KAVLI NEWSLETTER
Kavli Institute of Nanoscience Delft
No.02
June 2011

IN THIS ISSUE:

Photographer: Ruben Schipper

THE NANOLAB, THE UPCOMING COLLOQUIUM, AND THE KAVLI DAY

The response to our first newsletter was very positive. Many people appreciate the format. Some suggestions for improvements were made (further comments are welcome!), and we will incorporate these and move forward. Be sure to send Dominique Meijer (D.A.U.Meijer@tudelft.nl) or me your input – news, comments, suggestions, etc.

While the Kavli Institute of Nanoscience is quite diverse, we do share multiple common interests. One very concrete example is our joint Kavli Nanolab Delft. This state-of-the-art nanotech cleanroom is used by many of us, both at the Quantum and Bionanoscience departments. We have asked Emile van der Drift, managing director of the Kavli Nanolab, to write about this great facility. Read about it on page 8!

In this issue of the newsletter you can also learn about the upcoming Kavli Colloquium by Stephen Quake from Stanford, planned for June 23. Steve is a wonderful scientist who is world-leading in microfluidics. Additionally to that, he, remarkably, developed single-molecule experiments within a few years into a multi-million-dollar DNA sequencing company, while continuing to do science at the very highest level. On June 23 2011, he will tell us all about this 'DNA sequencing' in what promises to be a very interesting Kavli Colloquium. BN student Mathias Voges interviewed him about his endeavors. Read all about it on page 2 and 3.

Be sure to participate at our annual Kavli Day! September 22 is the date set for it this year. The day will feature lots of fun items: lunch at the Kurhaus, all sorts of beach games, a beach barbeque, and a scientific colloquium by special guest Paul McEuen, currently the Director of the Kavli Institute at Cornell, who is well known to many of us for his excellent nanoscience. On top of that, we will award that day for the first time the 'Kavli Delft thesis prize', a prize for the best PhD thesis written by a graduate student at our Kavli Institute of Nanoscience at Delft in the previous two years.

Finally in this newsletter, you can enjoy self-introductions by new faculty members Anne Meyer and Sander Otte, read columns by Jan Lipfert and Yuli Nazarov, and learn other news. Enjoy!

• **Cees Dekker**

Column

FRITZ AND HANS: AN ATTEMPT AT PHENOMENOLOGICAL UNDERSTANDING

The immediate motive to write this column is evident: J.E. Mooij was awarded the Fritz London prize. And though he has to wait for half a year to get his hands on it, we are all glad, consider it as our common achievement, and congratulate him from the depth of our common heart. Yet here I'd like to attempt a deeper study that, for the absence of exact microscopic theory, is bound to be phenomenological. By virtue of this approach, I have to disregard any personal detail however important it might seem.

The phenomenon of Fritz London is evident and lies within penetration depth. Foreign experience cannot be underestimated: it took only a year for this 1933 refugee to come up with a seminal theoretical contribution to superconductivity theory, long before this theory came into existence. It was a gem of phenomenology and implied a professorship. But how could an émigré penetrate the hearts of Duke colleagues so deeply as to make Fritz into a prize? When John Bardeen got this prize he did not hide it in his pocket; after a while, he returned back an amount 10 times greater to the prize fund, and that was no grant money. While we do not know what attracted him that strongly, it is well established that superconductivity, and thus research thereupon, requires attractive interactions.

The phenomenon of Hans Mooij is perhaps more complicated and certainly less explored. Why would a successful Shell employee run back to science? And if really looking for science, why would he run to a place where leading professors were not burdened with Ph.D. titles and published only once every two years in a local journal? And, if adjusted to such an environment, why work persistently at changing it into a Nature-publishing collective where almost any Ph.D. is a professor? Why, upon coining your own scientific reputation, would you care about, promote, and defend the research in fields so different from your own? Being successful in all that, why still look for new topics to investigate? Well, it is clear that the usual assumption of local, or contact, attractive interaction does not work here. The interaction must be global and arise from a kind of unbroken symmetry where your individual research and success is equivalent to those of others.

I wonder if we can comprehend this unusual symmetry in more exact terms. Actually, I do not care if we cannot. The point would be to accept its existence at the phenomenological level, understand the possible (and perhaps impossible) experimental consequences, and utilize the phenomenon. The author is indebted to J.E. Mooij for numerous manifestations.

• **Yuli Nazarov**

Interview

INTERVIEW WITH STEPHEN QUAKE

While the world was marveling at the advances made by the Human Genome project, Stephen Quake, now professor of Bioengineering at Stanford University, felt that the DNA sequencing technology used was in need of improvement. "It was an open scientific challenge, and we knew there would be important technological implications."

By means of single-molecule sequencing techniques, Helicos Biosciences, a company co-founded by Quake, can at present sequence an entire human genome within two weeks using less reactants and lowering the costs to just under 50.000 USD.

I was honored to interview next month's Kavli Colloquium speaker about his career and his views on the future of genomics.

How did it all start? Why the venture into the field of biophysics?
I was always interested in the interface between mathematics and physics. When I went to graduate school, my intention was to work on string theory. However in Oxford, most researchers were working on phenomenology, and I thought you might as well work on things where you can actually do the experiments in a straightforward way. I went back to some ideas I had learned in my undergraduate studies about polymer physics and single molecule manipulation and ended up pursuing a career on the interface of physics and biology.

Do you still enjoy working in an experimental field?
I very much enjoy small science, turning the knobs at a table-top and being in control of everything. The plumbing is endless amusement! It's charming because it's so simple to make. You can build these very powerful intricate devices with relatively small amount of effort.

What got you interested in DNA sequencing?
I started my career as an experimentalist measuring forces associated with DNA molecules and the enzymes interacting with them. We knew about the human genome project and that the then-existing sequencing technologies were thought to be inadequate. So it was quite natural going from single molecule biophysics to single-molecule sequencing technologies.

What was your motivation for starting Helicos Biosciences?
When you're working on technological problems in biology, and it requires some virtuosity, the number of people that can reproduce it is really small. The only way to make it available to a large number of people is to have a commercial venue that'll do all the engineering for you. We weren't interested in just publishing papers.

What have you learned from your time in industry?
An enormous amount! I really enjoy my role consulting for the companies. It has helped me to appreciate what are good problems to work on in an academic setting.

Was sequencing your own genome a life-changing event for you?
Yes. It's really a profound experience to look in a direct way at the inheritance of my parents and how it affected my life. I was one of a handful number of people to sequence their own genome. There was no rulebook for what it all meant; we figured all of that out ourselves.

How do you envision the interplay of genomics and health care in the future?
I don't think everyone will want to know their genome, and they wouldn't want their doctors to know it either. This is a perfectly defensible and fine choice. However, the other half that will want to know it will have access to some interesting information. They'll know what diseases they have increased risk for and should get tested for. Also which drugs will work for them and which won't. Hopefully it will lead to real quality of life improvements and good economies in the health care system.

Had you previously heard of the Kavli Institute of Nanosciences?
I actually helped write the proposal for the Caltech Kavli Institute of Nanosciences. Unfortunately I had just moved to Stanford when it was awarded and didn't get to participate in it. I think it's fantastic there's a Kavli Institute in Delft, given their very strong programs in nanosciences.

Will there be any surprises in store for us at the Kavli Colloquium?
I hope to educate the Delft community on the advancements in genomics and look forward to sharing my own perspectives on this.

Do you have any general advice for (under)graduate students in Delft?
Think broadly about science, pick the problems you're most passionate about, and follow these as far as they will take you!

• **Mathias J. Voges**

KAVLI COLLOQUIUM 2011

Kavli Colloquium

DNA SEQUENCING: IS THE GENOME USEFUL IN MEDICINE?

STEPHEN QUAKE, STANFORD UNIV.


Stephen Quake

June 23, 2011 will feature a Kavli colloquium by Stephen Quake. We are living in the genome age, where the productivity of DNA sequencers is advancing faster than Moore's Law. Stephen Quake will describe one contribution of biophysics to this field - the development of the first single molecule DNA sequences. He will then go on to discuss several applications of high throughput DNA sequencing in medicine, ranging from non-invasive diagnostics to the first clinically annotated human genome. •

15.00 h	Short introduction of new faculty of the Kavli institute
	15.00 Chirlmin Joo (BN): Pulling needles out of a haystack
	15.15 Sander Otte (QN): Magnetism of a single atom
	15.30 Anne Meyer (BN): Survival through destruction of stress-response proteins
15.45 h	Break
16.00 h	Kavli Colloquium by Stephen Quake,(Stanford University): DNA sequencing: Is the Genome Useful in Medicine?
17.15 h	Drinks & time to meet

Extra seminar

MICROFLUIDIC LARGE SCALE INTEGRATION

On June 24 Stephen Quake will additionally present a lecture: "Microfluidic large scale integration". The abstract for this Kavli Colloquium reads as follows:

The integrated circuit revolution changed our lives by automating computational tasks on a grand scale. Stephen Quake's group has been asking whether a similar revolution could be enabled by automating biological tasks. To that end, they have developed a method of fabricating very small plumbing devices - chips with small channels and valves that manipulate fluids containing biological molecules and cells, instead of the more familiar chips with wires and transistors that manipulate electrons. Using this technology, they have fabricated chips that have thousands of valves in an area of one square inch. They are using these chips to investigate a wide variety of biophysical questions. There is also a substantial amount of basic fluid physics to explore with these systems - the properties of fluids change dramatically as the working volume is scaled from milliliters to nanoliters! •

Kavli Colloquium

"DNA SEQUENCING: IS THE GENOME USEFUL IN MEDICINE?"

Date : June 23, 2011 at 15.00 hours
Location : Faculty of EWI, Mekelweg 4
Lecture room B

Extra seminar

"MICROFLUIDIC LARGE SCALE INTEGRATION"

Date : June 24, 2011 at 10.00 hours
Location : TN building, Lorentzweg 1,
Lecture room E

Upcoming Kavli Colloquia

KOSTYA NOVOSELOV

12 April 2012

University of Manchester

BONNIE BASSLER

6 juli 2012

Princeton University

RE-LEARNING HOW TO RIDE A BIKE

Introduction new faculty

Anne Meyer

ANNE MEYER, A SELF-INTERVIEW

Psychologists have developed the Holmes and Rahe Stress Scale to quantify the impact of stressful life events, ranging from "death of a spouse" (topping the scale at 100 life change units) to "minor violation of law" (at the smallest but still-significant amount of 11 LCUs). In the past year, I have racked up a larger-than-normal number of points on this scale, negotiating the waters of an intercontinental move (from Boston to Delft), a major change in responsibilities at work (from post-doctoral fellow to assistant professor), and re-learning how to ride a bike (not officially listed on the scale, but a harrowing experience after more than 20 years off).

While humans are quite accustomed to thinking about the effects of psychological stresses, my training in biology showed me that a much more immediate risk to health comes from physiological stressors. The vagaries of fluctuating temperatures, changing nutrient availability, and even the process of aerobic respiration itself present challenges to homeostasis that, if uncountered, can lead to lasting damage or death. I find it fascinating that organisms have evolved elaborate networks that can mount life-saving cellular responses, each one customized to the specific type of stress perceived by the organism.

My Ph.D. research at Stanford University into the conformational cycle of chaperonin enzymes first sparked my interest into the many different and unexpected ways that cells can respond to stress. High temperatures can cause proteins to unfold, losing the distinctive three-dimensional conformations that allow them to function appropriately. I discovered that barrel-shaped chaperonins can rescue these unfolded proteins by forming a lid to enclose them within a central cavity, forming a nanocage that provides a specialized environment favoring the folded state of client proteins. This initial foray into the field of biochemistry fueled my enthusiasm to learn more about the intricate molecular mechanisms that underlie the functions of proteins.

While DNA is popularly thought to control all cellular activities, a mention of the word "protein" often conjures the image of a piece of chicken breast – a limp, featureless block of nutrients more dietary than functional. For all that DNA pays a central role in the transmission of genetic information, I personally view it as fairly boring stuff. DNA is totally passive, lying in the cell like a high persistence-length pile of spaghetti and waiting for other agents to act upon it. Proteins, however, are the original nanomachines, using only a 20-character alphabet of building blocks to build enzymes in a menagerie of shapes and with an acrobat's range of motion.

My curiosity has been captured of late by Dps, a fascinating stress-response enzyme found in bacteria that I studied during my post-doctoral fellowship at MIT. Under conditions hazardous to cellular survival, Dps coats the bacterial chromosome and condenses it into a compact linear array called a "biocrystal." Bacteria that have undergone the process of biocrystallization are thousands of times more likely to survive in damaging environments and to avoid harmful DNA mutations and breakage. Not only is this response highly dramatic, involving an entire reorganization of the genome, it is also extremely rapid and completely reversible.

Reaching a complete understanding of the regulation and mechanisms underlying this little-understood phenomenon, which merges aspects of science ranging from microbiology to condensed-matter physics, will require expertise in many diverse areas of research. The broad scope and vibrant collaborative spirit of the Kavli Institute of Nanoscience therefore strike me as uniquely suited to host my research. Ultimately I believe that a better understanding of bacterial strategies for survival will lead to opportunities to fight opportunistic pathogens and preserve our own symbiotic microbiome.

As predicted by Holmes and Rahe, my first few weeks as an American expatriate in the Netherlands were indeed stressful, as I slept on an air mattress (while my real bed was on a ship floating somewhere in the middle of the Atlantic Ocean), paid for all grocery and home purchases in cash (prior to being able to obtain a Dutch bank account), and stored said groceries in our backyard shed while waiting for my refrigerator to be delivered (at least the December ice storm ensured that we had fresh milk!). Since then, things have been on a decided upswing as I have explored the beautiful canals and architecture around my new neighborhood while walking my dog, discovered the delicious food at Indonesian and Turkish restaurants, and enjoyed spectacular bird-watching every day on my commute to the university. So far, my bike-riding skills have only developed to the point where I can negotiate protected sidewalks with the gentlest of curves and bumps. However, I hope that soon I will be able to ride even as well as the six-year children that I see zipping through my neighborhood, for whom using these macromachines is no source of stress at all.

• Anne Meyer

EVER YOUNGER STUDENTS

Erik van der Boom, a 13 year-old student who has already completed high school and will start his university studies this year, has spent time in the research group of Val Zwiller. Erik performed quantum optics experiments on pairs of entangled photons, a type of experiment originally suggested by Albert Einstein that lies at the heart of quantum information processing. With entangled pairs of photons, a measurement on one photon immediately yields information on the other photon, wherever the other photon might be. These experiments are usually performed by TU Delft students as a practicum under the supervision of Barbara Witek. Erik was able to quickly master both the theoretical and experimental aspects of this research and wrote a very complete report that won the national first prize of profile works. In addition, Erik was invited to be a host on the national TV program 'De Wereld Draait Door' (DWDD), where he explained his work and mentioned his interest for quantum physics. •

Broadcast DWDD: www.j.mp/isP2Ci

NYNKE DEKKER IN FOM UB

Nynke Dekker has been appointed as a member of the Executive Board and the Governing Board of FOM. Nynke will become the youngest member and the first woman on the Executive Board in FOM's 65-year history, as well as the first member with a biophysics background. •

CURIE GRANT BLOSSER

Timothy Blosser (postdoc Cees Dekker lab) has received a Marie Curie International Incoming Fellowship (IFF) grant on 'BioNanopore – Biomimetic nanopore for a mechanistic study of the nuclear pore complex'. •

VICI GRANT FOR ERIK BAKKERS

Erik Bakkers (TUD and TU/e) has received a Vici grant on 'Control of nanomaterials.' Nanomaterials will become important for a diversity of applications. His research group will investigate the growth mechanism of semiconductor nanowires in order to engineer their optical and electrical properties at the atomic scale. •

RONALD HANSON TENURED

After 3.5 years of working as a tenure-track assistant professor, Ronald Hanson has received tenure. Additionally, he has been promoted to the rank of associate professor. Congratulations! •

New employees

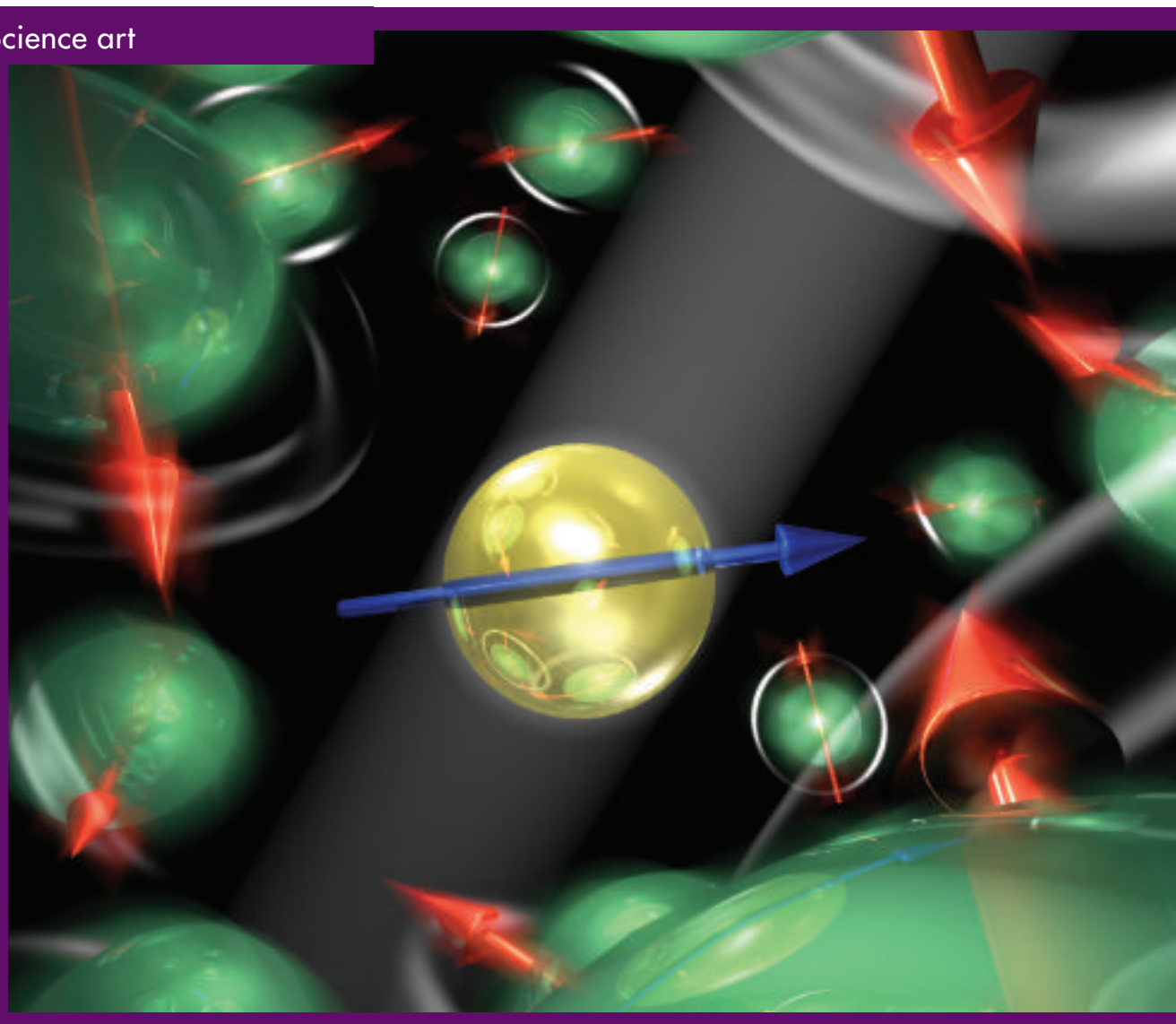
NEW EMPLOYEES DEPARTMENT BIONANOSCIENCE

Name	Date of employment	Title	Lab
Allard Katan	05/01/2011	Post doc	Cees Dekker Lab
Hugo Snippert	06/01/2011	Post doc	Cees Dekker Lab
Michela de Martino	07/01/2011	PhD	Anne Meyer lab
Stanley Dinesh Chandradoss	07/01/2011	PhD	Chirlmin Joo lab
Daniel Burnham	07/13/2011	Post doc	Cees Dekker Lab

NEW EMPLOYEES DEPARTMENT QUANTUM NANOSCIENCE

Name	Date of employment	Title	Section
Andres Castellanos	05/01/2011	PhD	MED
Jaime Alvarez	05/01/2011	Gast researcher	NF
Martin Soini	05/01/2011	PhD	QT

Science art



Single spins in diamond (yellow/blue) display quantum behavior even at room temperature, making them promising building blocks for future applications in quantum information processing and ultra-sensitive magnetometry. The quantum state of a single spin can be protected from unwanted interactions with surrounding spins (red/green) by high-precision magnetic pulses, as recently reported by Ronald Hanson's group in Science 330, 60 (2010).

Please send suggestions for 'Science Art' to Dominique Meijer, D.A.U.Meijer@tudelft.nl

News items

VENI GRANT FOR AKIRA ENDO

Akira Endo (Postdoc QN/NF) was granted a Veni on 'Nanoscientists' view of outer space' Nanoscientists and astronomers are working together to unravel the history of star formation. Endo's research team intends to develop a huge network of superconductive, far infrared detectors to detect how things were tens of billions of years ago. •

Akira Endo

CONTRIBUTE TO THIS NEWSLETTER

Input to forthcoming newsletters is very welcome. Please send any relevant material to Dominique Meijer (D.A.U.Meijer@tudelft.nl). If you like to contribute to this newsletter as an editor, please contact Cees Dekker.

Colofon

The Kavli Newsletter is published three times a year and is intended for members of the Kavli Institute of Nanoscience Delft and those interested. PDF versions of all Kavli Newsletters can be found at www.kavli.tudelft.nl

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A COUPLE OF TAKEOFFS AND LANDINGS

Introduction new faculty

Sander Otte

SANDER OTTE, A SELF-INTERVIEW

Question: what do Huygens, Van Gogh, Balkenende, and Fokke & Sukke have in common? You won't be able to guess, so I'll give you the answer. Apart from being both Dutch and famous (to various extents), they all perished together when a huge pile of metal buried them alive in an accident that involved me pressing the wrong button.

This answer, I realize, may have left you more puzzled than the riddle itself. Let me explain. Two missing pieces of information are that the aforementioned Dutchmen were actually atoms, and that the 'huge pile of metal' was only a few nanometers thick (which was nonetheless huge for the poor Dutchmen). This is what I do for a living: I pick some atoms, name them after famous people, grow fond of them, tickle them with small voltage pulses, and gently nudge them around – sometimes for weeks in a row – until sooner or later I watch them all die in some sad, unforeseen event. Such are the wonders of modern science.

The specific tool I use during these adventures is a Scanning Tunneling Microscope (STM). For now it suffices to say that the business end of such a microscope consists of a very sharp metal needle that can do exactly what I just described: probe atoms, push atoms around to any desired spot, and apply voltages locally to individual atoms. (For technical details I happily refer to my upcoming talk preceding the Kavli Colloquium of June 23.)

The first time I operated an STM was actually here in Delft in 2002, during an internship in Cees Dekker's group. (Back then he only had a group – can you imagine?) Since that time I have worked with many different STM machines: first during my Ph.D. research in Leiden, then at the IBM Almaden lab in California, and finally at NIST in Maryland where I recently finished a postdoctoral appointment. In all that time I studied more than just atoms. For example, at NIST we used an STM to investigate the electronic quantum effects in a layer of graphene. Here in Delft it is my plan to focus on the magnetic dynamics of atomic scale structures.

Apart from my love of atoms, I am hard-wired with an almost insatiable passion for aviation. Whenever I hear the sound of an airplane engine, my head will involuntarily twist upwards to search the sky for the winged source of the noise – an embarrassing instinct that I stopped fighting long ago. In 2007, I earned my pilot license, and since then I have flown many happy hours along the U.S. East and West Coasts. Today, financial priorities keep me temporarily grounded, but until I take the controls again I enjoy myself by watching the planes come in at Rotterdam Airport together with my two-year-old son and future pilot Thomas.

My fondest memories are of when my fascinations for science and aviation came together. On some days I would practice a couple of take-offs and landings in the morning before going to the lab to move around atoms in the afternoon. Sadly for the atoms, but fortuitously for me, on those days I pressed the wrong button only in the afternoon.

• **Sander Otte**

News

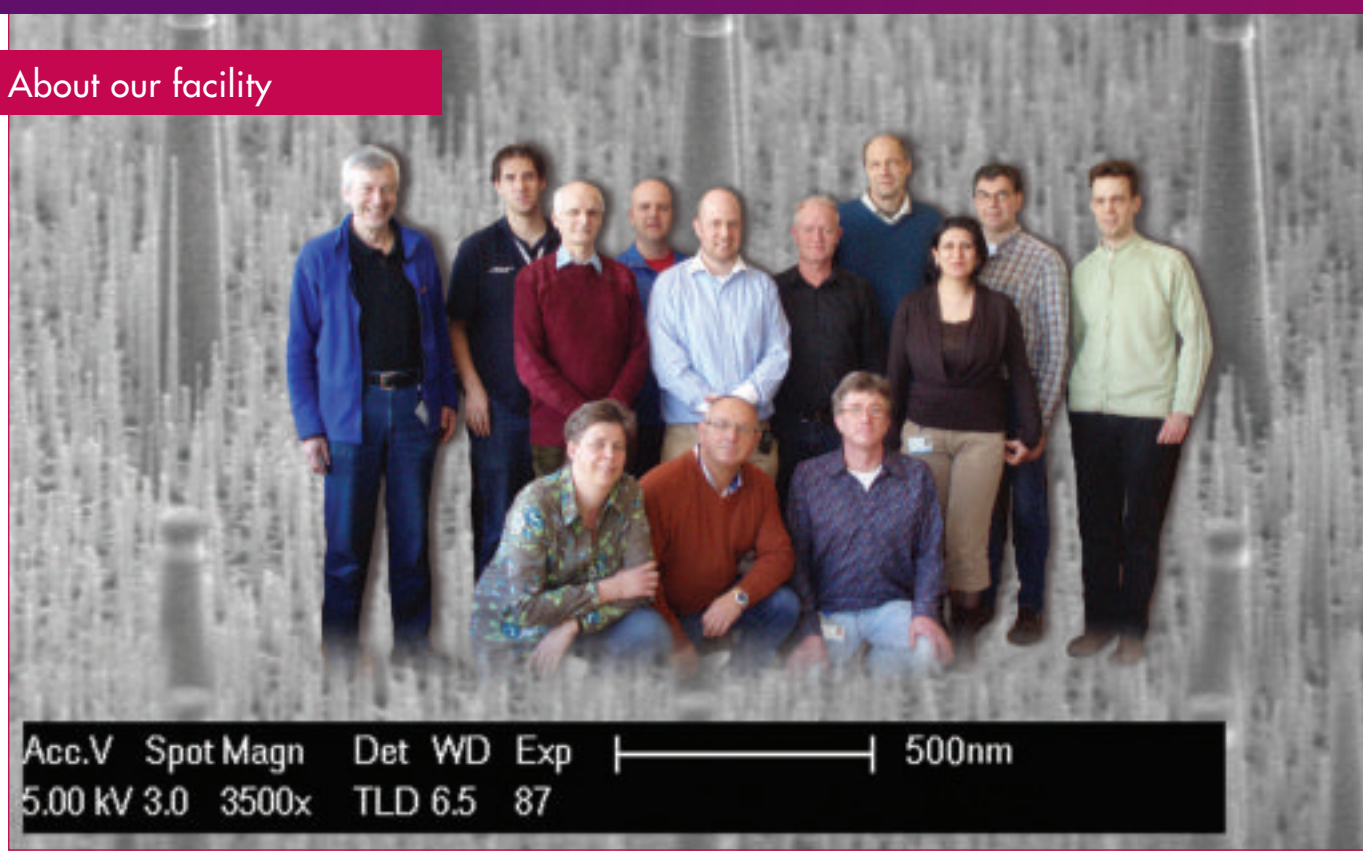
PROF. HANS MOOIJ WINS FRITZ LONDON MEMORIAL PRIZE

The Fritz London Memorial Prize is awarded to Hans Mooij in recognition for his experimental contributions to the understanding of nonequilibrium superconductivity, the properties of superconducting films and junction arrays, Josephson flux qubits, and electron quantum transport in these systems. The Prize will be awarded during the opening ceremony of the 26th International Conference on Low Temperature Physics to be held in Beijing, China August 10-August 17, 2011. •

Hans Mooij

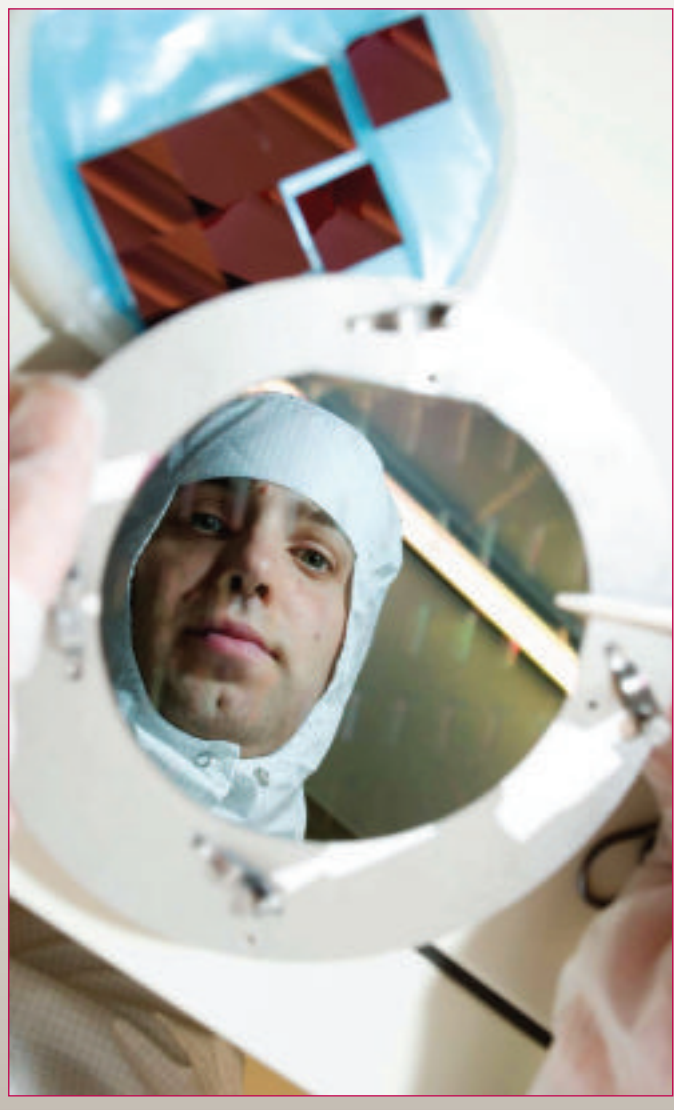
KAVLI NANOLAB DELFT

About our facility



Since May 2009, the Kavli Nanolab Delft has been operational in the new cleanroom environment of the Van Leeuwenhoek Laboratory (VLL). Lab operations are running at full speed now. Central characteristics are a user group of over 200, a 24/7 mode of operation, cutting-edge technology development, and, above all, attention to an optimal work climate with collective responsibilities.

The opening of the Kavli Nanolab on 20 May 2009 was felt as a great relief. After so many delays, hardly anybody could believe how smooth the operational start was. Was it the excess of samples prepared beforehand? Or was there an intentional period of delay to avoid obvious teething troubles? Whatever the reason, since September 2009 we have seen a rapid increase to over 200 students and researchers in this facility, 60% more than before at the previous location. Nowadays you may readily find over 30 people working simultaneously on their functional devices. The nice thing is that it still doesn't look crowded, as the work is distributed over many sections in a total area of 750 m_2. The 50% capacity increase seems sufficient to launch the prominent role nanotechnology is going to play.



Currently the TU Delft users (85% of the total) originate from the faculties of Applied Sciences, Electrical Engineering, and Mechanical Engineering. All departments within Applied Sciences use the facility, with Quantum Nanoscience and Bionanoscience obviously being the main user groups. The Kavli Nanolab has developed into a central meeting point to discuss and share technological experiences.

Almost all of our technological facilities are now efficiently accommodated in a single laboratory. We distinguish between general and specific functional modules, the latter related to research sections, the former for the full community. The real nano-techniques are performed in a low-vibration area. Active anti-vibrational feedback provides the finishing touch where needed. Even with a three-fold increase in wet bench area and 50% more cleanroom area, the energy consumption is still below the level of the previous lab. The key factor here is the novel energy-saving design of the wet benches that provides a five-fold reduction in air consumption when in the rest position.

The Kavli NanoLab at VLL houses several new techniques, thanks to the national NanoLab NL investment program. Typical examples are the Hitachi S-4800 scanning electron microscope (SEM) with sub-nm resolution; atomic layer deposition (ALD) for nano-growth of materials like Al_2O_3, TiN and HfO_2; and Plasma Enhanced Chemical Vapour Deposition (PECVD) for low stress and conformal growth of SiOx, SiNx and SiC layers. Our own dicing facility has also been operational for half a year now.

Thanks to a follow-up investment program (Nanolab NL 2), several other techniques are about to be launched: a low-end cryo-transmission electron microscope (TEM) with technical support for low-barrier access, a Raman microscope for carbon nanotube inspections, and reconfiguration of the oven stack for low-pressure chemical vapor deposition (LPCVD), as well as several other adjustments of existing infrastructure to improve throughput and performance.

Continues on page 9 >

> Continued from page 8

From a technological perspective, the helium ion-beam setup with sub-nm probe size from our partner TNO has arguably provided the most remarkable breakthroughs. Controlled and reproducible nanofabrication in the sub-10 nm range is now in reach. A related development is ultrathin ALD-grown inorganic layers as resist, showing 5nm feature size under He+ exposure. Growth in operations has inherently many positive aspects, but it also generates some concern. It poses stricter requirements to logistics, user support, facility organization and maintenance, and, last but not least, user discipline. Having about 7-10 new users attending the monthly introduction is becoming routine. This growth in volume implies an up to 3-fold increase in hands-on demonstrations where previously a single demo sufficed. Within 2-3 months, all new users return once again to pass their 'driver's license tests'. The concept of a mandatory 'user box' for each user provides convenience and keeps the user database updated.

Fortunately, the size of Kavli Nanolab team keeps pace with the increased usage to some extent. Following beam expert Hozanna Miro, who joined us last year, an experienced thin film expert will strengthen the team later this year. After all, it is the primary aim that the Nanolab team will be a partner in technology rather than playing the role of policeman. Our holy grail is that everybody will adopt the natural discipline demonstrated in training sessions. Only then is the understanding of facility sharing at the right level, making technology great fun!

With 75% of the users related to our Kavli Institute of Nanoscience, this research community is setting the main trends in technological achievements in the Kavli Nanolab. Quantum science and synthetic biology are important drivers. Spintronics, nano-optics, nanomechanics and biomolecular processes are the leading research themes. Typical nanostructures include a variety of single molecule approaches, (functionalized) nano-templates, semiconductor nanowire devices, and carbon-based nanosystems (carbon nanotubes, graphene, diamond). Appropriate interfacing to these nanosystems and material control are the crucial technological challenges, often combining bottom-up and top-down technologies. Kavli Nanolab is continuously working on developing all the essential technologies to pursue its multidisciplinary mission, now and in the future.

• Emile van der Drift

Emile van der Drift

Jan Lipfert

Column

SCIENCE IN THE EXPONENTIAL GROWTH PHASE

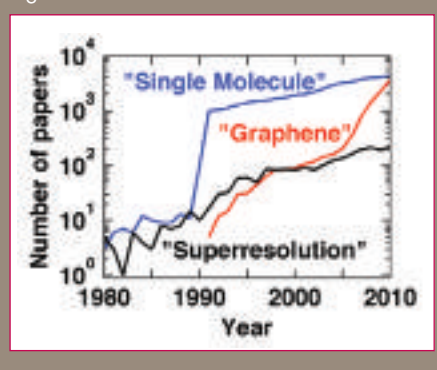
It has become fashionable to show plots with the number of papers in a given field as a function of time; usually to demonstrate the rapid or exponential growth of a particular "hot" field. As a typical example, I have compiled the number of annual papers vs. time for some selected hot topics (Figure 1). Clearly, our Kavli Institute of Nanoscience is well positioned in these rapidly growing areas. For the post docs and junior faculty amongst us, we can only hope that the growth continues long enough for us to get jobs and tenure. For the senior faculty, please contact me if you need a modified version of Figure 1 to impress your colleagues and funding agencies!

However, before we get too carried away with our hot fields, I would like to present you with two caveats. In biology, exponential growth is a common phenomenon observed in cell cultures, with obvious parallels to science. When bacteria (scientists) enter a new batch of culture medium (hot field), initially nutrients (funds) are abundant and competition is scarce. Under these ideal conditions, a constant rate of cell division (graduations) leads to exponential growth. However, sooner or later competition from other bacteria (groups) will become tougher while nutrients (funds) and (lab) space start to become limited. The bacterial culture (scientific field) enters the "stationary phase" (becomes "mature") and eventually faces starvation (obsolescence). The way out, of course, is to find a new habitat (scientific problem). Viewed through this lens, the recent transformations from "molecular biophysics" to "bionanoscience" and from "quantum transport" to "quantum nanoscience" present interesting cases. I imagine that only time will tell whether the new names are a poor choice (since they currently receive about two orders of magnitude fewer hits compared to their old counterparts, see Figure 2) or a brilliant move (if those new fields will turn out to undergo exponential growth in the years to come).

Finally, as a physicist's caveat against taking exponential growth too seriously, an anecdote from my Ph.D. advisor's graduate student days in the 1950s. One of his colleagues noticed that the distance between the front and back pages of the issues of Physical Review1 that arrived bi-weekly in the library was growing exponentially. This colleague extrapolated the exponential growth rate and predicted that by the year 2000, the front and back page of Physical Review (provided continuing bi-weekly publication) would be separating at a speed faster than the speed of light. Luckily, he concluded, this would not pose a challenge to Einstein causality, as the information content of Physical Review would have approached zero long before that time.

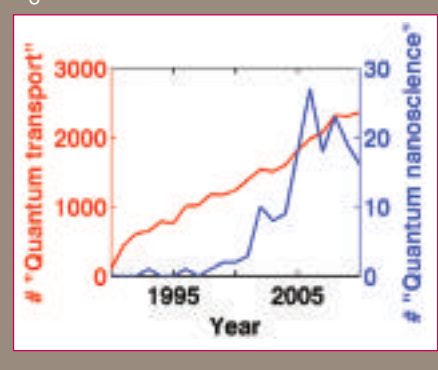
• Jan Lipfert

Figure 1



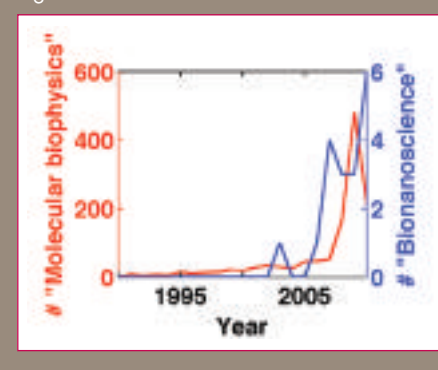
Number of publications in the ISI Web of Science by year for selected topics.

Figure 2



Number of publications in the ISI Web of Science by year for the search terms "quantum transport" and "quantum nanoscience"

Figure 3



And "molecular biophysics" and "bionanoscience"

KAVLI DAY 'ON THE BEACH'

Save the date: September 22

Paul McEuen

ON SEPTEMBER 22, ANNUAL KAVLI DAY WITH SPECIAL GUEST PAUL MCEUEN!

On September 22, 2011 we will have our annual Kavli Day with all employees of the Quantum Nanoscience and Bionanoscience departments. Our special guest of honor this day will be Paul McEuen, the Goldwin Smith Professor of Physics at Cornell University, director of the Kavli Institute at Cornell for Nanoscale Science, and since recently also a celebrated author of a popular scientific thriller. McEuen will present a Colloquium on his research. This exciting day will be filled with science, fun and sports. •

NANOTUBES AND GRAPHENE: BLURRING THE BOUNDARIES OF HARD AND SOFT MATTER

Nanoscale forms of carbon have properties that are characteristic of both soft and hard matter. In many ways, graphene is a "soft" membrane material: a flexible, robust, one-atom thick sheet with bending stiffness comparable to a lipid bilayer. Nevertheless, it has a stretching stiffness comparable to diamond and electronic properties that rival the best "hard" materials. A similar story holds for carbon nanotubes. In this talk we will present new results on the structural, physical, and electronic properties of nanotubes and graphene, emphasizing their dual soft and hard nature. Topics include grain stitching and patchwork-quilt structure of polycrystalline graphene membranes, the effects of thermal fluctuations on the properties of nanotube resonators, and the ultrafast carrier dynamics in nanotube and graphene p-n junctions. In each case, we find that these materials blur the boundaries of hard and soft matter in interesting and surprising ways. •

Paul McEuen
Laboratory of Atomic and Solid State Physics and
Kavli Institute at Cornell for Nanoscale Science
Cornell University

KAVLI DAY 'ON THE BEACH'	
12.30	Lunch at Kurhaus in Scheveningen
13.30	Colloquium by Paul McEuen (Cornell University)
15.00	A variety of activities on the beach
18.00	Drinks, chill & relax
19.00	Barbecue at a beach club
20.00	Announcement of the "Kavli Delft thesis prize"

You will all be officially invited in July. But please make sure you mark this date in your calendars already!