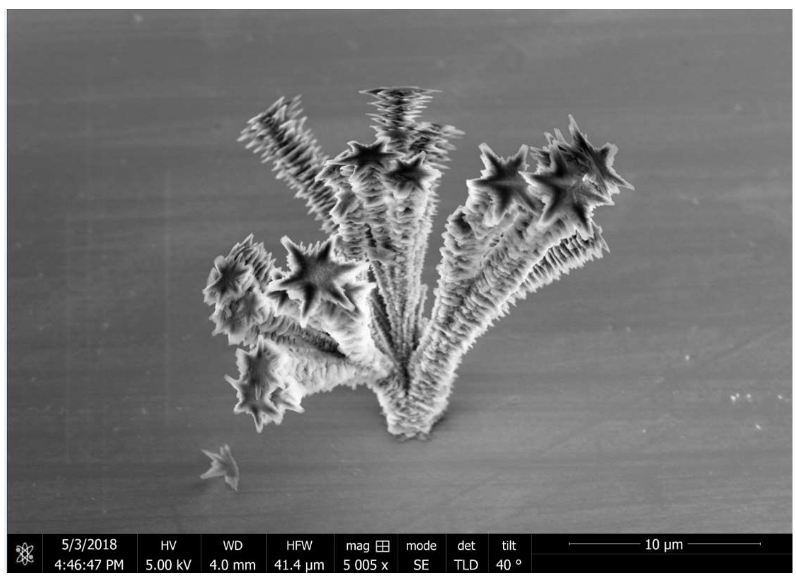

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DUTCH ASSOCIATION FOR CRYSTAL GROWTH
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DACG Secretary

Prof.Dr. Antoine van der Heijden
Leeghwaterstraat 39
2628 CB Delft

DACG board

Cover photo

Witherite crystal grown in the presence of acid orange 7. The formation of such crystals is discussed in Multi-layered Barium and Strontium Carbonate Structures Induced by the Small Organic Dye Acid Orange 7, Ariane V. Mader, Lukas Helmbrecht, and Willem L. Noorduin, Crystal Growth & Design 2021 21 (11), 6349-6356
DOI: 10.1021/acs.cgd.1c00823

From the editor

Dear all,
Our 50th anniversary symposium is history and we are looking forward to the next 50 years. Meanwhile life is "back to normal" and our fall symposium is just around the corner. This time Ardena in Oss is hosting the event.

In this issue you will find the annual report, an impression from DACG50 and links to interesting articles related to crystal growth.

Your ideas are welcome, and as always, it is easy to contribute to the FACET. Just send an email to the editor: Marketta Uusi-Penttilä

Looking forward to seeing you at the fall symposium!

Marketta Uusi-Penttilä

Young-DACG

Dear DACG members,

As all things eventually come to an end, so does my PhD journey, and along with it, my role as the Young-DACG representative. Consequently, the board is now seeking a successor!

In the capacity of Young-DACG representative, you become the voice of the younger generation within DACG. Given that this position is relatively new and lacks strict guidelines, there is ample room for creativity and exploration. Your primary role involves attending DACG board meetings and identifying opportunities to engage young DACG members more effectively. This may encompass conducting brief surveys to assess their needs and desires, or organizing activities that promote connectivity among members during the spring symposium. Additionally, we have exciting plans in the pipeline for organizing a Young Career Retreat in collaboration with the NVK.

I have greatly relished my involvement with DACG in this capacity. It provided me with an up-close view of the intriguing industrial and scientific facets of our field, and it facilitated the forging of meaningful connections with new acquaintances.

If you are a PhD student and are keen to assume this role, please don't hesitate to reach out to me via email at m.bistervels@amolf.nl or let us know in the coming fall meeting.

Best regards,
Marloes

Elias Vlieg appointed President of the IOCG, International Organization for Crystal Growth

Elias Vlieg, professor in Solid State Chemistry at the Radboud University, Nijmegen has been appointed president of the International Organization for Crystal Growth (IOCG). Elias Vlieg was officially inaugurated during the latest International Conference on Crystal Growth and Epitaxy (ICCGE-20, 30 July- 4 August, 2023) in Naples, Italy. He was already active within the organization as Executive Committee Member serving as co-vice president. The central objective of the IOCG is to establish a platform for scientists in the domain of crystallization, fostering the advancement of both theoretical principles and practical applications within crystal growth, crystal characterization, and interconnected scientific branches. The international consortium organizes various initiatives concerning crystal growth, most notably the triennial International Conference on Crystal Growth and Epitaxy, alongside topical meetings on crystal growth. The focus is on growth of crystals, which are essential for high-tech applications like computer chips, power electronics, energy production and storage and LED lighting, but also for the purification and manufacture of pharmaceutical compounds and food products. In his time as president, Elias Vlieg hopes to be working on "expanding the organization's scope to encompass all fields of crystal growth, including pharmacy and biomineralization, and creating a basic textbook that explains the principles that unite all applications of crystal growth."

* *

Registration DACG Fall Symposium

On the next page you will find the program for the Fall Symposium on November 30th at Ardena in Oss.

Participants are encouraged to bring a poster. If you intend to present a poster, please let us know when registering for the symposium.

Venue: Ardena Oss at Pivot Park, Kloosterstraat 9 RG, 5349 AB Oss
The venue is easy to reach either by train or by car. Ardena is a 7-minute walk from Oss railway station, just follow the signs to Pivot Park. If you are coming by car, choose Pivot Park (Kloosterstraat 9, 5349 AB Oss) as address.

To sign up for the symposium, please send an email to muusipenttila@nl.aspenpharma.com and transfer the registration fee to the bank account of the DACG:

Ned. Ver. Van Kristal Groei.
NL60INGB0004305158

The registration fee for the symposium is €30 for DACG-members and €45 for non-members. Please mention "DACG Fall Symposium 2023" in your payment. **Please sign up before November 25th, 2023**.
Also, please let us know if you have any dietary requests.

Marketta Uusi-Penttilä

DACG Symposium & Annual Meeting 2023

Ardena, Oss, 30 November 2023

09:30 – 10:00	**Registration and coffee**
10:00 – 10:15	**Welcome and introduction** Carmen Guguta
10:15 – 10:30	**Introduction to Ardena – company profile** René Steendam (Ardena)
10:30 – 11:00	**Crystallization in the pharmaceutical industry** Peter van Hoof (Ardena)
11:00 – 11:30	**Navigating a solvate jungle** Rob Geertman (Jansen&Jansen)
11:30 – 12:00	**API crystallization with Secoya technology** Nieké van Gils (Aspen API)
12:00 – 12:30	**How nanometer confinement changes the (de)hydration pathways of $CaCl_2$** Michaela Eberbach (TU/e)
12:30 – 13:00	**Lunch**
13:00 – 14:00	**General Members Meeting DACG / poster session**
14:00 – 14:15	**Coffee break**
14:15 – 14:45	**VSi_2: a boring material harboring fascinating physics** Valent Oldenkotte (Twente University)
14:45 – 15:15	**Pattern formation using reaction-diffusion driven crystallization** Christiaan van Campenhout (AMOLF)
15:15 – 15:45	**Bridging manganese clusters and materials formation: Polymorphism control in manganese oxide nanoparticles in hydrothermal synthesis** Nicolas Magnard (Leiden University)
15:45 – 16:45	**Company visit**
16:45 – 17:30	**Drinks / nibbles**

Venue: Ardena, Kloosterstraat 9, 5349 AB Oss

For sign up, see page 3 or DACG website!

DACG Annual Meeting, 30 November 2023

1. Opening
2. Finalize agenda
3. Minutes Annual meeting 21 October 2022
4. Documents sent / received: report of the financial audit committee (see agenda item 6)
5. Annual Report Oct 2022 – Oct 2023
6. Financial
   (a) Annual Financial Report Oct 2022 – Sep 2023
   (b) Report Financial Audit Committee
   (c) Budget Oct 2023 – Sept 2024
7. Board

Role	**2022 – 2023**	**Appointment deadline**
President	Carmen Guguta	Step down Oct 2024
Secretariat	Antoine van der Heijden	Step down Oct 2025
Treasurer	Hans te Nijenhuis	Step down Oct 2024
Webmaster	Hugo Meekes	Step down Oct 2023 (not re-electable)
FACET	Marketta Uusi-Penttilä	Step down Oct 2023 (not re-electable)

Since 2021 Marloes Bistervels (PhD student AMOLF) started to support the board as a representative of the Young-DACG.

Both Hugo Meekes and Marketta Uusi-Penttilä will step down from the board and are not re-electable. DACG-members who would like to apply for a board membership, can announce themselves by sending an e-mail to the DACG secretariat (antoine.vanderheijden@tno.nl), ultimately by 23 November 2023.

8. DACG 50 years
9. Status Stichting
10. Young-DACG (update by Marloes Bistervels)
11. Strengthening DACG's international network: feedback from Elias Vlieg (President IOCG and council member ENCG) and Burak Eral/Bart Zwijnenburg (Working Party on Crystallization)
12. Launching of new DACG website
13. Activities 2023 – 2024
    a. KNCV-event "Avond van de Chemie", 5 October 2023, Theater "De Lievekamp", Oss (https://www.kncv.nl/bijeenkomsten/1130/avond-van-de-chemie-2023/location)
    b. NNV Advisory Board Meeting, December 2023 (section boards will be invited)
    c. April 2024: spring symposium DACG, University of Maastricht, date to be decided
    d. September 2024: BIWIC @ Delft
    e. October 2024: DACG annual meeting + fall symposium, Nobian, Enschede, date to be decided
14. Questions before closure of meeting
15. Adjourn

DUTCH ASSOCIATION FOR CRYSTAL GROWTH
nederlandse vereniging voor kristalgroei

Annual Report Dutch Association for Crystal Growth (DACG)

October 2022 – September 2023

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Members
The total number of members is 81, of whom 7 are lifetime members. Included in this number are 32 new ("calendar year") members. The "calendar year" members that registered for the DACG annual meeting (21 October 2022) or for the DACG50 symposium held on 20-22 March 2023, are offered the possibility to attend a DACG symposium for the registration fee of a regular DACG member for the "live" symposium to be organized in November 2023.

Board
The DACG Board is shown in the table below. The Board had six online video meetings and one face-to-face meeting at AMOLF/Amsterdam (25 November 2022). Since 2021 Marloes Bistervels (PhD student AMOLF) started to support the board as a representative of the Young-DACG.

Role	2022 – 2023	Appointment deadline	E-mail
President	Carmen Guguta	Step down Oct 2024	carmen.guguta@technobis.com
Secretary	Antoine van der Heijden	Step down Oct 2025	antoine.vanderheijden@tno.nl
Treasurer	Hans te Nijenhuis	Step down Oct 2024	hans.te.nijenhuis@panalytical.com
Webmaster	Hugo Meekes	Step down Oct 2023	h.meekes@science.ru.nl
FACET	Marketta Uusi-Penttilä	Step down Oct 2023	muusipenttila@nl.aspenpharma.com

FACET Newsletter
The DACG Newsletter, FACET, was issued in February and October 2023. Marketta Uusi-Penttilä is the editor of the FACET. The objective of the newsletter is to stimulate the communication between scientists and users in the area of crystallization or crystal growth in the Netherlands. The newsletter publishes summaries of relevant PhD theses, upcoming events related to crystallization (conferences, symposia), highlights in crystal growth research and other activities relevant to crystal growers. Several academic scientists have been requested to collect news from their network/colleagues as input to the newsletter, but also members may submit input. Furthermore, initiatives, decisions and plans of the DACG will be published in the FACET Newsletter. FACET is issued electronically or can be downloaded from the DACG website. An overview of the DACG correspondents can be found on the DACG website.

Stichting "International Conferences on Crystal Growth"
Currently the Stichting Board consists of the DACG Board members. Funds remaining from the organization of the ICCG-11 in The Hague in 1995, were used as startup capital for the organization of the DACG50 held in March 2023.

Website
The DACG website (www.dacg.nl, hosted by Radboud University Nijmegen) provides information regarding the structure and activities of the association. All issues of the FACET Newsletter since 2000 are available electronically; links to Dutch research groups in the area of crystallization are available as well as those of foreign DACG 'sister' associations. We welcome any suggestions for improvements; please contact Hugo Meekes (h.meekes@science.ru.nl).

This year Carmen Guguta approached several companies for designing a new logo and building a new website. The new logo has been launched in March 2023. The new website is foreseen to be officially launched at the ALV in November 2023.

Young-DACG

Because of the DACG's 50th anniversary, no spring symposium was organized, which is typically aimed at the younger career members of the DACG. We did not plan a replacement event as earlier discussions with the "Young DACG members" concluded that holding two events per year was sufficient and any more would be overwhelming. However, during the anniversary event, we noticed an increase in the number of younger attendees, possibly due to previous focus on their involvement. The telegram group is currently inactive and may not be an effective means of communication. We will compile a list of all new members, including their permission for sharing contact information, so that quick updates can be sent and individuals can connect with each other. As for next year, the Young Career Retreat with the NVK (Nederlandse Vereniging voor Kristallografie, Dutch Crystallographic Society) could be a valuable event for the Young DACG members.

Meetings / excursions organized by DACG

On October 21, 2022 the DACG's symposium and annual meeting was organized at Technobis, Alkmaar, hosted by Carmen Guguta. To celebrate the 50th anniversary of the DACG, an international conference was held from March 20-22, 2023 in Amsterdam (see under DACG's 50th anniversary). Reports of the meetings have been published in FACET.

Activities relevant to DACG community

On 8 December 2022 Antoine van der Heijden attended the online NNV Advisory Board Meeting on behalf of the DACG Board.

DACG's 50th anniversary

In 1972 the Kontaktgroep Kristalgroei Nederland (KKN) was established. In 1998, the name was changed in Nederlandse Vereniging voor Kristalgroei, NVKG / Dutch Association for Crystal Growth, DACG. This implies that in 2022 the DACG celebrated its 50th anniversary. A commission, led by Prof Elias Vlieg, further consisting of prof Noushine Shahidzadeh, dr Burak Eral and Rose Pham prepared and organized the DACG50 symposium, which – due to COVID19 – took place from 20-22 March 2023 (instead of 2022).
In close cooperation with the editorial board of the *Nederlands Tijdschrift voor Natuurkunde (NTvN)*, two papers were published on physics-related aspects of crystal growth, one authored by Hugo Meekes and Elias Vlieg on *"Linksom of rechtsom met kristallen"* (appeared in NTvN September 2022, including an editorial about the 50th anniversary of the DACG by Hans te Nijenhuis) and another one by Wim Noorduin on *"Maak het met mineralen"* (NTvN December 2022).

Upcoming activities

- KNCV-event "Avond van de Chemie", 5 October 2023, Theater "De Lievekamp", Oss (https://www.kncv.nl/bijeenkomsten/1130/avond-van-de-chemie-2023/location)
- NNV Advisory Board Meeting, December 2023 (section boards will be invited)
- April 2024: spring symposium DACG, University of Maastricht, date to be decided
- September 2024: BIWIC @ Delft
- October 2024: DACG annual meeting + fall symposium, Nobian, Enschede, date to be decided

DACG50
50th Anniversary of Dutch Association for Crystal Growth

20 – 22 March 2023, Amsterdam

Three days of inspiring talks and discussions with crystal growth colleagues at Amsterdam Science Park Conference Centre. We can conclude that DACG50 was a success!

The organizing committee, Burak Eral, Noushine Shahidzadeh and Elias Vlieg (supported by Ms. Rose Pham) had put together an interesting and varied program. The event was sponsored by Technobis and TeraCrystal.

Sponsors and crystals for the organizing committee.

The Monday morning session began with the invited speaker Michael Zaworotko (University of Limerick) about Crystal Engineering: Then and Now. He talked about the introduction of crystal engineering: Imagine that you could predict how a crystal grows.

The session went on with talks from Vincent Peters (Utrecht University) about Stoichiometry effects on BaSO4 crystallisation, Marcel Rost (University of Leiden) about Nucleation and Growth of Nano-Islands and Arie van Houselt (University of Twente) about Presolidification governs the propagation of eutectic droplets.

The speakers of Monday morning session.

In the Monday afternoon session, the invited speaker Kimberly Dick Thelander from Lund told us about Real time investigation of crystal growth and nucleation of low-dimensional inorganic nanostructures. The next talk was by Erik Bakkers from TU Eindhoven. His talk was titled Selective Area Grown PbTe Nanowire Networks. Giuditta Perversi from Maastricht elaborated on Deep Eutectic solvents for controlled crystallisation: the case of Prussian Blue and Paul Tinnemans from Radboud University explained about Understanding irregular start of growth oscillations using surface X-ray diffraction.

The next invited speaker was Matthias Bickermann from Leibniz-Institut für Kristallzüchtung IKZ. He discussed Crystals, substrates, and technologies for Ga2O3 and functional oxides. Mike Leszczynski (Inst. of High Pressure Physics, Warsaw) discussed Crystallization in Nitride Semiconductor Research and Industry with some industrial examples related to laser diodes and laser projectors. Vikram Korede (Delft University of Technology) followed with his presentation on the Effect of laser exposed volume, irradiation position and solvent composition on non- photochemical laser induced nucleation studied with potassium chloride solutions. The last speaker of the day was Nagaraj Nagalingam (Delft University of Technology) showing us Laser-Induced Cavitation for Controlling Crystallization from Solution.

The speakers of Monday afternoon session.

The speakers of Tuesday morning session.

Tuesday morning began with an invited lecture from Sally Price (University College London): Can the crystal structures of pharmaceuticals be predicted? She discussed in detail the advantages and issues with crystal structure prediction.

The next talk was by Sarah Guerin (University of Limerick) who told us about Piezoelectric Biomolecules for Lead-Free, Reliable, Eco-Friendly Electronics. Then Oleksii Shemchuk (University of Louvain) showed us Innovative pathways to chiral resolution using cocrystallization tools. This was followed by Sjoerd van Dongen (AMOLF). He discussed Balancing Asymmetric Crystallization for Chiral Amplification. After a coffee break, Bart Zwijnenburg (Nobian) took us to the world of Industrial crystallization for NaCl production and Sebastiaan Godts (Ghent University) elaborated on The Crystallization Behaviour of Common Salt Mixture Found in the Built Environment. Just before lunch Rozeline Wijnhorst (University of Amsterdam) told us about the softness of hydrated salt crystals under deliquescence and Joshua Dijksman (University of Amsterdam) discussed Crystal puzzles in a glassy polymeric systems.

The speakers of Tuesday afternoon session.

Tuesday afternoon started with an invited lecture from Marc Prat (Insitut de Mécanique des Fluides de-Toulouse). The lecture was titled Evaporative growth of crystallized salt structures at the surface and inside porous media. Menno Demmenie (University of Amsterdam) continued with Ice crystallization in confinement and Henk Huinink (Technical University Eindhoven) discussed Dopants accelerate hydration transitions of salts by water assisted ionic mobilization. Melian Blijlevens (Radboud University) continued with NaI as candidate for heat storage. The session was concluded by Hans te Nijenhuis (Malvern Panalytical and DACG board member). He took us through 50 years of crystal growth in the Netherlands: a journey with steps, kinks and terraces. A journey that began in January 1972, development of the concept of crystals and growth theories, introduction of analytical techniques, simulations of crystal growth, and the conclusion that it is "easier to train a crystal grower to an astronaut than the other way around".

Tuesday ended with the anniversary dinner at 'Het West-Indisch Huis'. Again a good opportunity to connect with crystal growth colleagues.

The speakers of Wednesday morning session.

The invited speaker Marjatta Louhi-Kultanen (Aalto University, Finland) started the last day by discussing the influence of solution or melt viscosity on crystallization kinetics. Her lecture was followed by Janou Koskamp (Utrecht University) who told us about The impact of solution stoichiometry on crystal formation: Stability of charged triple- ion clusters. Next Ivo Rietveld (University of Rouen, France) discussed Urea derivatives as transporter molecules in sublimation crystallization. This was followed by Herma Cuppen (Radboud University). She discussed Applying simulations to understand the free energy landscape of polymorphic transitions: DL-methionine. Tom de Vries (Radboud University) continued with Improved link prediction methods for the discovery of Multi-Component Crystals and Simon Lepinay (University of Amsterdam) discussed Non equilibrium synthesis of nature-inspired multicomponent Iron salt.

The last speaker of the conference was Wim Noorduin (Amolf and University of Amsterdam) with his talk Make it with minerals: reactive crystallizations for self-organizing materials. Wim closed the loop that started on Monday morning with Michael Zaworotko's insight to history: Imagine that you could predict how a crystal grows. Wim discussed how to make functional materials by designing the crystals, making structures by design. He talked about tunable catalysts and luminescent biominerals. One can only be fascinated at the possibilities in the world of crystal growth!

Marketta Uusi-Penttilä

Prof. dr. A.E.D.M. van der Heijden
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Delft, October 2023

Announcement Piet Bennema Award for Crystal Growth

Every three years the Dutch Association for Crystal Growth DACG distinguishes a young researcher with the Piet Bennema Award for Crystal Growth for his or her high-level scientific research in the field of crystal growth. The prize is intended for the author of the best dissertation or other scientific publications (or a series thereof) that have been processed in an industrial context and are of importance similar to a dissertation. The prize consists of a certificate and a sum of money of € 1000.

Piet Bennema
Piet Bennema (1932-2016) is one of the founders of the study of crystal growth in the Netherlands. As a professor of chemistry of the solid state from 1976 until his retirement in 1998, he was affiliated with the Radboud University Nijmegen. In this period he elaborated on the theoretical concepts of crystal growth, leading to an improved understanding of the role of the bond strength in the prediction of the morphology of crystals and the role of supersaturation, two-dimensional nucleation, kinetic roughening and spiral growth during crystal growth processes. For his important contributions to the field of crystal growth, he was awarded the Frank Award in 1995 by the International Organization for Crystal Growth.

Candidates
Eligible for the award are both young Dutch and non-Dutch researchers who have largely carried out their research in the scientific field of crystal growth at a Dutch university or a Dutch company.

The candidate must have shown great competence as a researcher as well as scientific originality and productivity. Moreover, it must have a good understanding of the problems of the field.

For candidates who want to be considered on the basis of their dissertation, the latter must have been successfully defended at a Dutch university in the three years prior to the closing of the submission deadline (1 May 2021 – 30 April 2024). For academic publications, it also applies that these must have been published for the most part in the preceding three-year period.

Nomination
Supervisors can nominate candidates by means of a letter of recommendation together with the thesis or other scientific publications, as well as a motivation. The nomination must be submitted in triplicate to the secretary of the DACG.

The submission period for the Piet Bennema Award for Crystal Growth is from 1 October 2023 to 30 April 2024.

Award presentation
The Piet Bennema Award for Crystal Growth is awarded by the DACG Board. To this end, the board of the DACG appoints an assessment committee of three experts, who will evaluate the candidates and their scientific work against their competence in the research of crystal growth, scientific quality, productivity and originality and insight into the field.

The presentation of the prize and the associated certificate will take place during the autumn meeting of the DACG in October 2024.

On behalf of the board of the DACG,

Antoine van der Heijden
Secretary DACG
Technische Universiteit Delft, Dept. Process & Energy
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DUTCH ASSOCIATION FOR CRYSTAL GROWTH
nederlandse vereniging voor kristalgroei

Regulations for the Piet Bennema Award for Crystal Growth

1. The Board of the Dutch Association for Crystal Growth (DACG) awards a prize once every three years, consisting of a certificate and a sum of € 1000 to a young researcher for high-level scientific research in the field of crystal growth.

2. The award is intended for the author of the best dissertation or other scientific publications (or a series thereof) that have been processed in an industrial context and are of similar importance to a thesis. The dissertation must be successfully defended at a Dutch university during the three-year period preceding the selection procedure. The scientific publications should also have appeared in the previous three-year period.

3. The prize will be awarded by the DACG Board on the basis of an advice issued by a jury consisting of three experts, see under item 8. If the jury does not nominate a candidate, no prize will be awarded.

4. The DACG Board may adopt or reject the advice referred to under item 3. above. In the latter case the prize is not awarded.

5. Researchers who have carried out their research largely at a Dutch university or at a Dutch company are eligible for the award of the certificate.

6. The requirements for the award are that the candidate must have shown great competence as a researcher as well as scientific originality and productivity. In addition, he / she must have a good understanding of the problems of the field.

7. The DACG Board ensures that all activities in the context of items 1. to 6. of these regulations are carried out.

8. The DACG Board will be supported in its work by an assessment committee of three experts, from whom it can be expected that they have a good overview of the work of researchers in the field of crystal growth. The experts provide their advice in writing, with documentation, such as publications. Members of the assessment committee cannot nominate candidates themselves.

9. The presentation of the Piet Bennema Award for Crystal Growth takes place during the annual meeting of the Dutch Association for Crystal Growth. Justification of the award will be published after the award ceremony in the newsletter FACET.

Recent publications

- Ghada Badawy, Marcel A. Verheijen, Erik P. A. M. Bakkers, Tunable coupling between InSb nanowires and superconductors, *Physical Review Materials*, **7** (2023), 1, 016201.

  Affiliations
    - Applied Physics Department, Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands
    - Eurofins Material Science Netherlands B.V., High Tech Campus 11, 5656 AE Eindhoven, The Netherlands

  The quest for topological states in hybrid nanowire devices has ignited substantial research in perfecting the nanowire-superconductor interface. Recent proposals, however, suggest that these immaculate interfaces can lead to an overly strong superconducting-semiconducting coupling that "metalizes" the nanowire (i.e., dominates its intrinsic properties which are essential for hosting topological particles). One way to reduce this coupling is to add an insulating shell between the nanowire and the superconductor. Here, we explore cadmium telluride (CdTe) shells as a tunnel barrier at the interface between indium antimonide (InSb) nanowires and a superconductor. We demonstrate the growth of epitaxial, defect-free CdTe on InSb and high-quality superconductor deposition at cryogenic temperatures, enabled by the near perfect lattice match of CdTe and InSb and their comparable thermal-expansion coefficients. Using growth and etching, we control the thickness of CdTe shells down to a few monolayers. This level of control indicates the potential of these shells to serve as a knob that modulates the coupling between a nanowire and a superconductor, possibly introducing a new generation of nanowire hybrids suitable for topological Majorana devices.

- Jason Jung, Sander G. Schellingerhout, Orson A. H. van der Molen, Wouter H. J. Peeters, Marcel A. Verheijen, Erik P. A. M. Bakkers, Single-crystalline PbTe film growth through reorientation, *Physical Review Materials,* **7** (2023), 2, 023401.

  Affiliations
    - Department of Applied Physics, Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands
    - Eurofins Materials Science Netherlands BV, 5656 AE Eindhoven, The Netherlands

  Heteroepitaxy enables the engineering of novel properties, which do not exist in a single material. Two principal growth modes are identified for material combinations with a large lattice mismatch, Volmer-Weber, and Stranski-Krastanov. Both lead to the formation of three-dimensional islands, hampering the growth of flat defect-free thin films. This limits the number of viable material combinations. Here, we report a distinct growth mode found in molecular beam epitaxy of PbTe on InP initiated by pregrowth surface treatments. Early nucleation forms islands analogous to the Volmer-Weber growth mode, but film closure exhibits a flat surface with atomic terracing. Remarkably, despite multiple distinct crystal orientations found in the initial islands, the final film is single crystalline. This is possible due to a reorientation process occurring during island coalescence, facilitating high quality heteroepitaxy despite the large lattice mismatch, difference in crystal structures, and diverging thermal expansion coefficients of PbTe and InP. This growth mode offers a new strategy for the heteroepitaxy of dissimilar materials and expands the realm of possible material combinations.

- Marco Rossi, Ghada Badawy, Zhi-Yuan Zhang, Guang Yang, GGuo-An Li, Jia-Yu Shi, Roy L.M. Op het Veld, Sasa Gazibegovic, Lu Li, Jie Shen, Marcel A. Verheijen, Erik P.A.M. Bakkers, Merging Nanowires and Formation Dynamics of Bottom-Up Grown InSb Nanoflakes, *Advanced Functional Materials*, **33** (2023), 17, 2212029.

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  Indium Antimonide (InSb) is a semiconductor material with unique properties, that are suitable for studying new quantum phenomena in hybrid semiconductor-superconductor devices. The realization of such devices with defect-free InSb thin films is challenging, since InSb has a large lattice mismatch with most common insulating substrates. Here, the controlled synthesis of free-standing 2D InSb nanostructures, termed as “nanoflakes”, on a highly mismatched substrate is presented. The nanoflakes originate from the merging of pairs of InSb nanowires grown in V-groove incisions, each from a slanted and opposing {111}B facet. The relative orientation of the two nanowires within a pair, governs the nanoflake morphologies, exhibiting three distinct ones related to different grain boundary arrangements: no boundary (type-I), Σ3- (type-II), and Σ9-boundary (type-III). Low-temperature transport measurements indicate that type-III nanoflakes are of a relatively lower quality compared to type-I and type-II, based on field-effect mobility. Moreover, type-III nanoflakes exhibit a conductance dip attributed to an energy barrier pertaining to the Σ9-boundary. Type-I and type-II nanoflakes exhibit promising transport properties, suitable for quantum devices. This platform hosting nanoflakes next to nanowires and nanowire networks can be used to selectively deposit the superconductor by inter-shadowing, yielding InSb-superconductor hybrid devices with minimal post-fabrication steps.

- Christiaan T. van Campenhout, Hinco Schoenmaker, Martin van Hecke, Willem L. Noorduin, Patterning Complex Line Motifs in Thin Films Using Immersion-Controlled Reaction-Diffusion. *Adv. Mater.* **35** (2023), 2305191, 1–8.

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  The discovery of self-organization principles that enable scalable routes toward complex functional materials has proven to be a persistent challenge. Here, reaction-diffusion driven, immersion-controlled patterning (R-DIP) is introduced, a self-organization strategy using immersion-controlled reaction-diffusion for targeted line patterning in thin films. By modulating immersion speeds, the movement of a reaction-diffusion front over gel films is controlled, which induces precipitation of highly uniform lines at the reaction front. A balance between the immersion speed and diffusion provides both hands-on tunability of the line spacing (d = 10 – 300 µ) as well as error-correction against defects. This immersion-driven patterning strategy is widely applicable, which is demonstrated by producing line patterns of silver/silver oxide nanoparticles, silver chromate, silver dichromate, and lead carbonate. Through combinatorial stacking of different line patterns, hybrid materials with multi-dimensional patterns such as square-, diamond-, rectangle-, and triangle-shaped motifs are fabricated. The functionality potential and scalability is demonstrated by producing both wafer-scale diffraction gratings with user-defined features as well as an opto-mechanical sensor based on Moiré patterning.

- Marloes H. Bistervels, Balázs Antalicz, Marko Kamp, Hinco Schoenmaker, Willem L. Noorduin. Light-driven nucleation, growth, and patterning of biorelevant crystals using resonant near-infrared laser heating. *Nat Commun* **14** (2023), 6350.

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  Spatiotemporal control over crystal nucleation and growth is of fundamental interest for understanding how organisms assemble high-performance biominerals, and holds relevance for manufacturing of functional materials. Many methods have been developed towards static or global control, however gaining simultaneously dynamic and local control over crystallization remains challenging. Here, we show spatiotemporal control over crystallization of retrograde (inverse) soluble compounds induced by locally heating water using near-infrared (NIR) laser light. We modulate the NIR light intensity to start, steer, and stop crystallization of calcium carbonate and laser-write with micrometer precision. Tailoring the crystallization conditions overcomes the inherently stochastic crystallization behavior and enables positioning single crystals of vaterite, calcite, and aragonite. We demonstrate straightforward extension of these principles toward other biorelevant compounds by patterning barium-, strontium-, and calcium carbonate, as well as strontium sulfate and calcium phosphate. Since many important compounds exhibit retrograde solubility behavior, NIR-induced heating may enable light-controlled crystallization with precise spatiotemporal control.

- Christiaan T. van Campenhout, Hinco Schoenmaker, Martin van Hecke, Willem L. Noorduin, Patterning Complex Line Motifs in Thin Films Using Immersion-Controlled Reaction-Diffusion, *Advanced Materials*, **35** (2023), 2305191, 1-12.

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  The discovery of self-organization principles that enable scalable routes toward complex functional materials has proven to be a persistent challenge. Here, reaction-diffusion driven, immersion-controlled patterning (R-DIP) is introduced, a self-organization strategy using immersion-controlled reaction-diffusion for targeted line patterning in thin films. By modulating immersion speeds, the movement of a reaction-diffusion front over gel films is controlled, which induces precipitation of highly uniform lines at the reaction front. A balance between the immersion speed and diffusion provides both hands-on tunability of the line spacing ($d = 10 - 300$ μm) as well as error-correction against defects.

This immersion-driven patterning strategy is widely applicable, which is demonstrated by producing line patterns of silver/silver oxide nanoparticles, silver chromate, silver dichromate, and lead carbonate. Through combinatorial stacking of different line patterns, hybrid materials with multi-dimensional patterns such as square-, diamond-, rectangle-, and triangle-shaped motifs are fabricated. The functionality potential and scalability is demonstrated by producing both wafer-scale diffraction gratings with user-defined features as well as an opto-mechanical sensor based on Moiré patterning.

- Arno van der Weijden, Anne-Sophie Léonard, Willem L. Noorduin, Architected metal selenides via sequential cat- and anion exchange on self-organizing nanocomposites, *Chemistry of Materials*, **35** (2023), 2394–2401.

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  Shape-preserving conversion reactions have the potential to unlock new routes for self-organization of complex three-dimensional (3D) nanomaterials with advanced functionalities. Specifically, developing such conversion routes towards shape-controlled metal selenides is of interest due to their photocatalytic properties, and because these metal selenides can undergo further conversion reactions towards a wide range of other functional chemical compositions. Here we present a strategy towards metal selenides with controllable 3D architectures using a two-step self-organization/conversion approach. First, we steer the coprecipitation of barium carbonate nanocrystals and silica into nanocomposite with controllable 3D shapes. Second, using a sequential exchange of cat- and anions, we completely convert the chemical composition of the nanocrystals into cadmium selenide (CdSe) while preserving the initial shape of the nanocomposite. These architected CdSe structures can undergo further conversion reactions towards other metal selenides, which we demonstrate by developing a shape-preserving cation exchange towards silver selenide. Moreover, our conversion strategy can readily be extended to convert calcium carbonate biominerals into metal selenide semiconductors. Hence, the here presented self-assembly/conversion strategy opens exciting possibilities towards customizable metals selenides with complex user-defined 3D shapes.

- Sjoerd W. van Dongen, Iaroslav Baglai, Michel Leeman, Richard M. Kellogg, Bernard Kaptein, Willem L. Noorduin, Rapid Deracemization through Solvent Cycling: Proof-of-Concept using a Racemizable Conglomerate Clopidogrel Precursor, *Chemical Communications*, **59** (2023), 3838-3841.

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  We demonstrate that a conglomerate-forming clopidogrel precursor undergoing solution phase racemization can be deracemized through cyclic solvent removal and re-addition. We establish that the combination of slow growth and fast dissolution of crystals is ideal for rapid deracemization, which we achieve by repurposing a Soxhlet apparatus to realize the slow removal and fast re-addition of solvent autonomously.

- Malte Klitzke, Jonas Schön, Rosalinda H. Van Leest, Gunther M.M.W. Bissels, Elias Vlieg, Michael Schachtner, Frank Dimroth, David Lackner, Ultra-lightweight and flexible inverted metamorphic four junction solar cells for space applications, *EPJ Photovoltaics*, **603** (2023), 25, 1-9.

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  In this work an inverted metamorphic four junction (IMM4J) solar cell with 30.9% conversion efficiency in beginning of life conditions under the AM0 (1367 W/m^2) spectrum is presented. Additionally, our newest improved IMM3J cell, consisting of $Ga_{0.51}In_{0.49}P/GaAs/Ga_{0.73}In_{0.27}As$ subcells, with 30.6% efficiency is also shown. The IMM4J solar cells consist of $Al_{0.05}Ga_{0.46}In_{0.49}P/Al_{0.14}Ga_{0.86}As/Ga_{0.89}In_{0.11}As/Ga_{0.73}In_{0.27}As$ subcells and are epitaxially grown by metal organic vapor phase epitaxy (MOVPE) on a GaAs substrate. These IMM solar cells achieve power-to-mass ratios of 3 W/g or more, which is more than three times higher than standard germanium based triple or four junction space solar cells. The losses in comparison to the simulated near-term potential efficiency of 33.8% for the IMM4J are analyzed in detail. Furthermore, the irradiation behavior for 1 MeV electron fluences of 1×10^{14} e$^-$/cm^2 and 2.5×10^{14} e$^-$/cm^2 for the IMM4J cells was investigated. A roadmap to further develop this concept towards an IMM5J with a realistic begin of life (BOL) efficiency potential of 35.9% under AM0 is presented.

- Katsuo Tsukamoto, Erika Furukawa, Peter Dold, Mayumi Yamamoto, Masaru Tachibana, Kenichi Kojima, Kenichi Kojima, Elias Vlieg, Luis Antonio Gonzalez-Ramirez, and Juan Manuel Garcia-Ruiz, Higher growth rate of protein crystals in space than on the Earth, *J. Cryst. Growth*, **603** (2023), 127016, 1-6.

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  Comparative growth rate measurement of 51 lysozyme seeded crystals at various supersaturations under microgravity and in normal gravity were successfully conducted by ex-situ method in a Russian Foton-M3 recovery satellite. Growth rate of crystals both in space and on the Earth were calculated by measuring the thickness of each growth zone that was caused by the change of gravity level. It is surprising to find that growth rate under microgravity was the same as that in normal gravity or, unexpectedly, even larger by more than 20 %. The experiment was conducted in the satellite in 12 days under microgravity after 6 days transportation on the ground from Nijmegen, the Netherlands, to Baikonur, Russia. 51 growth cells were kept at 20°C after the protein solutions and the seeds were sealed.

The trace of movement of 2D macro-steps on the (110) face was visualized after the flight by laser confocal microscopy. These steps were buried inside the crystals, 0–140 µm deep from the surface and so they were grown in space. The observed elongated sharp 2D steps implies that the effect of impurity was considerably reduced in space condition, compared with the rounded shape of 2D steps formed with more impurities in normal gravity. The increase in growth rate in space could be concluded due to the reduction of impurities on the surface of crystals. Several space grown crystals were examined by synchrotron X-ray topography at KEK in Tsukuba after optical observations were completed. The change of lattice perfection due to the change from normal G to µG was investigated using local rocking curve analysis (peak position, intensity, full width at half maximum) as well as X-ray topography. Clear increase of diffraction and thus better perfection were observed when the gravity changed from normal G to µG condition. However, it should be noted that perfection of the space grown crystal reached the value of the best portion of the seed crystal that was carefully prepared on the Earth. Based on these data, increased growth rate in space is conclude to be due to the reduction of impurity effects at the surface of the crystals. Better perfection might additionally increase the growth rate.

- Natalia Mazur, Melian A.R. Blijlevens, Rick Ruliaman, Hartmut Fischer, Pim Donkers, Hugo Meekes, Elias Vlieg, Olaf Adan, Henk Huinink, Revisiting salt hydrate selection for domestic heat storage applications, *Renewable energy*, **218** (2023), 119331.

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In this work, we evaluate 454 salt hydrates and 1073 unique hydration reactions in search of suitable materials for domestic heat storage. The salts and reactions are evaluated based on their scarcity, toxicity, (chemical) stability and energy density (>1 GJ/m3) and alignment with 3 use case scenarios. These scenarios are based on space heating (T > 30 °C) and hot water (T > 55 °C) to be provided by discharge as well as on heat sources available in the built environment (T < 160 °C) for charging. From all evaluated materials, only 8 salts and 9 reactions (K2CO3 0–1.5, LiCl 0–1, NaI 0–2, NaCH3COO 0–3, (NH4)2Zn(SO4)2 0–6, SrBr2 1–6, CaC2O4 0–1, SrCl2 0–1 and 0–2) fulfil all of the criteria. Provided a suitable stabilisation method is found additional 4 salts and 13 reactions (CaBr2 6-0, CaCl2 6-0, 6-1, 6-2, 4-0, 4-1, 4-2, LiBr 2-0, 2-1, 2-0, LiCl 2-0, 2-1, ZnBr2 2-0) From this selection, only 2 salts/reactions (NaI and (NH4)2Zn(SO4)2) have not been extensively studied in the literature. Moreover, many well-investigated salt hydrates, such as MgSO4 and LiOH, did not pass our screening. This work underlines the scarcity of materials suitable for domestic applications and the need to broaden the scope of future evaluations.

- Sevgi Polat, Qi An, Huseyin Burak Eral, Influence of Glycyl-L-Glutamic Acid Dipeptide on Calcium Pyrophosphate Dihydrate Crystallization, *Chem. Eng. Res. & Tech.*, **46** (2023), 11, 2301-2309.

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  The increasing prevalence of calcium pyrophosphate dihydrate (CPPD) deposition disease, a form of arthritis with high inflammatory potential, has triggered considerable interest in the search for additives to prevent CPPD crystal formation, particularly in the field of biomineralization. In this context, CPPD crystallization in aqueous solution with and without glycine, glutamic acid, or glycyl-L-glutamic acid as crystal-growth modifier was experimentally investigated. The produced crystals were characterized structurally, morphologically, and in terms of their surface charge. In addition, the thermal degradation profiles of CPPD crystals obtained with and without the modifiers were characterized by TGA-FTIR, and the major volatile product was H_2O.

- Vikram Korede, Nagaraj Nagalingam, Frederico Marques Penha, Noah van der Linden, Johan T. Padding, Remco Hartkamp, A Review of Laser-Induced Crystallization from Solution, *Cryst. Growth Des.*, **23** (2023), 5, 3873–3916.

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  Crystallization abounds in nature and industrial practice. A plethora of indispensable products ranging from agrochemicals and pharmaceuticals to battery materials are produced in crystalline form in industrial practice. Yet, our control over the crystallization process across scales, from molecular to macroscopic, is far from complete. This bottleneck not only hinders our ability to engineer the properties of crystalline products essential for maintaining our quality of life but also hampers progress toward a sustainable circular economy in resource recovery. In recent years, approaches leveraging light fields have emerged as promising alternatives to manipulate crystallization. In this review article, we classify laser-induced crystallization approaches where light-material interactions are utilized to influence crystallization phenomena according to proposed underlying mechanisms and experimental setups. We discuss nonphotochemical laser-induced nucleation, high-intensity laser-induced nucleation, laser trapping-induced crystallization, and indirect methods in detail. Throughout the review, we highlight connections among these separately evolving subfields to encourage the interdisciplinary exchange of ideas.

- Vikram Korede, Frederico Marques Penha, Vincent de Munck, Lotte Stam, Thomas Dubbelman, Nagaraj Nagalingam, Maheswari Gutta, PingPing Cui, Daniel Irimia, Antoine E.D.M. van der Heijden, Herman J.M. Kramer, and Hüseyin Burak Eral, Design and Validation of a Droplet-based Microfluidic System To Study Non-Photochemical Laser-Induced Nucleation of Potassium Chloride Solutions, *Cryst. Growth Des.*, **23** (2023), 8, 6067-6080.

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  Non-photochemical laser-induced nucleation (NPLIN) has emerged as a promising primary nucleation control technique offering spatiotemporal control over crystallization with potential for polymorph control. So far, NPLIN was mostly investigated in milliliter vials, through laborious manual counting of the crystallized vials by visual inspection. Microfluidics represents an alternative to acquiring automated and statistically reliable data. Thus we designed a droplet-based microfluidic platform capable of identifying the droplets with crystals emerging upon Nd:YAG laser irradiation using the deep learning method. In our experiments, we used supersaturated solutions of KCl in water, and the effect of laser intensity, wavelength (1064, 532, and 355 nm), solution supersaturation (S), solution filtration, and intentional doping with nanoparticles on the nucleation probability is quantified and compared to control cooling crystallization experiments. Ability of dielectric polarization and the nanoparticle heating mechanisms proposed for NPLIN to explain the acquired results is tested. Solutions with lower supersaturation (S = 1.05) exhibit significantly higher NPLIN probabilities than those in the control experiments for all laser wavelengths above a threshold intensity (50 MW/cm^2). At higher supersaturation studied (S = 1.10), irradiation was already effective at lower laser intensities (10 MW/cm^2). No significant wavelength effect was observed besides irradiation with 355 nm light at higher laser intensities (≥50 MW/cm^2). Solution filtration and intentional doping experiments showed that nanoimpurities might play a significant role in explaining NPLIN phenomena.