university of groningen / faculty of science and engineering

Advanced Materials

SPRING 2020

50 years of materials science in Groningen

From the editor

When we started working on this issue, the preparations for the 50th anniversary of Advanced Materials research in Groningen were on full steam. For this we also dived into the archives, and encountered interesting documents that reflect decades of excitement and inspiration for opening new avenues for collaborative research on materials time and again. We went through long lists of former colleagues and stood still at their achievements for science, education and society (in this context have a look at the interviews of emeriti on p. and the historical reflection by Jeff Th.M. De Hosson on p. 4). We were looking forward bringing together the past and the present in a festive day at the Zernike Campus. Unfortunately, life had a different storybook and the world is on hold by the COVID-19 pandemic. While firstly being overwhelmed by the drastic measures all of us are facing today, it is likely that stopping our daily routines may comprise benefits as well. We currently have more time to critically reflect, develop some thoughts or ideas we had no time to go on with, look at data without disturbance, and read (scientific) articles with a good cup of coffee/tea. It may be the moment of finding the missing puzzle piece in your current research, identifying the route to go on with or simply reenergizing after years of operating under pressure. Whatever route you take, stay safe, take care, and enjoy reading about the past and the present of interdisciplinary materials research in Groningen. The last 50 years have shown many facets. We thank all of you who contributed to this success story, and it is great to celebrate this at a time where our community is buzzing with new ideas and initiatives!

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In this issue

Special

MSC/ZiAM in Groningen: Our golden boy!

by Jeff Th. M. DeHosson
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Prelude

An appropriate question in a commemorative flashback on fifty years Materials Science Center/ Zernike Institute for Advanced Materials (MSC/ZiAM) is: what about our genesis and when did 'materials science centers' nucleate in science history anyway? Was our MSC/ZiAM really such a new catch in an international context? In other words: what about our uniqueness?

While addressing these questions I concentrated upon the 'Western World', the reason of which is simply because documentation is more easily accessible in open literature. So, upfront I have to apologize to Russian, Indian, Chinese and Middle –East academic institutions. As a matter of course, to a certain extent 'materials research' has been around since the start of civilization of mankind, say in Lower Mesopotamia (3000 BCE and thereafter in China, India/ Pakistan, Western World et cetera).

But here I will focus, not on the genesis of the field of materials science as such but on the 'institutional organization' of materials sciences and ask myself: which university advertised the very first materials science center in academic history and its own educational and research program? Was it Groningen? That would be fantastic.

My search led predominantly to MIT Massachusetts Institute of Technology – Cambridge –USA (Fig.1) where extremely influential and inspirational departments of materials science & engineering (DMSE) and mechanical engineering arose. The present MIT DMSE nucleated on studies of mining, already dating back to the opening of MIT in 1865. In the 1940's, MIT discontinued the study of mining engineering and in 1967 the department name changed to the Department of Metallurgy followed in 1974 to the School and Department of Materials Science and Engineering. So, we can comfortably lean backwards and state that MSC/ ZiAM of Groningen in 1970 beat with ease MIT-USA (Fig.1).

However, within our national context we should admit that TUDelft was a real frontrunner in promoting interdisciplinary research, in fact much earlier than Groningen. Already in 1952 the so-called 'tussenafdeling metaalkunde'

Fig.1 : Genesis of Materials Science Centers and Depts., MIT-Cambridge-USA and Tech.Institute Northwestern U –USA with Morrie Fine as founding father in the history of Materials Sciences.

(Metallurgy) at the then Technische –Hogeschool, TH-Delft, was established by the Faculties (called 'Afdelingen') of Engineering Physics, Chemical Engineering and Mechanical Engineering. The professorial chairs belonged to the corresponding 'parental' Faculties and the 'tussenafdeling metaalkunde' was more like a '(sub) faculty' in Groninger vocabulary. The world famous Willie (Willem Gerard) Burgers (1897-1988) was professor of Physical Chemistry at Delft between 1940 and 1967 and he became one of the founding fathers of the Department of Metallurgy. Together with his colleagues M.J. Druyvesteyn of Engineering Physics and Peter Jongenburger of Mechanical Engineering, he envisaged around 1950 that materials, in particular metals, began to play such an important role in technological developments that research and education in metal science should be incorporated at TH-Delft. The next step, a transformation from Metallurgy to the (sub)faculty 'Materials Science and Engineering' was taken in 1989 by TUDelft, and indeed we may say with appropriate collegial joy and satisfaction: also on a national scale with the onset of the Materials Science Center in 1970 the University of Groningen was ahead of its time.

Although we passed by, at least historically, MIT and TUDelft, what about the rest of the world? Now, it is with regret to say: due to Northwestern University it is USA # 1, i.e. in line with: 'We are now NUMBER ONE in the Universe, by FAR!! — Donald J. Trump January 21, 2020 @realDonaldTrump'. Let me respond by saying: luckily enough the Universe is quite big spatioptemporally, i.e. in space and time, and we may tacitly claim 'Groningen NUMBER TWO'!

At Northwestern University-Evanston/Chicago, within the McCormick School of Engineering at Tech Institute (Fig.1), a new branch of physical science had been launched in 1958, through the efforts of Donald Whitmore (active at Northwestern University in the period 1943-1987); and advertised as Materials Science. Co-founder was Morris E. Fine (1918-2015) globally recognized as one of the top-leaders in the field of materials. He came to Northwestern with experiences of the Manhattan Project in Chicago and Los Alamos, followed by research at the historic Bell Labs in New Jersey, where he was hired by William Shockley due to his *interdisciplinarity*: he had studied solid state physics as well as metallurgy.

Among the Faculty in the seventies at NU, when I was a postdoc myself, 'Morrie' (for his soul mates, Fig.1) was Dean and there were big names like Jerome (Jerry) B. Cohen (1932-1999, fundamental and applications of diffraction, originally from MIT), Hans Weertman (1925-2018, dislocation theory), his wife Julia R. Weertman (1926-2018, properties of advanced materials) , et cetera [1].

After we signaled already the launch of Materials Science as a new discipline—world-wide !—the question arises how did it develop and how was it picked-up by the University of Groningen? At Northwestern there were, from 1958 onwards, four fields of interest: metals, ceramics, electronic materials, surface science, and polymers. New fields of research also require, besides new materials and new specialists, also new instruments, in what Hendrik Casimir (1909-2000)—a source of inspiration for me having known him personally —used to call the "science-technology spiral" [2][3].

In addition to research another interesting observation for me at NU was the impact that 'materials science & engineering' had on the great variety in professions and personal development of the students after the academic education, e.g. from a vacuum tube engineer—at the end of World War II—Morrie Fine became an expert in physical materials sciences. Thus, for the materials scientist, the fundamental concepts do not alter, however changes of the context in which they are used, make it a very attractive world of challenges and opportunities for students as well [3].

Nucleation and Growth

As clarified from the 'Prelude', Materials Science started as an interdisciplinary area of research that embraces, but does not replace, some disciplines of physics and chemistry. Indeed, traditionally chemists and physicists each have their own way of approaching a particular scientific problem and their interests emphasize their research on different parts of often the same problem. With this in mind our MSC was founded in 1970 with the aim of stimulating communication and cooperative research projects between groups in the (sub)faculty of physics and the (sub)faculty of chemistry involved in materials research. Even the (sub)faculty of the Dentistry

Fig.2: the MSC founding fathers: Top-down, left - right. Ad Dekker , Hendrik de Waard, Wim Nieuwpoort, Ger Challa, Franz Jellinek, Jan Kommandeur, Joop Arends, André Wegener Sleeswijk, Cor Haas, Sieb Radelaar and Paul Bronsveld.

School joined in the early days. The necessary upscale of the budget in the 70's for expensive equipment was also an important driving force to launch a materials science center. Concerted actions supervised by the MSC were thought to be the best strategy for success on local and national scale to get proposals for state-of-the-art instruments granted. The basic idea was that if MSC could present a multiannual plan for new instruments with open-access for each of us, it may lead to a higher success rate of external grants and benefits for everyone. The good thing was that right from the start it was a bottom-up informal 'Center', more like a 'federation'. The oldest document in our history is a letter by Cor Haas (1930-2019) and Franz Jellinek (1925-1992), dated 26-01-1970, proposing the creation of a "Working Group" for Materials Sciences. The principal founding fathers were based in Chemistry, e.g. Cor Haas, Franz Jellinek, Wim Nieuwpoort, Ger Challa, Jan Kommandeur (1929-2012) as well as in Physics with Ad Dekker (1918-1994), Hendrik de Waard (1922-2008) and André Wegener Sleeswijk (1927-2018). One research group of Joop Arends (1934-1998) joined from outside our Faculty, i.e. the Medical –Dentistry School, Materia Technica. The first chairman and secretary to the board were Sieb Radelaar (1939-2017) and Paul Bronsveld, respectively (see a concise compilation of the days past in Fig.2).

Becoming chairman of MSC myself in 1978 the total number of groups and professorial chairs was rather small (around 10) leading to a reasonably efficient organization of an informal 'Center', based on formal 'vakgroepen' with well–defined responsibilities and duties for everyone. Fig.3 displays a few annual reports of the 'great' MSC, which turned out not so great in annual reports! Only a very few, less than 10, annual reports appeared over the past 50 years!

Interestingly the entire structure of our Faculty, with 6 (sub)faculties in Groningen was neatly arranged in 1970 and built on a far less complicated structure compared to the current, very complex situation 50 years later, comprising of so many research institutes and schools of education (in total about 20 or so). Administration and administrators in the 70's were also minimal. Rather, the individual professors were in charge, and running their own business in education, research and administration. But 'boundaries' between (sub) faculties and groups hampered communication, collaborations, mutual use of equipment and for that reason a bottom-up informal 'Center' was an excellent catch. Right from the start informal discussion meetings, seminars, colloquia, workshops, Vlieland conferences- the very first one was held in 1970 on the island- et cetera, contributed a lot to the mutual interactions, in particular among the PhD students.

The aim of the Center was, and still is, to retain and respect the expertise in various disciplines, but at the same time to set the stage for making optimum use of the expertise at hand without sacrificing high quality. In 1993 the MSC was recognized by the Royal Netherlands Academy of Arts and Sciences (KNAW) as a leading research institute & school in the field of materials science followed by the recognition by the Ministry as National Research Center MSC-plus in 1999 and a name change in 2007 Zernike Institute for Advanced Materials. See also: https://www.rug.nl/research/zernike/organisation/zernikeinstitute2007now.

The downside of the upgrade in official status, from the 'federation' MSC to Research Institute MSC, around the 90's by the University/Faculty of Mathematics and Natural Sciences was that it resulted, much to my regret, in the formal loss of Materia Technica (Joop Arends -see Fig.2, Jaap ten Bosch and Henk Busscher) of the Faculty of Medical Sciences. We were told that MSC had to be restricted to one Faculty. An 'interfaculty institute' turned out violating important (?) administrative rules. My escape route offered to the Exec. Board of the University, out of this formal argument, was an upgrade of MSC to the level of a 'University Institute' with the same status as KVI (Nuclear Physics Institute), i.e. directly under supervision of the Exec. Board avoiding conflicts among faculties and beyond the direct control of any single Faculty. You can imagine that this revolutionary idea was (n+1) bridges, with n>>1, too far for our own Faculty. I remember that Eric Bleumink, President of the University and Simon Kuipers, in those days vice-Chancellor, questioned whether MSC was already at 'the same top level' as KVI (indeed very professionally directed by Rolf

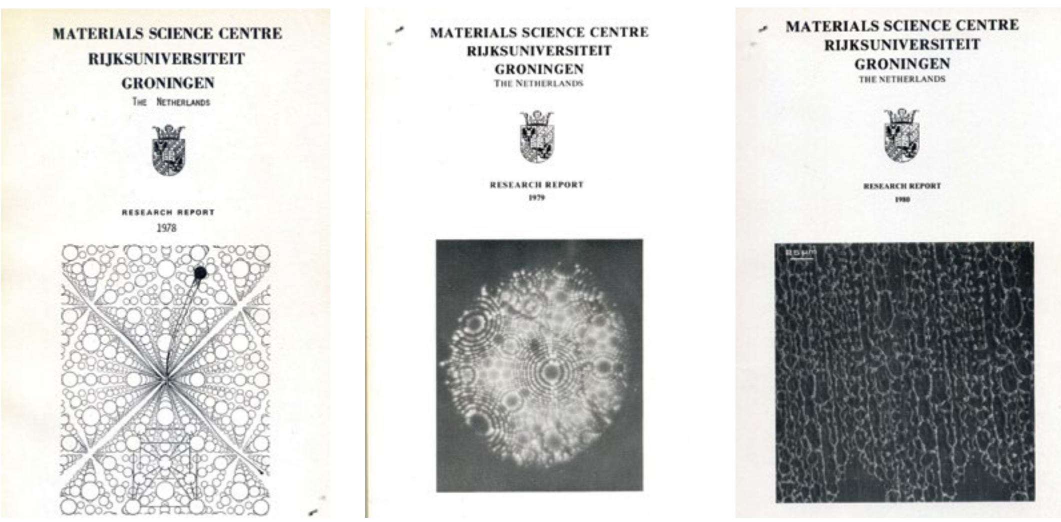


Fig.3: Annual reports MSC 1978 -1980.

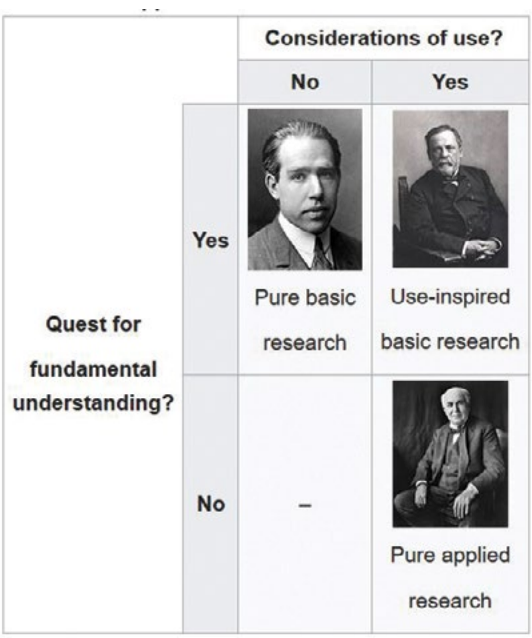
Siemsen) and whether we were already that great. Although I was arguing firmly my leitmotiv at the time 'you do not have to be great to start; you have to start becoming great!' the proposal was rejected and my 'escape route' offered became rather an 'exit route': merely a missed and wasted opportunity, I must say.

As regards education in the period of 'growth': the interactions among various research groups and activities in the context of the MSC/ZiAM were of particular relevance for Master/PhD student projects in engineering physics. Definitely it has played a very positive role in broadening the scope and horizon of students. The interactions between disciplines of physics and chemistry provided engineering physics fertile ground for doing relevant engineering research, e.g. on structure-property relationships in materials science, design and characterization within device nanophysics, and optoelectronics and micro-mechanics. Not surprisingly the core interests of MSC were 'fundamentals', whatever that may mean, not 'applications'. I remember in 1978 and many years onwards, that I had to convince the Faculty board and later also several MSC directors of the importance and relevance of 'fundamentals in engineering' and 'use-inspired basic research'. The Faculty and sometimes the MSC board gave me a hard time but I survived without too many scratches and harm.

Coming from USA as a postdoc to Groningen in 1977, I very much believed (after inspirational discussions with Morrie Fine, see above), in the "Pasteur's Quadrant" of research that is both fundamental and useful. Louis Pasteur's research is thought to exemplify this type of method, which bridges the gap between 'fundamental' and 'applied' research. (see [4]).

Fig.4 Pasteur's Quadrant was in particular appropriate for materials science since that field developed from the understanding that the performance of many types of useful materials systems (metal, polymers, ceramics) are fundamentally related through parameters that describe 'internal structures', at various length- and time scales.

As said before: the fundamental materials concepts do not alter, however changes of the context in which they are used, make it a very attractive world of challenges and opportunities. One can also see these evolutions in the field of research of Materials Science. The scientific papers produced in those late 1970s illustrate how closely Materials Science was still related to Solid State Physics. In much the same way that Solid State Physics itself



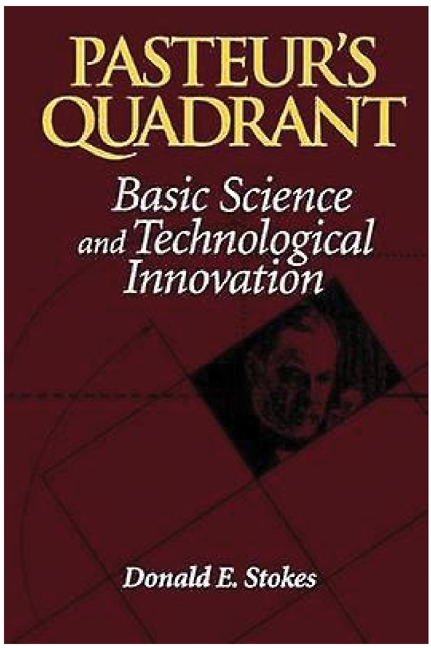


Fig.4: Pasteur's Quadrant – Basic Science and Technological Innovation; top: Niels Bohr, Louis Pasteur; bottom: Thomas Edison (see also [4]).

1.Title of the Programme

Materials Science:
design and functionality of novel systems

2.Contact person and address

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Lab. Polymer Chemistry

Nominated Thrust leaders:
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Prof.dr. R.M. Kellogg
Prof.dr. G.A. Sawatzky
Prof.dr. J.Th.M. De Hosson
Prof.dr. D.A. Wiersma
Prof.dr. T.M. Klapwijk

At Nijenborgh 4, 9747 AG Groningen
The Netherlands

Application number:135

Title: Materials science: Design and Functionality of Novel Systems

In reviewing this proposal I am using the rating system employed by the National Science Foundation in the USA: that is, excellent, very good, good, and fair. I want to state clearly that the one person whose research work I am the most familiar with is Prof. J. Th. M. De Hosson .
Criterion A The research programme is of excellent quality;

The academic quality of this thrust group is excellent.**no comment**

The originality and innovative potential is very good to excellent. The idea of novel hybrid and functionally gradient materials is not completely new, as the authors state, but their approach is quite catholic and, therefore, the potential for new discoveries is great.**no comment**

The complementary talents and expertise of Profs. Sawatzky and De Hosson has the potential for producing highly 'nonlinear' new results.**no comment**

The research program suggested by Profs. Sawatzky and De Hosson is highly relevant to the development of this field and the combination of Prof. De Hosson's materials science expertise and Prof. Sawatzky solid-state physics expertise is exactly the type of approach that is highlv likelv to be successful.**no comment**

Profs. Sawatzky and De Hosson have prepared a coherent and focused research program.
no comment

Criterion B

Prof. De Hosson's research accomplishments are certainly at an international level and his research work is highly competitive with similar work done at major materials science departments throughout the world.**no comment**

Criterion C The researchers involved must be of excellent academic quality - able to compete world-wide at the highest level in the area of research concerned.

Prof. De Hosson has an outstanding track record of producing high quality experimental results, as well as performing simulations. And he has certainly been able to compete extremely well at an international level. The productivity of his present research group is incredibly high and I would rate his group as the best materials science group in the Netherlands at a university. **no comment**

Fig.5: (a-left): front page proposal NRC-MSC 1998, (b-right): review and comments to thrust 2.

had emerged as the physics behind crystallography [5]—let's say, since Max Born's Dynamik der Kristalgitter (1915)[6,7]—Materials Science branched off from Solid State Physics as a generalized form of Pasteur's Quadrant, with strong crystallographic and physical and chemical accents in subfields of metal & alloys, polymer physics & chemistry, ceramics, semiconductors, device physics and nanoscience &technology [8]. It is also noteworthy that in the 'growth period' of MSC-plus new initiatives of MSC started in September 2003, not only for research, but also concerning education, i.e. an international Top Master programme in Nanoscience, closely following the research philosophy of MSC, which was very well appreciated by the Master students for the combination of curiosity oriented and application driven aspects in both physics and chemistry.

Top-of-the-Top and Over-the-Top

Research costs money. There are still politicians in The Hague dreaming that research generates immediately cash-flow to the government. It seems that over the whole period of 50 years, higher education and research at universities were a popular money spinner and a cash cow in cuts of any government whatsoever, irrespective of its specific political color of purple, green, red, black, orange, and what else do we have today. Nonetheless, the field of materials sciences did pretty well (comparatively). The strength of MSC/ZiAM is definitely our creativity, ingenuity and international collaborations. Also, we as βs — at least some of us — are good writers of exciting proposals for external funding.

With hindsight and in fact to my pleasant surprise, science policy on 'materials' from 'The Hague' was rather consistent and, most importantly for academic research, without too many big discontinuities (in the first derivative with respect to time). On the national level FOM, SON and STW were the most professional, influential and terrific sponsors of materials sciences over many, many years, also in conjunction through the Priority Program on Materials Research of the Netherlands Organization for Scientific Research (NWO, The Hague) in the 90's. In particular, the Priority Program on Materials Research (PPM), with a total budget of more than 36 M€, stimulated interactions between academia and Dutch industries in the fields of materials. Noteworthy, on its turn PPM was a natural result of the AGM discussions and reports, Advies-Groep-Materialen of the Ministry of Economic Affairs in the 80's, et cetera. Again AGM was an 'organic' follow-up of the early days, i.e. in the 70's FOM established already a program, in particular on Metals, within the 'werkgemeenschap FOM-Metalen-TNO'. All these stimulating activities, like the Priority Program on Materials Research et cetera, were bottom-up concerted actions from the academia and well received by the community.

In contrast, the origin of the National Research Centers, including MSC-plus and NOVA in Groningen, was not a bottom up idea from academia and not even suggested by the Ministry of Education, Culture and Science. Interestingly, in the Netherlands, —and quite extra-ordinary for this country, I must admit—the innovative onset of top institutes

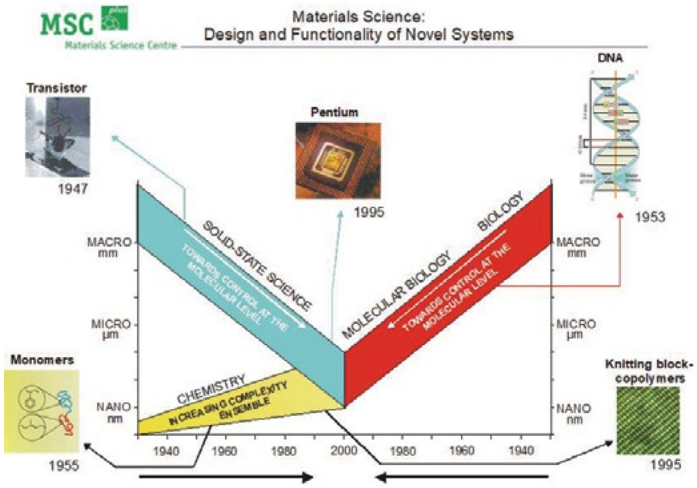


Fig.6: 'famous cartoon' by Georges Hadziionanou visualizing our conceptual ideas in 1998.

came first in 1995 for technological top institutes (TTIs). It did not arise from the academia but instead it was imposed by the government supported by Dutch industries, a USA like top-down mode, namely in particular through the efforts of Hans Wijers, an alumnus of our University of Groningen who served a term as Minister of Economic Affairs (1994-1998).

Very much in line with Dutch science politics and policy of science, in 1998 the Ministry of Education, Culture and Science felt itself passed by the Ministry of Economic Affairs. The appropriate reaction was not a big surprise (Newton's third law, please note the minus sign) to the field and very much as expected: 'NWO should organize Centers of Excellence, but, on the contrary, for basic research and without industrial partnership, albeit with an open eye for valorization'. As a consequence in 1998, the Materials Science Center (MSC), together with leading researchers from the Groningen Biomolecular Sciences and Biotechnology Institute (GBB) and the Stratingh Institute for Chemistry and Chemical Technology, submitted a proposal through the Executive Board of the University to NWO for an innovative research programme, combining chemistry and physics, and, to some extent, biology. It was entitled Materials Science: design and functionality of novel systems (Fig.5a).

All these aforementioned initiatives were steadfastly backed by the University's Executive Board, chaired successively by Profs. Eric Bleumink, Simon Kuipers, and Sibrand Poppema, by the Board's vice-presidents Marius Kooyman, Koos Duppen (1953-2011), Jan de Jeu and I assume continuous support will be provided by our - since October 1st 2018- executive board, Jouke de Vries (president) and Hans Biemans (vice-president). Likewise, University's Rectores Magnifici Doeko Bosscher, Folkert Van der Woude (1933-2012), Frans Zwarts, and Elmer Sterken and at present Cisca Wijmenga but also in particular Dean Piet Van der Kruit stimulated the start of the technological top-institutes (called Dutch Polymer Institute –DPI and Netherlands Institute of Metals Research –NIMR). That policy was sustained at the start of National Research Center MSC by Dean Douwe Wiersma.

In fact the overall mission and objectives of NRC-MSC in 1998 did not differ much from the original ones in 1970, e.g. to attain a position as an internationally recognized leading materials research and training institute; to conduct research addressing fundamental questions in the field of functional materials; to optimize the synergy and knowledge transfer between the disciplines of physics and chemistry; to educate a new generation of researchers in a crossdisciplinary approach to better prepare the graduates relative to the diversity and quality of skills needed in society.

The novelty of the proposal and I am convinced this was the quantum leap to get it granted was the following: the classical materials triangle concerns the integrative approach in the three aspects of structure, property and chemical composition. The MSC-plus proposal added to this traditional view, the latter of which was advocated mainly by MIT and Northwestern U in the 1960's, an extra dimension, say the 3rd dimension, by an unconventional linkage to the field of bio-molecular sciences, in which the design aspects were included as well.

In particular the sprightly novelty of the proposal was based on the formulation of two challenging novel classes of potentially functional materials and our smartest strategy was not even trying to compete with other, more conventional material science centers in the Netherlands but rather with research institutes that also operate at the edge of the unknown in this '3rd dimension'.

It is relevant to emphasize that the interdisciplinary research we envisaged utilized the broad range of expertise offered by recognized experts without sacrificing the leading role played by individual scientists in their particular area of research. Fundamental understanding is essential if one aims in the long term at the design of materials whose functionality can be durably controlled and maintained.

The NRC-MSC was and is aimed at achieving international leadership in materials research and education, in critical areas of innovation, by means of a crossdisciplinary research program. Specific research objectives were formulated for three scientific thrust areas and the programme was visualized by Georges Hadziioannou by his 'famous' cartoon displayed in Fig.6:Molecular Bio/Organic Materials : Design, Construction and Control; a transition from traditional inorganic solid materials and polymers towards the unconventional but fascinating possibilities for molecular design offered by organic chemistry and biochemistry; thrust leaders George Robillard and Dick Kellogg.

Novel Hybrid and Functionally Gradient Materials; basically different properties obtain when different components are fused together on nanometer scale, new materials so to say, with properties determined by the interface regions rather than the components themselves; thrust leaders George Sawatzky and Jeff Th. M. DeHosson.

Electro-Magnetic Functionality: Photonics and Transport Properties combining the existing high level experimental and theoretical expertise of specialized research groups into a concerted effort to characterize and exploit optical, electric and magnetic properties of the new materials envisaged; thrust leaders Douwe Wiersma and Teun Klapwijk.

Originally 22 proposals were reviewed by NWO and only 6 programmes were funded under this scheme after 2 rounds of assessments. Its beneficiaries became known as National Research Centers (NRC), initially for five years (1999-2003) but stretched later after several mid-term evaluations with different amounts of money-money-money, up to 2021. To distinguish the programme from its primary participant, the MSC, the name MSC *plus* was introduced.

When I was approached by the scientific directors, the passionate and creative Georges Hadziioannou (at present U. Bordeaux, France) and the always super-enthusiastic George Sawatzky (at present U. British Columbia, Canada), to write as member of the board the thinking-out-of-the-box proposal for MSC-plus/ZiAM I needed a sparring partner, whom I found within one femtosecond (….of Douwe Wiersma) in the person of my inspirational and wise colleague Wim Nieuwpoort (emeritus Theoretical Chemistry, chairman of the board in 1997), and one of the founding fathers of MSC in 1970 (see Fig.2)!

With hindsight, it was rather remarkable that we succeeded in 1998, with excellent reviews, yes of course for all thrusts (see as an example Fig.5b), but 'only' # 5 out of 22 proposals nation-wide over all αβγ disciplines. Please note that the top 6 were granted, so we just made it, and NOVA – astronomy

UK 26

Bluff your way in toponderzoek

Het is echter te simpel om te beweren dat de bèta-lobby zich onrechtmatig bijna alle topscholen heeft toegeëigend. Nadere bestudering van de dieptestrategie-aanvragen zou namelijk wel eens aan het licht kunnen brengen dat sommige bèta's gewoon betere schrijvers zijn.

Fig.7: UK March 19th 1998 about the ZiAM and NOVA top-research proposals.

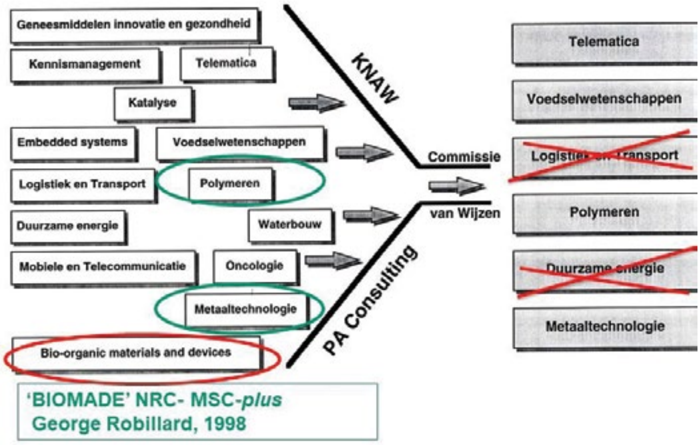


Fig.8: left (a) Part of the in total 36 proposals submitted for top-institutes 1997-1998 and to the right (b) in 2011 even more 'up-to-the-top' supported by 7 (!) Ministries.

Leiden-Groningen-Amsterdam-Utrecht-Nijmegen became #1 on the NWO ranking list, as far as I remember. Our proposal could not make it up to #1, not because of issues of quality and novelty as such, but because it was singular, restricted only to Groningen. In particular Eric Bleumink, in 1998 the President of the University was strongly arguing against an official collaborative effort within the country for MSC as an institute. Basically he was afraid for a full sell-out. Although I was trying hard to convince him that there is an essential difference between 'science-on-sale' and 'science-for-sale', I failed. So, in the end it became a high risk/high gain proposal and luckily enough, based on the intrinsic quality of the proposal, we succeeded.

I remember that the announcement by NWO of the 6 'winning A-teams' generated a lot of disappointments and agitation in the country, in particular among the colleagues of Humanities, Law schools, Linguistics et cetera, because almost all 6 grantees were based in Sciences. National and local newspapers jumped onto the story and after (thorough?) analysis (see Fig.7) it was concluded by UK-Newsletter that β-s, i.e. neither α-s nor γ-s, won the battle in the 'bluff-your-way-to-the-top' because our thinking-out-of-the-box MSC-plus proposal was presented, with:

- *shameless and impudent self-recommendation;*
- *nearly overconfident and reckless ambitions, phrased in clear and perspicuous prose;*
- *suggesting that the targets as formulated in the proposal will be achieved for sure;*
- *a disciplined, uncompromising consensus and structure of natural harmony.*

(Copied from the University Newsletter UK March 19th 1998, translated from the original text in Dutch). Please note: for your future applications all four bullets are equally important for getting your proposal granted!

We should realize that in the period 1995-1998 in total 36 proposal were submitted, for the label of excellence and 'top', see Fig.8a, i.e. 22 to NWO NRCs and 14 for TTIs and in the end 10 were granted, 6+4 respectively.

I consider the outcome as a fair balance between basic research and use-inspired basic research in Pasteur's terminology. After the start of NRC-MSC in 1999 of 'lonely-at-the-top', not to be confused with 'lonely-at-the-tap', two decades later almost everyone seems to belong to the top of something.

It is really amazing that in 2011, with far less free money around for research compared to 1998, the Ministry of Economic Affairs took the lead (again), on behalf of no lesser than 6 other Ministries with a policy paper, entitled: 'up-to-the-top', Fig.8b. Ministries involved were: Economic Affairs; Science & Education; Foreign Affairs; Infrastructure; Health; Finance; Defense. Embracing so many Ministries is already suspicious from the viewpoint of efficiency, budgets and real impact, but indeed it reflects typically the Dutch way of handling difficult issues of denominating excellence: 'lonely-at-the-top' becomes rather 'crowdy-at-the-top'.

The prime advantage of this top-down initiative in 2011 is that the outcome is very well predictable without unpleasant surprises: every researcher in Holland has to belong at least to one, preferably to more than one top sector, and the total number of sectors will not exceed the number 10. Nonetheless, the impact of all of this was very substantial, in particular onto the NWO policy and programmes for basic research funding. Indeed I was right. The final results were: 9 top sectors and yes everyone seems to be absorbed in at least one top sector.

However, the contrast to the 1998 period of high risk/high gain is clearly visible and becomes worrisome because the loss of balance between pure basic-research and use-inspired basic research. From 'top-of-the-top' in 1998 becomes 'over-the-top' in 2020 (e.g. USA can do with just 2 top sectors). It looks rather from high risk/high gain to a situation of low risk/low gain. Nevertheless, I understood that at present the NWO Themacommissie Materialen under the inspirational leadership of Albert Polman (Amolf-Amsterdam) is trying to reshape order-in-disorder through 'Materialen consortia', which sounds like a kind of 2nd PPM to me, and I hope to see ZiAM-plus firmly sitting in the driver-seat of several of those consortia.

Wrap up

It goes without saying that these past fifty years MSC/ZiAM did a superb job, developing from a bottom-up informal 'Center' like a federation consisting of 8 loosely-bound 'vakgroepen' to a more formal structure of a strong and visible institute in which about 25 groups work together on joint topics of interests. It has been greatly flourishing over so many years due to the many active members optimizing the synergy and knowledge transfer between the disciplines of physics, chemistry and biology.

MSC/ZiAM has not only become mature as a professional organization but something very special indeed because of the interdisciplinary research and as an internationally oriented training institute for your people, utilizing expertise of each other without sacrificing the leading role played by individual scientists in their particular area of research. So, MSC/ZiAM basically means for individual materials researchers an extension of the degrees of freedom with multi-added-values at a higher level of international impact. That is something for each of us within the university to enjoy.

Let me conclude with a quote by Georges Hadziioannou and myself when we were writing together many letters as director and chair to the Faculty/University board two decades ago but being still very applicable to the MSC/ZiAM today: "One of the interesting things about materials science is that you never know what will happen tomorrow. Therefore modestly but hopefully wait and see what the linkage between condensed matter science and bio-molecular science will bring. We are confident: a sparkling, animating and lively marriage"!

Congrats to MSC/ZiAM with the superb successes in the past 50 years and a big hand to our sparkling "Golden Boy".

Groningen, February 8th, 2020

References

[1] M.E. Fine and H. Marcus, 'Materials science and engineering, an educational discipline', Annual Reviews of Materials Science 24 1-17 (1994).

[2] H.B.G. Casimir, 'The science-technology spiral', in: Haphazard reality–Half a century of science, New York: Harper & Row, 1983, pp.294-313.

[3] E.C. Bain, Transactions of the American Institute for Metallurgy and Engineering 68 625-639 (1923).

[4] D.E. Stokes, (1997). Pasteur's Quadrant – Basic Science and Technological Innovation*.* Brookings Institution *Press. pp.* 196. ISBN 9780815781776)

[5] See S.E. Weart, L. Hoddeson, E. Braun, and J. Teichmann (eds.), Out of the crystal maze: chapters from the history of solid state physics, New York (NY): Oxford University Press, 1991.

[6] Leipzig-Berlin: B.G. Teubner. It was integrated in F. Klein and A. Sommerfeld (ed.), Encyklopaedie der mathematischen Wissenschaften (Leipzig: Teubner, 1898-1926). An adapted version, co-authored with K. Huang, appeared in 1954 as Dynamical theory of crystal lattices (Oxford: Clarendon Press).

[7] Paul Bronsveld and Henk Kubbinga (eds), Festschrift in honor of Jeff Th.M. De Hosson, ISBN 978-90-814428-0-0, Groningen University Press, 2012, Reprinted 2nd Edition 2019, pp.584.

[8] Jeff Th.M. De Hosson, Put the Pedal to the Metal, ISBN: 978-94-034-1349-5, Groningen University Press, 2019, pp.602.

50 years Material Science Centre

In april we celebrated the 50th anniversary of the Zernike Institute for Advanced Materials (ZIAM), or Material Science Centre (MSC) as it used to be called. Over the years, many people have contributed to the founding and thriving of our institute. For this article we spoke to several of these important persons who will also be part of the celebrations in April. What do they remember most about their time at MSC?

Ria Broer

Ria Broer worked at the University of Groningen from 1987, first as KNAW-researcher and later as professor, teaching and doing research in the field of theoretical chemistry. For a long time she was the only female researcher in the MSC.

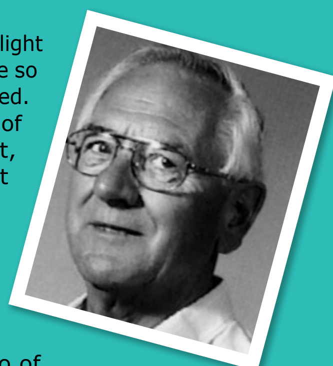
"When I started working at MSC, I never really thought that people saw me different because I was a woman. The atmosphere was good and I enjoyed myself. I did sometimes feel that I was overlooked, but I always thought it was because I was not good enough. When I read about these things later, I realized that many women experienced similar things, and that being a woman most probably also played a role. But 2003 was a turning point. I was finally appointed professor, and in the same year Petra Rudolf and Katja Loos joined the MSC. A year later Beatriz Noheda arrived as one of the first Fellows in the successful Rosalind Franklin Program that was initiated by Douwe Wiersma when he was dean. Right now, we have many very talented female researchers. That is very important, and we have to show the young women that they can make it, those who don't as well as those who do like the spotlights. It is the research that counts."

"With all this new talent we attracted as MSC – both female and male – we are also able to conduct really interesting research. The work on spin transport by Tamalika Banerjee and Bart van Wees is only one example. I like it that we define projects combining theoretical and experimental research, chemistry and physics. That was a challenge in the beginning, because chemists and physicists often speak different languages and theorists and experimentalists often have different interests, but it really improved our research. Many of my colleagues from outside Groningen and abroad are jealous of our research environment."

Ger Challa

In 1965, Ger Challa from Akzo-research started as a professor of polymer chemistry at the University of Groningen. Until his pension in 1993, he was involved with the development of polymer chemistry and the MSC.

"The starting point of the MSC were the meetings on Vlieland, initiated by physicist Dekker and chemist Jellinek. In 1970, all the groups from chemistry and physics went to Vlieland, where we gathered to share our research and come up with new ideas. It was a really important step, that was supported by several professors who wanted to cooperate more. For our polymer chemistry group is was special that we were also invited, it was a recognition of the quality of our research. We had so many unforgettable years at Vlieland, it really strengthened the cohesion between all the groups who worked on materials, in one way or another."



"It is hard to pick one highlight of all these years, because so many good things happened. In our group the arrival of Pennings was important, because he brought knowledge from DSM, finally resulting in the very strong fiber Dyneema. However, we also had some difficult times. In the eighties, we were part of the MSC but also of a national polymer research centre. That research centre was meant to bring the research in the Netherlands closer together. So we basically had to spread our attention, and that did us no good. Luckily the cohesion of the MSC stayed, and the polymer group is now thriving again and getting back."

Georges Hadziioannou

Georges Hadziioannou came to Groningen in 1989 from IBM in Silicon Valley, California, and started as a professor in polymer chemistry. He was the director of the MSC for three years, and was the main applicant of the proposal that led to the awarding of the Bonus Incentive Scheme, locally more known as MSC+ or dieptestrategie.

"When I came from Silicon Valley, I was filled with ideas about new innovations and subjects that we could explore. The cooperation of the MSC was perfect for exploring these ideas further, and I really enjoyed developing my research there. Together with George Robillard, I even set up a weekly lunch meeting where we debated new ideas. During these meetings we really pushed students to think outside the box, and think about the future. Right after I became the director, there was a call for proposals for institutes of excellence. Without knowing it, we had already prepared for this during our weekly meetings. It was just a matter of selecting the right ideas and writing it down."

"I think that one of the strong points of the MSC is the way it is organized. There was no real hierarchy, everybody was equal. You could speak openly and really put research on the forefront. During national meetings I saw that our organization was different from other universities. But I do think it helped, because even the students were very involved. And without good students, you can't get anywhere. Many of the students I saw pass during my years at the MSC are now top of their fields. They really helped the excellent research and made it possible to develop really new functional materials."

Jeff De Hosson

Jeff De Hosson has been a professor of applied physics at the University of Groningen since 1977. During this time, he has been involved as chairman and executive board member of the MSC for over 25 years. One of the things he remembers most is the start of a more interdisciplinary approach, and the proposal that led to the MSC+.

"When we started with the idea of a larger, interdisciplinary Material Science Centre, it was really new. There were only a few institutes in the world which had this kind of cooperation. It gave us a lot of opportunities to learn from each other and try things we otherwise might not have. For instance the work at the onset of MSC on just ordinary sand as possible storage memory for computers, that we worked on stimulated by George Sawatzky. That was exciting and exemplary. It didn't work at all although some signals got stored in the sand, but we did have a lot of fun. And of course we did a lot of things together that did work out well, a lot of important small steps in different fields of research."

"I remember I thought the MSC was so good that we should get a higher status within the university, comparable to that of the KVI (centre for atomic & nuclear physics). So I went to the executive board and argued that material science was just as important as nuclear physics. But then the president asked if the MSC actually was as good as I claimed, and I almost leaped out of my chair. I was firmly arguing that you do not have to be great to start; you have to start becoming great and told him to wait and see. A month later we were selected by NWO as one of the 6 national research centres!"

George Robbilard

George Robillard joined the Physical Chemistry Section of the Department of Chemistry in 1974 to work together with the late Professor Herman Berendsen in a, then, new Dutch research initiative, the application of Nuclear Magnetic Resonance to biological systems.

"For the first ten years I was pretty oblivious to the activities of the MSC, even though my colleagues in the Physcial Chemistry Section, George Sawatzky, Jan Kommandeur and Douwe Wiersma, were some of its earliest and most active members of the MSC. We were all happy and did our own thing. That changed in the mid-eighties as funding started to dry up and the government stressed avoiding duplicating research. Funding was to be channelled to the top research groups brought together in multidisciplinary Top Institutes. MSC was awarded that status early-on, followed by other institutes in Groningen. In that same period, molecular nanotechnology institutes started to spring up around the world that attracted the best young talent. We also joined in with NanoNed, together with the TU Delft and TU Twente, and established three state-of-the-art nano-labs"

"My fondest memory of MSC and that time of setting up the nanotechnology research is the meetings we organized to get people on the same page. Most scientists only speak the language of their own specialization, so we needed to learn more about all those different languages. So in the meetings, we let a biologist teach the chemists and physicists about their area of expertise and

vice versa. Not just what certain terms meant or how processes are done, but also what their research could add to other disciplines. I learned a lot during those meetings, and people really enjoyed it. I don't remember if these meetings were the direct reason we decided to form an MSC+, but it did help to enrich the cooperation."

Wim Nieuwpoort

Wim Nieuwpoort has worked as a professor in theoretical chemistry at the University of Groningen from 1967 until 1996. Besides his research, he was involved with the MSC. During the origin of the MSC+, when organic chemistry and biochemistry joined the MSC, he was the chairman of the MSC-board.

"The MSC started as a very practical gathering, which made it easier to share equipment and collaborate on projects. This led to interesting research, for instance from George Sawatzky, who really developed photo-electron spectroscopy. And the polymer group was also thriving in this system. During my time as chairman we decided to expand further, because the biochemistry also became more and more involved in interdisciplinary research. Those were exciting times, but it also was a challenge. Because we couldn't buy all requested equipment at once, we made a sort of schedule. However, everybody thought that their research was the most important, and that we should buy their equipment first. That sometimes led to some tensions, but nothing that we couldn't resolve."

"One thing I remember most about my time as chairman, is the time one of our researchers thought he deserved a spot as professor, but the executive board did not agree. In the end they conducted a meeting to talk about it, which I also had to attend. The meeting got very heated. At one point the president of the board said: 'Even if you bring in a Noble Prize, that doesn't mean you deserve a spot as professor'. The researcher stood up and we

thought he might attack the chairman, but then the secretary intervened. He took a toy mouse out of the pocket of his jacket and put it on the table, where it started to spin around. Everybody was so surprised by this that we immediately got quiet and just looked at the mouse. It was really weird, but effective to stop the fight. And the researcher got his way in the end, he did become a professor."

Douwe Wiersma

Douwe Wiersma joined the Chemistry Department in 1971 as lecturer in physical chemistry, after a two-year postdoctoral fellowship at the University of Pennsylvania. He was promoted to professor in 1977 and retired in 2008. He was dean of the faculty from 1998 until 2007.

"The start of the MSC around 1970 was very informal and based on good relationships between the professors in the faculty. It was also based on the fact that most groups in the sixties were poorly equipped compared to current standards, and that the senior staff realized that sharing of equipment was essential for real progress. Later, George Sawatzky became the first director and under his leadership the MSC was very successful in raising research funds and achieving the status of a top-research institute."

"I clearly remember our movement from the basement of the Chemistry Building at the Bloemsingel to the new Building in Paddepoel in 1972. We carried our own, sometimes heavy, apparatus to the new laboratories. Among the equipment, inherited from a staff member no longer interested in using it, was a ruby laser, that could fire only one shot per minute. Although very cumbersome to work with, I decided to try and do some experiments with it. One day just before firing the laser, I realized that I had forgotten to take out the mirror that we used for alignment. Without thinking, I took the mirror out of the fully charged laser cavity. The system discharged and I got unconscious for a few seconds. When I recovered I realized that the mirror had turned into a piece of transparent glass. The silver evaporated during the discharge and probably saved my life. This event did not turn me away from lasers. On the contrary, nonlinear optical spectroscopy became my field of research. Highlights were detection of the first photon echo in a molecular solid on Christmas eve 1975 (with Aartsma) and the generation of the shortest optical pulse of 4.5 fs in 1997 (with Baltuska & Pshenichnikov). This latter achievement made it into the Guiness Book of Records."

Shirin Faraji's mission to control "the dance of atoms and molecules with light"

by Andrii Degeler

Fundamental theoretical research is the cornerstone of science. Yet, it is often underrepresented in public discourse outside of the university walls — in part, because it is not easy to explain in layman terms. Despite this challenge of communicating the complexities of cutting-edge research, Shirin Faraji, the chair of Theoretical Chemistry at the Zernike Institute for Advanced Materials, is passionate about helping more people to understand her work.

"I always say that when a molecule absorbs light, it starts dancing," she explains, sitting in her office at the university campus. "The question is, how am I going to tell the molecule how to dance? How do I make sure that it dances the way I want it to? How do I teach it the right moves? How do I control molecular motions?"

She goes on to explain that these molecular dances are watched by other molecules and everything around them; their dancing can and does sometimes affect all nearby "spectators."

Shedding light on science

Armed with research experience in coupled electron-nuclear dynamics of photo-excited systems, electronic structure methods for large molecules, and molecular dynamics, Faraji joined the University of Groningen in 2017 as an associate professor at the Faculty of Science and Engineering. The focus of her current research lies exactly in the domain of the metaphor mentioned above: she develops hybrid classical/quantum dynamical methods for studies of light-initiated processes in complex environments.

"Light plays a crucial role in our daily lives, such as human production of vitamin D, the 24-hour biological clock (circadian rhythm), and vision. Light is also exploited in modern technologies, e.g. solar cells, converting sunlight to electricity; and photomedicine, using light to activate or transport drugs, or to destroy tumor cells," Faraji explained.

"All these processes involve the interaction of molecules with light. How do molecules behave when they are exposed to light? It's all about the dance of atoms and molecules, happening extremely quickly in a tiny fraction of a second, that can be predicted, controlled and exploited using quantum mechanics and theory."

In 2018, Faraji's proposal entitled "Watching chemistry happen with light" was awarded a VIDI grant, providing financial backing for her innovative and impactful work in this direction.
Now, Faraji's research group is also creating efficient and user-friendly ways to work on computational chemistry problems. The goal of this work is to lower the entry barrier into this field of research

and make it easier for students to learn the ropes.

In theory and practice

In Groningen, Faraji is an inspiring leader of a large research group, which consists of a postdoc, six PhD, and five M.Sc. students. Along with her team, Faraji has already made significant contributions in the field of theoretical and computational chemistry by employing theoretical and computational chemistry tools to obtain atomic-level mechanistic insights into light-induced processes and quantum effects in biomolecules and novel materials.

In addition to their interest in overcoming fundamental challenges in the field, the group members are also pursuing exciting applications, such as photo-switchable molecular motors relevant for molecular electronics, photo-switchable DNA used in nanotechnology, singlet fission in molecular solids to increase the efficiency of solar cells, and excited-state processes of far-red fluorescent proteins used in optogenetics. This amounts for a wide and impressive range of activity in a diverse and fertile field that is full of potential for great scientific breakthroughs.

Building the future

In addition to her fundamental scientific research activities, Faraji is also involved in developing scientific software infrastructure. She is contributing code to several software packages, most notably Q-Chem, one of the world's leading quantum chemistry software programs. Q-Chem software enables innovative science worldwide and has become rather popular: for example, in 2019 it was cited in 446 peer-reviewed publications. Recently, in recognition of her leadership, Faraji has joined the Board of Directors of Q-Chem Inc., a company that maintains and supports a large and vibrant scientific community of developers (currently, more than 300 developers all over the world).

> “I believe science is a great unifying force that can bring people from different cultures and backgrounds together”

Owing to Faraji's active participation in scientific events and various personal initiatives, she is already well known in the chemistry and physics communities in the Netherlands. Faraji serves on several scientific boards, including the NWO, the Dutch Research Council, the working group for Fundamentals and Methods of Chemistry, and the Lorenz Center Chemistry board at Leiden.

In 2019 Faraji was inducted into the Young Academy Groningen (YAG) and became an integral part of the Internationalization and Diversity working group. The topic of diversity is close to Faraji's heart, as she has first-hand experience of gender biases in professional life.

"The YAG is an exciting and vital initiative that has the ability to play a significant role in shaping the landscape of the university science policy by providing a unified voice and I would like to contribute to this voice on an (inter)national scale," she said. "I believe science is a great unifying force that can bring people from different cultures and backgrounds together."

Woman in science

"Being born after the Islamic revolution in Iran and growing up during the war made me understand complex geopolitical situations and taught me how to survive within an oppressive social environment," Faraji said. "Living on three continents over the last three decades has made me realize that globally, there is tremendous potential and talent in women. Yet, judging by the number of tenured female professors versus the number of PhD graduates, only a fraction of this talent remains in academia. As I advanced through my career, I naturally assumed a mentoring role for female doctoral and postdoctoral researchers. I have a strong vested interest in the long-term success of women in science that goes beyond the constraints of national boundaries."

Addressing the diversity problem in fundamental science is a long-term challenge, but Faraji is happy to take it on, one step at a time. With her level of commitment and the things she's already achieved in her career – both in "doing the science" and "doing for science" – she is certainly one to make an impact. A researcher passionate about science well beyond "molecules dancing in the light", she takes great pride in building up the community around it — helping it to be diverse, well-informed and engaged.

Predicted and proven, but yet to be tamed: How George Palasantzas is uncovering the mysteries of the Casimir force

by Andrii Degeler

What started more than 70 years ago as a theoretical scientific discovery, has now become the sole focus of dozens of research groups across the globe. The Casimir force, named after the Dutch physicist who correctly predicted it in 1948, was first measured more than 20 years ago; and yet, it still holds a number of secrets, intriguing scientists all over the world.

"I was the chair of the Casimir network in Europe, which includes more than 60 groups," said George Palasantzas, full professor in physics at the University of Groningen. "I also receive papers from people that I know from outside Europe.

"I'd say there are now about 100 groups working on different aspects of Casimir forces. They all focus on different things, from surface-molecule, molecule-molecule, or surface-surface interactions. We're focusing on the latter. The adjacent topics include geometry, optical properties, interaction between graphene layers, cosmology, gravitation, etc."

Born and raised in Greece, Palasantzas received a PhD from Northeastern University in Boston, Massachusetts, and moved to the Netherlands to continue his research in 1996. Together with his group at the Zernike Institute for Advanced Materials, he's been busy studying the Casimir effect and uncovering its possible applications.

Building blocks

The Casimir force only manifests on the nanometer scale, which is why it took almost 50 years for scientists to actually measure it accurately. It's defined as the attractive force between two objects in a vacuum put at up to 10 nanometres apart.

The simple explanation of the nature of the force lies in the fluctuating electromagnetic fields made of virtual particles. The short distance between the objects restricts the wavelengths that can appear there, which means that the fluctuations in the surrounding space will always be stronger. The effect is that the objects are pushed together.

"The building blocks of our universe are not electrons or quarks," Palasantzas said. "We're also used to labelling these building blocks as cubes, or bricks, but they are not any of these things. The building blocks are fluctuating fields, which can be confined between boundaries to generate these Casimir-like forces. If your building block is a fluctuating field, imagine these continuous substances… It's hard to grasp."

Research focus

The Casimir force is extremely important for quantum physics, and Palasantzas' group is working on and experimenting with different aspects of it. One of the important topics here is changing the sign of the force, transforming it from attractive to repulsive.
Some 12 years ago, the repulsive Casimir force was still a theoretical prediction, but since then it has been experimentally proven to be achievable. Palasantzas' group keeps iterating with different materials of the plates and the matter between them.

"I have been doing a lot of work with nanoparticles and the Casimir effect," Palasantzas said. "I've tried to relate, especially in the Casimir effect, my previous knowledge about surface roughness, how the morphologies are affecting the Casimir force.

"For example, you have a flat surface and a rough surface. How would this affect surface forces or even functional properties of interacting systems? So, our focus is the morphology of nano-structures and surface interactions."

Another focus point of the group is the wetting phenomenon: simply speaking, the researchers are looking for the effect that different surface morphology may have on the spreading of liquids on it. Unlike the Casimir force, the topic of wetting has been around for more than 200 years — and yet there's still much more to be uncovered.

A better understanding of wetting is important for the areas like self-cleaning, anti-icing, adhesion and friction of material surfaces, fluid flows, printing, etc. In addition to that, a lot of attention has been paid in recent years to the possibility of creating superhydrophobic surfaces, that is, ones that are extremely difficult to wet. In nature, a good example of such a surface is the lotus leaf.

> "The building blocks of our universe are not electrons or quarks but fluctuating fields, which can be confined between boundaries to generate these Casimir-like forces."

The practical applications of superhydrophobic surfaces Palasantzas' group is working on include things as simple as car windshields or water trapping. The applicability in this industry is harder to achieve, though, as it obviously requires a transparent material. On a larger scale, hydrophobicity is important for self-cleaning surfaces, including special paper, which has antimicrobial properties and fits perfectly for surgical operations.

Applying force

As for the Casimir effect, the seemingly weak force can also have extremely strong consequences in the real world — but not before the researchers have found ways to control and adjust it.

One of the most widely publicised real-life applications of this fundamental research lies in its potential use in switches in nanoelectromechanical and microelectromechanical systems (NEMS/MEMS). One of the possibilities, which Palasantzas worked on as part of a research group 10 years ago, is to make a switch of the AIST, an alloy of silver, indium, antimony and tellurium. The AIST switches between crystalline and amorphous states, which changes the magnitude of the Casimir force.
"The state remains stable even when the power is turned off, which is a unique feature," Palasantzas said in an interview for the New Scientist about the invention.

The repulsive Casimir force also has enormous potential for real-life applications. It could induce what's called "Casimir levitation" to be used in nano- and micro-bearings, making them effectively friction-free. In addition to that, the repulsive Casimir force could be the solution to a stiction issue in microengineering, which the attractive force has created.

Professor Katja Loos: "I have no problem speaking in the terms of the industry"

by Andrii Degeler

At the beginning of her career as a university professor, Katja Loos was told by the national research evaluation committee that the research direction she'd chosen had no future and she'd "never succeed." A decade later, her group's papers are paving the way for an extremely important change in the chemical industry that could make polymer production far more sustainable and environmentally friendly.

Loos, who was born and raised in Germany and moved to Groningen in 2003 to take the role of assistant professor, actually considered a career in physics back in high school.

"When we had chemistry in school, I liked it, but I liked physics more," Loos said. "We also had the opportunity to do company internships through school, but there were no places related to physics. So I went for something chemistry-related — and I really liked it and decided to study chemistry."

Research focus

In her progression from assistant professor to full professor at the University of Groningen, Loos has formed a 20-strong research group that focuses on certain important areas, which could have a transformative impact on both the fundamental science and the everyday lives of many people.

The first research topic, which also happens to be the one perceived to have "no future" ten years ago, is enzymatic polymerisation. The idea here is to offer a new method of creating polymers, avoiding the high temperatures which have driven emissions and the use of toxic materials as catalysts. Examples include the recent results on enzymatic polymerization of biobased furan monomers to for instance PEF, which is used for fizzy drinks bottles as a greener alternative to PET. In addition, enzymatic polymerisation allows for the creation of new polymers that weren't possible with the old methods.

> "We have to do something for the climate and for the environment."

Another research direction is block copolymers. This involves connecting different polymeric blocks of monomers on the molecular level, creating a number of blocks arranged in a linear pattern. Achieving this allows the researchers to create materials with interesting properties or in unusual shapes. For example, piezoelectric foams based on block copolymer templates could be used in high-end audio systems due to their sound transmission capabilities. Another interesting achievement is composite magnetoelectric materials that could potentially be used for next-generation memory devices.

Part of Loos's group is also involved in a project, the goal of which is to create slow-digestible starch.

"In foods like potatoes or corn, the starch [is contained] in the grains," Loos said. "When you boil or shred them to make flour, you set free the molecules of amylose and amylopectin which a human digests very quickly. If you eat something made of white flour, like a cookie or a baguette, your glycemic index spikes. This is not a problem for me and hopefully not for you, because our body is used to it. But for some people — for instance, those who suffer from diabetes or are about to develop it — that's really dangerous."

With the slow-digestible starch that Loos's group is working on, it's possible to make normal products based on white flour safe for anyone who's sensitive to blood sugar level changes. This research project has already covered significant ground and is close to achieving its goals. The final stage would involve controlled experiments with animals and humans as subjects, which is "out of scope" of the research group, that is focusing on the fundamental science.

> "Students love working close to the industry"

"I have no problems speaking in the terms of the industry," she said, explaining that polymer chemistry is a fairly applied science, which makes partnerships with private players effective and mutually beneficial.

The range of the collaborations is extremely wide, but the common thing is that the industry in general is becoming more aware of sustainability issues. This awareness and the rising demand of green solutions makes the research done by Loos much more relevant in today's society.

In one of the recent projects, the group worked with BASF on a project of enzymatic transfer of sugar units from biomass "to any monomer that we usually have in plastics," Loos said. This method, which allows sugar to be extracted effectively from waste, is now used in the production of sustainable soap, shampoo, even paints and coating products. To drive the adoption of the research and facilitate knowledge sharing, Loos also runs two public-private partnerships with a variety of stakeholders.

The first one, Soft Advanced Materials (SAM), is a project worth €3.6 million co-financed by industry players and the NWO. It involves 11 PhD students working in different universities across the Netherlands on a wide range of topics that fit three main directions: adaptive materials, sustainable materials, and platform science. Loos's group is focusing on enzymatic polymerisation of green monomers, which is similar to what it did in earlier projects.

Redox-flow is the way to go

by Renée Moezelaar

The amount of batteries we use in everyday life keeps on increasing. But we don't only need them to make our phones or laptops go longer without charging. There is also a growing demand for larger batteries that can store the excess of sustainable energy we don't immediately need. These are the kind of batteries that Edwin Otten, professor of Molecular Inorganic Chemistry at the Stratingh Institute for Chemistry, wants to develop. But he doesn't think the current lithium-ion systems will do the trick, we need some redox-flow.

Lithium-ion batteries are a great invention that made our everyday life easier. They can store a lot of energy in a small space, and have a relatively long lifetime. But they are not perfect. Just think about the stories of exploding mobile phones or laptops. "The main problem with these lithium-ion batteries is that all the active material is present in a single package", says Otten. "This makes for a very efficient system, but it also creates a safety concern. If the separator membrane fails then all reactive components are in contact with each other. This leads to internal short-circuit and heat generation."

Separate tanks

Otten thinks the solution can be found in a different system: the redox-flow battery. This battery consist of two separate tanks filled with molecules in solution, and a small interface in the middle. "This interface is basically a small electrochemical cell", Otten explains. "When you want to generate or store electricity, you pump the solutions around and they meet at the membrane of this cell. The molecules are oxidized or reduced at the electrode of this small cell, and electrons flow through the membrane." The size of the interface determines the power output of the battery: "The larger the cell, the more contact there is between the two materials and the more reactions take place."

The main advantage of these two tanks is that the solutions are not in contact when the pump is turned off. Otten: "The negative and positive sides are separated, and that makes the system relatively safe." Unfortunately, the separate tanks don't make the battery last forever: "When you pump the solutions around, sometimes the molecules cross over to the other side of the membrane and react. This really irreversibly kills your battery."

Organic molecules

There are a few commercially available redox-flow batteries, but they are based on vanadium. This is a relatively expensive metal with a very volatile price, and it is not that common. "These systems are not very widely implemented, mostly because of the cost", Otten says. "So we are looking for new, cheaper systems, and we think we can make them with organic molecules." These organic redox-flow batteries have been around for about a decade now, and Otten thinks they can really make a difference: "The elements we use are much more widely available, and you can tune your redox potential or solubility quite easily by adding or changing substituents." The only problem is finding a suitable molecule: "Not many organic molecules have multiple stable redox states, so that makes it hard. But we are working with a class of stable organic radicals, that hopefully stay together for at least a few hundred cycles of charging and recharging."

To make the challenge even greater, Otten wants to use the same molecule on both sides of the battery. "Typical organic redox-flow batteries use different molecules in each tank. But we want to use one molecule that you can oxidize and reduce, so when it crosses over the membrane you don't lose any capacity, just a bit of charge." If the system works, Otten thinks it will meet a large demand. But he does not have the illusion that he can replace lithium-ion batteries. "Because you have the molecules in solution, it takes up more space than lithium-ion. So you won't see this kind of battery in cars or phones." Therefore he focusses more on stationary applications, for instance for large solar or wind farms, or even in the basement of houses. "For those applications it does not matter if the system is slightly bigger, especially if it is safer and has a longer lifetime."

Mix of systems

If you ask Otten, it is hard to predict where the field of battery-research will be in about ten years. "We are nowhere near the limits, we can still make a lot of improvements in both lithium-ion and redox-flow. We think that organic molecules are the way to go, but you never know." One thing is for sure, batteries will become even more important than they are right now: "With the transition to more sustainable electricity we need more ways to store this energy. And it does not even really matter what kind of system this will be. Redox-flow, lithium-ion, storing energy in molecules, it is all possible. In the end we need a mix of all available technologies to face the challenge."

"The nice thing about this consortium is that there are a lot of theoretical scientists participating who sometimes have completely different views on how to do things," Loos said. "That makes it very beneficial for PhD students to participate [and be exposed to different viewpoints]."

The second, smaller consortium run by Loos focuses on self-assembling materials — from car tyres to various coatings and many other products. The industrial partners include global giants like Continental, ASM, and Tata Steel, which don't get exclusive patents out of this collaboration, but do gain access to academic research and talent. For the universities, projects like this solve funding problems and make it easier to bring the research out of the lab to create real and measurable societal impact.

Another way to bring the research closer to everyday life and to the industry is through the Honours Master "High-Tech Systems and Materials" (HTSM) that Loos coordinates at the University of Groningen. With innovation at its core, the programme offers extra courses, as well as an assignment from an industrial partner.

"Students love working close to the industry," Loos said. "They need to write a product proposal, create a business case, and then they spend three weeks full-time with the company — and it's amazing how much of a transformative experience it is."

The work continues

The full implementation of enzymatic polymerisation by the industry is certainly not there yet, but Loos expects it to start happening in the near future. It'd take a company to build a completely new factory to switch to the new method, she said, and it's understandable that not many are rushing to do that as it requires a huge financial investment. However, when the need for new production facilities becomes more pressing, Loos doesn't doubt that the manufacturers will go for the greener options.

As for the research, Loos expects that enzymatic polymerisation and furan-based monomers will continue to play a significant role for the group. The scientist plans to focus on green solvents for the industry, as well as on recycling.

"It doesn't help that you make your polymers well if you don't have good end-of-life criteria for your materials," she said. "We need to strive to make a plastic bottle out of another plastic bottle. We have to do something for the climate and for the environment."

The two sides of hydrogen production

by Renée Moezelaar

Hydrogen seems to be a very necessary element of the sustainable society. And it is a logical choice given its many perks: hydrogen doesn't emit CO2 when you produce or use it, and you can use it in different ways. That is why researchers are throwing themselves into this area of research, and look for new materials that could make the hydrogen production more efficient. But professor Wesley Browne of the Stratingh Institute for Chemistry takes a slightly different approach. He tries to make the side-reaction of the hydrogen production more useful, and create local systems that would provide both energy and chemical feedstock.

"Hydrogen will give us energy security, and make us less dependent on oil from Saudi Arabia or gas from Russia", says Browne. "And to maximize its potential, we need to look at the production from every angle." That is why Browne does not only look at the hydrogen process from an energy point-of-view, but also wants to use it to produce a chemical feedstock for industry. "At this moment we produce lots of oxygen as a by-product of hydrogen. This is totally useless", says Browne. According to him, we can better use the hydrogen reaction to make other chemicals like hydrogen peroxide: "The challenge is not the hydrogen production itself, but what you do on the other side. If we can work that out, you could use the hydrogen production to fuel other chemical reactions." He is for instance looking at the possibility of using the oxidation reaction of the hydrogen production to produce hydrogen peroxide. "That would be a great second molecule to make, because it is a useful oxidant in many industrial processes."

Large quantities

One downside of this approach is that hydrogen has to be produced in very large quantities, and it is unlikely to find another molecule that we need that much. But Browne does not think this needs to be a disadvantage: "This means we don't have to find one very successful reaction, we just need to be able to make lots of different chemicals." To make this work, Browne is collaborating with other groups that search for new materials and electrochemical cell designs. He does a lot of excited state spectroscopy and other mechanistic studies to find out what materials might do the trick. Right now, most of the large-scale photocatalytic hydrogen production run on platinum electrodes. "That is a very expensive material, so it would be better to find some cheaper alternatives that make it more accessible. And different materials will also make different reactions possible."

The key seems to be to find a system that allows the whole reaction to take place in one step. "You don't want to produce oxygen, transfer that to a different reactor and then make other chemicals. That wastes to much energy and time." A nice example of the efficient process is found in Delfzijl, where they use iron and titanium electrodes to make chlorine for their salt.

> "The challenge is not the hydrogen production itself, but what you do on the other side. If we can work that out, you could use the hydrogen production to fuel other chemical reactions."

Hydrogen is also produced during this reaction, as a sort off by-product. Browne thinks we need more reactions like this, but it is also very important to tune these reaction to the local need: "You don't want to transport hydrogen, that wastes a lot of unnecessary energy. If you can make hydrogen locally, and make sure the by-product is a chemical that a nearby company needs, you can create a great infrastructure."

Local transport

This locally produced hydrogen can then be used for things like public transport and trucks. "One of the main advantages of hydrogen is that you can refill your tank quickly, and it gives you more range then current electric motors", says Browne. "And if you need more, you can very simply add another stack of electrochemical cells." This flexibility is also the reason why Browne views hydrogen as a good buffer for the fluctuation in sustainable wind- or solar energy. "You can very easily adjust the production to the availability of electricity. And you could also store this other chemical, and for instance burn it again if you need extra energy."

Unfortunately this local system is still far away at the moment. Researchers first need to find new materials that would aid this system. "A lot is going on in universities all over the world", Browne says. "And we are getting closer and closer. We just need to find lots and lots of different oxidation reactions that would add value to the production." But even if they do, Browne thinks companies would not turn around that easily: "For companies it is easier and cheaper to just keep on using their current systems. Only if they are forced to change by for instance new laws that would prevent them from using certain materials, they would very carefully take the leap."

Newsflash

Shirin Faraji elected as member Young Academy Groningen.

Rifka Vlijm started as Assistant Professor Molecular & Cellular Scale Biophysics.

Jun Yue appointed as Associate Professor in Green Process Intesification.

Shirin Faraji elected to Q-Chem board of directors.

Molecular Biophysics post-doc Adéla Melcrova won prize of Josef Hlávka for the Best Czech Students and Graduates.

Master's student Hans Beukers won Shell Graduation Award for Physics.

Katja Loos has been awarded the Friedrich Wilhelm Bessel Research Award of the Alexander von Humboldt Foundation, Germany.

Maria Antonietta Loi has been awarded a Materials NL Challenges grant by the NWO.

NWO Material Challenges grant for Francesco Maresca.

ERC Consolidator Grant for Marleen Kamperman.

Paolo Pescarmona part of large interdisciplinary consortium within the NWO Crossover programme RELEASE.

Topsector Bio-based Economy grant for Eric Heeres.

Topsector NWO HTSM Grant for Francesco Maresca

The Polytechnic University of Bucharest has awarded the academic title of Doctor Honoris Causa to Prof. Siewert Jan Marrink.

Unilever Research Prize for master student Daan Blunt.

Artem Shulga won Best Thesis Award of the Groningen Engineering Center.

Province of Groningen supports knowledge development of green process technology initialized by among others Francesco Picchioni.

Rifka Vlijm won FameLab Groningen.

Two new professors for the Stratingh Institute: Natahlie Katsonis and Tibor Kudernac are appointed as of April 1st as Professor Active Molecular Systems and Associate Professor in Life-Like Supramolecular Mechanics, respectively.

NWO VICI grant for Professor of Molecular Biology Giovanni Maglia.

Christina Paulino from the Groningen Biomolecular Sciences and Biotechnology Institute (GBB) has been awarded the 2020 NVBMB prize.

Reaching out and spreading the chemistry

by Renée Moezelaar

If you work long and hard on your research it makes sense that you would like to talk about it. But talking to your colleagues is a whole different story than explaining difficult chemical terms to your parents or friends. For Jim Ottelé, PhD student in the group of Sijbren Otto, this is a challenge he likes to take on. According to him, science communication should be every researchers' responsibility.

Most PhD students spend their time doing research and trying to find out why their reaction isn't working the way it should. But for some, just spending days on the lab is not enough. Ottelé is one of these people. He spends much of his free time talking about science to everyone who wants to hear it. "I think it is important that the general public knows what is going on in science", says Ottelé. "There is so much misinformation going around, and people don't know what is true anymore. I think we have an obligation as researchers to do something about that."

And so Ottelé often gives presentations about his research and the research that is conducted in the Otto-group. The audiences he speaks to are very diverse. His last few presentations were for high-school chemistry teachers who want to keep in touch with recent research. "I gave an hour-long masterclass at the Woudschoten Chemistry conference, a big meeting of all chemistry teachers in the Netherlands", Ottelé explains. "The audience there is genuinely interested in what we are doing and if they can use it in their classroom."

Coincidental

Of course Ottelé didn't start out speaking to hundreds of people at once: "Actually it was all quite coincidental. As a student I used to work at events like Zpannend Zernike and the Chemistry Olympiad, and there I met people who were interested in what I did. When they offered me the chance to spread my story further I immediately took it." Through these events, he developed a taste for science communication. Such a taste, that he decided to start up his own project. "Together with our scientific coordinator Gaël Schaeffer and Renske de Jonge from Science-LinX we came up with the idea for a series of lectures by professors that would be fun and informative for all citizens of Groningen, called Noorderlab."

The main goal of these Noorderlab-lectures is to introduce the public to established and upcoming researchers who work in Groningen. "Five professors from the Stratingh Institute, like Ben Feringa and Gerard Roelfes, will give the lectures. But we will also ask five starting professors to record podcasts about their research and career. In this way, we show multiple sides of science." With a bit of luck, the project got funded and is now in development. "We have support from the KNG (Royal Natural Sciences Society), and hope to start the first lecture series in autumn." But Ottelé doesn't stop at his own institute: "We hope to make it a yearly event, each time introducing a different institute and different researchers. This makes it a very diverse event. In the end I hope that the citizens of Groningen have a much better idea what kind of research goes on at the university, or at least at the Faculty of Science and Engineering."

Very lucky

Ottelé thinks he is lucky that he gets the time and space to work on projects like this. "I think not every professor would allow me to speak at all these events and spend so much time on science communication." If you ask him it should be a core responsibility of every researcher to share their findings with a larger public: "So much public money is spend on research, and much of the results are hidden behind paywalls or in language laypeople don't understand. I think every scientist should at least try to reach the public." Of course not every subject is obviously suitable for the general public. "Sometimes it is very hard, but you can always find a way. It is so nice to hear that people really start to think about things you told them, and maybe even apply them in their lives. The trick is to try to relate it to something they know, use metaphors or even experiments to show how things work."

In the end it all comes down to the willingness of the researchers. But the university can also help a lot: "In my opinion institutes can do more to encourage their employees for these kind of events. Right now you have to figure it all out yourself." For enthusiastic scientists who now also want to work more on outreach, Ottelé has one last advice: "You have to start small and meet the right people. But you can start things up by for instance calling up your old high school and offer to give a guest lecture, or join an event like the Weekend van de Wetenschap. Just try it, if people know you like these things, they eventually will find you."

Starting up in academia: The entrepreneurial journey of Artem Shulga, founder and CEO of QDI Systems

by Andrii Degeler

Artem Shulga and his colleagues were devastated. The group of young physicists to whom he belonged had just lost a drone worth a few thousand dollars above the sarcophagus of the nuclear power plant in Chernobyl, Ukraine. The year was 2010, and Shulga was tasked with measuring the radiation level above the reactor, which proved to be high enough to cause the drone to crash.

What should have taken a few weeks, flying an octocopter using a fancy VR-like headset and a joystick, ended up in a year of painstaking measurements with a kite. Conventional technology as it was, the kite could only get to the required area when the wind was right, so the group often had to spend time just hanging around waiting. After that was finally over, Shulga, who achieved a bachelor's degree in applied physics before starting the project in Chernobyl, decided to go back to university.

"A friend of mine had moved to Groningen previously to follow a master's program, and he told me — it's nice here, why don't you apply as well?" Shulga said. "I considered staying in Ukraine, you know, that Chernobyl stuff was interesting. But then I thought — I can always come back to it. But now I already have my roots here in Groningen."

Researcher turned entrepreneur

In the nine years since the drone incident, Shulga has been awarded a master's and then a PhD degree from the University of Groningen. Recently, he launched QDI systems, a startup that could revolutionise the medical X-ray industry.

The journey has been anything but easy, however. "My English was very poor when I first arrived here, so over the first few months I attended the lectures, recorded them, and then sat at home in the evening with a dictionary translating what had been said," Shulga remembers. "I was trying to get used to it. I was also watching some TV series in English, like Friends and The Big Bang Theory, so then it became easier."

As part of a project during the master's programme, Prof. Maria Antonietta Loi introduced Shulga to the concept of quantum dots, tiny semiconducting nanocrystals with special optoelectronic properties that can change depending on their size. Excited by the wide range of potential applications of quantum dots, Shulga chose them as the focus of his PhD research and eventually came up with a way to use them in X-ray detectors for mammography.

Right place, right time

QDI's technology is based on the fact that quantum dots are sensitive to X-rays, which they convert into an electric charge. The TFT panel underneath the layer of quantum dots then generates the digital image by amplifying the charges within pixels and "translating" the charges into digital data.

This is not the first attempt at using quantum dots in X-ray detectors. Some years ago, the industrial giant Siemens also tried to work on a similar solution, but couldn't find a way to create a film of quantum dots that would be able to extract generated charges into the TFT panel. Over the past few years, however, researchers across the world have developed better methods to create such films using so-called quantum dot inks.

The main benefits of Shulga's quantum dot-based X-ray detector, compared to the current ones that are made of amorphous selenium, is that it's easier and cheaper to produce, while also offering better contrast. The quantum dots of lead sulphide are first made into a liquid solution and then sprayed onto the substrate.

"Amorphous selenium detectors are made in an extremely controlled environment," Shulga explained. "If there is even a single atom contaminant on the TFT panel, the amorphous selenium layer could start crystallizing and doesn't work anymore. But what we are doing now is just spraying [the quantum dot solution], not even in a clean room, just under the fume hood, and it still works."

The better contrast at lower radiation doses that can be achieved by using lead sulphide quantum dots could be particularly important for customers in the Nordics where the maximum radiation dose received by the patient during a mammography scan, is heavily regulated, Shulga added. Therefore, it would make it less dangerous for women to undergo mammography tests more often in order to diagnose tissue irregularities as early as possible.

The empowered founder

Shulga got the idea of launching QDI systems in the last year of his PhD, during a three-month internship at the University of Tokyo. After announcing the plan to his colleagues at the Zernike Institute for Advanced Materials, he received strong support from the institute and was introduced to Venture Lab, a business accelerator headquartered at the university campus.

At Venture Lab, Shulga went through a year-long development programme that taught him the basics of growing a startup from scratch. Currently, QDI systems is a team of four people working on the prototype of an X-ray sensor that can be used to demonstrate the innovative technology of the company.

As for financial support, Shulga is cautious not to raise VC funding too early in the life cycle of his startup to keep as much equity as possible. Together with his own savings that the founder had to live on throughout the first year after founding the company, Shulga has received €60,000 worth of grants from the NWO and SNN. This money has to be spent on feasibility studies and proof-of-concept demonstration.

"Of course it's nice to publish a paper in a journal, but it feels even better when someone can apply your technology and use an actual product made out of it."

After the prototype is ready, Shulga's ambition is to win licensing deals with major players in the mammography market to grow the company further. He's planning to stay connected with the alma mater but isn't inclined to pursue an academic career.

"I really like scientific research, but I also value this industrial approach we have at QDI," he said. "Of course it's nice to publish a paper in a journal, but it feels even better when someone can apply your technology and use an actual product made out of it."

university of groningen

faculty of science and engineering