UT nieuws SPECIAL

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MESA+
INSTITUTE FOR NANOTECHNOLOGY

# NANOLAB

# FEEL WELCOME IN THE LAB

**The NanoLab is open to everyone, is what technical-commercial director Miriam Luizink wanted to have us know when we asked for her reasons to make a special about this lab. 'People should feel welcome there. By issuing a special, we hope to lower the barrier.' Because let's be fair: it all sounds very clean and high-tech, this NanoLab. And it is, but there's so much more to it...**
**Whoever reads this special, will have to agree. Students, technicians, researchers but also entrepreneurs show their role in the NanoLab, full of enthusiasm and pride. Like Floris Falke, designer engineer and project leader at the UT spin-off LioniX: 'There's still an interplay between us and the university. That's great. We're situated nearby and the NanoLab is a research laboratory. That's why so many things are possible.'**
**Other than PhD or postdoc research, more things happen in the NanoLab. Like the occasional sqeezed-to-death flesh-fly or splash of toothpaste under the magnifying glass. Why? Definitely read this special. Then you'll understand why some wear blue suits and others wear white ones. You'll be amazed about the huge diversity of the NanoLab, while realising at the same time that it's the people who do it.**

**Maaike Platvoet, editor UT Nieuws**


## Colophon

This journalistically independent special of UT Nieuws was established in collaboration with MESA+

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**On the cover:** a low-temperature scanning tunnelling microscope. This 'sensing microscope' uses an extremely thin needle – the tip consists of one atom – to feel what the surface of materials look like and is able to picture that in a very detailed manner. (photo: Eric Brinkhorst)

# Content

Miriam Luizink is looking back on eight years at the NanoLab

# 'THE LAB IMPRESSES'

Being the technical-commercial director of MESA+, Miriam Luizink got the NanoLab under her care as well. She took part in the renovation, the developments of the High Tech Factory, the shifting in focus areas concerning subsidy applications and she was elected Twente Business Women of the year 2010. How does she look back on eight years at the NanoLab, now that she will start a new position as director strategic business development from the 1st of July?

TEXT: SANDRA POOL | PHOTO'S: ARJAN REEF >

'At least I'm leaving the NanoLab behind in a good state', Luizink says with a large smile. 'The Netherlands Organisation for Scientific Research (NWO) granted an application from NanoLabNL of 22 million euro last Tuesday (1st of July, ed.). 'My successor gets to implement that', Luizink says, 'but it feels good to leave this way.'
NanoLabNL claimed a similar project five years ago. At the time, MESA+ got six million to establish the new BioNanoLab laboratory. The two subsidy applications were submitted under the name of NanoLabNL. It's a national consortium on nanotechnology. 'A collaboration that has intensified enormously during the past years', Luizink says. 'Together with three other locations, Delft Eindhoven and Groningen, we invest in facilities and we discuss where we are going to implement what. Every site has its own specialisms that you want to do justice to.'

## Roadmap

The UT is the lead partner of NanoLabNL: Luizink is the chair. She believes that it's incredibly important to join forces. 'If you want to take on a leading role, you have to be important to the Netherlands. Therefore, the interests should transcend the institute and university. That happens when you combine efforts. This is why we are in the National Roadmap Large-Scale Research Facilities as NanoLabNL, next to 28 other research facilities.' A position on this roadmap paves the way for major subsidy applications. NanoLabNL was successful in both calls, in 2009 and now in 2014.
Company use of the NanoLab becomes increasingly important,

## Janneke Hoedemaekers

**Alumnus Janneke Hoedemaekers will be the new business director at MESA+. She will succeed Miriam Luizink. Hoedemaekers (1983) is a UT alumnus. She studied engineering physics and philosophy of science, technology and society. At the moment, she is a strategic advisor on European innovation at the Amsterdam Economic Board.**
**One of the things that Hoedemaekers wants to advocate at MESA+, is further commercialisation, something that was also important to predecessor Miriam Luizink. 'Collaboration with companies is very important. We need to make sure that our research finds its way to the market.'**

Luizink says. 'The UT is doing well. Companies are responsible for forty percent of the utilisation hours. That's a lot, also in international perspective.' Business cases, think about spin-offs, are crucial to a region's economic development and innovation, according to Luizink. 'It's about doing top research and looking for practical applications at the same time.' To promote that, NanoLabNL has been awarding innovation vouchers since 2013. 'Innovative companies can deploy such a voucher to use our facilities. We've had three rounds. 13 out of 28 vouchers went to Twente.'

### Highlight

Next to more national collaboration, business cases and the stimulation of valorisation, the renovation of the NanoLab and the opening by the, at the time, crown prince Willem-Alexander (fall 2010) were real highlights to Luizink. 'We're located wonderfully, in the campus centre and in between research groups, in a new lab with character. 'The new lab annually attracts 1500 visitors from all over. 'Students guide people around and they do that very professionally. High Tech Factory companies take their customers here as well. Such a lab impresses, is what they say.'
Although Luizink believes that Twente is doing well, a lot more is possible. 'We're currently working together with a German and a Korean research institute and a university in Hungary. They use the research facilities on our campus. We could expand that.' The same goes for the regional interest of the lab. 'Many more regional companies could benefit from the presence of the NanoLab and other campus facilities.' It's something that she will actively take up in her new position as the director strategic business development. I


## Head cap

The cap, which reaches until the waist, is what you put on first. In that way, it's impossible for hairs to fall onto the rest of the suit.

## Safety glasses

Mandatory because of the presence of chemicals, even for spectacle wearers.

## Strip

The cleanroom suit doesn't have any pockets; they collect dust. There's a strip on the chest to cling a pen or tweezers onto.

## Material

People are amongst the major pollution sources in the cleanroom. When standing still, humans already generate 100 thousand particles per minute such as breath, sweat, hairs and skin flakes. The cleanroom-suit is made of a 100 percent polyester fabric. This fibre lets through a thousand times less than cotton, when talking about particles larger than 0.3 micron.

## Gloves

Made of nitrile and packaged in a cleanroom compatible way. You throw them away when you leave the cleanroom. Actually, you already have to replace them if you scratch your face for a minute, because of the skin flakes that come onto your fingers.

# A CLEAN SUIT

They're occasionally called Martians, the staff who work in the cleanroom of the NanoLab. How does their suit ensure that the cleanroom remains as clean as possible?

## Laundry

There are new suits every Thursday. Used clothing is washed and packaged cleanly on a weekly basis in a special cleanroom launderette at the company Micronclean in Bolsward.

## Boots

You step into the boots while still wearing your own shoes. The boots have a rubber layer underneath them to counteract the wear and tear of the fabric, and for comfort. When putting on the boots, you always keep them from the floor. You sit on a bench and can only put down your feet at the cleanroom side of the bench.

## Colour

The suit comes in three colours. Blue for the cleanroom staff (operators), green for our cleaning team and maintenance parties and white for all 'regular' users (a.o. students, PhDs, companies). The colour is just there for recognition, otherwise the suits are identical. Operators have their own suits, others have to circulate.

TEXT: PAUL DE KUYPER | PHOTO: RIKKERT HARINK

# BRIEFCASE WITH ULTRA HIGH VACUUM

**DOMINIC POST** (36) has been a technician at the research chair Inorganic Materials Sciences (IMS) for three years now. He's responsible for the technical maintenance of the thin film laboratory three with for instance Pulsed Laser Deposition systems (PLD) and instructs the users of the laboratories. In addition, he designs, builds and tests new equipment.

TEXT: SANDRA POOL | PHOTO: RIKKERT HARINK >

'The so-called vacuum suitcase is a good example of a recently developed device', Dominic Post says. 'It's a briefcase the size of a football. Scientists use it to transport samples. That's easy. Because of its size, the suitcase is easy to take with you in a train or car. It's a lot smaller and portable.'

Post explains how special the conditions of the suitcase are. 'There's an ultra high vacuum (UHV) since the samples can't come into contact with pollution. Therefore, the pressure in the suitcase is as low as possible, <1 x 10-10 mbar.' 'It contains a compact UHV-pump that creates the desired situation and keeps the number of atmospheric gas particles as low as possible. In the lab, we connect the suitcase to the COMAT-system (Complex Oxide MATerials). Because the linking part of the suitcase has been in touch with open air, we need to pump and burn that part clean. That takes about two days. Yes, you need some patience for that.'

Thanks to a battery, it's possible to save samples under UHV conditions for maximally three days. After that, the suitcase needs to be plugged in to AC power. According to Post, exchange is only possible when a laboratory has the same connection system. 'And the amount of such labs is growing.'

## New asset

To Post, these tasks are the icing on the cake in between regular assignments. Together with his colleague Henk Veldhuis, he is additionally responsible for the maintenance and repairs in the laboratories of the chair IMS, where researchers work with Pulsed Laser Deposition, amongst others, to create layers of a few nanometres. 'We fill lasers with new gas or we replace parts. We crawl below the devices ourselves to do a check. If we can't fix it, we involve the supplier.'

A new asset due this summer, is the NanoProbe. We'll connect it to the COMAT-system. Researchers will use the NanoProbe to analyse nanostructures on the surface. To be able to do this with multiple 'probes' at the same time will be a huge advantage.'

The new device still needs to get its own place in the COMAT-lab, however. 'We will break down a wall to get more space. That will be quite some task.' I

Cleanroom freelancer Kechun Ma works many evening hours

# ‘THE CLEANROOM FEELS LIKE MY SECOND HOME’

TEXT: SANDRA POOL | PHOTO: RIKKERT HARINK >

Kechun Ma (44), better known as Kees at the UT, consequently signs in every night. ‘You have to announce it beforehand if you want to use the cleanroom at night. I do that every day. My wife occasionally asks if the cleanroom is my second home. Sometimes it feels that way. From around four o’clock in the afternoon, I start planning my research for that night. The big advantage is quiet. Multitasking is achievable, too. Then I do multiple researches on different devices simultaneously. That’s possible, because most people leave for home after six. I work on something peacefully without feeling that I keep someone.’

Another benefit of working at night is the pace with which Ma serves his customers. ‘If a customer needs something the next day, I quickly jump into the cleanroom that night.’

Once, after a night of work in the lab, Ma started to worry in his bed. ‘I couldn’t recall if I had switched off a certain device. I returned to the UT and together with a security officer we checked if the machine was off. Fortunately, that was the case. Then I could sleep calmly.’

It was the only time when Ma was in the lab after midnight; other mid-night activities don’t occur. ‘The lab is opened until ten p.m. That’s a good thing, because as a researcher you always want to finish as much as possible. Often you still want to do this or that, and you forget about the time.’

Kechun Ma's work changed from nights of tough labour at the Chinese restaurant to nights of doing research in NanoLab's cleanroom. As a researcher in the Inorganic Materials Science Group (IMS) and with his company MicroCreate, he's a grateful user of the laboratory's long opening hours. 'If the customer wants something fast, I arrange it.'

## Charged by the hour

The home front is used to it, Ma says. 'We're from the catering industry. 'Working at night and during weekends? I grew up with it.' After they settled down in Oldenzaal from the Chinese motherland, his parents ran a Chinese restaurant. Later, they moved to Enschede. Ma grew up amongst orders and restaurant visitors. Later he helped along. That's how things were.

'Meanwhile, I studied electro engineering. He graduated in 1996. After a few years of working in industry in micromechanics, he came to the UT as a researcher. First as a researcher in the department Transducers Science and Technology, and now at IMS. 'We make MEMS-chips (Micro Electronic Mechanical Systems), integrated with PZT-materials (piezo), to transfer electricity into movement and vice versa.'

He does that part-time. 'I'm a cleanroom freelancer as well. Yes, the entrepreneurial spirit just happens to be there. When we sold the restaurant, something was gnawing away inside me. I had spare time', he jokes. As a freelancer going by the name MicroCreate, he manufactures custom-made chips in the NanoLab for departments and small companies that don't have the capacity or knowledge to do it themselves. 'I have the knowledge and the right to work in the cleanroom. I'm very acquainted with the equipment and know the way. That's interesting to some small companies. They hire me to develop or analyse something for them. It's a very simple concept, I just charge by the hour, really. Nice and transparent.' I

# COATINGS AT THE ATOMIC SCALE

After studying in China and the United States, postdoc **ZHAOLIANG LIAO** (29) came to the NanoLab in Twente. He works six days per week – frequently until late at night – with coatings and thin films.

TEXT: JOHANNES DE VRIES | PHOTO: RIKKERT HARINK >

The coatings and thin films that Liao is working with, are very tiny amounts of oxide ceramics: magnetic material in which at least two elements can be found, obviously combined with oxygen. 'I produce those coatings and thin films in the NanoLab,' Liao explains. 'Afterwards, I can research and even influence their characteristics. Because it concerns such small amounts of the material, you're able to monitor at the atomic level. For instance, we can put two different atomic layers together to see how that influences the characteristic of the material.'

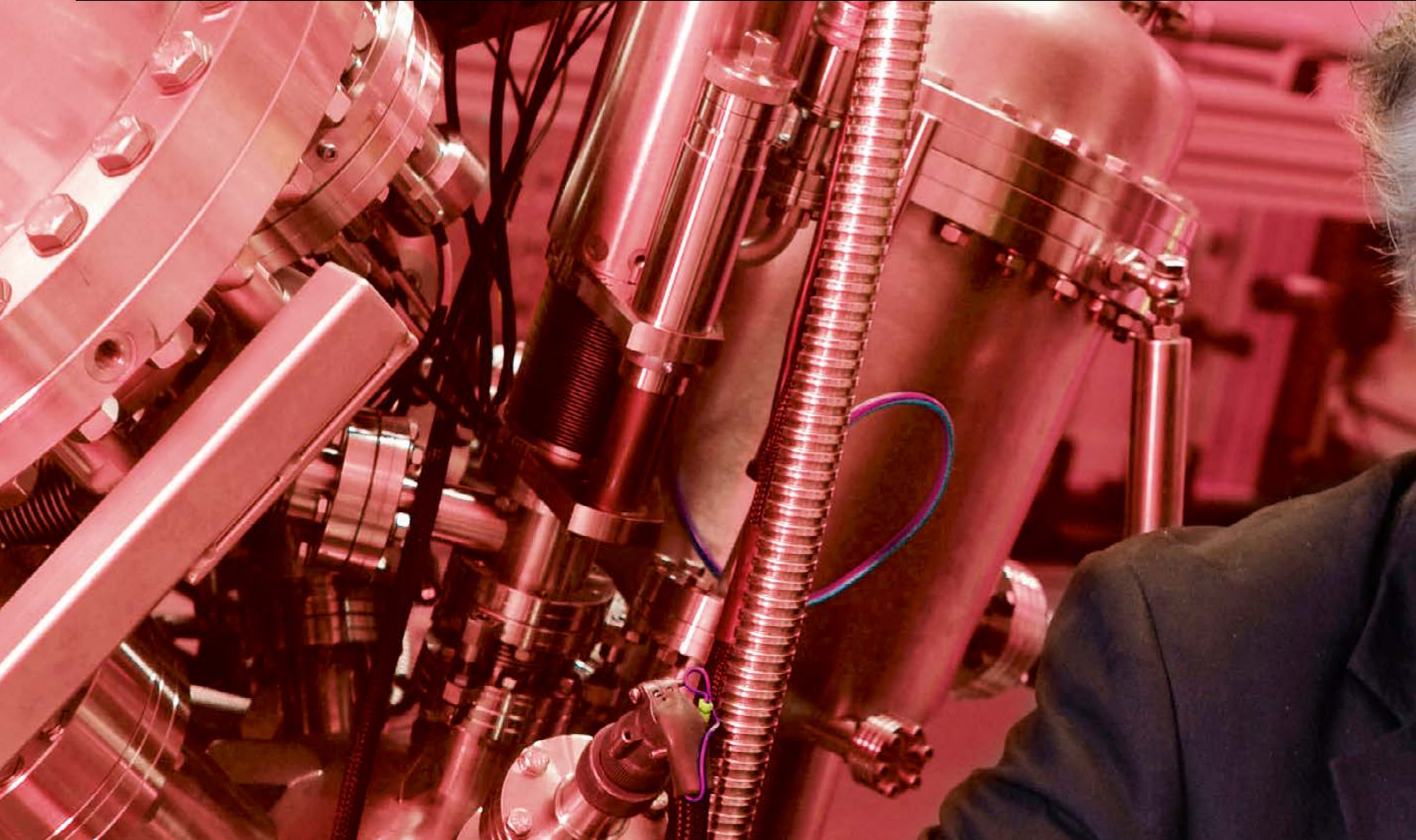
That those changes at such tiny scale can change the characteristics of material severely, is a fact. Liao explains: 'We're discovering new effects of these materials, that don't occur in nature. We can instigate totally different kinds of magnetics at the nanoscale.'

A self-evident application of his research is the storage of information on memory devices, because magnetics plays a huge role in that.

## Closed cluster system

Amongst the reasons for Liao to come to Twente, are the facilities and instruments in the NanoLab. He uses a so-called cluster system in his research, in which manufacturing- and analysis equipment are directly connected. In this way, the materials that are subject to research are no longer influenced by, for instance, dust and water from the air. The UT isn't the only institution to research the coatings and thin films that Liao is working with. Therefore, the postdoc of the inorganic materials science group collaborates with universities from the United States, Canada, Austria and Belgium. Liao himself came from China, studied there and was a PhD at both the Institute of Physics at the Chinese Academy of Sciences as well as Louisiana State University. 'As a result, I have two degrees; one from both universities,' Liao states with pride. All the while, he and his wife are living on campus since the summer of 2014. She is a postdoc at the UT as well.

I work long hours, usually until nine at night, I do that six days per week. I spend half of that time in my office, the other half in the lab. At the moment, we feel very comfortable in the Netherlands. But I'm not sure where we will be working in the future. In our view, it could be anywhere in the world.' I



MESA+ Director Dave Blank

# 'WE'RE ONLY AT THE BEGINNING OF THE NANO REVOLUTION'

There's a wish list that's continuously playing in the head of Dave Blank. At times, having the newest equipment is an absolute must to keep belonging to the international leading edge, the scientific director of MESA+ believes. 'The nano field is constantly moving.'

TEXT: EGBERT VAN HATTEM | PHOTO: ERIC BRINKHORST >

The MESA+ NanoLab is a 'tool' that one research group uses more than the other. Or better said: one group uses 'different' equipment than the other. The list of instruments, production facilities and measurement technology is impressive: from thin-film manufacturing at atomic level to analysis- and measurement instruments, mask manufacturing, lithography- and etching machines. On top of that, many departments possess their own specialist equipment, professor Dave Blank explains.

'The extraordinary thing is that the MESA+ researchers have indoor access to up-to-date equipment. And they're proud of it. That contributes to the image of the institute. The NanoLab is an advertisement for the region as well. We trained students to be tour guides. Last year, we had more than 2500 visitors coming over.'

Every year, there are approximately eighty new users of the cleanroom: students, new PhD candidates and people from industry. The role of the technicians is crucial in this, according to Blank. They've been here for a longer time and are aware of the devices, and how to get the most out of them. Giving courses and personal guidance, they ensure that users are able to work with the devices themselves as much as possible.

Blank believes its important that students and PhDs develop their research skills themselves. 'I remember that from when I was younger', he says. 'Sometimes a self made thin-film does something totally different from what could be expected during an experiment, and then you see it for yourself. That's unlike giving the film to someone else who executes the analyses. When you do it yourself, you'll look for creative solutions within the range of possibilities you have, exactly because you've been involved in the whole process.'

## New challenges

Previously, the cleanroom was mainly associated with ICT-production techniques. The nano discipline is much more diverse today. There are 35 groups within MESA+. New materials and lab-on-a-chip applications have become major subjects of the NanoLab.

Blank: 'We have regular strategy meetings. That's when we discuss new challenges and how our institute can make the difference. At strategic research orientations we're looking for clustering and coherence: nanophotonics, nanomaterials for energy applications, nanotechnology for medical innovations and nanodevices.'

'Like a coach, I try to enthuse people over the trends that I see at conferences, in committees or as a national and international policy maker. MESA+ has outstanding professors and tenure trackers who have a good sense of the role that fundamental research plays as a source of inspiration for applications in the near future and beyond. To that end, the NanoLab needs to keep advanced no matter what. If there is a new way to scale back a certain structure from hundreds of nanometers to tens of nanometers, we have to buy or develop that new equipment to maintain our leading position.'

'Investments to do nano research happen to be high, which increases the pressure for scientific staff to perform and attract projects. Given what we've already achieved, we want to continue in the future playing field of nano technology. As a matter of fact, we're only at the beginning of the nano revolution. That we, as a university, play such an important role in it, is fantastic.' I

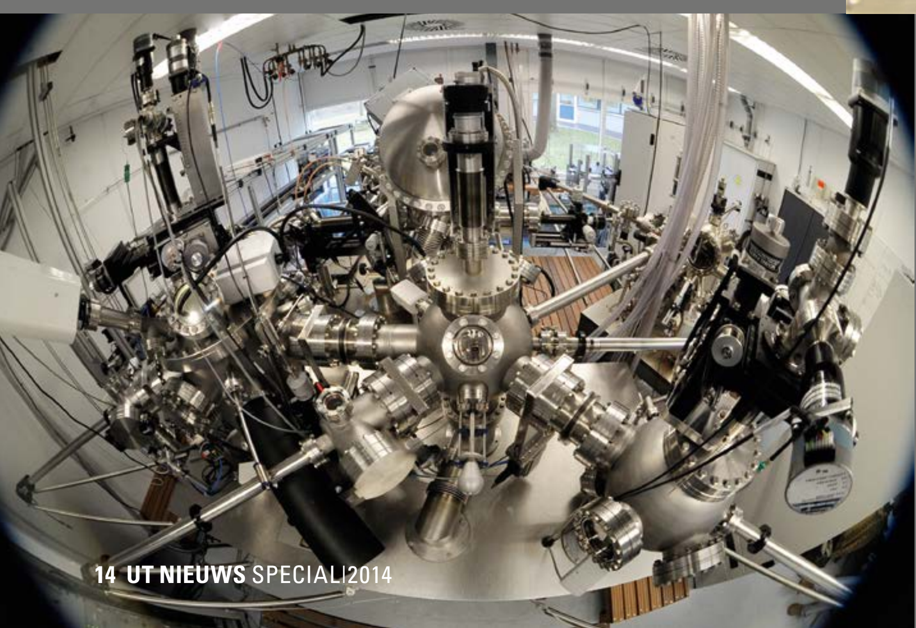

# 'EVERYTHING NEEDS TO STAY AS STABLE AS POSSIBLE'

Low vibration, an extremely accurate aircontrol and 85 sensors to measure the gas concentration. Everyting in the NanoLab is about stability, control and safety. That primarily happens behind closed doors in order to secure the open character of the NanoLab. UT Nieuws takes a tour around the most remarkable spaces. Gerard Roelofs, head of the NanoLab, guides us.

TEXT: SANDRA POOL | PHOTOS ERIC BRINKHORST AND ARJAN REEF >

## ▲ ▶ Cleanroom

'There are almost two hundred research devices in this cleanroom', Roelofs says. 'The costs vary between a hundred thousand euro to a purchasing price of beyond a million euro.' Everybody who uses the cleanroom has to attend a course beforehand. There is an introduction for newcomers on a monthly basis. 'During an intake, we explain for instance how the users should behave and dress. After one and a half week of training, the new users usually need at least a month to get fully acquainted with the needed equipment in the cleanroom.' Furthermore, there are so-called wet benches, meant to clean and etch the substrate. Next, there's a part with a yellow light. 'Meant to cure the photosensitive polymers. The final part of the cleanroom has a VC-G-floor. That's the vibration qualification of the floor. The floor is 90 centimetres thick and has an eight hundred square metre surface. There is a foundation of about four hundred piles underneath, that are anchored to a stable sandbank 20 metres below. This creates a solid mass that minimises vibrations.'



## ◀ COMAT

Another unique research facility is the COMAT-system (Complex Oxide MATerials). 'Researchers use lasers to build atomically thin layers with the so called Pulsed Laser Deposition technique. There are various configurations that they use to analyse the created layers.'

## ▶ Control room

'Everything needs to be as stable as possible in the laboratories and the cleanroom. That's why we have this control room', Roelofs says. 'I prefer that nobody is in here. Then everything functions properly. We mainly monitor. 85 sensors constantly measure the gas concentration in the building. Should there be any disturbance or leakage, an alarm goes off. Everyone who uses the lab has to register upon arrival. In the case of an emergency we go outside to a central place, where we check if everybody from the NanoLab is there. We try to find out what happened by using monitoring and logbooks.'

## ◀ BioNanoLab

Then there's still the BioNanoLab, that's been put into use in the Zuidhorst in 2012. 'The research focuses on cell analyses, protein structures and membranes. The special equipment with microscopic and spectroscopic techniques are also situated in a conditioned area. Next to that, we have the so-called ML-II laboratory in which the equipment for cell analyses is situated. Additional rules apply here, because people work with biological materials.'

## ▶ SEM and TEM

There are other laboratories surrounding the cleanroom, where scientists perform adjacent research. 'We have a Transmission Electron Microscope (TEM) and a Scanning Electron Microscope (SEM) at our disposal. Researchers use those for element analysis and for discovering and researching the composition of a layer.'

## ▼ Cellar

'Some of the research devices that are upstairs in the cleanroom, need peripheral equipment such as coolers or vacuum pumps. Those are in the cellar. Maintenance is a big advantage. That's easily done because you don't need to wear a cleanroom suit. Next to that, it saves a tremendous amount of space in the cleanroom aera.'

## ◀ Gas cylinder room

There are a total of 26 gas canisters in the gas cylinder room. 'They are very specific gases, some of them are dangerous. Every canister has its own cabinet from where we feed the research equipment. One cylinder lasts half a year to a year. To connect them requires specialised knowledge. We especially train our staff to do this. They attach and detach the cylinders according to a fixed protocol.'

From Turkey and Russia to Twente because of the NanoLab

# 'WE WANT TO STAY IF WE CAN'

The UT may be a relatively small university but the MESA+ NanoLab is widely known the world over. That shows in the many nationalities who are working in the lab, such as Sertan Sukas from Turkey and Alexander Prokofyev from Russia. Both are postdocs at the BIOS lab-on-a-chip group at MESA+.

TEXT: MAAIKE PLATVOET | PHOTO: GIJS VAN OUWERKERK >

Nowhere else did they find a lab like the one at the UT, Sertan Sukas and Alexander Prokofyev say. And nowhere was it this organised and pleasant to work, the postdocs from Turkey and Russia unanimously add. 'If we can, we want to stay.'

The 32-year old Sertan Sukas soon figured out that if he wanted to continue in microfluidics after finishing his study mechanical engineering, there weren't many options in Turkey. 'The Middle East Technical University has a cleanroom, but I couldn't really progress in my research field there. I think I was amongst the first in Turkey to deal with lab-on-a-chip technology. The discipline especially speaks to me because of the challenges it poses. The technology needs to be built layer by layer out of nowhere.' Smiles: 'In the cleanroom I learned to be very patient'.

Sukas wanted to gain more experience abroad, preferably in Europe. He managed to get a PhD position at the UT in 2007. 'I was very impressed with the cleanroom at the UT. I saw multiple laboratories in Europe, but none of them are organised as efficiently as at the UT. Personally, I also like working in the large space. Although many researchers are working simultaneously, there is never a sense of crowdedness. And the support from the technicians is a real advantage. I was used to do maintenance activities myself. Thanks to the presence of the technicians there's more time left for me to do my research.'

## Unique in Europe

Postdoc Alexander Prokofyev has been in the Netherlands for a shorter time than colleague Sukas. He's been at the UT for one year and a half, after working at the University of Utrecht for a short while and being a PhD in Hamburg. 'I was immediately impressed with the cleanroom at the UT. I saw comparable facilities in Europe, but they were all smaller. The lab at the UT is unique in Europe. The excellent organisation of everything is especially striking. You can find manuals for everything on the Internet. And there's an online description with pictures of all gear. That makes it very easy to find something and to get down to work with it.'

Prokofyev as well as Sukas would like to continue working for the UT. 'I still have about eight months left before my contract ends', the Russian postdoc explains. 'I'm planning to apply for some grants, which will hopefully result in research money with which I can finance my position.'

The same goes for Sukas. 'I like it here, but I want to make the next move at the same time. And I have to do that together with my wife, since she is also working at the UT as a postdoc. It would be nice if I could stay at the UT for a while, but that means I have to collect research money. And that makes my future insecure. Eventually, my wife and I would like to return to Turkey in approximately five years. But for now, we will just continue to work hard at the UT.'

# HEAVY USER IN THE LAB

LioniX is the main commercial user of the cleanroom, according to UT-alumnus **FLORIS FALKE**, who is  also regularly around himself. Issued by of its customers, LioniX develops and manufactures all kinds also components and products based on microsystem technologies. If should anything happen to the lab, we have an immediate problem.'

TEXT: SANDRA POOL | PHOTO: RIKKERT HARINK >

The NanoLab cleanroom at the UT is the lifeblood of LioniX B.V., located in The Gallery. That the company, as an external party, can use the lab is an essential condition for the company's right to exist. 'Should anything happen to the cleanroom in one way or another, we have an immediate problem', Floris Falke from LioniX says.

LioniX is a spin-off from the UT and has been operating as an independent private company for thirteen years now. 'The interplay between us and the university is still there, which is great. We're situated nearby and the NanoLab remains a research laboratory. That's why so many things are possible.'

LioniX is specialised in the production of optical components at the microscale. We develop new products for our clients, based on microsystem technologies. This concerns very tiny chips for telecom applications, for example.'

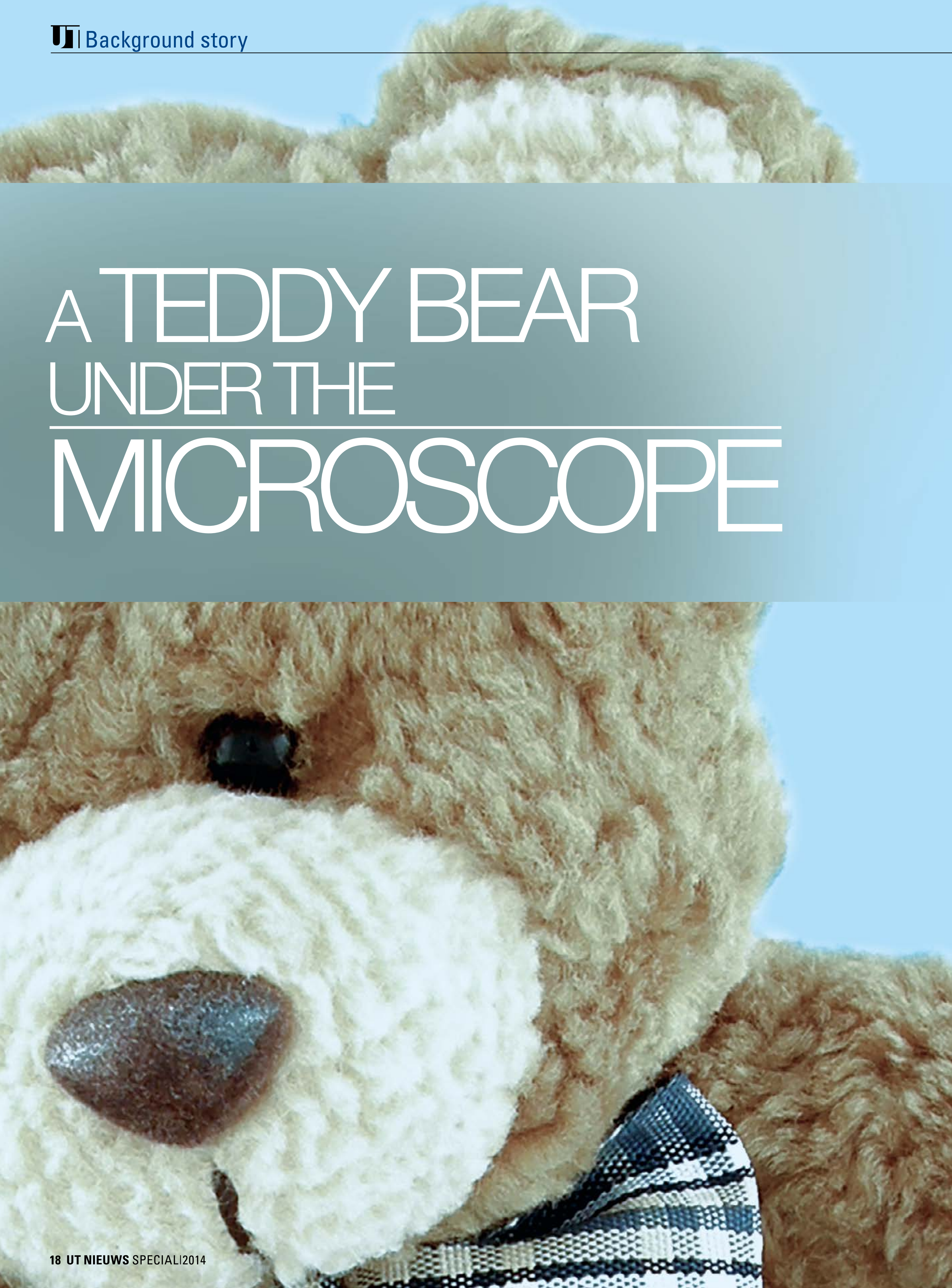
Next to that, LioniX focuses on microfluidics, optofluidics and surface modifications. 'We design chips for biotechnology, chemistry and pharma, for example. 'Take in mind lab-on-a-chip or cell-on-a-chip applications. The so-called Life Marker Chip is a good illustration, Falke says. 'It is a micro laboratory that's looking for specific molecules on Mars, hoping to find evidence for previous life on the red planet.'

## No production laboratory

For all these applications, employees of LioniX can be found in the cleanroom on a daily basis. 'As a company, we are the main user of the cleanroom. I go in there myself regularly, as well.' After his study in electro engineering, finished in 2008, the alumnus started working as a process engineer at LioniX. 'I gained a lot of experience in the lab. One year later, I started to work as a design engineer/project leader and focus on the development of new processes.

I also maintain relations with customers or project partners, but when a new process needs to be developed, I still work in the lab.'

LioniX develops products at small scale in the NanoLab. 'When we need volume, we turn to other laboratories. The NanoLab of the UT is clearly a research lab and not a production laboratory. 'No problem,' Floris Falke says. 'Because of its research status, many things are possible and we have access to many facilities. Essential to our core business.' I



# A TEDDY BEAR UNDER THE MICROSCOPE

Using one of the best microscopes in The Netherlands, NanoLab-microscopist Mark Smithers researches numerous products on behalf of companies. Toothpaste, storage boxes, antibacterial socks and even a teddy bear have been subjected to his electron beam. His weirdest research object? A squeezed-to-death blow fly on a metal sun-blind.

TEXT: PAUL DE KUYPER >

Toothpaste should contain miniscule calcium particles  for an even brighter denture and some socks have silver in them to prevent smelly feet. Manufactures regularly state that their products have improved thanks to the addition of nanoparticles. But can they live up to their claims? Consumers can't check. After all, you can't see whether or not those nanoparticles are really in there.
NanoLab-technician Mark Smithers can. He's already been working with the high resolution scanning electron microscope (HR-SEM) and its ancestors for a quarter of a century now. The device is one of the most accurate microscopes in The Netherlands. One  is able to see the materials present in a product, down to the nanometre scale.
A room at the end of a blind corridor in the NanoLab is where Smithers scans his wide-ranging samples on a daily basis. His most important customers are PhDs, but also microtechnology companies from the region regularly knock on his door. Occasionally, he gets extraordinary requests. If Smithers wanted to put a teddy bear under his microscope? And if that succeeded, could he do it with some detergent and an anti-bacterial sock, too?

## VOLATILE IONS

'That sock and teddy bear, together with approximately thirty other products, were in a box from the National Institute for Public Health and the Environment (RIVM) four years ago', Mark Smithers elaborates. He lists: 'Toothpaste, deodorant, a storage box made of hard plastic, detergent...'. The RIVM wanted to know if the nanoparticles of which manufacturers claimed they were in the products, were actually present. It wasn't about the safety of the products, Smithers clarifies. 'If a product enters the market, it already needs to have been tested for safety. The RIVM only wanted to know if we would really be able to observe the nanoparticles.'
That appeared more tricky than expected. Smithers was able to demonstrate the presence of nanoparticles in half of the products. He found calcium particles in toothpaste and antibacterial socks indeed contain nano amounts of silver to neutralise the smell that bacteria spread (see box).
Miniscule particles weren't found in other products. The technician needed to report the most mind-captivating example, the teddy bear, as a 'failed sample': No nanoparticles found whatsoever. The same (negative) result applied for the bacteria-repellent storage box that was supposed to contain silver particles.
Even if Smithers didn't find the particles with his HR-SEM, doesn't mean they are not there. 'Perhaps the amounts were really miniscule. It could be that they are in the product in the form of ions. Ions are so volatile that we can't observe them with our microscope. Deodorant, for example, holds silver ions that we can't see.'

## SQUEEZED-TO-DEATH BLOW FLY

Fortunately, Smithers hardly has to disappoint his other customers. The RIVM project was a special assignment, not daily practice. The technician: 'About seventy percent of the work comes from PhDs. They can make very tiny nanostructures on other devices, but they need this microscope to see if that structure got the exact intended shape and structure. They want to know the diameter of the pores in their membranes, for instance.'
Smithers gets the remaining assignments from regional micro technology companies, often spin-offs from the UT. 'But I also get requests from ceramics industry. They could be looking for the cause of discolouration in bricks. In that case, it's not about nanoparticles but about crystals that the microscope is able to detect and analyse.'
'The weirdest object I have ever had under the HR-SEM?', Smithers repeats the question. 'No, not that teddy bear. A smashed blow fly on a metal sun-blind. When rolling up the blind, the fly was squeezed to death. The manufacturer wanted to know if the acids from the insect caused tiny holes in the metal. That's an exception, mind you. Most firms simply want to know if their inventions work. To that end, they need to know what their products look like on the nanoscale.' I

## How to scan an antibacterial sock?

Half an hour. That's all the time the HR-SEM needs to understand what materials are in an object, according to Mark Smithers. But how does that work?

**Smithers explains by means of an antibacterial sock. First, you need a sample. 'You simply cut a piece. It can be maximally 10x10 cm, but the smaller the better. In this case, I cut out several pieces. Silver particles have the capacity to neutralise the odour of sweat. But they're expensive, maybe they're not everywhere, but only where you sweat a lot. Like near the toes.'**
**Smithers uses carbon tape to stick the samples on a small plate that he puts in the room of the HR-SEM. 'Paper, textile, metal, rubber, plastic. We can measure everything. The only limitation is water. This is because we test in a vacuum (water will evaporate, ed.). This is why we need to dehydrate liquids first, but that can also change the characteristics of the matter.'**
**First, the HR-SEM measures the shape and size of the material. Then, the sample gets into a room with an electronic beam. Smithers: 'This is how we see the contrast difference between particles with  high and low atom numbers. We have results within half an hour: a scan showing all the materials present in the antibacterial sock. It appears that silver particles were indeed processed in the heels and toes. HR-SEM is a very beautiful technique to get such a first impression of a material.**


Foto: Eric Brinkhorst

# MOTH EYE

Photo 1

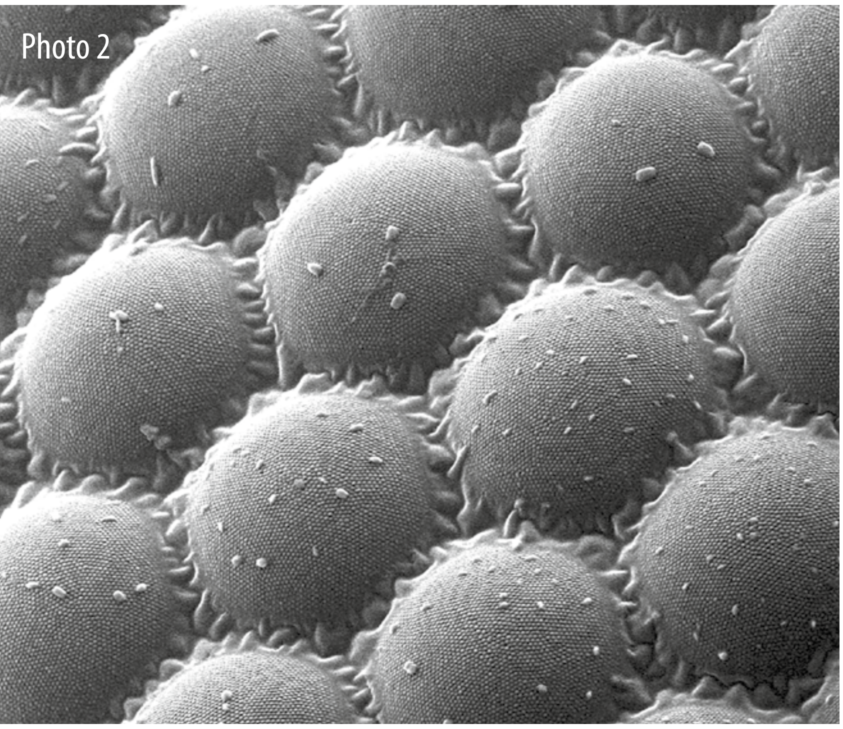


Photo 2

TEXT: MAAIKE PLATVOET | PHOTOS: MARK SMITHERS >

A sunflower, that's perhaps what you first think of when you see the alongside pictures. However, it's something totally different: the eye of a moth. These images are made in the NanoLab by NanoLab-technician Mark Smithers and show different enlargements of this part of the moth.

**PHOTO 1** depicts the eye on the millimeter scale. One can observe the hairs surrounding the eye and thereafter the feather scales covering the head. **PHOTO 2** is an image on the micron scale illustrating the compound eye structure of the moth. **PHOTO 3** shows the moth eye surface and in particular the anti-reflective coating structure on a scale of 200 nanometre. The squares on the eye surface are salt particles (seen on photo's 2 and 3). Those crystals do not occur naturally on the moth eye, Mark Smithers says. They most probably occur after death during dehydration as the moth lies in the window sill.

Smithers took the photos last year using an SEM, a scanning electron microscope. The moth was used to educate school pupils about Nanotechnology whilst visiting the Nanolab. 'I fixed the moth with carbon glue and then coated it with a very thin layer of gold. We need a coating for electrical conductivity. Afterwards, an electron beam scanned the moth eye and electron micrographs were made.'

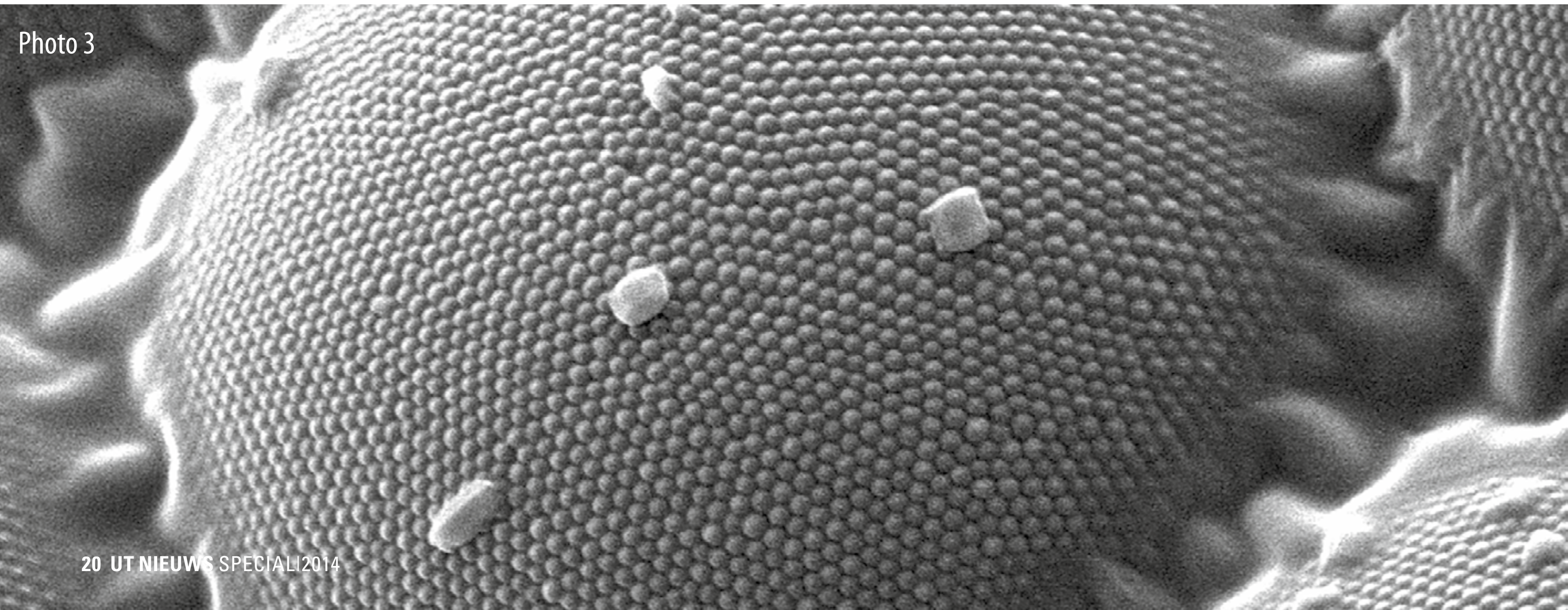


Photo 3

# ISOLATING ELECTRONS FOR QUANTUM COMPUTATION

**FILIPP MÜLLER**, PhD candidate at the NanoElectronics group, works in the cleanest part of the cleanroom. With his research, he hopes to contribute to the development of a quantum computer.

TEXT: PAUL DE KUYPER | PHOTO: RIKKERT HARINK >

'What a transistor is like to a regular computer, we try to make for the quantum computer in our department', Filipp Müller explains. 'We want to imitate the transistor functioning at the nanoscale. A quantum computer works with quantum bits, the so-called qubits. A qubit, for instance the spider of an electron, can take on values between 0 and 1. We try to create a nanostructure in which we can isolate an individual electron.'

'We manufacture those nanostructures onto silicon', Müller continues. 'Other groups investigate different materials, but we choose silicon because that's also used in the current chip technology. The existing chip manufacturing infrastructure needs fewer adaptations for qubits in silicon than if we would use other materials.'

## Ultra clean

Müller came to the UT three years ago, after a physics education in Germany. At the moment, seven researchers work on the project, but he was the first. 'In this project, we work with the so-called CMOS-technology, which stands for Complementary Metal-Oxide-Semiconductor.' Müller helped to establish this manufacturing process in the NanoLab.

'Before you're allowed to research anything in the cleanroom, you have to draw up a process document', he explains. 'You consult the technical staff on whether or not you can work in the way you planned. Obviously, it's important that you will be able to work safely, but also that your research doesn't intervene with other experiments. That's called cross-contamination in the lab.'

The manufacturing line for CMOS-technology is called the ultra clean line (UCL), according to Müller. 'The UCL belongs to the cleanest part of the cleanroom. You're only allowed to work with a few materials there, like silicon, silicon oxide, phosphorus, boron and arsenic. Our nanoscale research is very sensitive to impurities.'

'Our device fabrication combines micro- and nano-fabrication. We manufacture large basic structures on a wafer (a slice of silicon, ed.) with microtechnology (photolithography). Afterwards, we write nanostructures on it, using electron-beam lithography. The smallest patterns have a resolution of approximately twenty nanometres. Sometimes you're working on a sample for weeks. The real challenge is that all structures need to be aligned with an accuracy of 5 nanometres. When the sample is ready, we research how the structures behave electronically, in a helium dewar at extremely low temperatures.'

His goal is to contribute to the quantum computer, but Müller underlines that that won't be here overnight. Not so strange, he believes. 'A lot of research still needs to be done. The present-day computer also needed decades to evolve from idea to mass production.' I


# Klein Poelhuis

## Total solutions in technical installations

### Looking further

Klein Poelhuis is a modern supplier of total solutions in technical installations. Our major strength is to create and realise innovative, energy-efficient concepts with optimal comfort. We go beyond craftsmanship and a reliable 24-hour service. We contribute to the end result by using our expertise during the entire trajectory from the first drafts until delivery and service & maintenance. We have to, because the complexity of technology in the construction industry is increasing. Already for that reason alone we like to think along from the outline phase onwards. Whenever possible, we look for collaboration with professional partners who can lift the end product to an ever higher level: chain-thinking fits us like a glove.

Chain integration is the optimal form of collaboration
In chain integration, multiple parties from construction industry work together on project-basis to perform better, faster and cheaper, and to decrease costs of failure. The starting point in chain integration is openness, trust and guts. We believe that chain integration works, if all parties commit themselves 100%, are willing to change and if they comply to certain requirements, like full transparency, joint profit- and loss accounts and synergy because of mutual interest.

### 3D BIM

An important step in limiting foundation and failure costs (estimated at 5-20%) is working according to an integrated BIM-Model. BIM (Construction Information Model) stands for a design approach where all involved parties – including the client – work within one model and are able to follow each other's progress. The jointly chosen parts and solutions are visualised in 3D. In that way, the client and his staff know exactly what the installation will look like and can adjust if necessary.

### LEAN

Klein Poelhuis is convinced that also the 'lean'-principle offers a lot of potential to increase efficiency and reduce failure costs in construction. However, it's a requirement that one looks beyond the boundaries of one's own working field. After all, a solution that is chosen from a certain discipline can only deliver maximum leverage when it's in harmony with the processes from other disciplines. To secure that harmony, we involve our suppliers and subcontractors from the earliest stage in the development of our solutions. Thanks to this solid joint preparation we get to a situation where planning steers construction instead of the other way around. This saves costs and additionally, almost always leads to a reduction in construction time.

### Total Cost of Ownership, life cycle thinking and sustainability

Using our Total Cost of Ownership Tool, we can already calculate the total costs of the realisation, renovation, preventative maintenance, corrective maintenance, energy and preservation during the definition phase of a project. Klein Poelhuis is convinced that chain integration results in a better process, higher quality, lower costs, faster construction and satisfied end users and staff.

Klein Poelhuis has been a reliable partner in the realisation of the cleanrooms for years. The below projects have been realised during the past years or are still under construction:

- Installation and adaptations Nanolab University of Twente;
- High Tech Factory University of Twente;
- BB&S building Thales Hengelo;
- Demcon Enschede;
- Cleanroom Encapson BTC building Enschede.

27-year old **NIRUPAM BANERJEE** came from India to the UT four years ago. For his PhD in the Inorganic Materials Science Group of professor Guus Rijnders, he spent quite some hours in the NanoLab.

# GOING TO THE LAB, EVEN AT NIGHT

TEXT: MAAIKE PLATVOET | PHOTO: RIKKERT HARINK >

Banerjee studied physics at the University of Calcutta and at the Indian Institute of Science in Bangalore, but afterwards really wanted to go somewhere where he could apply his knowledge. 'Although I had never heard of The Netherlands, I eventually wanted to go to Twente because of the NanoLab and the excellent reputation of the department of Guus Rijnders. To me, it was a marvellous opportunity to come here, because I couldn't have done this PhD anywhere else. Specifically because of the lab.'

His research is titled: Piezo-electric nano-scale electromechanical devices. 'Piezo-electric materials have a huge application potential (like touch screens, ed.), because they have the capacity to generate electrical energy from mechanical transformations', Banerjee explains. 'My PhD aims to develop integrated design- and manufacturing methods for so-called NEMS-systems (nano electromechanical systems), based on piezo-electric materials. To achieve that, I thought of a new manufacturing strategy to be able to develop a pattern of multiple layers of piezo-material. In the meantime, I was able to prove that these new patterns keep their piezo-electric characteristics at the nanoscale. Based on this performance, we are capable of building sensor devices with ultra-high mass sensitivity, for instance.'

## CONTINUING UNFINISHED BUSINESS

'During my four year PhD trajectory I was in the NanoLab for an average of three days per week for 3,5 years', Banerjee explains. 'The technology that I research in combination with the facilities are really unique in Twente. I find it convenient to live on campus, so that I can also easily go to the lab at night. That freedom is something that I appreciated a lot.'

After his dissertation, Banerjee would like to stay at the UT for a while, as a postdoc. 'Because there's a lot of unfinished work that I would like to continue with.' Eventually, it's his goal to return to India and to contribute to the fast-growing economy. 'I hope to bring a new piece of technology to India, in order for the country to develop further.' I

What are the everyday applications for nanotechnology?

# NANO IN YOUR IPHONE AND YOUR SOCK

TEXT: JOHANNES DE VRIES | PHOTOS: ARJAN REEF >

All nanoparticles that end up in the environment, also need to be able to be filtered out. The **MEMBRANE TECHNOLOGY** that the UT uses consists of some kind of straws that are sealed at one end. The straws have holes of approximately 200 nanometres in them. Water can go through the holes, whereas nanoparticles up to 20 nanometres are being stopped (so even if the hole is ten times as big).


Many **SUNBLOCK PRODUCTS** (creams as well as sprays) contain nanoparticles. Titanium oxide and zinc oxide reinforce the activity of UV-filters. In the NanoLab, such products are tested: how many nanoparticles are in them and what's the effect?

Nowadays, there are **SOCKS** on the market that have silver nanoparticles in them for bacterial disinfection. Handy for people with perspiring feet, for instance. Similar to the sunblock, the NanoLab also studies the distribution and effect of the particles in these socks.


In the NanoLab, research is being executed on new transistors and materials for electronics use. Also your **IPHONE** contains nanoelectronics, that ensure your phone has a memory comparable to a desktop computer from a couple of years ago.

Medimate's **LAB-ON-A-CHIP** is a kind of mini-laboratory where everybody can analyse their own blood. A small drop on the chip with nanotechnology is enough. After that, a device of around twenty by ten centimetres can read-out the chip.

# GRADUATING IN THE CLEANROOM

Those who want to do their graduation project somewhere unique, probably soon think about an exotic company or a faraway country. However, three UT-students simply stayed on campus to do their graduation assignment. They found their placement in the NanoLab.

TEXT: JOHANNES DE VRIES | PHOTO: ARJAN REEF >

**JOËL VAN TIEM** (22) regularly locks himself up in the cleanroom of the NanoLab. 'Before you're allowed to go there, you have to follow a course,' Van Tiem explains. 'There you learn about the safety rules, what to do when a fire breaks out, for example. But also how to deal with nanoparticles that have come onto your clothes.'

Van Tiems graduation assignment for his master electrical engineering is about the so-called angular acceleration sensor, a kind of organ of balance in electronics. He clarifies: 'The organ of balance is a tube with liquid inside it. When you rotate the tube, the liquid moves as well, but with a certain delay. That delay is the measure for the angular acceleration.'

Angular acceleration sensors are already in iPhones, amongst others, but they work according to a different technology. 'Because of that, many angular acceleration sensors are sensitive to other movements – for instance going backwards – during rotation. Our technology isn't.'

Van Tiem and his supervisor make the tubes for the angular acceleration sensor in the NanoLab. There, they 'sputter' electrodes on them with a two hundred nanometre (0.0002 millimetre) height. 'It has to be at the nanoscale,' he clarifies. 'Only then are you able to define the acceleration precisely. On top of that, it obviously needs to fit in your phone!'

**PEPIJN BEEKMAN** (26) spends around twenty hours per week on average in the cleanroom of the NanoLab, to prepare chips of approximately one by one and a half centimetres. On the chips, he makes membranes that resemble human cell membranes.

'You can do various things with that,' he explains. 'You can add proteins to research what happens in the cell membrane afterwards. But I do something different. I make hollow membranes from them, with a thickness of approximately a hundred nanometres. Because of that, they become some kind of tubes where you can put in something. In that way, you can transport medicine through the human body, for instance.'

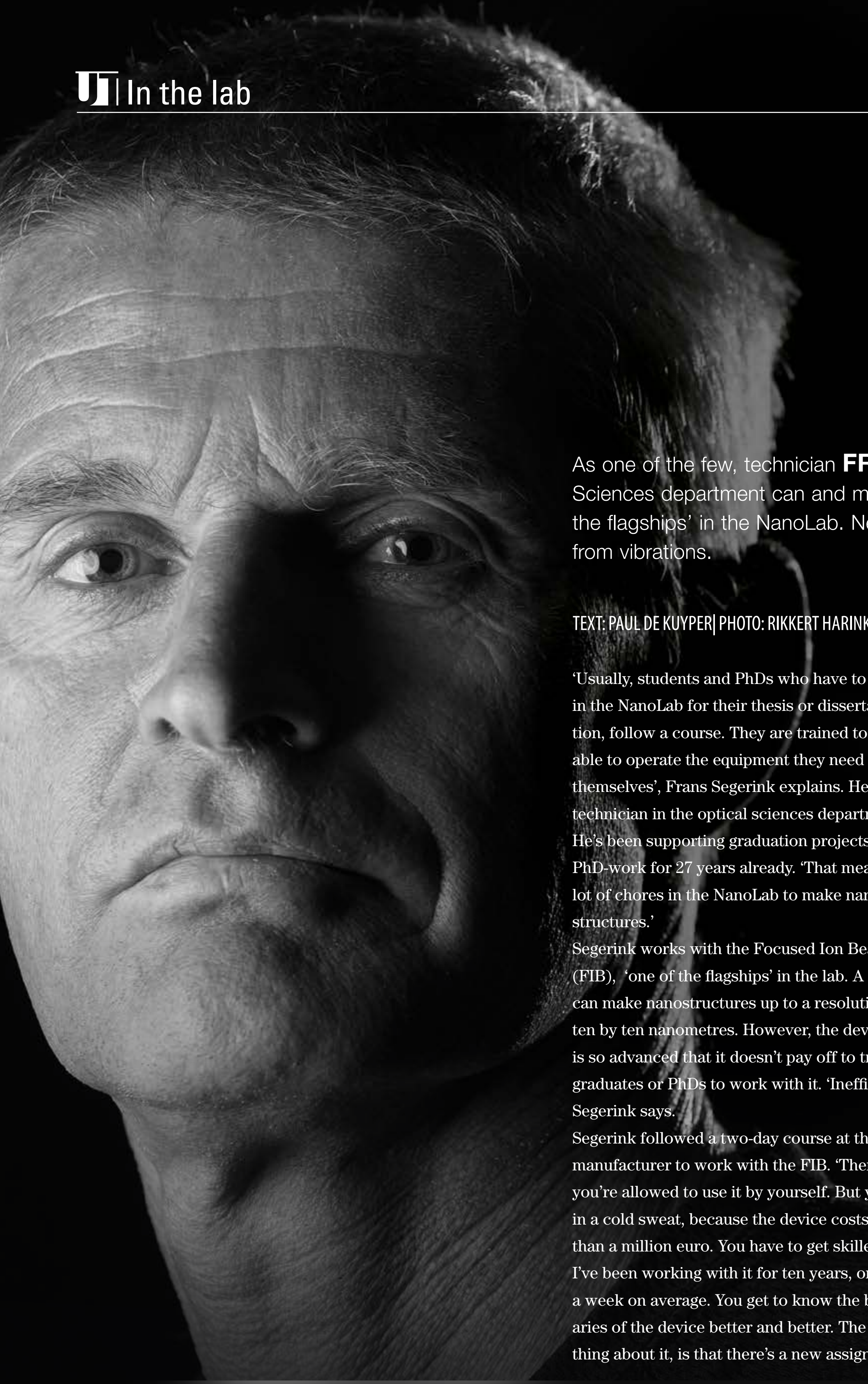
This has many interesting application possibilities, the nanotechnology master student believes. 'Certain proteins ensure that the membrane will only attach to a specific kind of tissue. In this manner, you can influence the medicine's direction.'

**ROBIN BUIJS** (23) is doing two masters: electrical engineering and applied physics. Because he's combining his masters into one graduation project, he is working in the Transducers Science and Technology department for a full year. He spends eight weeks of this year in the cleanroom.

His department is specialised in the fabrication of complex structures in silicon, the same material where computer chips are made out of. Those structures are made at the nanoscale.

Buijs is not allowed to discuss what he's doing in the NanoLab exactly. 'We need to apply for a patent on our technology first.'

The application possibilities aren't any less interesting, though. 'Within the project, the idea evolved to develop a new kind of camera where pictures can be adjusted after having been taken. In that way, you'll never have photos that are out of focus again.' I



As one of the few, technician **FRANS SEGERINK** from the Optical Sciences department can and may work with the Focused Ion Beam, 'one of the flagships' in the NanoLab. Next to that, he monitors if the lab remains free from vibrations.

TEXT: PAUL DE KUYPER| PHOTO: RIKKERT HARINK >

'Usually, students and PhDs who have to work in the NanoLab for their thesis or dissertation, follow a course. They are trained to be able to operate the equipment they need by themselves', Frans Segerink explains. He is a technician in the optical sciences department. He's been supporting graduation projects and PhD-work for 27 years already. 'That means a lot of chores in the NanoLab to make nano-structures.'
Segerink works with the Focused Ion Beam (FIB), 'one of the flagships' in the lab. A FIB can make nanostructures up to a resolution of ten by ten nanometres. However, the device is so advanced that it doesn't pay off to train graduates or PhDs to work with it. 'Inefficient', Segerink says.
Segerink followed a two-day course at the manufacturer to work with the FIB. 'Then you're allowed to use it by yourself. But you're in a cold sweat, because the device costs more than a million euro. You have to get skilled on it. I've been working with it for ten years, one day a week on average. You get to know the boundaries of the device better and better. The nice thing about it, is that there's a new assignment every time. It never turns into a routine. You're always busy tinkering to get the most out of the possibilities of the FIB.'

## Earthquake in Italy

Besides working with the FIB and engaging in other technical support, Segerink keeps an eye on whether or not the floors of the NanoLab still sufficiently absorb vibrations from outside. 'We want things quieter than quiet around here, because our devices operate on an atomic level', Segerink explains.
He has developed a measuring arrangement with very sensitive sensors. 'We can see from the measurements if there are users inside. We even notice the difference when people have their breaks. We also monitor the influence of freight transport on the Hengelosestraat. That's important because a whole new bypass might be constructed around campus (behind the Horst, ed.). Very rarely, our sensors even feel earthquakes from as far as Italy. Then you see peeks in our graphs. Fortunately, all measurements show that our floor still sufficiently absorbs to be able to do our research. In any case during the night and in weekends, but also during the day we usually comply to the strictest requirements. Of course, that's a nice conclusion.' I

# TINKERING TO EXPLORE BOUNDARIES