FOM

NWO Physics

The profits of cooperation

About FOM's Industrial Partnership Programmes

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COLOFON

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Contents

A breath of fresh air in physics

The gaping gap that has arisen between fundamental and industrial research needs to be powerfully bridged. We took this task upon ourselves during a conference about the future of Dutch physics, held in Nijmegen in March 2004.

FOM board members and top researchers, including a Nobel Prize winner and several Spinoza laureates, attended this meeting. Representatives from industry, the Technology Commission of the Confederation of Netherlands Industry and Employers, the Netherlands Organisation for Applied Scientific Research (TNO), the technological top institute M2i (former NIMR) and administrators from universities, the Royal Netherlands Academy of Arts and Sciences, the Ministry of Education, Culture and Science and the Netherlands Organisation for Scientific Research (NWO) were also present. Within the space of just two days, this diverse group managed to reach several important conclusions concerning the strategies of FOM and the NWO Physics Division.

Prof. Ronald Griessen, chair FOM

At that time, we concluded that industry had turned its back on physics. Instead of performing its own research, it had appeared both easier and cheaper to simply purchase the knowledge needed. Nobody had realised the danger that soon there might no be longer any staff within the company capable of absorbing the results from new research.

In turn, fundamental science had also turned its back on industry. For decades, fundamental researchers had convinced themselves and each

other that research with a technological perspective was, by definition, not interesting.

During the meeting in Nijmegen, however, there was clearly enough momentum for an effort to reunite the two cultures. Literally. Because if you want to close the gap, you have to meet up with each other regularly. The Industrial Partnership Programmes are a concrete expression of this line of thought. FOM already cooperated with industry, especially with large companies such as Philips and Shell. Despite the financial difficulties we faced in 2004, the Executive Board still decided to make funds available to increase the size and scope of investments in this area. The new form given to this cooperation is based on three pillars: scientifically challenging research with potential for innovations that benefit the economy, matching funding from FOM and the industrial partner, and regular personal contact between the researchers, preferably involving internships and/or research activities on site.

Now, four years later, I am pleasantly surprised about the rate at which these programmes have developed. The research field has proved to be far more creative in finding cooperative partners than I had expected. And companies are apparently willing to bridge the gap financially, in some cases with considerable sums of money. Is there better proof of their commitment?

Of course it is not our intention to convert all physicists into technologists. We shall always continue to strive for a healthy balance between pure curiosity-driven and application-driven fundamental research. The Industrial Partnership Programmes have, however, provided a breath of fresh air in physics. Fresh air that moves with the times. For example among my students, also the really good ones, I notice an increasing commitment to societal issues. Rightly so and very fortunately. After all, our society faces several serious problems that threaten its very existence. Surely it would beg belief if the cream of the class failed to consider such matters occasionally?

I am glad that the young researchers at FOM within the Industrial Partnership Programmes get acquainted with the world of industrial research. This allows them to develop an awareness of what it is to translate fundamental ideas into practical applications. Wherever their future careers might take them, this experience can only be for the better.

Prof. Ronald Griessen
Chair FOM Executive Board

WHAT IS FOM?

FOM is the Foundation for Fundamental Research on Matter, which was founded in 1946 to promote fundamental physics research in the Netherlands. FOM employs around 900 people. It performs research at three institutes (FOM Institute for Atomic and Molecular Physics AMOLF, National Institute for Subatomic Physics NIKHEF in Amsterdam and the FOM Institute for Plasma Physics Rijnhuizen in Nieuwegein) and in research groups at almost all Dutch Universities.

International experts assess the research that takes place within FOM against stringent criteria. It undertakes some of the best fundamental physics research in the world.

Each year FOM turns out about 90 young doctoral researchers. Most of these remain in the research world at Dutch and foreign universities and in industrial R&D. FOM receives most of its funding from the Netherlands Organisation for Scientific Research (NWO) and the FOM Executive Board is also the board for the NWO Physics Division. Further, FOM also receives incomes from partnerships with companies and from European funds. Its total turnover is approximately 80 million euros per year.

WHAT ARE INDUSTRIAL PARTNERSHIP PROGRAMMES?

In 2004, FOM decided to increase its own contribution to the Dutch knowledge economy. It wants to do more fundamental research in areas where there is a high chance of innovations that will benefit the Dutch economy. The Industrial Partnership Programmes (IPP) are an outcome of that decision. In these programmes, FOM researchers work intensively with researchers from industry. They carry out research that offers no guarantees but which could yield groundbreaking innovations.

Conditions

The partners determine the precise design of the programme. There are six basic conditions that all programmes must meet:

- It concerns fundamental research by FOM staff in close cooperation with researchers from one or more companies.
- The programme covers a research area with good prospects for innovations and challenging scientific questions.
- The partners jointly formulate the research objectives.
- Clear agreements are made about the intellectual property rights and disclosure.
- Companies finance at least half of the programme budget[1] *in cash*.
- Each programme budget amounts to at least 1 million euros.

Approach

Proposals for Industrial Partnership Programmes can be submitted at any time; there are no deadlines.

Each Industrial Partnership Programme starts with a good match between academics and the private sector. FOM has appointed two programme officers with industrial work experience to help the parties find each other. They play an active role in establishing contacts between professors and industry,

[1] This contribution includes 15% overhead costs, excluding Dutch VAT.

as well as providing expert advice and support during the formulation of a joint programme proposal.

This proposal is assessed by experts from the Netherlands and abroad. This guarantees a very high scientific level. Ultimately, the Executive Board of FOM decides whether a programme should be funded (see the diagram on page 36 for the exact procedure). If a proposal is approved then the professor concerned will be responsible for recruiting suitable PhD students and postdocs. They will be employed by FOM on a temporary basis. The consortium will decide where the research is to take place: at the university or in a FOM institute, at a company or at a combination of locations.
The programme officers also encourage industrial partners to start a research programme parallel to the IPP.

An Industrial Partnership Programme is led by a programme committee, in which representatives from all participants in the consortium are present. The FOM Bureau provides a programme officer, who supports the committee in safeguarding the scientific progress and supervises good cooperation and compliance with contractual agreements. Wherever possible, the partners are relieved of practical tasks.

Open and closed
Industrial Partnership Programmes can be open or closed. In a closed programme, all of the projects are already defined when the application is submitted. The consortium is therefore already established. In the case of an open programme, a call for proposals is held. All Dutch researchers can submit proposals for research projects within the theme defined in the programme. International experts then assess individual projects instead of the overarching programme proposal. The best of the projects assessed are funded.

Budget
Each year FOM makes 3 million euros available for Industrial Partnership Programmes. Together with the contributions of individual companies this, therefore, provides a research budget of at least 6 million euros per year.

TRAINING OF EXPERTS ESSENTIAL FOR RETAINING DUTCH RESEARCH CULTURE

Original contributions based on knowledge

'The Industrial Partnership Programmes demonstrate that it is perfectly possible to consolidate strengths', says Dr Peter Wierenga, chief executive officer at Philips Research. 'We ought to take this sort of initiatives far more often; then we could promote the Netherlands as an innovative country and strengthen our international competitive position. In the Netherlands we are not particularly motivated by the challenge of increasing a factory's productivity from 98 to 99 percent; other countries are far better at that. We need to get the most out of innovation, as that is what we excel in. However, our efforts are too fragmented and, therefore, fail to present the Netherlands as an innovative country to the world. We need to pluck up courage to look and act beyond the boundaries of our own organisations. FOM and Philips have already demonstrated that this is possible.'

Silke Diedenhofen (FOM PhD student, left) and Dr Peter Wierenga (Philips)

Friendship

Philips and FOM have enjoyed a close friendship since the founding of FOM in 1946. Many former FOM PhD students find a job at Philips Research. They are most welcome there says Peter Wierenga. 'With a FOM researcher you know that you will not get an ivory-towered academic walking into your lab. In terms of personality they are often more mature than other PhDs. They have clearly not been left in an isolated corner doing doctoral research for four years without anyone else taking an active interest in them.' However, real cooperation between two organisations requires far more than just friendship. Wierenga: 'With the Industrial Partnership


PHILIPS

‘THE PROGRAMME SUPPLIED THE FIRST PATENT APPLICATIONS AMAZINGLY QUICKLY’

Programmes the contacts have become less informal. A FOM group has now taken up residence on our campus. These young researchers remain real scientists, but they are embedded in an industrial environment and are fully involved in the life of the laboratory. Following some initial teething problems, this symbiosis now works superbly. The programme has already delivered the first patent applications. Moreover, the FOM group are masters at profiling themselves; contacts have already been made with other groups, cross-links that we would not have otherwise thought of. Who knows, these contacts might also yield some interesting results. In this setting we can realise breakthroughs that would otherwise have remained beyond our reach.’

Typical Dutch

Other than breakthroughs and patents, the training of experts is also an important objective for Philips in the programmatic cooperation with FOM. Wierenga: ‘A few years ago we started to recruit foreign specialists out of sheer necessity. We certainly do not regret the fact that the community here has become more international. But the proportion of people here that are trained far away from the Netherlands should not reach 90 percent. There is still something of a typical Dutch research culture that we would like to retain. The traits? A flat organisation, where people can easily talk to each other, do not hide things for their own sake, and dare to take initiatives. In short: creative, flexible and focused on cooperation. Such a climate enables us to realise our ambitions: doing things that have not been done before. That is how you obtain originality on the basis of deep scientific insights.’

Silke Diedenhofen is a PhD student at the FOM Institute for Atomic and Molecular Physics and is based at the High Tech Campus of Philips.

I really appreciate such flat organisation

'I came from Germany to the Netherlands because my husband got a job here. When I heard about this FOM-Philips vacancy, I immediately became enthusiastic. During the four years of my PhD research I have become intimately acquainted with two worlds. We work on the Philips campus four days a week, and one day per week we are in Amsterdam. At AMOLF they ask: is it novel? At Philips they ask: what are the costs and what can it be applied to? I learn things from both worlds. It is fantastic that, at the Philips laboratory, your neighbour might be a chemist or a biologist. We happily mix with each other and the tone is informal. The contact between you and your professor/boss is far greater than in Germany. Thanks to the approachability of people here you can learn a lot.

Each morning I leave home at 07.00 and I am not back until 20.00 in the evening. It is a tough schedule but definitely worth the effort. We are performing optical measurements on nanostructures such as nanowires and optical antennae. Nanowires are ultrathin wires with a diameter of 10 to 100 nanometres. Nanowires are currently a hot topic throughout the world. Their successful application would make it possible, for example, to produce light of a higher intensity. At Philips we have access to a fantastic infrastructure that a university could never afford. I really enjoy that. And it increases the chance of finding something special. Of course you always hope that one day you will observe something that nobody else has ever seen before.'

Programme:	Microphotonic light sources
Partner:	Philips
Commitment:	3 postdocs, 2 PhD students, 1 technician, 1 group leader, 1 professor
Locations:	FOM Institute for Atomic and Molecular Physics in Amsterdam and on the Philips campus
Duration:	2005-2010
Total investment:	1.7 million euros, plus 3.3 million euros in kind by Philips

BLAZING THE TRAIL WITH SOLAR CELLS

A revolution or nothing

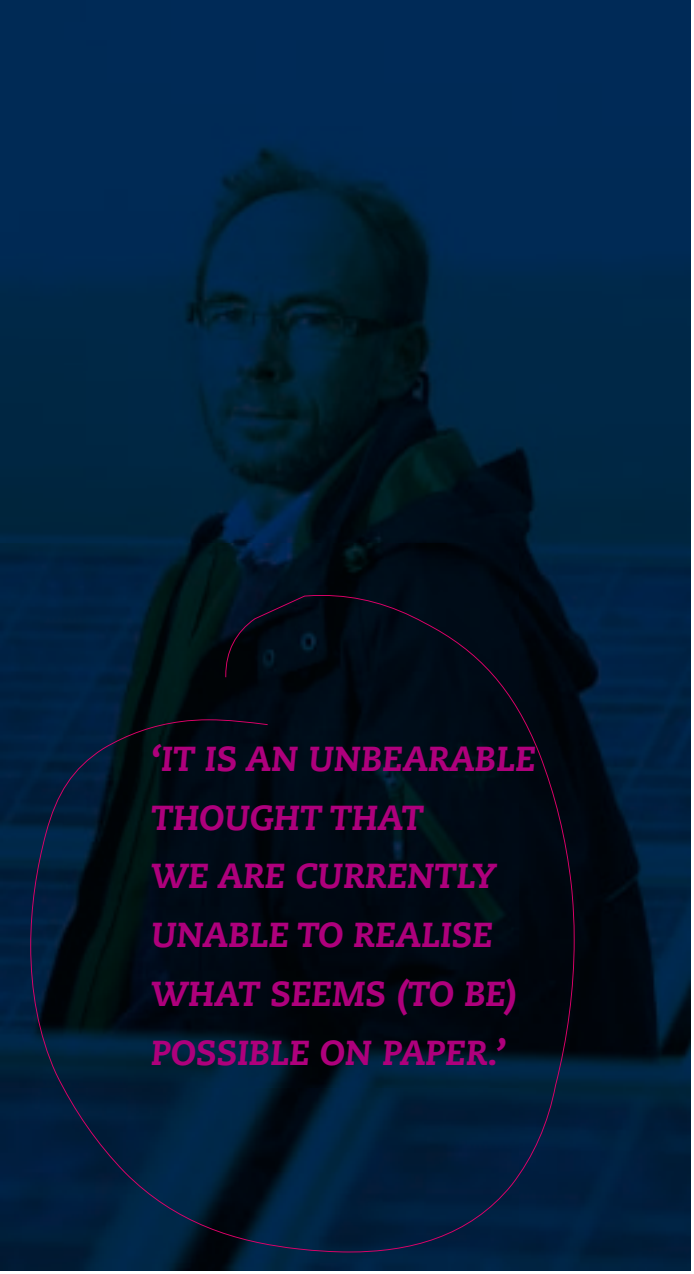
‘It could all be futile’, says Prof. Wim Sinke, senior researcher solar energy at the Energy research Centre of the Netherlands and chair of the Joint Solar Programme, ‘all of the experiments, workshops and money’. ‘That is, if a directly applicable result were the only objective. However, if you never investigate anything, you can be sure that you will not find anything. And our research could potentially cause a revolution. It might enable us to manufacture a new type of solar cell that is either very cheap, highly efficient or both.’ Sinke quickly adds that of course research is never really in vain. New knowledge is always acquired. This may be useful at a later date and perhaps in a completely different area.

Intolerable

The Joint Solar Programme is an open, high-risk Industrial Partnership Programme which searches for fundamentally new ways of converting light into electricity. Everyone who has a good idea in this area can submit a proposal.

Prof. Wim Sinke (ECN)

Silicon solar cells convert up to 25 percent of the sunlight into usable energy, and that is quite close to the estimated upper limit for this material. The world record for highly advanced cells based on a combination of different semiconducting materials is about 43 percent. A wealth of unbelievably advanced technology and process control lies behind both figures. However, physics shows that the theoretical maximum yield for the conversion of light into electricity is much higher still. ‘It is an intolerable thought that we currently realise far lower yields than would appear to be possible on



paper. In the Joint Solar Programme we are exploring the boundaries of what is possible, or better, what could be possible. We are looking for both new methods to convert light into electrical energy and for new materials to make this process cheaper, electronic plastic for example.’

Just in time

The Industrial Partnership Programme was developed in 2004 out of the notion that part of the research spectrum was missing in the Netherlands. Although a lot of good work was being carried out on the technological development of solar cells, too little was being done at a fundamental level. And without these new fundamental insights, you cannot play a significant role in international solar cell research in the longer term. ‘It would be utter folly’, says Wim Sinke, ‘if the cream of scientists worldwide were involved in this and we failed to keep pace, despite the wealth of knowledge we possess in the area of solar energy.’ Fortunately, the Netherlands responded just in time. FOM and the Shell Research Foundation were prepared to finance fundamental research into solar cells on a fifty-fifty basis. Sinke is the programme committee’s chair. That will be an administrative challenge: all these researchers from different disciplines, open tenders and international committees, who assess the proposals. On the contrary, says Sinke. ‘On top of my other work at ECN, I have no time whatsoever for practical issues. However, FOM takes care of such matters superbly so I do not have to worry about them. This means: little hassle but lots of benefit.’

Reassuring

A unique aspect of the Joint Solar programme is that Shell is a partner that is fully aware of the essence of fundamental research, how long it takes and the risks involved. Clichés about industry versus academia do not apply here. Sinke: 'The Shell people allow us breathing space. They try not to be too sensitive about keeping things secret with a view to patents. And they do not continually hassle us about when something will be ready. They are also researchers in heart and soul. They do, however, have a different perspective and pose different questions than academic scientists would. This exchange is extremely useful. Sometimes the industrial researchers ask for applications, whereas you are not focussing on those yet yourself. Sometimes they also protect people from themselves. Dutch researchers are so trained these days – almost deformed – to continually indicate any potential applications in sight. Not everyone can cope with that. It is then very reassuring if somebody from industrial research says: *I want you to find out exactly what is going on here; we will discuss the applications at a later date*.'

Legendary paper

It is too early yet to say whether the Joint Solar Programme will pay off. According to Sinke: 'We have a fantastic starting point though. Thanks to this programme, research groups, which previously did other things, are now working in this area. We have succeeded in bringing the cream together which is hardly surprising, as the study of solar cells is an attractive area for scientists. You are putting your efforts into something useful, without having to compromise your purely scientific ambition. Because that one legendary paper about solar cells that hundreds of scientists will soon be citing is just around the corner, even if we do not yet know where that corner is. Fingers crossed that it will be in the Netherlands.'

Programme:	Joint Solar Programme
Partners:	Shell, NWO Chemical Sciences
Commitment:	11 PhD students, 8 postdocs, 2 technicians, 7 professors
Locations:	FOM Institute for Atomic and Molecular Physics, Delft University of Technology, Utrecht University, Eindhoven University of Technology, University of Groningen
Duration:	2005-2010
Total investment:	3.2 million euros

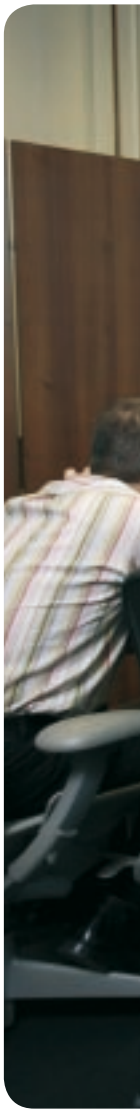
HIGH TECH COMPANIES NEED OPEN INNOVATION MODEL

An expansion of brain power

‘Sometimes you need to take a plunge’, says Dr Frank de Jong, advanced technology manager at FEI Electron Options. ‘If you never undertake high risk research, you will never manufacture anything that keeps you one step ahead of competition.’

A medium-size company such as the American/Dutch concern FEI does not automatically participate in high risk fundamental research where, by definition, the outcomes are not clear in advance. In October 2007, FEI signed a contract for an Industrial Partnership Programme with FOM. ‘As a high-tech company you cannot permit yourself just to do things you know will succeed’ explains Frank de Jong. ‘We have done our utmost to maximise the chances of a positive outcome of this project. And if it bears any fruit, it will give an enormous boost to our competitive position. I have high expectations for the programme but we will see what happens; in four years time we can draw up the balance.’

Dr Frank de Jong (FEI Company)



Cars

FEI manufactures electron microscopes that are sold to laboratories and microelectronics producers throughout the world. Nowadays, clients expect far more than just a microscope. De Jong: ‘If you could make an engine and tyres 120 year ago then that was sufficient to market a car. Now you need to know all about car radios, airbags, navigation systems and so forth. Something similar is happening with electron microscopes. We are continuously looking for adjacent fields where we can provide added value for our clients. For


QUANTA 3D FEG

‘DUTCH RESEARCHERS ARE GLAD TO DO EACH OTHER A FAVOUR; IT IS RARE THAT ONE WINS AND THE OTHER LOSES.’

example, with the equipment we currently supply it is not only possible to examine the smallest structures, but also to process these. Or you can analyse a laboratory sample with the help of X-rays.’

Commercial spirit

FEI therefore needs an ever-increasing amount of know-how across a gradually growing area in order to keep up with its clients’ high expectations. ‘We can no longer do that by ourselves’, says De Jong. ‘Certainly not the fundamental part; it would be pure arrogance to think that we are the best in that.’ FEI feels comfortable to work in the ‘open innovation model’, which Dutch employers and the Dutch government have passionately campaigned for in recent years. The open exchange of knowledge between public and private partners from different countries is the key objective within this approach. De Jong: ‘By working together with scientists we enable ourselves to considerably expand our brain power. We are always on the look out for suitable partners. With this approach the Netherlands is one step ahead of the crowd. This is not so much due to the high scientific level, you can find that elsewhere as well, but to the pleasant atmosphere of cooperation here. People are glad to do each other a favour; it rarely occurs that one party wins everything and the other loses the lot. Our American colleagues are amazed by this culture. Perhaps this mentality is a remnant of the Dutch commercial spirit.’

New sources

About 18 months before the start of the programme, FOM and FEI jointly organised a workshop about subjects related to electron microscopy. FOM invited researchers from all relevant academic

groups in the Netherlands to this event. At this meeting, a host of new contacts and ideas arose that were further explored in the subsequent months. Eventually, this resulted in an Industrial Partnership Programme, in which FEI has FOM as a partner but works with various research groups. Amongst others, experiments are being carried out with new sources of electrons and ions that might make the microscopes far more powerful. Research is also taking place into photonic structures at the nanoscale, and tomography: the imaging of 3-D structures. This part of the programme could lead to new software that might extend and improve the applications of electron microscopes.

Having a chat

Several conditions need to be met before a company thinks it worthwhile to participate in an Industrial Partnership Programme, says De Jong (see box top right). One of the most important of these is that a company must also employ experts that have sufficient knowledge to converse with the scientific researchers on an equal footing. FEI has assigned four senior scientists to act as contact persons. About once every two weeks they spend a day in the laboratory of the so-called scientific partner. 'We had previously carried out technological projects with researchers in which user committees met several times per year. You briefly meet up, attend an informal presentation, everyone thinks its fantastic and subsequently people go their own way. Now we do not just have a brief half-hour chat; we spend the whole day talking to each other. The exchange of information is more profound; you get a better feeling for what is going on, can exert more influence and you gain more from the partnership.'

TIPS FOR COMPANIES WHO WANT TO COOPERATE WITH UNIVERSITIES

- An innovative company must take the plunge and should undertake high risk research
- Choose a subject of strategic importance
- Ensure that the research is embedded in the overall research programme
- Search for a group that really is prepared to enter into a partnership with industry
- Do not look too far away from home, geographical proximity is important
- Do not focus solely on the scientific level, but also on the research culture
- Make sure you have your own specialists that are of a sufficient level
- Allow your own experts to be actively involved in the research
- Arrange the intellectual property rights in such a way that you may pluck the fruits yourself

Programme:	Microscopy and modification of nanostructuring with focused electrodes and ion beams
Partner:	FEI Company
Commitment:	8 PhD students, 2 technicians, 4 professors
Locations:	Delft University of Technology, Eindhoven University of Technology, FOM Institute for Atomic and Molecular Physics
Duration:	2007-2011
Total investment:	2.7 million euros

HAVING A GRIP ON A SWIRLING MASS

Bubble dynamics

‘Contact with industry gives pure fundamental research new impulses’, according to Prof. Detlef Lohse, professor of Physics of Fluids at the University of Twente. ‘It confronts us with stimulating scientific questions.’ He gives three-phase flow as an example: a turbulent mix of fluid, bubbles and particles. The behaviour of bubbles in turbulence and the behaviour of particles in turbulence had both been already studied, but the combination of all three had never previously been studied at a fundamental level. No wonder, as the system is so complex and yields so much data that it cannot be described or analysed in scientific terms. A computer would need thousands of years to calculate the rapidly changing positions of all of the particles in such a turbulent mixture.

One bubble

Roger Jeurissen (FOM PhD student, left) and Prof. Detlef Lohse (University of Twente).

Still, gaining an understanding of the interaction between particles and bubbles in turbulence is important for industry. Lohse’s group is now attempting to distil a simplified entity from this complex system, which can still be captured in an algorithm that is experimentally verifiable. At the University of Twente they have an 8-metre high bubble column for such experiments. Soon they will also be acquiring ultra-rapid cameras, which, with a speed of tens of thousands of images per second, can record what occurs and then display this in slow motion. Have there been any successes to date? Yes, says Lohse. ‘Within such a turbulent, swirling mass we are starting to gain a fairly good idea as to which forces affect a single bubble. Now we are taking it a step further by examining the interaction between bubbles.’

'PREVIOUSLY, CONTACTS WITH INDUSTRY WERE ALMOST CONSIDERED DIRTY, NOW EVERYONE FINDS THEM STIMULATING.'

Ink jet printers

Detlef Lohse is involved in various Industrial Partnership Programmes on FOM's behalf: investigating bubble flows with AkzoNobel, Corus, DSM and Shell (see also page 28) and various projects with different companies clustered in 'Dispersed multiphase flow': research into the behaviour of drops, particles and bubbles in fluids. Insights from this diverse programme can, for example, be applied in the oil industry but also in the manufacture of creams and foodstuffs. They also came in handy to improve the performance of ink jet printers. A persistent problem that occurs is that the ink heads become blocked by small bubbles that develop in the ink. Researchers from the Department for Physics of Fluids, partly based at Océ, are trying, together with the industrial researchers, to overcome this problem by either preventing the formation of the bubbles or by getting rid of the bubbles quickly.

Number theory

Although Lohse is a warm proponent of targeted cooperation with industry, he expects that revolutionary discoveries will come from a different angle. 'Real innovation is unpredictable. When Einstein devised his theory of relativity, he did not envisage that this would lead to the GPS system some hundred years later. Or who would ever have thought that number theory would one day prove to be practically relevant? Now it is used on a large scale by banks to transmit protected data. And even our own concepts, which were found to be relevant for ink jet printers, arose from fundamental research. The fundamental new insights come from open research that has no specific direction and is not limited in any way whatsoever. We must never throw that type of research overboard,

because, in the longer term, it is also important for our knowledge economy. Contacts with industry, however, are valuable due to the stimulating questions with which they give free research a new impulse. And also due to the direct societal contribution, and because they smooth the path to a working environment for students and PhDs in which they feel comfortable.'

Dirty

A good mix between academic and applied research is Lohse's ideal. 'I believe that, by now, this is something we all agree on as well. The culture within the physics community has changed with regard to this. Several years ago, contacts with industry were considered to be almost dirty by some. Presently, everyone experiences such contacts as stimulating. This is what the then Board of FOM intended and this has now been achieved, by means of discussions, financial incentives and the initiation of the Industrial Partnership Programmes. I am pleased about this. It is far healthier than when you completely shut yourself off from society as a scientist.'

Roger Jeurissen is a PhD student at the Department of Physics of Fluids at the University of Twente and has worked on site at Océ in Venlo for the past three years.

Like a child in a sweetshop

'Printers are not really my thing but attractive technology is. For Océ, technology is the most important competitive factor and so I am in the right spot. Here you walk around like a child in a sweetshop.

What I find so interesting about industry is that companies come with exciting new problems. A company that encounters a problem will, first of all, look for relevant publications. If none can be found, they will contact us. Therefore, it is often uncharted territory. Furthermore, it also has "societal use". Such an abstract idea does not particularly grab me. I much prefer solving a problem for someone awaiting the solution. Here at Océ an increasing number of people are approaching me with questions. I can often help them to clarify a problem. This gives me a sense of gratification; I like to make people happy.'

Programme:	Dispersion multiphase flow
Partners:	Technology Foundation STW, Corus, AkzoNobel, DSM, Marin, Shell, Unilever, WLI Delft Hydraulics, Océ, Twister, Unilever, TNO, Yara
Commitment:	25 PhD students, 5 postdocs, 11 professors
Locations:	University of Twente, Delft University of Technology, various companies
Duration:	2000-2007
Total investment:	4.8 million euros

WHY PARTICIPATE IN INDUSTRIAL

ADVANTAGES FOR INDUSTRIAL PARTNERS

- You remain on the cutting edge of know-how
- You gain the chance to acquire important patents
- You gain access to top level knowledge and research instruments
- Problems within your company can be tackled at a fundamental level
- Research themes you find interesting are embedded in an academic environment
- You educate young experts in a research field of interest to you
- You come into close contact with potential new employees
- You perform research of an outstanding level
- The research costs are far lower than if you were to do the work in-house
- You strengthen your scientific networks and access to adjacent fields
- Via a single point of contact, you gain access to an active network of physicists; you conclude a single contract with FOM and then you are free of any further administrative hassle
- You strengthen your company's visibility and reputation

INDUSTRIAL PARTNERS

PARTNERSHIP PROGRAMMES?

ADVANTAGES FOR ACADEMIC PARTNERS

- You perform research that benefits society
- You increase your budget for fundamental research
- You come into contact with challenging scientific problems from industry
- You can experiment in an industrial setting, in an infrastructure that is often more advanced and of higher quality than a university's
- You enrich the training of your doctoral researchers and students
- You enhance your reputation with potential industrial clients
- You lay a foundation for further application-driven research, for which a lot of government subsidies are available

ACADEMIC PARTNERS

BREEDING GROUND FOR MUCH-NEEDED BUBBLE RESEARCHERS

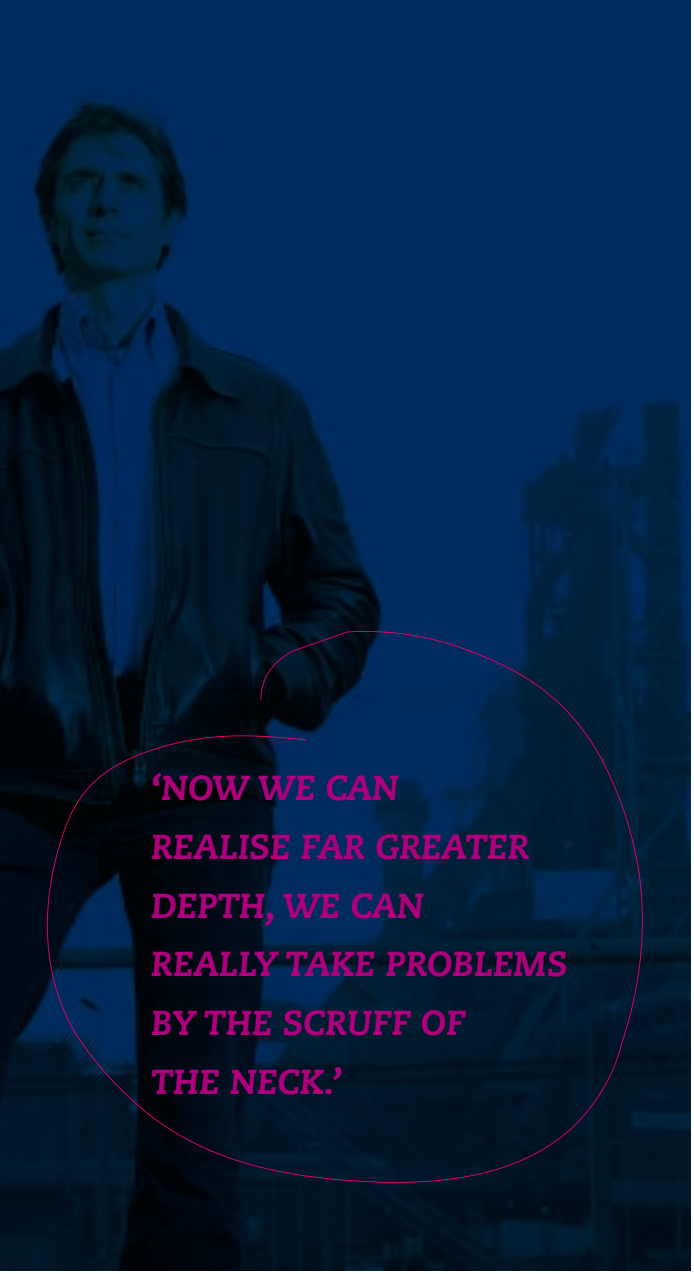
Bubbly flow

The availability of well-trained experts is by far the most important reason for Corus to remain in the Netherlands, says Dr Tim Peeters, group leader Computational Fluid Dynamics at Corus Research in IJmuiden. An industrial complex such as Corus, with its enormous blast furnaces, steel and rolling mills and cladding lines, cannot simply be relocated to a different country. However, the labour costs here are high and the government imposes stringent conditions with respect to the environment. 'The handful of industries that are still located here have to compensate for this by realising a high production quality, which entails an outstanding control of the processes. And that can only be realised with well-trained specialists.'

Mixing steel

Dr Tim Peeters (Corus)

The need to train the desperately needed specialists, is one of the reasons why Corus became a participant in the recently started Industrial Partnership Programme *Fundamentals of heterogeneous bubbly flow*. Researchers from academia and industry are cooperating in this programme to gain a better understanding of the behaviour of bubble flows. A better understanding can in turn lead to improved products. Bubbles are essential during the manufacture of steel, says Peeters. 'We use them to bring about chemical reactions and we inject them to 'mix' the liquid steel so to speak'. But how much should we inject, how large should the bubbles be and how long should we continue for the best result? Our production processes take place on a very large scale; we are not interested in one, ten or a thousand bubbles but far more.



We cannot simply just experiment. If we want to achieve something, we need to provide strong arguments for our experiments. Presently we are not well enough acquainted with how gas and fluid interact with each other in large systems.’

Bubble behaviour

The study of bubbly flows is a classical research field. For the past thirty years researchers have been trying to gain an understanding of bubble behaviour. In recent years, however, advanced research techniques have become available. Now we actually have a chance of making a big step forwards. The programmatic partnership between FOM and four companies – AkzoNobel, Corus, DSM and Shell – each of which in their own way use bubbles in their production processes, provides an outstanding framework for this, says Peeters. ‘At last critical mass is being given to research into a fundamental problem that would otherwise have landed on the shoulders of one or two PhD students. Then you would get bogged down in individual projects, small steps; and after each project you would lose precious time looking for new resources. Now we can realise greater depth, we can really take problems by the scruff of the neck. And there is real interest in the subject. That could, for example, be seen at the very first meeting of all project partners. The focus, at such events, is often on the practical agreements you want to make with each other. In this case, however, a heated discussion about the subject matter took place straightaway. For the PhD students, who had scarcely started their research, it was something of a baptism by fire I believe. Yet such a debate is challenging.’

Peeters acknowledges the cultural differences between academia and industry. 'In academia the culture is more informal and the plans less strictly defined. Related to this is the fact that loose ends are not tolerated at universities. We are more pragmatic, are satisfied with a solution that is sufficient in practice, even if we have not fully understood the problem at a theoretical level.'

People

Peeters thinks that the biggest asset of the programme is probably the structural contact that occurs between experts from different perspectives – physics and chemistry, the steel industry, oil recovery and the chemical industry – who are all working on the same problem. 'Those contacts were present in the past but remained limited to the management level. That was a pitfall, because knowledge is filtered if all of the contacts are maintained by one person. Only when you bring together all the experts in a specific field, can progress be made. The real exchange of knowledge does not occur via reports and books but via people.' This is also why the PhD students do not remain in their own laboratories but undertake internships at the participating companies. This provides a different form of contact altogether from just coming together for seminars, however often such seminars might take place. 'Only once they have been here for a while, do they develop a feeling for the pivotal problems, and we gather an idea of what their capabilities are.'

Major step

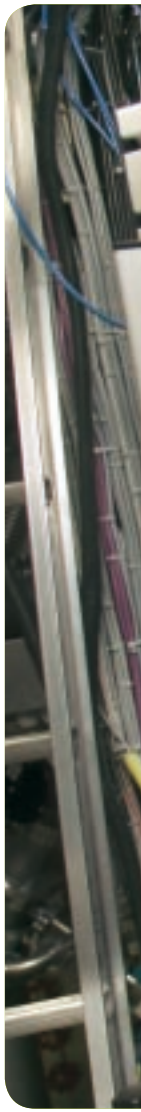
Gaining an idea of PhD students' capabilities is an important secondary objective of the partnership programme: the training and recruitment of good experts. 'We do not just get the specialised doctoral researchers from FOM here, who we can initiate into our problems, but our contacts with the academic world also reach out to the students. And bear in mind: if we all are capable of making this major step forwards then we can produce better products against a lower cost price. This strengthens the competitive position of Corus and that of our customers and suppliers, which is no small matter when you realise this easily concerns some 100,000 jobs.'

Programme:	Fundamentals of heterogeneous bubbly flow
Partners:	AkzoNobel, Corus, DSM, Shell
Commitment:	4 PhD students, 2 professors
Location:	University of Twente
Duration:	2007-2012
Total investment:	1 million euros

FULL SPEED AHEAD TO A NEW GENERATION OF WAFER STEPPERS

Ultraviolet adventures

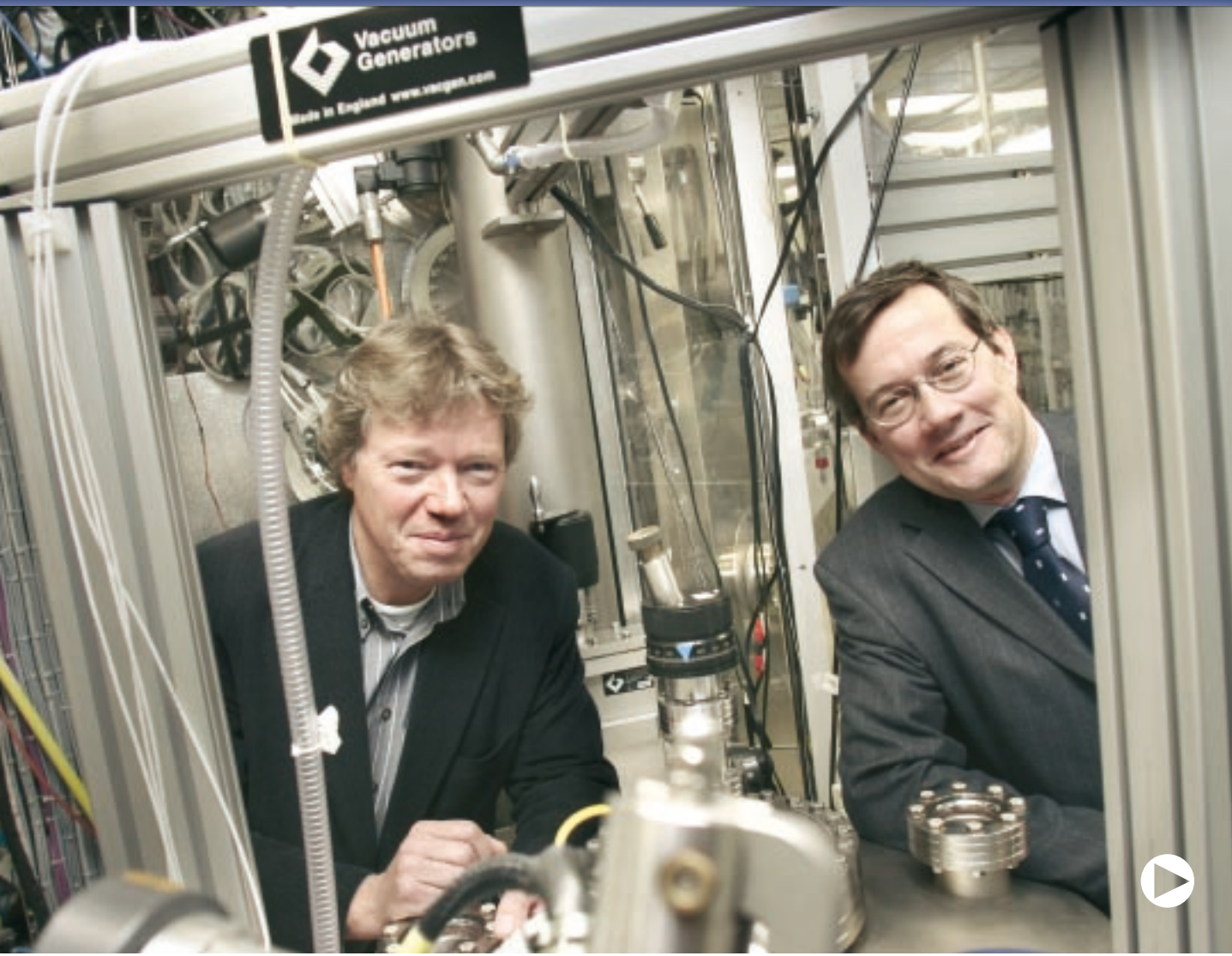
‘Cooperating with industry is exciting’, says Prof. Fred Bijkerk, from the FOM Institute for Plasma Physics in Rijnhuizen. ‘You cross the boundaries of your own discipline and enter an obscure area where there are high stakes for your partner. Something might work superbly in the laboratory but then cannot be scaled up to an industrial product. Does it have potential as an application? How much work will be involved in realising this? Is it worth the effort? Before you can make a reasonable estimate of this, you really need to familiarise yourself with an industrial environment and find some enjoyment in that. Only then can you develop a healthy physical intuition for the area between papers and demos on the one hand and successful applications on the other. You need intuition, but also a good dose of recklessness. As my former professor used to say: if you keep both feet firmly on the ground, you will never make a single step forwards.’



Prof. Fred Bijkerk (Rijnhuizen, left) and Dr Stephan Muellender (Carl Zeiss)

World record

The combination of empathy, intuition and recklessness has worked out well for Bijkerk and his German industrial partner Carl Zeiss SMT AG. They hold the world record for the reflection of extreme ultraviolet light. For those who do not know what this involves: it concerns mirrors for the latest generation of wafer steppers, i.e. machines used to make chips in the electronics industry. Costs: a tidy 27 million euros per machine.


Vacuum
Generators

Spark

One way of making even smaller structures in the future is to image the chip structures with extreme ultraviolet light. This has a wavelength of 13.5 nanometres. To realise this, wafer stepper mirrors reflecting enough of this ultraviolet light, need to be incorporated into the machines. Ordinary mirrors reflect just 1 percent of this light. Rijnhuizen and Carl Zeiss have managed to produce a mirror of one hundred extremely thin layers, which reflect not 1 but 70.2 percent of the ultraviolet light. Such mirrors have been used in the first prototypes of the new generation of wafer steppers. ‘It is fantastic to witness that this works,’ says Fred Bijkerk. ‘And I am not the only one that feels this spark of excitement. All of my PhD students get a kick out of seeing that their research is being used in such a large and complex machine.’

Bijkerk has always been interested in cooperating with industry. Even before he gained his doctorate as a physicist, he approached Carl Zeiss at the start of the 1990s to convince them of the applicability of his work. As a pioneer of this approach, he is pleased that FOM has set up the Industrial Partnership Programmes. ‘With this initiative, FOM demonstrated for the first time that it is committed to making industrial applications part of the entire research terrain. In my view, this is a completely new approach and I am very glad about it; it is great if your own organisation creates the space for something that you find important and stimulating yourself.’

Fast

Meanwhile much still needs to be done before the new wafer steppers can be profitably marketed.

Bijkerk: 'You are continually confronted by new obstacles. The current mirrors become soiled too quickly and then gradually fail to function. That is simply not acceptable for such an expensive machine. Our aim now is to ensure that the mirror functions for at least 30,000 hours before it needs to be cleaned. This, once again, raises new and exceptionally interesting fundamental questions about the physicochemical processes underlying the contamination. And what is so great about working with industry is: once a problem has emerged then no amount of costs or effort are spared in finding a solution. Whereas before we only had our own laboratory, now we can go to Berlin and carry out large-scale experiments with the most advanced equipment.' Because a solution must be found, and fast. 'Research results are more or less ripped out of your hands to be applied. Even though we do not understand everything and even if there are still some loose ends. "We'll sort that out along the way", the partner calls. That is just part and parcel of the game. Exciting.'

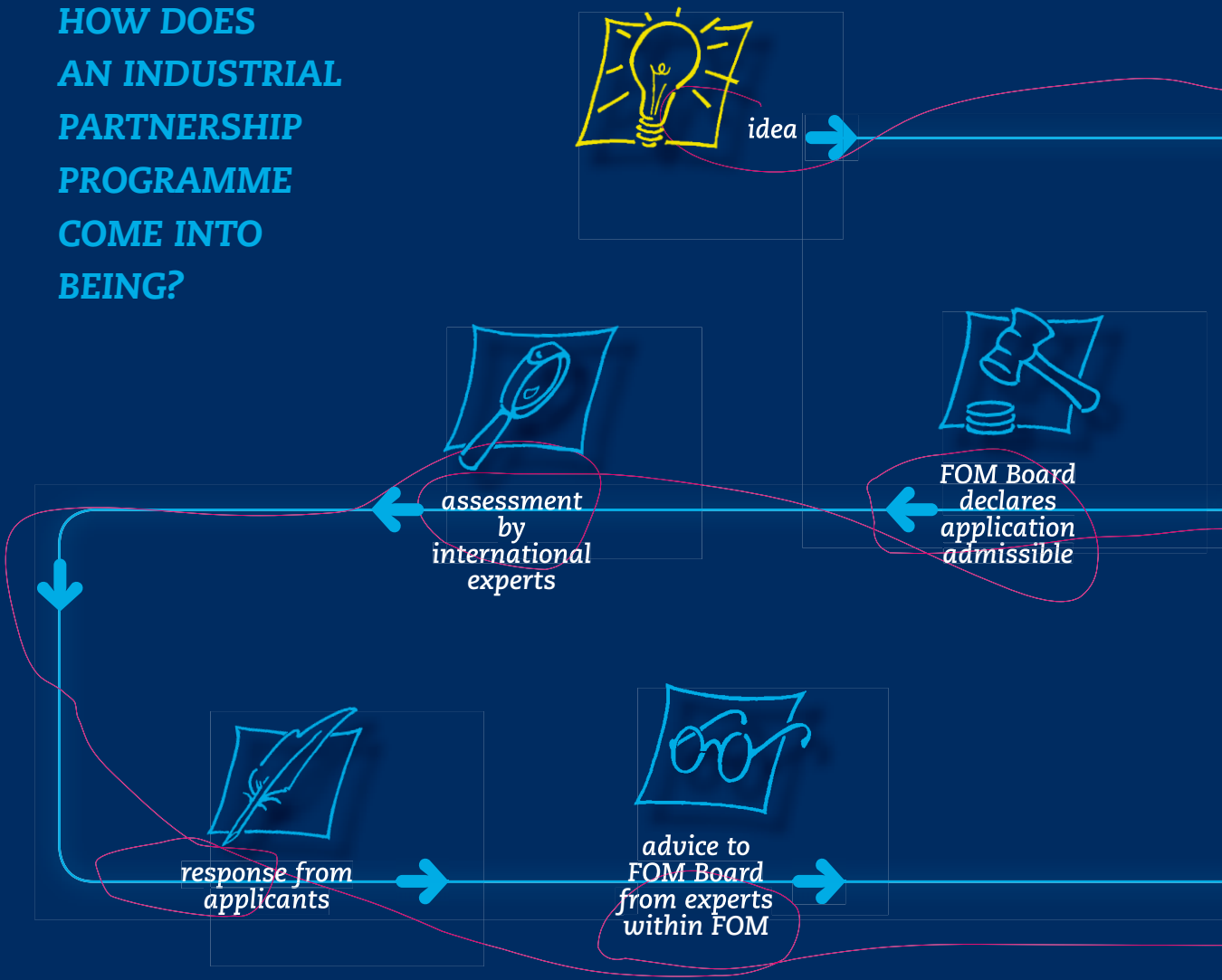
Dr Stephan Muellender is team manager coating development at Carl Zeiss SMT AG, a German manufacturer of lenses and optical instruments

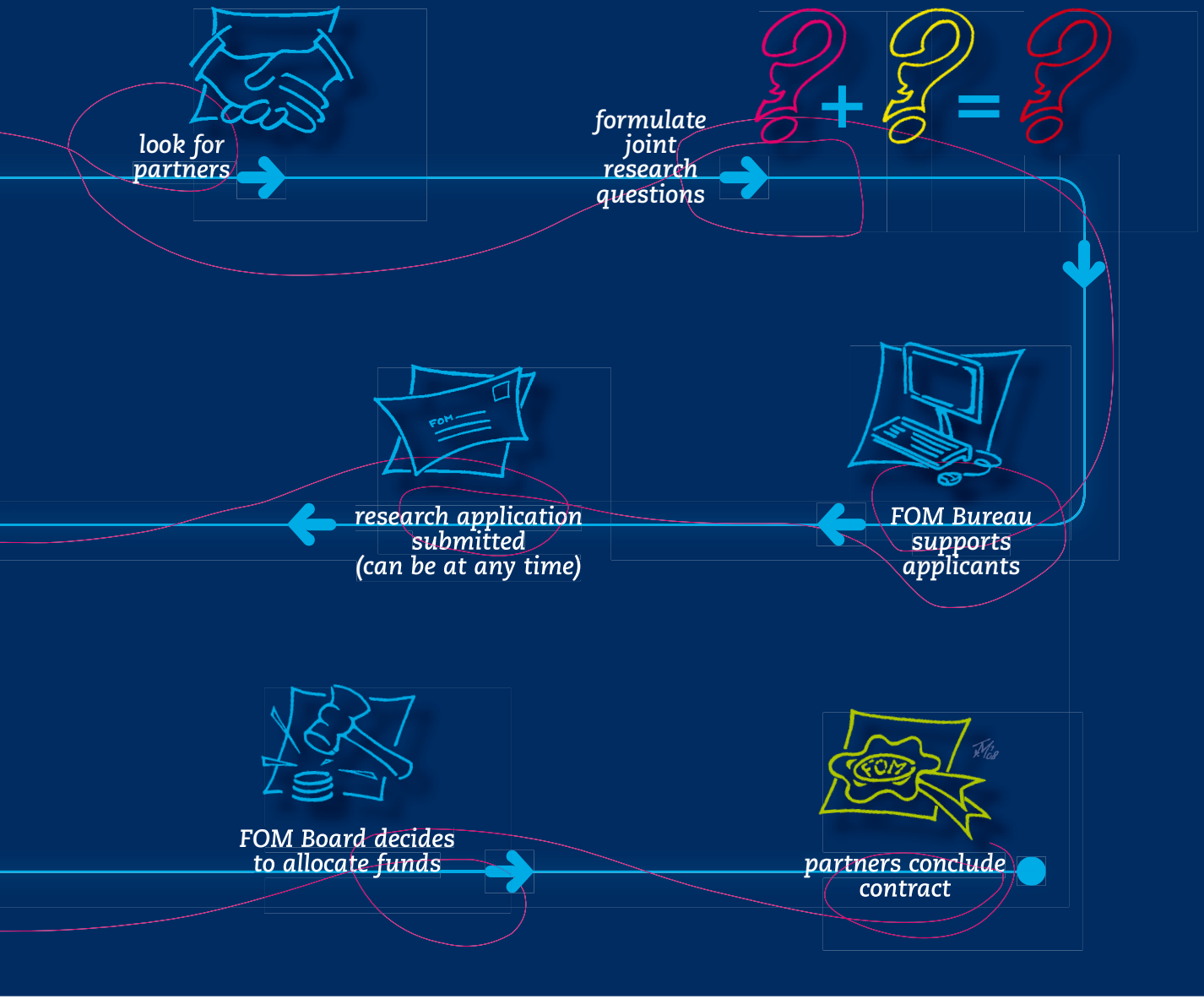
Glad that we have found FOM

'When Carl Zeiss decided ten years ago to commit itself to a new generation of mirrors for ultraviolet light, we went and searched for experts in this field. In this pioneering phase, cooperating with a scientific institute is more worthwhile for us than employing the specialists ourselves. First of all, they are scarce and secondly, it is never certain whether a particular line of research will succeed. Slowly but surely, however, as the project progresses we execute an increasing amount of the developmental work ourselves.
Back at the start, we held a competition. Besides the group of Bijkerk, a German, a Russian and an American group took part and FOM proved to be the best.
The seven years of cooperation have been fruitful. There are now two prototypes of the new generation of wafer steppers for producing chips. That is a milestone. In two years time these machines need to be in production. Yep, things move fast. We do not determine the speed; this is dictated by the chip manufacturers. Every two years the memory on a chip needs to be doubled. We are, however, in time and look to the future with confidence. I am glad that we have found FOM.'

Programme:	Extreme UV multilayer optics
Partner:	Carl Zeiss SMT AG
Commitment:	6 PhD students, 2 postdocs, 2 professors
Location:	FOM Institute for Plasma Physics
Duration:	2005-2010
Total investment:	7.9 million euros

HOW DOES AN INDUSTRIAL PARTNERSHIP PROGRAMME COME INTO BEING?




look for partners
formulate joint research questions
FOM Bureau supports applicants
research application submitted (can be at any time)
FOM Board decides to allocate funds
partners conclude contract

SHELL PRESENTS PROBLEMS TO PHYSICISTS VIA ONE-STOP SHOPPING

The little grey cells

'If I read that something new has been discovered about superconductors and I want to know if it is relevant for us, my FOM contacts enable me to contact an expert in New Zealand in no time', says Dr Alexander van der Made, manager external research at Shell. 'We want to remain innovative in the area of energy. This is a very broad discipline in which it is impossible to keep abreast of all of the developments yourself, let alone do your own research in each of the areas. Access to a network of external experts is far more useful to us. For example, we can easily keep abreast of developments in solar energy. Several times a year, the scientists, who work in the Joint Solar Programme (see page 14), come together to report on new developments in this area and we can always contact them should we come across something that rouses our curiosity. That is why Shell is glad to be a partner in the Joint Solar Programme. It is a win-win situation for both parties: Shell enables scientists to carry out fundamental research at a high level and to visit congresses all over the world, so that they remain well-informed of the latest developments. In exchange for this, we gain access to their knowledge and networks.'

Dr Alexander van der Made (Shell)

Oil and gas

Shell cooperates with FOM in three Industrial Partnership Programmes. The newest of these, *Innovative physics for oil and gas*, has just started. An open programme, for which Shell has laid out a number of challenges that it faces during the exploration for and the production of oil and gas.

The company invites the physics community to come up with solutions. ‘Use the little grey cells’ as it were.

What are these challenges then? ‘Broadly speaking there are two. Both are concerned with improving the methods for finding and recovering fossil fuels. The first question is: how can we search better below ground to find new oil and gas reserves. Are there perhaps new speculative physical techniques that could make this possible? The second question is: how can we better predict the quantities of these oil and gas reserves that we can actually recover. There is still a lot to be gained in this area.’

A healthy balance

Van der Made is absolutely confident that the money Shell invests, will be used well. A confidence that has grown over the course of time, he indicates. ‘Dutch physicists are extremely good. And that is an understatement. Moreover, our country has a long tradition of scientific researchers, who cooperate with industry. Issues such as handling sensitive company information confidentially never gives rise to problems. People are accustomed to that. And, in turn, Shell is familiar with Dutch academia.’ Since the fragile start made about one hundred years ago, Shell, like many other large companies, has swung between outsourcing a lot of research and performing much research itself. Van der Made believes that a healthy balance has now been found in this respect. ‘In a number of areas it is far more efficient for us to commission explorative research to be done elsewhere. We employ people that can develop good ideas further, so that we can apply them.’

India and China

In the future, Shell wants to invest more in partnerships with India and China. We expect that interesting research groups will emerge there, whereas in the Netherlands good science students are, unfortunately, becoming increasingly rare. However, maintaining good contacts with Dutch researchers is still attractive, says Van der Made. 'It is handy when the people you work with are just an hour away. For example, I cannot phone a colleague in China this afternoon, because he will be asleep. What is more, we Dutch researchers literally and figuratively speak the same language. Yes is yes and no is no, for example, whereas our Eastern colleague might say yes and do no.'

Smoothly

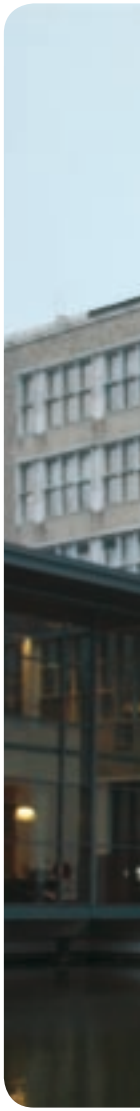
Shell does business with hundreds of universities throughout the world. Such cooperation takes place in a variety of forms. Recently, an analysis was made of effective methods. The way Shell and FOM cooperate emerged as one of the better methods. Van der Made: 'We would like to apply this model more often. Everyone here is enthusiastic about it.' The secret lies in the one-stop shopping. The FOM Bureau gives Shell access to the entire physics community in the Netherlands, because in some way or other all physicists are connected with FOM. None of the hassle of eight different contracts with eight professors. FOM rakes the lot together and at the end of the journey Shell receives a single invoice. This always runs smoothly, according to Van der Made: 'The staff at the FOM Bureau are clearly experts at organising large research programmes. This means we can concentrate on the content, and everyone can do what he or she is good at.'

Programme:	Innovative physics for oil and gas
Partners:	Shell
Locations:	various universities
Duration:	2008-2013
Total investment:	3 million euros

MATERIALS RESEARCH BRINGS SUCCESS FOR COMPANIES

Knowledge, expertise, jackpot!

Converting fundamental knowledge into economic industriousness can sometimes proceed rapidly, observes Dr Sibbe Hoekstra, director of the Materials innovation institute (M2i). Chassis parts which now only need to go in an oven once and not twice, an endlessly stronger and lighter material for aeroplane fuselages, faster production of lampposts and double ship hulls that allow larger quantities of freight to be safely transported. Dozens of examples can be given about how fundamental knowledge of material properties has, within a few years, led to a higher value product or a more efficient means of production and, therefore, a greater profit.



On the shelf

Unfortunately, this does not happen as a matter of course. Dr Sibbe Hoekstra: 'For a long time, there has been the belief that fundamental knowledge would automatically penetrate society and would lead to profitable applications. Things, however, are not quite that simple. You need to drag the application out, otherwise a lot of knowledge will remain collecting dust on a shelf.'

Dr Sibbe Hoekstra (M2i)

M2i is one of the technological top institutes set up in 1997. Half of its funding comes from the Ministry of Economic Affairs, a quarter from the universities and the remaining quarter from the participating companies, the members. Originally M2i made a strong contribution to materials research but now it mainly focuses on the valorisation: it attempts to put knowledge and expertise onto the work floor as

quickly as possible. Over the past five years we have become aware in the Netherlands of the real need for this, says Hoekstra. The policy of the Balkenende cabinets, the work of the Innovation Platform and the emergence of the Asian economies have all been important contributing factors in this respect. ‘If we want to be able to hold our ground against international competition in the future, we need to produce knowledge that is profitable and which we can make available to our industry. Because industry is one of the key drivers of our economy.’

‘Flying squads’

M2i has developed refined methods for being able to shift from knowledge to cash in a few steps. Participating in the Industrial Partnership Programmes of FOM falls under the first step: acquiring fundamental knowledge that the members need. The second step is translating fundamental insights into applications. Other university researchers are employed for this. In the third step M2i ensures that the results are actually applied. It supervises the starting up of new knowledge intensive businesses and utilises *flying squads* to visit companies offering free specialist advice or looking for strategic combinations.

Broker

M2i is a special partner for FOM, as it brings together the interests of various companies. With this, fundamental knowledge not only comes into the hands of a few multinationals but also smaller businesses. Equally FOM is interesting for M2i, as it offers access to an enormous network. In this way, M2i keeps well-informed about what is going on in fundamental research and can provide its members with exactly the type of expertise they need.

M2i as a knowledge broker for companies and FOM as a broker in fundamental research; it would appear to be a golden match. 'True', says Hoekstra. 'There is a lot of high-quality knowledge in the Netherlands and enough entrepreneurialism but the entire area is very fragmented. The Industrial Partnership Programmes offer a solution to this problem. By consolidating strengths and making links more efficient, we can achieve more with the same effort.'

Marriage

M2i recently concluded the first Industrial Partnership Programme with FOM. A new programme has commenced. The aim of the new programme is to obtain a fundamental understanding of how the properties of materials change under the influence of miniaturisation. Eight years of cooperation have passed, and a new partnership of four years has just started. Is the marriage between FOM and M2i a happy one? Although Hoekstra strongly confirms this, there is a certain hesitation in his voice. Is the love indeed so mutual? 'Fundamental researchers prefer not to be hassled with questions about applications. Once they have got the money needed, they would rather shut themselves off from the outside world "Quiet, recording. In four or five years time we will be able to show you what beautiful fruits have been borne." Perhaps understandable, but definitely not productive. Yet I must say that the mentality has started to change more recently. People are becoming more receptive to outside influences. Whether that is entirely of their own accord or due to the prevailing circumstances, I do not know, but to be honest that does not really matter. By this change, FOM is an even more valuable partner for us.'

Programme:	Size dependent material properties
Partner:	M2i and affiliated companies
Locations:	various universities
Duration:	2008-2013
Total investment:	2 million euros

NETWORKING

FOM encourages contacts between science and industry by bringing together experts from both worlds at contact days, workshops and seminars. During these meetings, small and large companies can be informed about the latest state-of-the-art research in their field.

The industrial contact day *Bubbles, drops and powders, towards a sparkling mix of theory and practice*, for example, brought together specialists from various backgrounds in the area of multiphase flow. Also a *professors' day* was held together with ASML, where professors could become thoroughly acquainted with the people and technological processes at this Dutch market leader in lithographic systems. And there was a discussion day *Biophysics meets biotechnology* at which scientists and experts from, for example, Philips, DSM and Organon had the chance to collectively brainstorm about applications of research in the life sciences.

Sometimes the seed is sown for an Industrial Partnership Programme during these events. Even when this is not the case, valuable long-term contacts are often developed.

OVERVIEW

For a detailed overview of all current
Industrial Partnership Programmes please visit www.fom.nl.

INTERESTED?

If you would like to know more about FOM or the Industrial Partnership Programmes then please contact:

- Marcel Bartels, +31 30 600 1217, marcel.bartels@fom.nl
- Dr Pieter de Witte, +31 30 600 1217, pieter.de.witte@fom.nl

Marcel Bartels (right) and Dr Pieter de Witte.