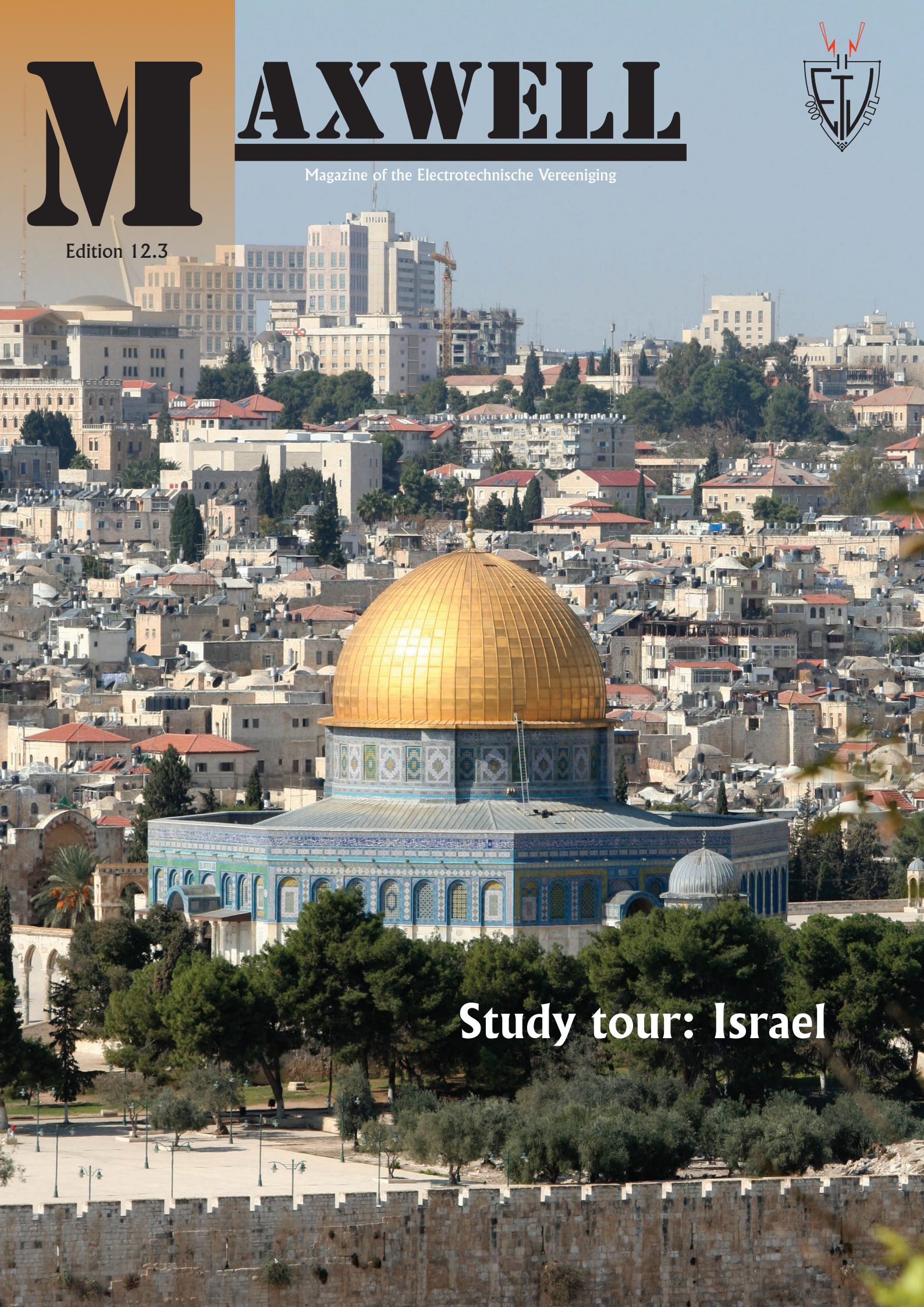
MAXWELL

Magazine of the Electrotechnische Vereeniging

Edition 12.3



Study tour: Israel

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FromtheBoard

You might have heard them sometimes, the rumors coming from the government that students should be able to focus more on their study. Which means spending less time on a job on the side or other activities. And be sure to graduate in the given time of 5 years. They find it important to deliver students as fast as possible to the labour market. A logical conclusion, as it is the most profitable for both university and government.

But on the other side the universities wants to deliver students which are as complete as possible. Graduates who, besides there academic knowledge, have experience with working in multidisciplined groups, are internationally focussed, widely oriented and prepared to enter into business. Your time as an academic student is seen as one of personal growth and development, the time where you really grow to manhood. This desire of the universities is supported by the government, because they know that the knowledge economy is what keeps the Dutch economy going.

The universities try to deliver these "complete" graduates by stimulating students to do something besides their study. Studentprojects, board or committee work at study associations or student societies. Things which are all very valuable experiences, but which does also cost time, energy and, in most cases, money.

That's the point where it goes wrong. While at one side universities try to stimulate students to do something besides their study, on the other side they are the ones who make it harder and harder to do so. Over the last years a lot of rules have been introduced, or will be introduced in the near future, all with the aim to stimulate students to complete their study faster. For example the "harde knip", which means that you can't begin with your master before completing your bachelor. Or a "bindend studie advies" which forces you to get a certain amount of ECTS each year.

Resulting effect for a student is that you are expected to put quite some time and effort in your study to stay on a nominal progress. In Delft this means at least 30 hours a week, and for most student probably a bit more. Then the side activities take up a couple of hours. And to finance all of this most of the students just need a job on the side. In most cases, this is just too much for students to stuff in one week, with the resulting effect that one of these things is put on one side.

As board of the ETV, we are the ones that experience this trend as one of the first. It is getting harder and harder to find people for the ETV committees. Most heard argument? Just the shortage of time. Students are busy with studying, hoping not to get problems with the "harde knip". A very worrying situation, without enthousiastic committee members the ETV simply can't exist.

Luckily, one thing is clear. By putting the students under such workload they learn something that will be useful for the rest of their lives. How to divide their limited amount of time among their numerous obligations. Luckily there also is the Maxwell, for all the times of relaxation. I wish you lots of pleasure with this alumni edition!

On behalf of the refreshing Board,

Thijs van Leeuwen

Editorial

WHAT ELSE IS NEW

One of the constant things in the universe is change. The Maxwell is no exception in this. Since the last edition the Maxwell has gained some new entities. In the first place we welcomed two new members. They will help realising and improving the Maxwell while the older editors are preparing to leave the board of editors.

Furthermore this Maxwell features several new sections. While the President of the ETV was searching all media to collect a number of interesting gadgets to present in this Maxwell, Joost van Zwieten visited Prof. van der Sluis to ask some questions. The answers to his questions will have to wait but Joost dit not leave the professor empty handed. Instead Prof. van der Sluis will enrich our knowledge with a recipe for egg nog.

Those of you who have been waiting for this edition with their soldering iron in their hand will be disappointed. Instead of the regular circuit schemes, we provide you with another form of entertainment. We expect all ETV-members and alumni will be provided with enough light-hearted and academic articles.

Johan Splinter, Editor

Contents

Elektrische fiets

De Sparta mét bestaat al vele jaren, vele kennen de fiets met een motor op benzine. De techniek staat echter ook niet stil bij Sparta. en maken daarom nu de elektrische variant.

Is real study tour

Every two or three years the ETV organises a study tour to visit companies and cultrural events in different countries. In november 2008 a group of 24 students payed a visit to Israel.

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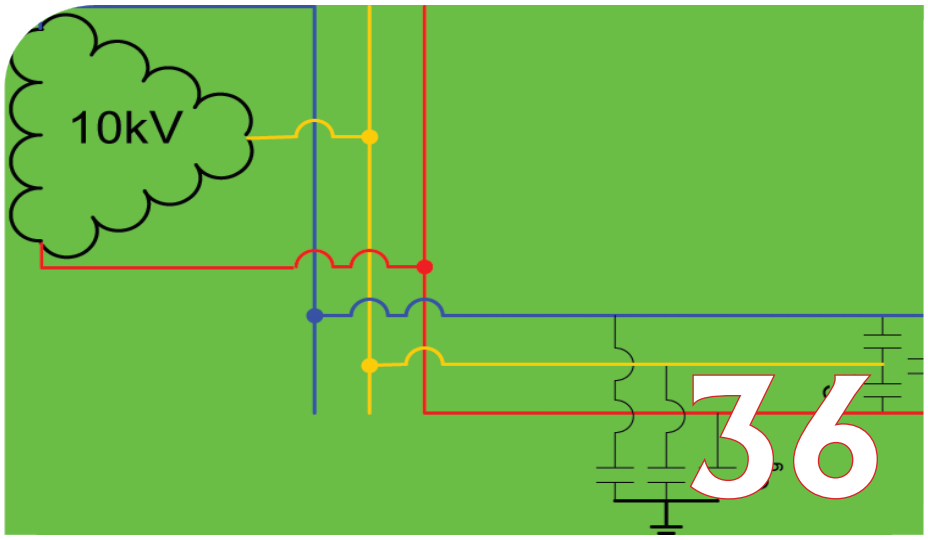
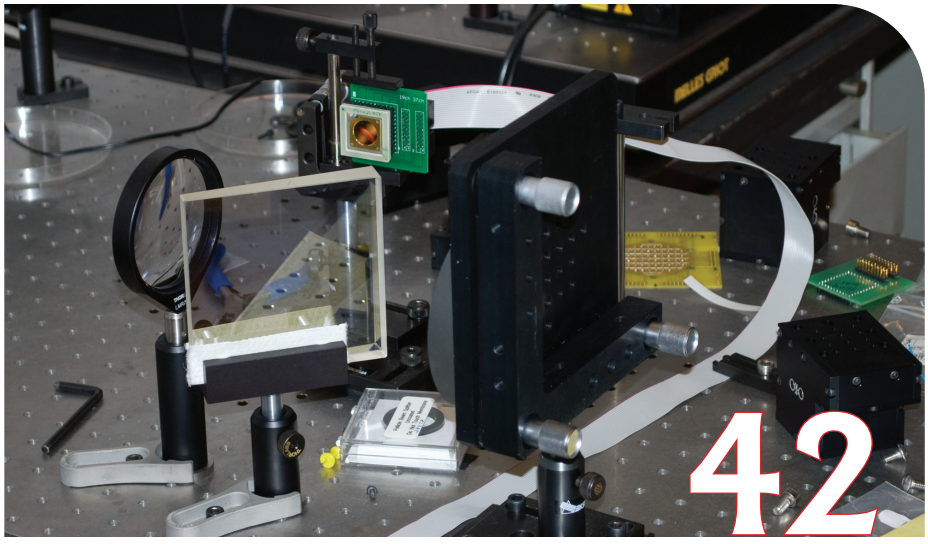


Graduation report

Arjan van de Meer graduated recently at the TU-Delft. His thesis was about a comprehensive protection relay coordination study in ungrounded 10 kV distribution networks.



Interview Flexible mirror

An interview with the founder of Flexible Optical BV. A company specialized in making flexible mirrors.

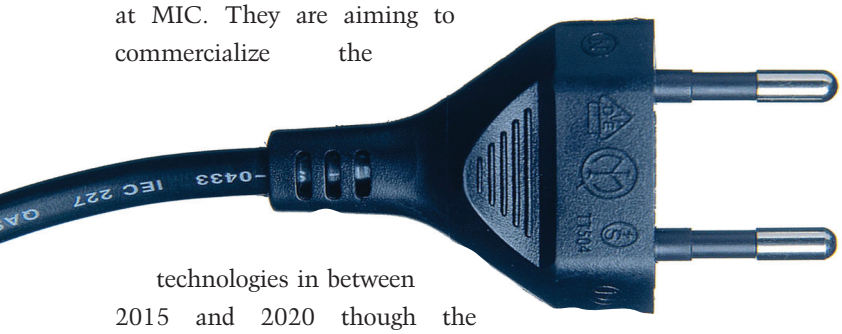
Newsflash

Japan Kicking Off Wireless Power Supply Effort

Tetsuo Nozawa, Nikkei Electronics

Japan's Ministry of Internal Affairs and Communications (MIC) has been working on R&D and standardization of wireless power transmission technologies, which enable noncontact or wireless power supply to home appliances like TVs.

Toshiba Corp made the proposal of the R&D and standardization, which is currently being evaluated by an ad hoc team under the Radio Wave Policy Council, a study group at MIC. They are aiming to commercialize the technologies in between 2015 and 2020 though the schedule may change depending on the difficulty of the technology development, according to the team.



The ad hoc team considers that three types of technologies have to be established.

- A technology that utilizes a general electromagnetic induction method and features a transmission range of less than several millimeters, electricity of several hundred watts or less and a frequency less than several hundred kHz

- A technology that was developed by Massachusetts Institute of Technology (MIT) and is called resonant induction. Using a frequency ranging from several to several hundred MHz, it is capable of wireless transmission with a transmission range of several tens of centimeters and electricity of several hundred watts.

- A technology for receiving radio waves by a highly-efficient receiving circuit and retrieving DC power via a rectifier circuit.

The first technology, which has already been adopted for some products on the market, is expected to be standardized by 2015, according to MIC. As for the second and third technologies, "we are about to pinpoint issues, aiming to commercialize the technologies around 2020," according to MIC.

NANOTECH STORAGE INVENTION SQUEEZES 250 DVDS ONTO A QUARTER

Kit EatonMon

Nanotechnology is all about the science and engineering of incredibly small devices, so breakthroughs in information storage density are to be expected. But a team from two U.S. universities has achieved a breakthrough in self-assembling nanotech devices that enables truly amazing data storage options.

The scientists from University of California, Berkeley, and University of Massachusettes Amherst have invented a way of packing an array of polymer molecules tightly together. The polymer chains are chemically different from one other, and form a block copolymer when bunched up: This arrangement is actually self-forming, and creates a tight grid of molecules when viewed from above.

The team's breakthrough has been to use a feature of sapphire crystal to create vast fields of these blocks--previously an impossible feat, since the blocks break down past a certain scale as disorder kicks in. The sapphire facets are cut and

NEC Claims Organic Radical Battery Advance

Kouji Kariatsumari, Nikkei Electronics

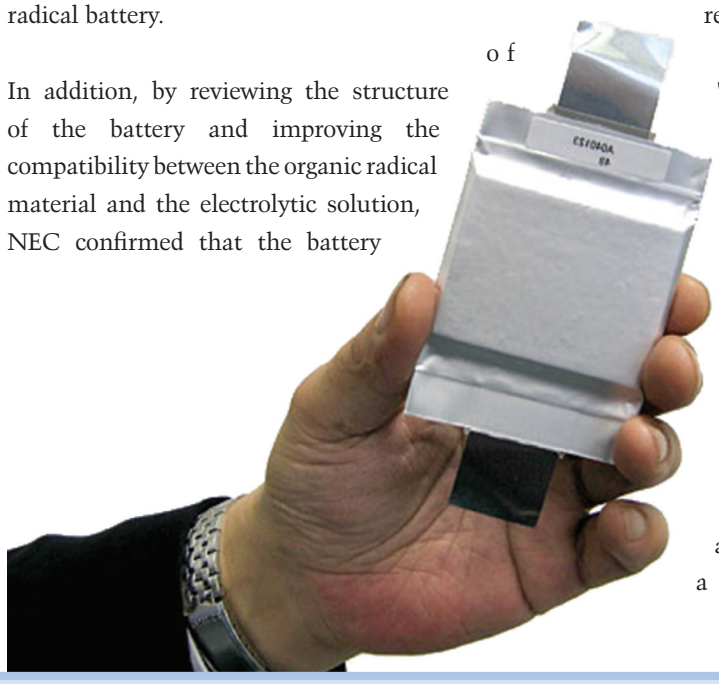
NEC Corp enabled an organic radical battery to be repeatedly charged/discharged 10,000 times or more with one second or shorter pulse discharge while enhancing its power density.

By utilizing a printing technology and a technique to evenly disperse electrode ink, the company increased the uniformities of the organic radical material and the carbon fiber, thereby reducing the internal resistance of the positive electrode of the organic radical battery. As a result, the power density of the battery was increased to 5,000W/L, which is three times as high as that of the company's existing organic radical battery.

In addition, by reviewing the structure of the battery and improving the compatibility between the organic radical material and the electrolytic solution, NEC confirmed that the battery can be repeatedly charged/discharged 10,000 times or more.

Specifically, when using a coin-sized organic radical battery with a thickness of 1mm or less, it is possible to discharge with a high current of 1A, achieve a high power output of 2W and repeatedly charge/discharge 10,000 times or more with a current of 100mA, according to the company.

An organic radical battery is a secondary battery that stores electricity utilizing the oxidation-reduction reaction of stable radical. The battery was first announced by NEC in 2001. It utilizes the oxidation-reduction reaction of a substance called "radical," which has unpaired electrons in the outermost shell of the electron orbit.



The battery allows high-speed charging/discharging because the reaction proceeds at a high speed. Also, a gel-type flexible electrode can be created by infiltrating an electrolytic solution into a composite positive electrode consisting of an organic radical compound and a carbon fiber.

Targeting the power sources for next-generation terminals such as highly-functional IC cards, electronic paper and wearable devices, NEC intends to improve the usability of the battery by combining it with contactless charging technology, etc.

Part of the research and development of the battery was conducted under the project called "Basic Technology Development for Fiber Materials with Advanced Functions and New Structures," which is promoted by Japan's Ministry of Economy, Trade and Industry (METI) and Japan's New Energy and Industrial Technology Development Organization (NEDO).

The printing technology and the technique to evenly disperse ink were developed by DIC Corp, while the improved radical material was co-developed by NEC and Sumitomo Seika Chemicals Co Ltd.

The new battery is scheduled for display at the International Nanotechnology Exhibition and Conference (nano tech 2009), which runs from Feb 18 to 20, 2009, at Tokyo Big Sight.

heat-treated which causes them to form nano-scale sawtooth ridges, and when the copolymer grid is formed on these ridges, the scale problem disappears.

As a result, if the molecules were arranged to store electronic data as bits, the nano device represents a data storage capacity of 10 terabits per square inch--1,250 gigabytes of data in an area only slightly bigger than a postage stamp. That's a storage density some 15 times greater than seen before.

The technology to store and retrieve data on that scale is in its infancy, but will certainly catch up now that the nano-scale storage medium seems possible.

Activities of the Electrotechnische Vereeniging

Lunch Lecture Technolution: Wafer clamping

16 december - author: Joost Kerpels

Tuesday the 16th of December, the ETV was visited by a delegation of Technolution. Senior Consultant Alex van den Heuvel came along with them to give us the presentation. The lecture had the complex and interesting title: "High voltage power amplifier for electrostatic wafer clamping".

When wafers are created, it is very important that the silicon plates don't move or shake the tiniest bit. One possibility is to clamp the wafers physically with claws. In production however, this takes way to much time. Every silicon plate has to be attached and released one by one. Another solution was necessary. ASML came with the solution of 'electrostatic wafer clamping'. This idea is based on the principles of a magnetic field. When a high positive voltage is applied underneath half the plate, and a negative equal voltage underneath the other side, the total becomes zero, thus completing the circuit.

To accomplish this, a special voltage supply was necessary. Techolution was asked to create such a supply. The voltage regulation had to be very precise. Not enoudh voltage and the wafer wouldn't be stable, too much voltage and the wafer would bent, causing incorrections. This also depends on the plate size and distance between the plate and the potential. For this, Technolution invented a four quadrant supply that can be reglated between -4kV and 4kV with a very high precision. Alex van den Heuvel showed us the exact circuits nessecary for this supply and the solution to all the problems they ran in to.

It was an interesting lecture, that covered both micro-electronic and high voltage electronics. A nice combination!

Christmas Lunch in the /Pub

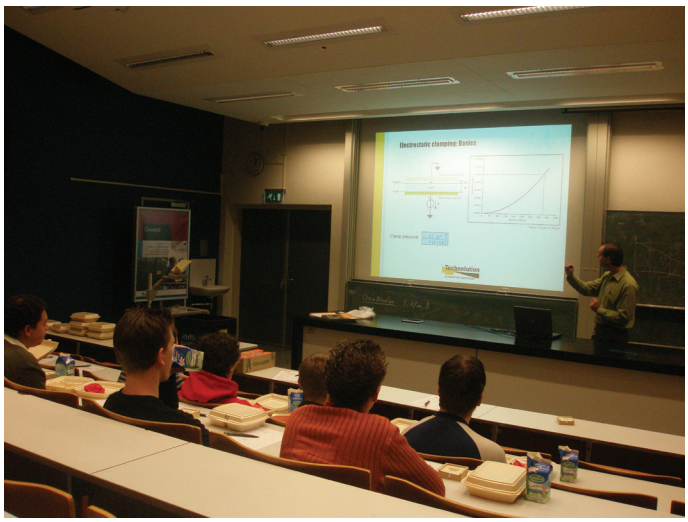
19 december - author: Jeroen Ouweneel

Sinterklaas had only just left the country, when Santa took his place, continuing the festivities of the last month of the year. All around the faculty, christmas decorations started to appear. This, of course, could only lead up to one last highlight just before the christmas-holidays: the annual Christmas-lunch of the Electrotechnische Vereeniging.

On the early morning of December 19th, the board had been brewing the traditional 'Glühwein' according to the traditional and top-secret ETV-recipe. When entering the /Pub, the aroma of the wine could be smelled already.

Lots of tables were prepared with lunch, and soon after the beginning of the lunch-break all of the seats were filled. Not only students attended, but also staff members of the faculty.

All of a sudden, Santa, for some reason wearing a fresh green waistcoat, entered the /Pub, and took his seat next to the christmas-tree. He raised his voice, and welcomed all of the visitors. Then it was time for a christmas-story, but this year's story wasn't the traditional one.



A lot of students attended the Technolution Lunch Lecture

Santa Claus pouring the traditional ETV-Glühwein

The /Pub was filled with members and faculty staff as well during the Christmas Lunch

Instead of Joseph, Maria and the baby Jesus, the roles in this story were played by Daniel, Laura and an unintended baby. The baby was born in a garagebox, when three guys from the street called Gio, Evan and Milow, came to congratulate the pair with their baby. They didn't prepare any presents, but improvised some gifts: a prepaid refill card, a breezer and a coat for Laura.

After this refreshing story, it was time to start lunching. For the Treasurer, this was the moment to collect the final payments, so he started making his round.

A christmas story and a tasty lunch later, it was time for the final hours of work before a well-deserved christmas holiday.

Ski trip in Bottrop, Germany

22 december - author: Johan Splinter

In the near past the ETV had the custom to organize a ski trip to the indoor sport centre in The Hague, the Uithof. The interest in this trip became less each year however, so the ETV discontinued this tradition. Meanwhile a new phenomena was introduced. Due to a lot of members being at their parents place during the holidays, the ETV Board decided to introduce a recess around the Christmas days. A group of ETV-members was not content with these changes and decided to organize their own ski trip to Alpincenter Bottrop in Germany.

In the afternoon of 22 December two cars left Delft for a long drive to Bottrop. After arrival the participants could choose between renting ski's or a snowboard. For a small financial compensation however we were given the opportunity to change in between.

The entrance fee did not only offer unlimited access to the snow hall, it also included free food and drinks. Although the descents is one of the longest indoor descent in the neighbourhood, the time it took to get to the top of the hall was much larger. This may have been one of the reasons why, after some hours, a small group decided to divide their selves from the rest of the group and started drinking in the included après ski café. From that moment on the part of the group continuing to make use of the snow facilities only diminished, and eventually the entire group decided to go back to Delft, where we arrived about one 'o clock at night.

Some of the attending ETV-members in Alpincenter Bottrop

Sparta mét

Ervaringen van een elektrotechnisch ingenieur in de fietsenbranche

Bijna heb ik een hondje doodgereden. Het werk zat erop; ik fietste mét ondersteuning langs het Apeldoorns kanaal. Net iets te laat zie ik de lijn midden over de weg, die de wandelaar rechts met het hondje helemaal links verbindt. Ik rem nog, maar het mopshondje schiet met een gilletje, een schreeuw eigenlijk, van de linker naar de rechterkant van de weg. De lijn rond de nek heeft op miraculeuze wijze losgelaten, wat de redding van Frits betekent. Zo blijkt de hond te heten want de wandelaar roept 'O Fritsie'. Na gedegen onderzoek blijkt het beestje het nog te doen en vervolg ik mijn weg.

Auteur: Steef Niesing, M.Sc.

Ik mag mij dagelijks bezighouden met wat wij noemen de Sparta ION. Deze fiets bezit alles wat een elektrotechnicus begeert en brengt mij iedere dag met een gemiddelde snelheid van 30 km/h naar mijn werk. Naast de tijdsbesparing levert dit soms een gevaarlijke situatie op, getuige de introductie. Gelukkig wegen de baten ruimschoots op tegen de lasten, waarbij de vroegtijdige dood van een mopshond wellicht nog onder het kopje baten mag vallen.

Graag wil ik u een impressie geven van mijn werk op de ontwikkelafdeling van Sparta en het opzetten van de motorproductie in China, maar eerst een uitleg van ons product 'de elektrische fiets'.

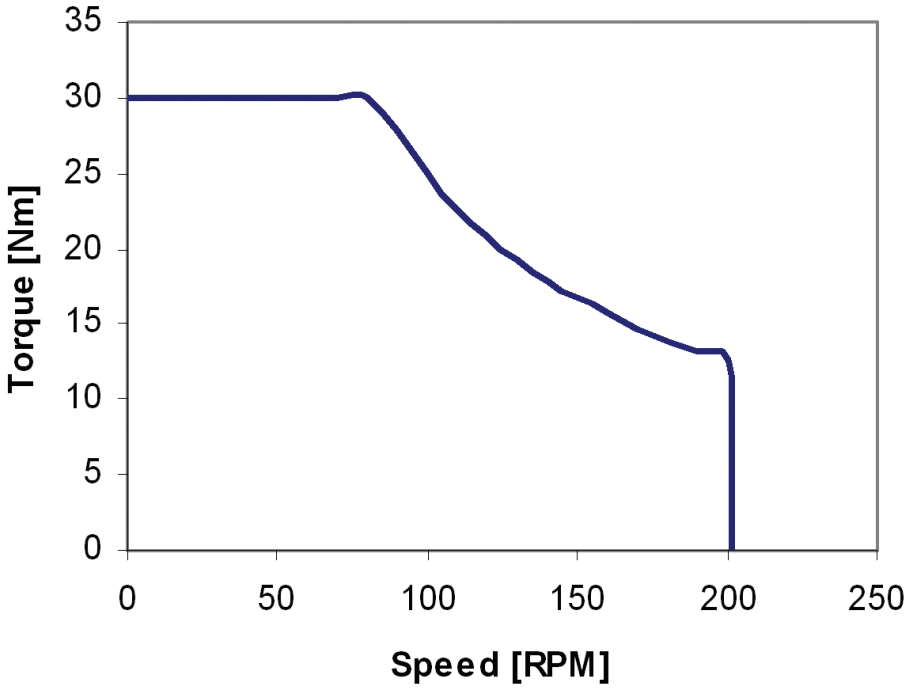
De elektrische fiets

Zoals gezegd, de Sparta ION heeft alles wat een elektrotechnicus begeert. Een batterijsysteem met bijbehorend Battery Monitoring System (BMS), een motor met geïntegreerde electronica en Torque Measuring System (TMS) en een display voor de systeeminformatie. Voeg daarbij een communicatiebus om de componenten met elkaar of met een pc te

laten praten en alle elektrodisciplines zijn vertegenwoordigd.
Pedal Electric Cycle, ofwel Pedelec, is de typering voor het product wat zojuist in hoofdcomponenten beschreven is. Op de fiets werkt het als volgt:
Als fietser trap je de pedalen rond met een bepaald koppel. Dit trapkoppel wordt gemeten door het TMS. Op het display kun je instellen welke mate van ondersteuning je prefereert. Dit vertaalt zich naar een bepaalde assistentiefactor AF. Deze factor is gedefineerd als:

$$AF = T_m/(T_m + T_{trap})$$

Dit houdt in dat als het trapkoppel (T_{trap}) 10 Nm is en de AF 0,5 dat het gevraagde motorkoppel (T_m) dan ook 10 Nm is.



Figuur 1: WT-karakteristiek Accell motor

Afgestudeerd

Tijdens het afstuderen op de afdeling Electrical Power Processing (EPP) had ik het idee dat ik het erg druk had. Eén van mijn begeleiders moest hier om glimlachen, wat ik nu begrijp. Het afstuderen is de mooiste, maar ook de enige kans om iets geheel tot de bodem uit te pluizen en verslag te leggen wat geheel aan jouw eisen voldoet. Daarna zal die kans je door de factoren tijd en geld niet snel meer gegund worden, ergo, geniet van deze fase!

Binnen EBCC mag ik zorg dragen voor het ontwerp en de productie van onze motoren. Wat betreft mijn functie is mijn officiele titel 'motor engineer'. Ik ben begonnen op 1 maart 2007, twee maanden na mijn afstudeerpresentatie. Mijn verwachtingen lagen vooral op het vlak van de sturing van de Accell-motor. Gedurende mijn afstuderen heb ik mij verdiept in het optimaliseren van de schakeltechnieken voor een 200 kW inverter met als doel de verliezen te minimaliseren. De motor maakt ook gebruik van een driefase-inverter, zie daar de overeenkomsten. De grootste ontwerp-gerelateerde uitdaging voor de sturing is de kracht rimpelloos op de weg zetten, zó dat de fiets comfortabel fietst. De sturing in assembly en C++ is er gekomen, maar niet door mij geschreven. Het opzetten van de productie én het optimaliseren van het ontwerp kon niet in de tijd gecombineerd worden. Voor het

Figuur 2: Fritsie, bijna slachtoffer van de elektrische fiets

optimaliseren is een extern bedrijf ingezet. Mijn rol hierin is vooral het begeleiden van het proces om stap voor stap tot het gewenste eindresultaat te komen.

Dit was mijn eerste leerpunt, werk dat je niet zelf kunt doen uitbesteden en begeleiden zó dat het resultaat acceptabel is. Verder heb ik vooral geleerd wat werken is. Nog steeds is dit een proces wat niet klaar is en wellicht nooit klaar komt. Het komt voornamelijk neer op het managen van je workload door het continu stellen van de juiste prioriteiten. Deze manier van 'druk' heb ik tijdens mijn studie nooit ervaren, dit doordat je uiteindelijk alleen verantwoording aan jezelf hebt af te leggen en niet aan een klant of baas.

Het academicus zijn heeft voor mij nog niet volledig naar tevredenheid invulling gekregen. Het afstuderen stond vooral in het teken van (Mathcad) modelleren, metingen en verslaglegging. Op dit moment bestaan mijn werkzaamheden vooral uit het begeleiden van productiegerelateerde processen. Voor de toekomst wil ik me meer richten op waarde toevoegen voor Sparta op het gebied van motorontwerp. Maar nu meer over de motorproductie.

Motorproductie

Wat betreft de motor is het bijzonder dat het ontwerp ervan in eigen huis ligt, mechanisch en elektrisch. Formeel heet de motor die wij nu toepassen een permanent magnet synchronous

machine with concentrated windings and inside out configuration', vanaf nu geheten Accell-motor. De motorkarakteristiek moet aansluiten bij de lastkarakteristiek. De last wordt in dit geval bepaald door de mens op de fiets. De mens neemt plaats op deze briljante vinding: frame, 2 wielen, kettingaangedreven, balanceren en gaan. Wat je tegenhoudt: rolweerstand, luchtweerstand en, mocht je een helling willen pakken, de zwaartekracht.

Op basis van deze balans kan een gewenste koppel-toeren karakteristiek bepaald worden. Voor onze motor ziet deze er grofweg uit als in figuur 1.

Wat opvalt zijn de begrenzingen: onder 80 RPM begrenst de fasestroom het maximale koppel, daarna is er het wettelijk verplichte maximale uitgangsvermogen van 250 Watt, vervolgens is er boven de 200 RPM een koppel van 0 omdat dit met 25 km/h correspondeert; boven deze snelheid mag de motor niet ondersteunen.

Het produceren van de motor met geïllustreerde karakteristiek vindt plaats in China. De eerste fase van het opzetten van de productie staat in het teken van de 'supply chain'. Aan de hand van de belangrijkste onderdelen in de motor zal ik proberen elektrotechnische dilemma's aan de orde te stellen in deze fase.

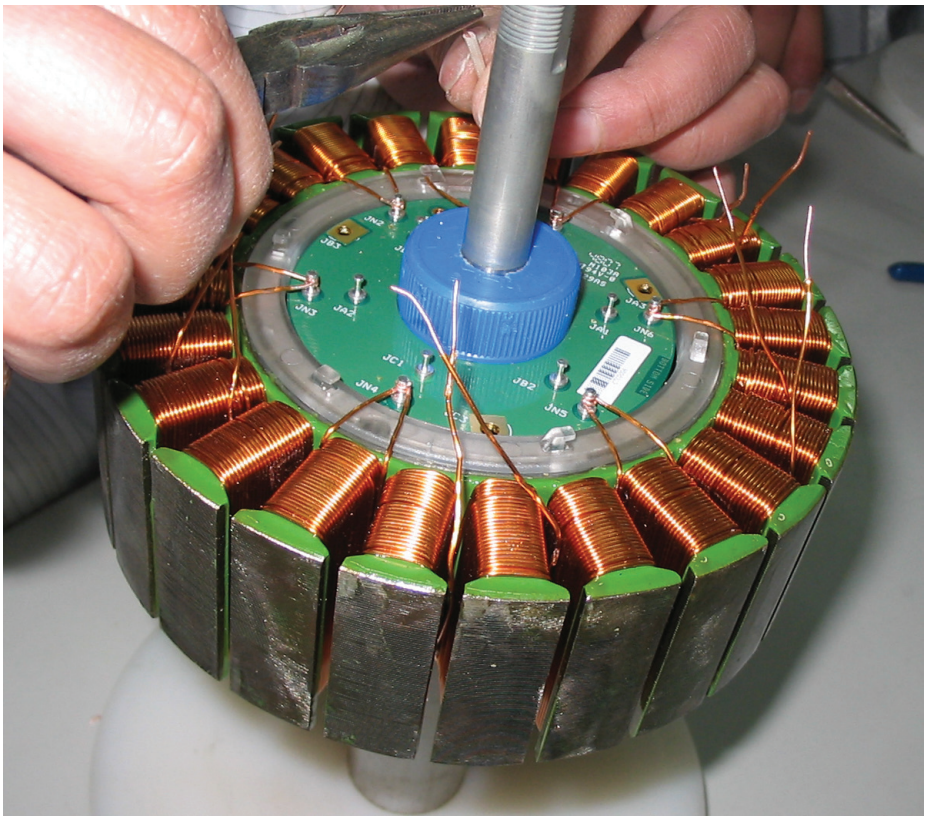
Electronica

Een van de grootste electronica-leveranciers ter wereld is bereid om met ons samen te werken. Een interessante discussie in de new product introduction (NPI)-fase is de volgende: de balans tussen compact ontwerpen en testbaarheid. In de productie van een geassembleerde PCB wordt onderscheid gemaakt tussen 'in circuit testen' (ICT) en 'functional circuit testen' (FCT). Voor onze toepassing worden beide gebruikt. ICT is meer gericht op componentniveau: zitten de juiste componenten op de juiste plaats. FCT is, zoals de naam al doet vermoeden, gericht op de functies die de PCBA moet gaan uitvoeren. Deze test kan zo uitgebreid gemaakt worden als gewenst. Het besef dat al deze testen van groot belang zijn is bij mij gegroeid door ervaring uit de praktijk. Het gaat feitelijk om het afdekken van risico's. De kans dat er iets mis gaat zo klein mogelijk maken en áls er iets mis gaat precies weten waar, zodat een gerichte actie de fout kan herstellen. Nu wordt de testbaarheid gedefinieerd als 'test coverage', wat feitelijk een balans is tussen excitatiepunten en uitleespunten. Je moet ergens bij kunnen om te exciteren en uit te lezen. Hiervoor moeten via's, surface mounted of through hole componenten 'aanprikbaar' of door middel van testpunten te bereiken zijn. Dit kost weer ruimte op de toplevel van je PCB en juist deze ruimte is één van de te optimaliseren parameters, wat over het algemeen inhoudt: minimaliseren. Zie daar een engineering dillemma.

Wikkelmachine

De eerste serie motoren is handgewikkeld. Dit betekent dat in China één stator per dag gewikkeld wordt door één persoon. Los van de arbeidskosten betekent dit dat opschalen niet of nauwelijks mogelijk is. Eén van de opdrachten was dan ook het vinden van een leverancier voor een wikkelmachine. Er blijken maar drie leveranciers te zijn wereldwijd. We komen uit in Japan, waar in gesprek blijkt dat snel en netjes wikkelen van koperdraad ingewikkeld is. Netjes wikkelen betekent geen gekruiste draden. Gekruiste draden betekent een slechtere kopervulfactor, een verslechterde warmteoverdracht en meer koperlengte (weerstand).

Om perfect gewikkelde statoren te krijgen moet het oppervlak een profiel hebben. Dit profiel heeft een pitch die gelijk moet zijn aan de draaddiameter plus de dikte van een laklaag met toleranties. Deze pitch beperkt je vervolgens ook weer in



Figuur 3: Handwerk aan de spoeldraden van de motor

OVER SPARTA

Sparta maakt deel uit van de Accell Group. Accell Group is een internationale groep van ondernemingen actief in het ontwerpen, ontwikkelen, produceren en de marketing en verkoop van fietsen, fietsonderdelen en -accessoires en fitnessapparatuur. (Zie www.accellgroup.nl)

Binnen Accell fungeert het Ebike Competence Centre (EBCC) als de denktank waarin de elektrische componenten worden ontwikkeld. Het is een dynamische, snel groeiende afdeling met engineers op gebied van software, hardware en mechanica. Afgelopen jaar zijn we gegroeid van vijf naar twaalf man. Mocht je interesse hebben in een stage of afstudeeropdracht gerelateerd aan ons product, neem dan contact met mij op.

Steef Niesing t: 055-538 6279
m: s.niesing@sparta.nl

de keuze van draaddiameter én door het verdisconteren van toleranties in de pitch kun je met een vlak oppervlak en het goed inregelen van de machine potentieel een hogere kopervulfactor halen. Uit deze keuze is uiteindelijk een stator met een vlak oppervlak gekomen, ook omdat er in de toekomst misschien een andere draaddiameter gebruikt gaat worden.

Koper en ijzer

In essentie is een motor niet meer als de E=BLV en F=BIL regel. Koper en ijzer, stromen, spanningen en krachten. Waar deze essentie naar voren komt is op een beurs met toeleveranciers voor motorproducenten CWIEME (http://www.coilwindingexpo.com).

Voor wat betreft het rendement van de motor spelen logischerwijs de koperverliezen de grootste rol, daarna de ijzerverliezen. Koper is bij het wikkelen geoptimaliseerd, zo dik en zo netjes als mogelijk. Een kort voorbeeld van een toepassing waarbij het ijzer een rol speelt: fietsen zonder ondersteuning. Wat dan belangrijk wordt is de weerstand van de motor, dezelfde magneten die je namelijk helpen in bekrachtigde toestand, houden je tegen in onbekrachtigde toestand. De heen en weer slingerende flux in het ijzer remt je af. Dit kan voor het 'fietsgevoel' hinderlijk zijn, zeker in vergelijking met een fiets met een normale versnellingsnaaf. Wat te doen? Op CWIEME kun je geholpen worden bij de stand van Arcelor Mittal.

Nulserie

De eerste serie machinegewikkelde motoren wordt geleverd. Een box met zeventig motoren is op een pallet bij ons laboratorium verschenen. Er volgt een periode van testen met bijvoorbeeld een metalen splinter die kortsluiting veroorzaakt in een Hallsensor. Hierdoor mist de sturing positie-informatie en stuurt niet goed aan, met als gevolg een haperende motor. Op deze fout is procesgerelateerd een melding richting de leverancier gegaan dat er absoluut geen metaalsplinters in de electronica terecht mogen komen. Schoon werken! Verder is er ontwerpgerelateerd een wijziging doorgevoerd die er voor zorgt dat de motor uitschakelt en een melding geeft als één van de Hallsensoren defect is. Dit voorkomt een vervelend gevoel voor de consument en met de melding kan een dealer gericht actie ondernemen.

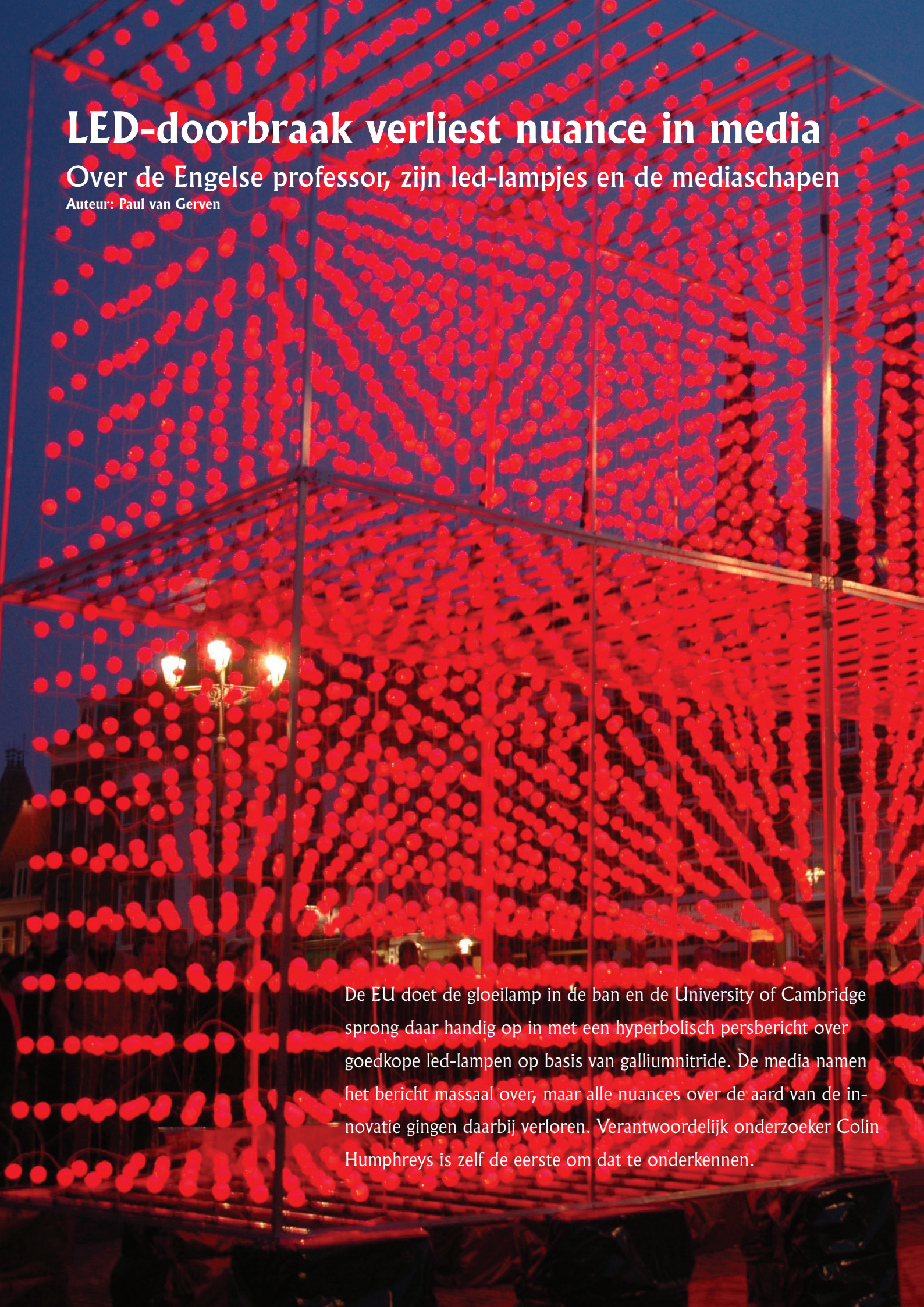
Uitleiding

Aan de hand van voorbeelden heb ik geprobeerd duidelijk te maken hoe elektrotechniek terugkomt in de ontwerp- en productiefase van ons product. Er is natuurlijk meer te vertellen, voor vragen mag u zich altijd tot ondergetekende wenden. Samenvattend is de praktijk uitdagend en ik kan van harte aanbevelen werkzaam te worden of blijven in het elektrotechnische domein.

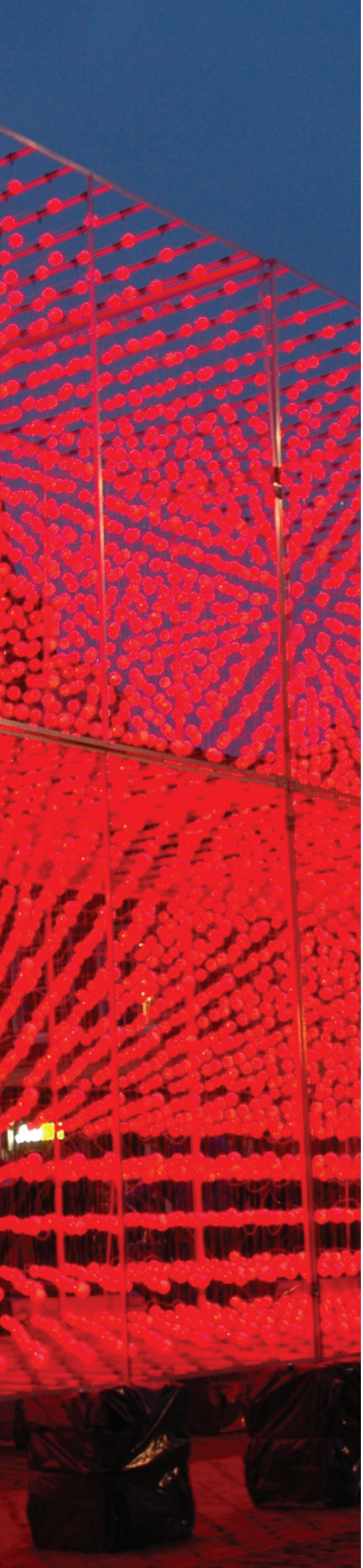
LED-doorbraak verliest nuance in media

Over de Engelse professor, zijn led-lampjes en de mediaschapen

Auteur: Paul van Gerven



De EU doet de gloeilamp in de ban en de University of Cambridge sprong daar handig op in met een hyperbolisch persbericht over goedkope led-lampen op basis van galliumnitride. De media namen het bericht massaal over, maar alle nuances over de aard van de innovatie gingen daarbij verloren. Verantwoordelijk onderzoeker Colin Humphreys is zelf de eerste om dat te onderkennen.



'Magische lampen gaan elektriciteitsrekening drastisch verlagen', zo luidt vrij vertaald de kop van het persbericht dat de University of Cambridge op 29 januari de deur uit deed. Het pittige statement miste zijn effect niet: de Britse pers dook er gretig op. De ene krant na de andere repte van de ontdekking die de productiekosten van de witte-led-lampen – want daar gaat het persbericht over – flink zou drukken, wat huishoudelijk gebruik van de zuinige halfgeleiderlichtjes eindelijk interessant zou maken. Uiteindelijk konden zelfs de respectabele BBC en New Scientist niet achterblijven.

Kijkers en lezers kregen fraaie rekenvoorbeelden voorgeschoteld. Het lampje van amper twee pond zou tot honderdduizend uur of zestig jaar meegaan en twaalf keer minder energie verbruiken dan een gloeilamp. De gemiddelde consumenten zou er 75 procent kostenbesparing op zijn verlichting mee kunnen bewerkstelligen en het verlichtingsaandeel in zijn elektriciteitsrekening kunnen reduceren van 20 naar 5 procent. Om nog maar te zwijgen van de gunstige effecten op het milieu. Acht energiecentrales zouden dicht kunnen, als alle Britten onmiddellijk zouden overschakelen.

In werkelijkheid had professor Colin Humphreys van de University of Cambridge een dergelijke 'magische' lamp niet gemaakt. De materiaalkundige had galliumnitride op een wafer van silicium weten te leggen, en wel van een kwaliteit die waarschijnlijk goed genoeg is om led-lampen mee te maken. Omdat silicium een veel goedkoper substraat is dan het gangbare saffier, zowel wat betreft materiaal- als verwerkingskosten, liggen minder dure led-lampen dus in het verschiet.

Het bewuste persbericht spendeert welgeteld 33 woorden (één zin) om uit te leggen wat de onderzoekers nu precies voor elkaar hebben gekregen. De rest van de in totaal 392 woorden gaan voornamelijk over hoe geweldig led-lampen zijn. De emeritus hoogleraar zelf is bovendien verre van bescheiden. 'Dit zou heel goed de heilige graal kunnen zijn in termen van de verlichting van de toekomst. We zijn heel dicht bij de realisatie van zeer efficiënte, goedkope lampen', aldus zijn statement.

Lekker weinig wetenschap, een milieuvriendelijke insteek en nog goed voor de portemonnee ook – meer dan genoeg ingrediënten voor een stevige, zij het kortstondige hype. Curieus genoeg bleef die deze keer beperkt tot het Britse eiland. Meestal verspreidt zoiets zich als een lopend vuurtje. Een zeker chauvinisme, het nieuws was tenslotte op en top Brits, kan daarbij een rol hebben gespeeld.

Toch doet de communicatiedienst van Cambridge zijn hoogleraar tekort met zo'n karig persbericht. Het Britse laagje galliumnitride op silicium is namelijk erg interessant, ook al bouwt het – zoals altijd in de wetenschap - voort op eerder ontwikkelde strategieën.

Blauw, wit, groen

Galliumnitride (GaN) is een van de meest belangrijke halfgeleiders na silicium. Marktonderzoeker Strategies Unlimited voorziet dat de GaN-markt in 2011 goed is voor 9 miljard dollar - een schijntje vergeleken met siliciumgebaseerde chips, maar toch een verdubbeling ten opzichte van 2006. De eerste massatoepassing van GaN is de blauwe laserdiode, onmisbaar voor de grotere opslagcapaciteit van bijvoorbeeld Blu-ray. Het lasertje verwierf zelfs wereldfaam toen Sony's

Playstation 3 (uitgerust met Blu-ray) vertraagd werd omdat de laserleverancier moeite had zijn verplichtingen op tijd na te komen. Dit uiteraard tot ongenoegen van fans die al maanden reikhalzend uitkeken naar de release van de console.

GaN heeft nog meer in huis. Dankzij een relatief grote band gap is het materiaal uitermate geschikt voor robuuste schakelingen. Kosmische straling, hoge temperaturen en andere schadelijke invloeden deren GaN veel minder dan bijvoorbeeld galliumarsenide of silicium. GaN-schakelingen hebben bovendien een hoge breakdownspanning: ze werken en blijven werken bij voltages waarbij de concurrentie het in de regel begeeft. Dankzij deze eigenschap kunnen ze ook meer vermogen produceren, of liever gezegd: hebben ze een hogere vermogensdichtheid. De efficiëntie van de omzetting hoeft daar niet eens onder te lijden – integendeel.

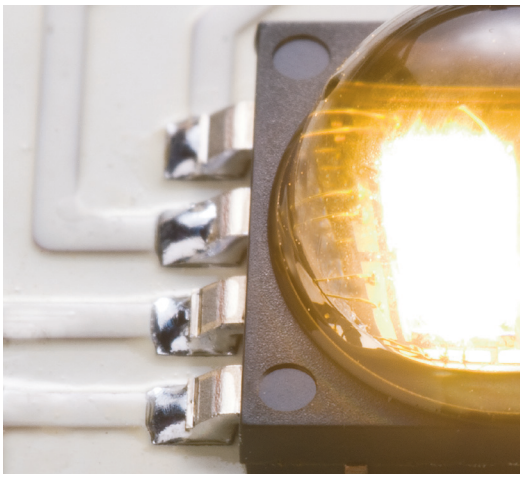
In de vermogenselektronica maakt GaN dan ook een gang van niches in de militaire markt en de lucht- en ruimtevaart, waar tegen een stootje kunnen een dikke pre is, naar commerciële toepassingen als basisstations in gsm-masten. Veel energiestromen gaan tegenwoordig op een of andere manier door siliciumschakelingen, en die zijn voor verbetering vatbaar. Er liggen dus interessante mogelijkheden voor duurzamere, zuinigere, goedkopere, kortom betere GaN-vermogenselektronica. In Nederland zijn NXP en TNO actief op dit gebied (zie 'Europa, NXP profiteert mee van groei GaN', Bits&Chips 17, 2008). In Vlaanderen draagt Imec het vaandel.

En dan is er nog de led-verlichting - momenteel goed voor ongeveer 3 procent van de wereldwijde verlichtingsbehoefte, maar de verwachting is dat efficiënte leds een aanzienlijk groter marktaandeel gaan veroveren. Galliumnitride is daarbij van grote waarde. Het materiaal is namelijk essentieel om wit licht te krijgen. Van zichzelf zendt het blauw licht uit, een gevolg van de grote band gap, maar met een fosfor die het gedeeltelijk omzet in geel, krijg je een witte lamp. Het is ook mogelijk groen licht uit het materiaal te persen door het te mengen met indium. Dit is vooral handig voor displays.

Assortiment

Ongeacht de toepassing heeft galliumnitride ook een vervelende eigenschap: het laat zich niet zomaar op silicium deponeren. GaN-kristallen moet je bij meer dan duizend graden Celsius laten groeien. Omdat silicium en GaN bij afkoeling niet met dezelfde snelheid krimpen, ontstaan scheuren. Saffier of siliciumcarbide krimpen met een meer vergelijkbare snelheid en zijn daardoor wel geschikt als substraat. Maar silicium is goedkoper, beschikbaar in grote wafergroottes en er is decennia ervaring beschikbaar om het te verwerken. Wafers van zuiver GaN zijn sinds enkele jaren ook een – dure – mogelijkheid, maar makers van lasers, leds of vermogenselektronica zouden het liefst saffier of siliciumcarbide inruilen voor silicium.

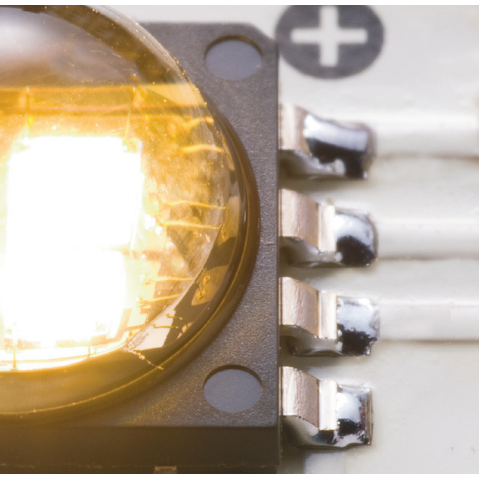
Gelukkig is daar een trucje voor. Een bufferlaagje van bijvoorbeeld aluminiumgalliumnitride (AlGaN) doet wonderen. In 2006 rapporteerde Imec bijvoorbeeld al AlGaN-geassisteerde kristal-op-kristalgroei (epitaxiaal) van GaN op een 150 mm silicium wafer. Vorig jaar slaagden de Leuvenaren er samen met de Duitse machinebouwer Aixtron in die prestatie te herhalen op een 200 mm wafer. Dit onderzoek was



gericht op vermogenselektronische schakelingen.

Wie de mediaberichten over Colin Humphreys leest, krijgt de indruk dat hij zo'n beetje hetzelfde heeft gedaan als Imec. Ook hij heeft met behulp van AlGaN een laagje GaN op een 150 mm wafer gelegd, maar dan met een led-technologie in het achterhoofd. Het persbericht en de artikelen in de media laten echter bijna allemaal na om te vermelden dat Humphreys nóg een bufferlaagje introduceerde: siliciumnitride (SiN). Dit materiaal zou de vorming van defecten tegengaan, wat de efficiëntie van leds ten goede komt. Een innovatie mag het niet heten, want anderen gingen de Engelsman voor.

'Of het nu om leds of vermogenselektronica gaat, voor beide toepassingen is het de kunst om materiaalstress onder controle te houden', vertelt programmamanager Power Electronics Marianne Germain van Imec. 'Bij vermogenselektronica is de extra uitdaging dikke lagen maken, die ervoor zorgen dat de schakelingen bij hoge spanningen kunnen opereren. Voor leds is een laag van enkele microns dik genoeg, maar hoe lager de defectdichtheid, hoe hoger de efficiëntie van de leds.' Imec heeft zijn programma voor



GaN-vermogenselektronica sinds kort uitgebreid met onderzoek naar led-technologie.

Humphreys heeft een defectdichtheid gehaald van rond de 108 per vierkante centimeter. Dat is niet uitzonderlijk. Germain: 'Wij zitten op ook 108 per vierkante centimeter. We steken er voorlopig geen moeite in om dat verder naar beneden te brengen. We kiezen ervoor de efficiëntie vooral op te krikken door de externe kwantumefficiëntie te verbeteren, dus door zo veel mogelijk van het opgewekte licht nuttig te gebruiken.'

Ondanks de vergelijkbare defectdichteid heeft Humphreys echter een efficiëntierecord gezet. Dat feit noemen de media nauwelijks, terwijl het zonder twijfel nieuwswaardig is. Humphreys' groep haalt uit zijn GaN-laag een interne kwantumefficiëntie (lichtopbrengst ten opzichte van toegevoerde energie) van 40 procent. 's Werelds grootste led-lampenmaker Cree haalt 70 procent op een siliciumcarbide substraat, maar de Britse leds op basis van Humphreys' ontdekking zijn waarschijnlijk een stuk goedkoper te fabriceren.

Het is ten slotte vermeldenswaardig dat er al bedrijven zijn die GaN op silicium in hun assortiment hebben. Het Amerikaanse Nitronex maakt er power-schakelingen mee en Sanken heeft de droom van de led-industrie in wezen al vervuld, al is het onduidelijk welke wafergrootte de Japanners hanteren. Wafers met een diameter van 2 inch zijn veel makkelijker te 'bestuken' met GaN dan 6 inch (150 mm) exemplaren. Het lijdt echter geen twijfel dat er nog veel onderzoek te doen valt om verbeteringen te bewerkstelligen.

Opsnoepen

Het vervelende is dat wie de berichtgeving erop naslaat, de indruk krijgt dat Humphreys een wereldprimeur claimt met de bufferlaagstrategie. Dat is niet zo en de hoogleraar is zelf de eerste om dat te onderkennen. 'Om de materiaalstress onder controle te krijgen en de defectdichtheid te reduceren, hebben we zonder meer sterk voortgebouwd op het werk van anderen', laat hij weten in een schriftelijke reactie. 'Ik ben er echter van overtuigd dat wij dat beter hebben gedaan dan wie dan ook. Ik ben me niet bewust van onderzoek dat een hogere interne kwantumefficiëntie heeft weten te halen.'

Humphreys is dan ook niet gelukkig met de berichtgeving in de media. 'Sommige stukken deden me huiveren', zegt hij over artikelen van journalisten die blijkbaar fout op fout hebben gestapeld door verkeerd over te schrijven en Humphreys niet te contacteren. Anderen namen die moeite wel, maar toonden weinig interesse in de wetenschappelijke nuances. Dat is slechte journalistiek, al zou je ook vraagtekens kunnen plaatsen bij de hyperbolen in het Cambridge-persbericht die een en ander hebben aangezwengeld.

Eigenlijk het enige puntje van kritiek dat je zou kunnen hebben op Humphreys is dat hij mogelijk wat al te optimistisch is over de commerciële toepasbaarheid van zijn werk. Kant-en-klare devices heeft hij immers niet laten zien, alleen efficiëntiemetingen. De Engelsman denkt echter dat zijn lampjes commercieel nu al levensvatbaar zouden zijn, gezien het kostenaspect. 'Maar natuurlijk zouden we de prestaties nog verder willen opkrikken.'

Leds hebben grote voordelen en zullen zonder twijfel een groter aandeel van de lichtmarkt opsnoepen, zeker nu de EU de gloeilamp in de ban heeft gedaan. Het is echter niet duidelijk of het werk van Humphreys daar een significante bijdrage aan gaat leveren,

Advertentie Hier invoegen: pagina18Smit.pdf

GADGETS

E-ink Phone

Numerous concepts exist for mobile cell phones, but this particular Phone has a special feature. It doesn't make use of a conventional active display, like LCD or OLED displays, but uses E-ink technology instead. Since E-ink only requires energy to change the image on the screen, this means the energy consumption of the screen is only a fraction of today's phones. This phone combines a beautiful design with low energy consumption.

Philips MASTER LED

The use of conventional light bulbs is nearing its end. The best alternative aren't low energy light bulbs but LED based lights. This Philips Led lamp line-up contains 7 W Luxeon LED's which generate the same amount of light as a 40 W conventional bulb. With a pricetag exceeding €50 they aren't cheap, but the lifetime is fifty times longer than the normal bulb so in the long term the LED lamps are a bargain.

Asus We-PC

Shown at CeBit 2009: the Asus We-PC. The idea originates from wepc.com, an online Asus community, and consists of a netbook with two touchscreens. Both can be used as a keyboard with the keys displayed on the screen. When, on the other hand, you are reading an E-book, you can use it as an actual book. Finally a netbook which is more than just a "mini-laptop".

G-Raid Mini$_2$ SSD

External harddisk aren't a new gimmick anymore, but this one is! A beautiful casing at first glance, but the real beauty is inside. It contains two laptop size solid state disks so it's silent (no moving parts), energy efficient and very quick. Quick because of the SSD's itself, and because of the smart RAID controller inside. You can configure the disks in RAID 0, which results in data rates that exceed 200 MB/sec. Connect the disk to your pc with Esata, USB2.0 or Firewire 400/800. Perfect to accompany your high-performance laptop.

Toshiba TG-01

Many iPhone look-a-likes, that's what the phones shown at CES 2009 looked like. By far the most impressive one was the Toshiba TG-01. Only 9.9 mm thick, but packed with a 4,1" 800x480 display, a 1 GHz Qualcomm processor, GPS, Wi-fi and 3G. It runs a new Windows Mobile 6.1 OS with a special Toshiba graphical shell. Recent salesfigures of the HTC Touch Diamond show the iPhone is not unbeatable anymore, and this Toshiba certainly can compete. One to keep in mind when considering a new smartphone.

Roadmice

A mouse is not something extraordinary at all. Most of them are grey, more or less round and with a little red light at the bottom. But this one is different! Everybody loves one or more types of American musclecars. And now you can afford to use your own. Roadmice makes all different types of them, just to be sure you can cruise the web in style. They even have working headlights!

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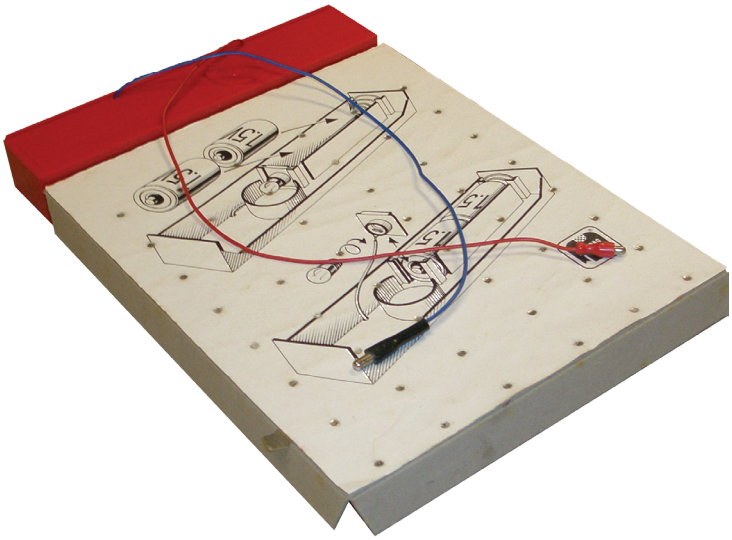
Electro

A new aproach to an old game



In life it's all about choices. No, you are not about to read a philosophical article about metaphysics. Although it would be interesting to give an overview of determinism from an Electrical Engineer's point of view, this article is about a board game all (Dutch) electrical engineers like and how to modify it into an even better version.

Author: Marijn van Dongen & Johan Splinter

Most of the readers of this article will have at least some affection with Electrical Engineering. It's interesting to think about how you did end up having interest in electronics (and when doing so we are actually practicing a little bit of metaphysics). Some of us might have the very trivial reason of having a dad or brother who was a hobbyist with electronics (chances of having a female relative with these interests are neglected here). It's easy to roll into the field if you were grown up among home made valve audio amplifiers or amateurist radio communication equipment.

Others will agree with the famous Dutch philosopher 'Baruch Spinoza', who was representing the theological determinism. According to him we actually didn't had much of a choice about where to end up in life, because the whole universe is determined by God, until every small detail. Ending up in electronics is equivalent to saying 'God made me do it'.

Yet another group might not have a very explicit idea of how they ended up doing electronics. When they were finishing high school and exploring the horizon of higher education, at some point they simply chose for Electrical Engineering. It's hard to grasp what exactly made them do this. Was it the enthusiastic student who guided them around in the building, was it the lightning flash produced in the High Voltage Lab or was it the nice hotdog with electrocuted sausage served during the lunch? In all of these cases it's arguable to think that the subconscious mind might have played a big role in your decision: something in the back of your mind suddenly made you choose.

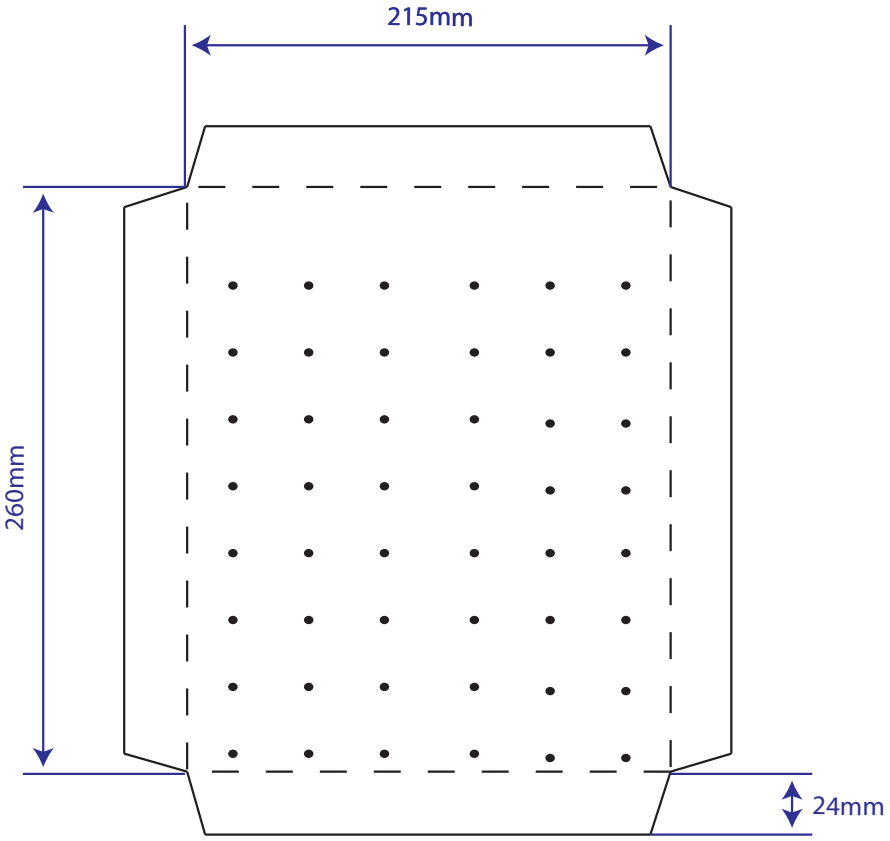
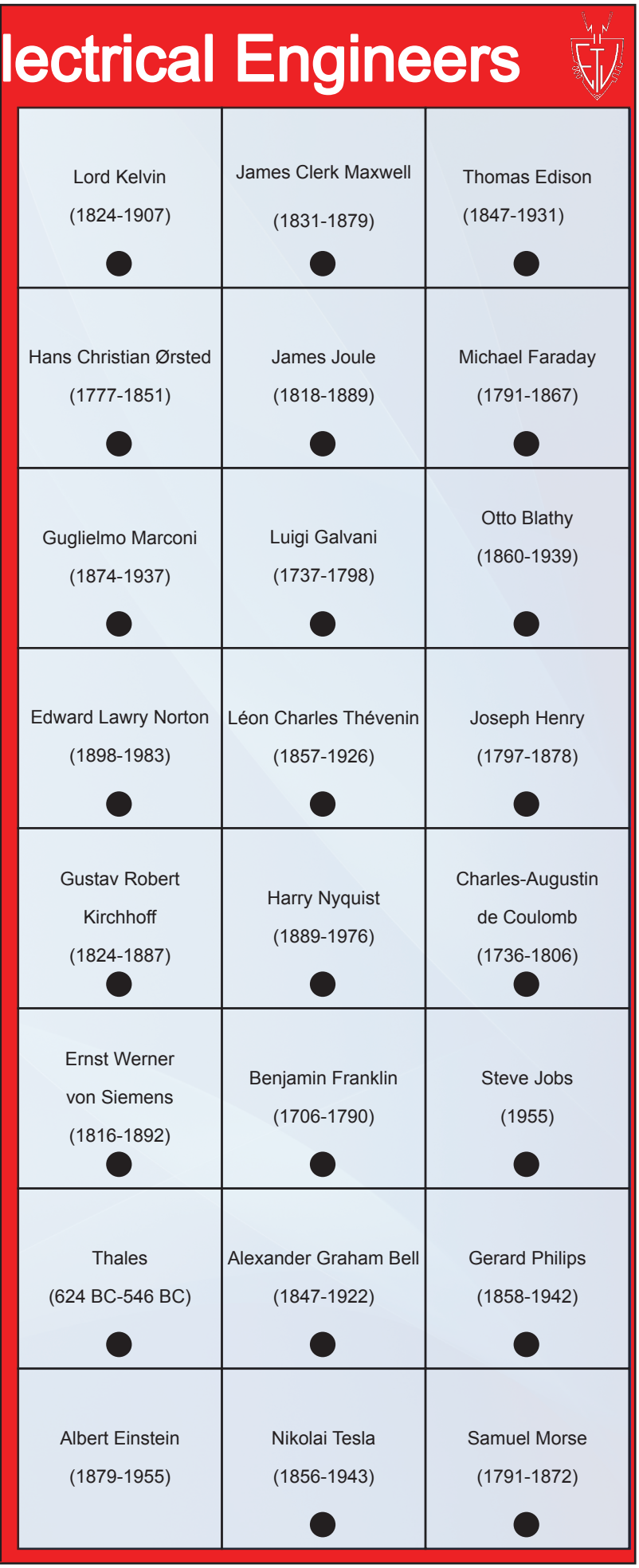


Figure 1. The layout of the Electro game board



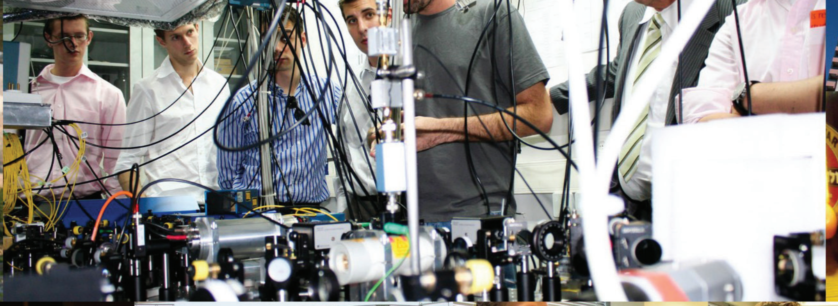
And that's the point where the old 'board' game comes in! Generations of (Dutch) children are grown up with board games produced by the company 'Jumbo'. Literally everybody has played 'Ganzebord' and 'Scrabble' with their family members. Another very common game is called 'Electro'. The purpose of the game is to solve puzzles by making pairs of two matching pictures out of a grid consisting of 48 pictures. The match is made by means of an electrical connection with two little wires. When the match was correct a light would switch on, indicating a correct match and resulting in a smile on the children's face.

Having understood the basics of 'Electro', it's trivial to see that this classic board game guarantees hours of fun time for little kids. And although it might sound a little unlikely it is very well possible that, when you were choosing your further education, somewhere in the back of your head a little flashback was made to the 4 year old version of yourself, playing Electro with all the excitement of a little kid.

And now it's time to make that flashback even stronger. In this article you'll find everything you need to make your own version of Electro, completely adapted to the needs of a grown up Electrical Engineer. Have fun playing it and bring back that 4 year old version of yourself!

Create your own Electro game

The Electro game is actually a very simple form of electrical puzzle. The game consist of two blocks, one on the left and one of the right. These blocks are divided in 24 small squares. Each square on the left corresponds to a square on the right. In this article you'll find an example spread with famous Electical Engineers and other persons who contributed to the world of Electrical Engineering. In the left plane you can see their pictures, in the right plane you can see their names. On the lower of each square you'll find a black dot.





Tilly Weil* · California
Norman & Rosita Winston Foundation · New York
Sonnya & Fanya Woll · New York
Sam Zacks* & Ayala Zacks-Abramov · Canada/Israel
Daphna & Richard Ziman Family · California
Dora & Ian Cameron* · Australia
Chais Family Foundation · California
Morris Goldstein* · Florida
Louise & Alex Grass · Pennsylvania
John Hammond* · Australia
Bruno Peter Hylston (Hilfstein)* · Australia
Madeleine Lejwa* · New York
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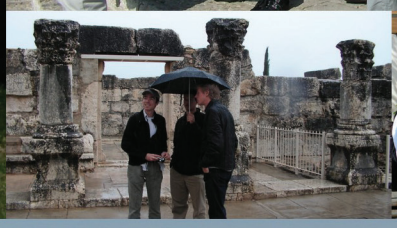
Rose & Paul Feher



Re{is}

is real study tour 2008

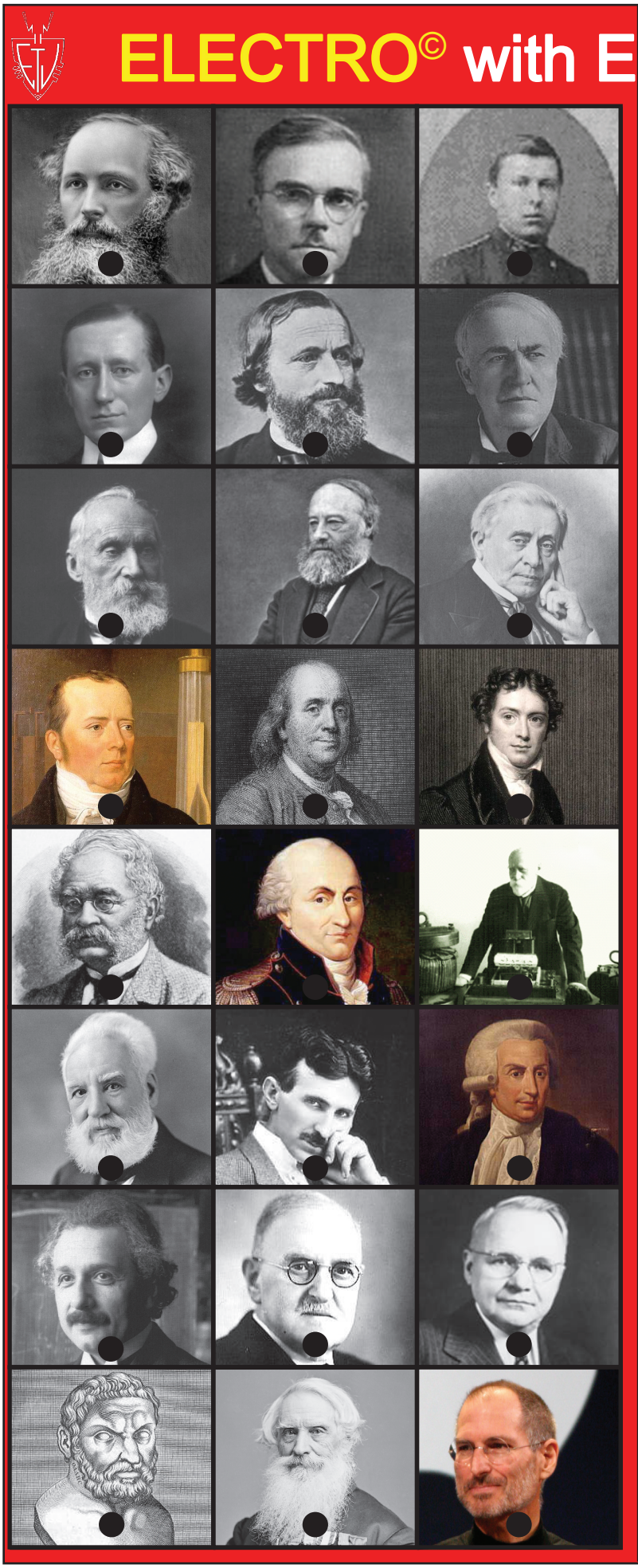
After cutting out the spread these dots have to be perforated. Those of you who are fortunate to still own a version of the Electro game can put the spread on their original equipment and find small circles of metallic foil right underneath the perforations. The circles of corresponding squares are now connected, and a simple circuit tester consisting of a battery and a lamp will show whether two squares correspond to each other.

Those of you so unfortunate not to own their own copy of the Electro game can buy one, or create one theirselves. First draw figure 1 in the right scale on a piece of cardboard, and cut it out. The exact location of the holes can be found by laying the spread on top of it. The hard part is to attach pieces of paper foil on the backside of the plane, and to connect the right pieces to each other. Providing the reader with the right configuration would spoil the puzzle altogether, but interested readers can contact the editorial board of the Maxwell by e-mail, and will be provided with the needed information.

Once the back of the game has been constructed, a circuit tester can be used to check for the right answers. Such a circuit tester can consist of a battery and a lamp or a buzzer, but a multimeter will also suffice.

Conclusion

Finally the author would like to apologize for the fact that this article has covered quite a lot of deterministic topics after all. This is against the promise in the introduction. However, the average Electrical Engineer has little interest in philosophy and the introduction was not meant to scare you out. Maybe after all some subconscious part of your brain even let you enjoy it and makes you realize that philosophy is actually not so bad at all!



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Is real study tour

Report of the Re{is} to Israel

Every two or three years the ETV organises a study tour to visit companies and cultrural events in different countries. After the Columbus Study Tour 2006 to North and South America (see Maxwell Year 10) in 2006 it was about time to organise a relatively small study tour. In november 2008 a group of 24 students payed a visit to Israel. This is a small summary of their experiences during the two weeks visit.

Author: Tamar Kraneburg

Saturday November 8, 2008

The first participants got awakened by a phone call from the ETV board telling them to prepare themselves for two beautiful weeks of study tour. Some two hours later the entire group of 24 students gathered at Schiphol. Ready to travel to Israel, ready to expand their view on the world and to immerse themselves in a totally different culture. The Is real study tour had commenced. This article is a short description of the Re{is}, for a more detailed and elaborate report you can read the final report, which will be available at the ETV from the end of January.

Over a year ago a committee of five students was assembled with the task to organise the next ETV study tour. Since the previous tour – the Columbus Study Tour – was a so-called `large tour' of four weeks, this new trip would be only two weeks long in order to make sure neither time nor cost would prevent anyone from participating. After asking around the faculty for tips and suggestions about where to go there were two possible destinations: Scandinavia or Israel. In her infinite wisdom the committee decided that Israel would be the place to go, a land that is most famous for its history of violence, but that nowadays is also renowned for its excellent scientists and a remarkable concentration of high-tech industry.

After some preparatory activities in The Netherlands it was time for the (Is) real deal: travelling with 24 ETV'ers to Israel for 16 days. We were accompanied by prof. Ligthart (IRCTR) and prof. Hellendoorn, and our special advisors Thomas Cohn and Kobi Kurtz. In total we visited 14 companies, three universities and one institute for research/graduate studies. Apart from these study-related activities, there were also three `cultural trips' to get a broader view of the country. The first ten days we stayed in Tel Aviv, and the remaining six we slept 100 kilometres north in Haifa, near the Lebanese border.

Figure 1:The first plane that took the participants to Zürich, from where the flew to Tel-Aviv

After an uneventful flight we picked up the three rental vans that would transport the group for coming two weeks. The next morning everyone got up and got ready to start the exploration of the new surroundings. While the committee picked up professor Ligthart from his hotel, the participants enjoyed the Israeli weather. The sun was out and temperature was a nice 25 degrees Celsius, a welcome change from the cold weather in Delft.

Sunday, November 8th 2008

The first day of excursions was a treat for would-be Power Engineers. We went to Ashkelon and visited a large coal power station, a major desalination plant and a smaller second power station that was gas fired. The salt was removed from the Mediterranean seawater by pushing it with very high pressure – 70 bar – through a membrane to achieve reverse osmosis. The gas fired plant next door provided the necessary energy. That night we also had our first collective dinner of the Re{is}. After enjoying a nice meal some Delftenaren also took the opportunity to discover the Israeli drinking culture.


An array of membranes used for the desaltation of water


Research on photovoltaic panels in Shoshana Dann

Monday, November 8th, 2008

The next morning we had to get up early for a long drive through the Negev Desert to Ben-Gurion University. After a couple of short but important stops along the

The participants blocking the view to Temple Mount in Jerusalem

Mirrors used for concentrating solar power at the Wiezmann Institute

way, we arrived in Sde Boker. Here researchers are working on finding out the best way to handle the climate on the desert. We learned about building technology to handle the extreme heat and cold, and visited a testing facility for solar energy systems. In the afternoon we went to Ben-Gurion's main campus in Be'er Sheva. Here we met some Israeli students who explained that this university is involved in a lot of volunteer work in the community – around on in three students participate in these projects.

Thursday, November 9th, 2008

The next day we had a cultural trip to Jerusalem. Led by our guide Rina we visited as many of the important and impressive things this ancient city has to offer as we could in one day. Starting at Mount Scopus, we went via Mount Olives into the Old City. Here we visited the Wailing Wall and followed a part of Jesus' path to his crucifixion (Via Dolorosa). At the end we also went to the Israel Museum where the Dead Sea scrolls are exhibited.

Wednesday, November 10th, 2008

Wednesday it was back to serious business. The drivers' guild led us to the famous Weizmann Institute. Since there is no EE department here, we visited the department of Physics. Here we saw a lot of electro optics and laser technology. We were bombarded with atto and femtoseconds, absolute zero, subatomic particles and other fundamental physics. In the afternoon we had a tour around the Solar Tower, where sunlight is focused by an array of mirrors, and saw some biomolecular computing.

At the last moment the committee managed to organise a cultural intermezzo. Tel Aviv is known around the world for its many Bauhaus-style buildings, which make it a UNESCO World Heritage Site. That evening fellow Dutchman Frits de Wit took us on a relaxing walk to the

most important and beautiful examples of Bauhaus. The tour was finished off with a beer or two in one of Tel Aviv's well known bars: Mike's Place. On our way back to the hostel later that night we also encountered our first and only rainfall in Tel Aviv.

Thursday, November 12th 2008

Thursday was reserved for the industry that built Israel's reputation: defence. In the morning we went to Elbit, producers of the high-tech helmet for the JSF, and saw very advanced electronics applied in the military field. In the afternoon we went to MBT Space, a subsidiary of Israel Aerospace Industries. MBT Space, designs, launches and manages Israeli satellites for both commercial and military purposes.

A robot used for military purposes presented at Elbit

Once again we also had an activity scheduled in the evening. On the faculty of Electrical Engineering of Tel Aviv University the participants were presented a talk about studying in Tel Aviv, followed by an impressive presentation by the Peres Center for Peace. This NGO, founded by Shimon Peres, tries to bring Palestines and Israelis together by encouraging regular people to get to know each other and cooperate.

Friday, November 14th, 2008

Friday was the chance to get some rest from the first long, hard days. However, only a handful of participants took this opportunity because most of them went to the West Bank, another last-minute addition to the itinerary. Toine van Teeffelen proved that the Dutch really can be found all around the world. He is living in the Palestinian town Bethlehem for 13 years now, and took the group for a tour along the Security Wall and a refugee camp. After this the participants got a chance to talk to a couple of young Palestinians and saw Bethlehem's centre. At the end of the day we met a couple of Palestinian students and then it was time to head back to Tel Aviv to say goodbye to prof. Ligthart and his wife, and to welcome prof. Hellendoorn to the group.

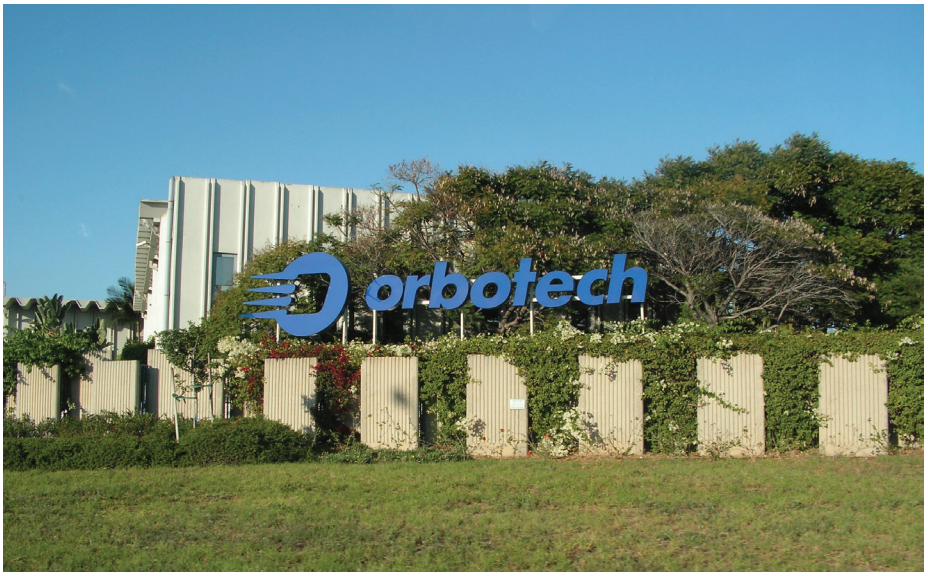
Saturday, November 15th, 2008

The second week of the Re{is} started with a couple of `must see' cultural excursions. After another long drive through the desert, our first destination was Masada, a citadel from the Roman Era looking out over the Dead Sea from a high cliff. A gondola took us up to the ruins of the old fortress, accompanied by a group of partying Brazilian lunatics and loud (Delfts) songs. After this visit we continued on to the Dead Sea where we found that all participants indeed stayed afloat in the salt water, even at 420 meters below sea level.

You can't leave Israel without a visit to the dead sea

Sunday, November 16th, 2008

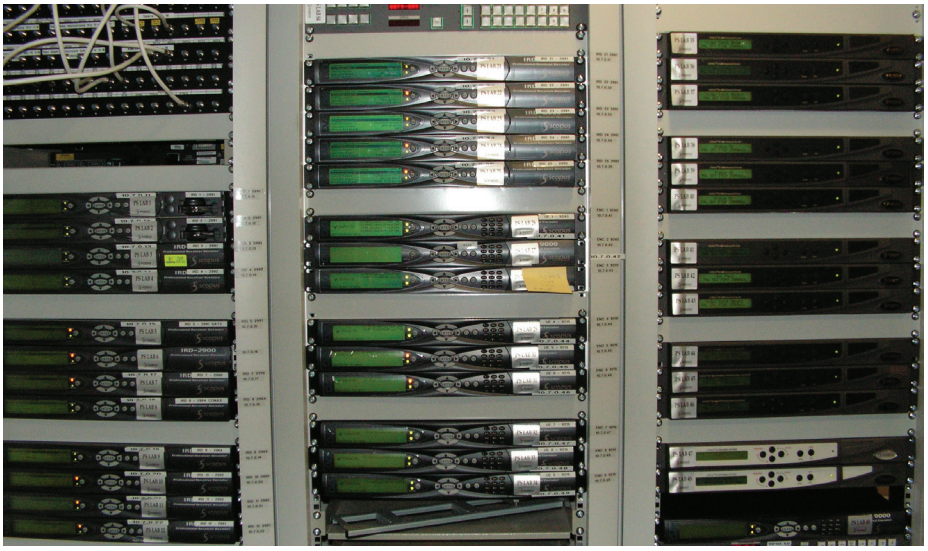
After this relaxing day it was time for some electrical engineering again. The day started at El-Mul, a company specialised in designing electron detectors for scanning electron microscopy. After this visit we crossed the street for a visit to Orbotech. This is the market leader in the development and testing of PCB's in all shapes and sizes. The day ended at a small high-tech start-up company, Mantis Vision. In this tiny company (30 employees) they were able to capture high quality 3D imagery using smart projections and algorithms and a single video camera.



The orbotech sign

Monday, November 17th, 2008

On day ten we went to video networking giant Scopus and Xsight. Like Mantis Vision, Xsight is one of the many, many start-up companies in Israel. We were welcomed as `Delpht Students' and got an elaborate presentation on a detector for airport runway safety, which also included a live demo of the system in testing at Boston's Logan airport. The Delphtenaren also got an inspiring talk by Alon Dumanis, an ex-general that is now assisting start-up companies on the long road to success. Immediately after our visit we relocated to our home base for the last couple of days: Haifa. Upon arrival we quickly discovered Eli's Pub opposite the hostel and at midnight we celebrated Poley's birthday, who seemed proud of his accomplishment even though he already was the oldest member of the group.

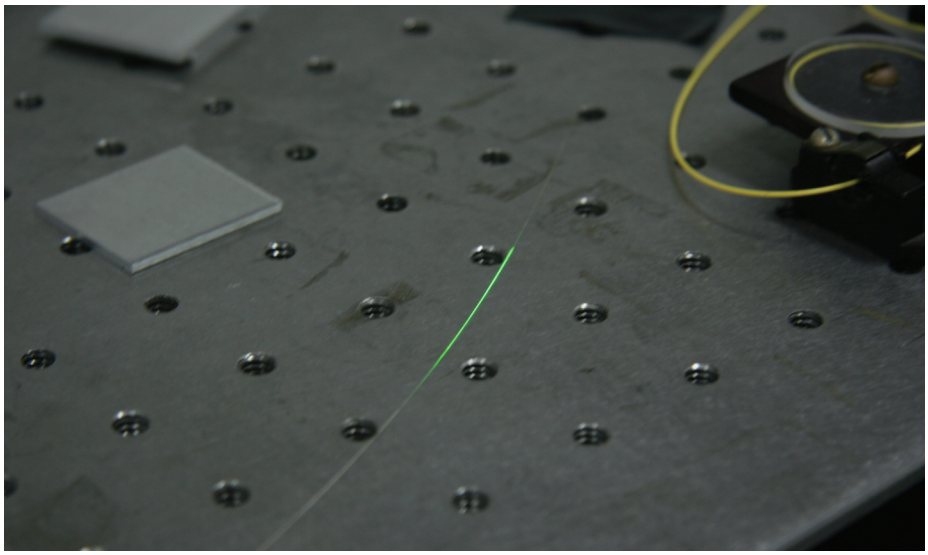


Arrays of Scopus digital video devices

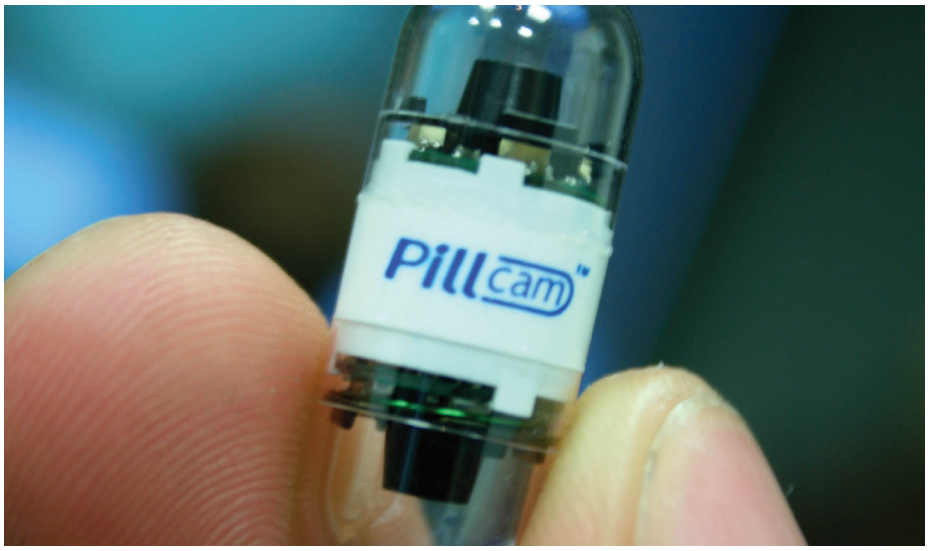
Tuesday, November 18th, 2008

Our first full day in Haifa was not very full at all. At the last moment it turned out Philips Healthcare was not able to host a group of interested engineers, so the morning programme was cancelled. After lunch we had a short visit to Intel's Israel Design Center. Here the following legendary words were spoken: "Do you guys know what a MHz is?". After we explained our background we got a tour of the testing and validation laboratory,

A demonstration model at Xsight



Fiber optics at Technion



A camera in the shape of a pill at GivenImaging

A day in the kibbutz, not about Electrical Engineering at all

where they check the latest chip designs. That night it was time for a time-honoured ETV tradition: it was the third Tuesday of the month so we celebrated an international edition of Kobus Kuch.

Wednesday, November 19th 2008

On Wednesday everyone went to the university of Israel: the Technion. This University of Technology also boasts a medical faculty, something that would be a great addition in Delft. After an introduction by the associate dean of EE (also a good friend of our own dean), several professors presented their work. This was followed by an extensive tour by the different research groups and a meeting with some Technion students. One notable detail was the fact that there was no activity in the Power Engineering field, due to a lack of qualified personnel. We finished the day at the Technion incubator were we got a demonstration of an exoskeleton by a start-up called Argo that enables a paraplegic to walk upright.

Thursday, November 20th, 2008

Thursday started with a loud `Lang zal hij leven' for Berghuis. Equipped with a brand new driver's keppeltje and a big grin he then set up our navigation lady Amy to guide us to Saifun Semiconductors. Here we were explained their smart MirrorBit technology for flash memory. That afternoon it was time for our final company visit: Given Imaging. After some confusion – Amy did have her flaws – we managed to find the correct building. Given Imaging has developed the PillCam, a tiny camera capsule that should make invasive endoscopy a thing of the past.

Friday, November 21st, 2008

The next day should have been a quiet day off, but 17 participants had a different idea. They headed to a kibbutz, where we were welcomed by Rina, our guide in Jerusalem. She showed us around the kib-

butz grounds, and afterwards we had fun in the pool with the ETV-strandbal and creating artificial dams as true multidisciplinary engineers. Back in Haifa we explored the nightlife, which ended Kranenburg vs. The Rest: 1-0.

Saturday, November 22nd, 2008

Our final full day of the tour was the first day with disappointing weather. This meant our panoramic view from the Golan Heights was somewhat diluted. Afterwards which we visited some famous sights from Jesus' time near the Sea of Galilee, had lunch in the only restaurant that was open on Shabbat and made a short stop in Nazareth.

After returning to the hostel everyone had some time to rest before we went for our final collective dinner. Our rest was abruptly interrupted when the committee's stressfles turned up missing from the room. There was no time for too much stress, we had to go to the Isabellabar for our meal, with special guests Thomas and Sabine Cohn and professor Uri Kupferschmidt and his wife Tamar. Professor Kupferschmidt gave an enlightening explanation about differences between `old' and `new' Israel. The committee president Kranenburg delivered his final speech, and participant Kleijn also spoke some words to thank the committee and presented them with a small gift to ease the pain of the missing stressfles.

Sunday, November 23th 2008

So, after 15 days and almost 2300 km travelling around Israel filled with company excursions, unique experiences and partying as long as we could it was time to head back to our cold frog country. After the tiresome check in and security ritual everyone converted their last shekels into burgers and coffee at the airport. During our transfer in Zürich we were surprised to find ourselves in the middle of a snowstorm, which delayed us for two hours. In the end we landed at the Polderbaan around midnight, and the Is real study tour had come to an end. Everyone who participated will agree that this study tour has more than deserved its place in the long tradition of ETV study tours. Lehitra'ot!

More information

Interested readers are encouraged to contact the ETV board to review or obtain a (digital) copy of the preliminary report and the final report. These reports contain more information about the visited places and companies, and include a more comprehensive report of the excursions.

A typical view of the Sea of Galilee

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Graduation Report

Directional relay coordination in ungrounded medium voltage networks using a real-time digital simulator

Author: Ir. Arjen A. van der Meer

The thesis describes a comprehensive protection relay coordination study in ungrounded 10 kV distribution networks. Until now, single phase-to-ground faults (also: earth-faults) were never interrupted because resulting fault currents were relatively small. Since the earth-fault current amplitude is proportional to the total medium-voltage (MV) network cable capacitance, these fault currents continued to increase as the distribution networks continued to expand.

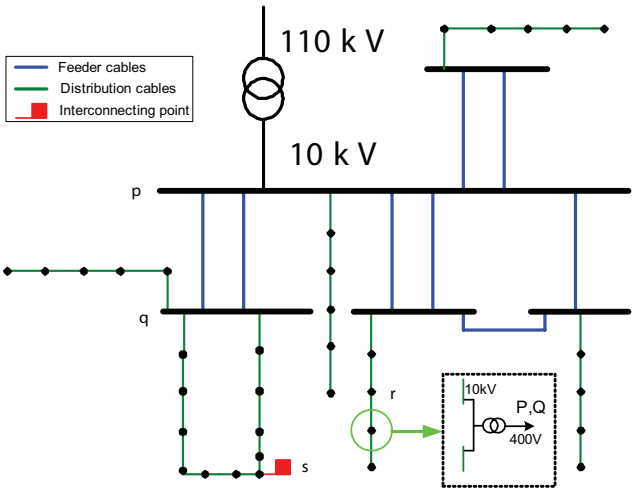


Figure 1: A typical radial MV network

In some ungrounded MV networks, the steady-state earth fault current can be as high as 800A. In order to interrupt earth-faults correctly, they should be distinguished from other types of short-circuits. This is generally done using protection relays which do not only measure three-phase voltages and currents, but also the cable sheet current (or zero-sequence current). Direction determination and relay coordination is a bit more complicated since the fault current source (cable capacitances) is distributed along the MV-network. The study tries to tackle these challenges by proposing a generic relay coordination method in which boundary conditions like cable length and MV network size are considered. During the study, closed-loop operation of a real time digital simulator (RTDS) was used for model verification.

Electricity grid

The current electrical power system was formed over a period of about 120 years. Small isolated grids were combined to larger networks over the past 50 years to obtain better economical efficiency and a more reliable electricity supply. Consequently, electrical power is generated in a centralised way and transported through the high voltage (HV) grid and HV/MV transformers to the MV distribution network. Figure 1 depicts a simplified one-line diagram of a radially constructed three-phase distribution network, which is the most common topology used for MV networks. The blue cables between node p and node q are feeder cables, the green cables are distribution cables with MV/LV transformers (black dots). As can be seen, most cables have only one feeding point (like node q), which makes them vulnerable to disturbances elsewhere in the MV network and therefore, selective earth-fault interruption in each particular cable section is necessary.

Symmetrical components, ground faults and neutral grounding

During normal operation, a balanced, sinusoidal set of three-phase voltages and currents is present: the sum of voltages and currents equals zero. During a short-circuit, phase conductors are touching each other, the cable sheath or both: the sum of either voltages and currents do not equal zero anymore and, as depicted in Figure 2, the set of three-phase phasors is now decomposed in three sets of balanced phasors, namely:

- A positive-sequence system in which the phasor sequence is clockwise
- A negative-sequence system in which the phasor sequence is counter-clockwise
- A zero-sequence system in which all three phasors are equal

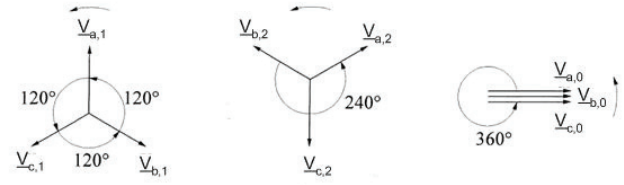
As will be shown later on, the zero-sequence system is very important for earth-fault detection and interruption. First, let's have a look at Figure 3, which is in fact the left part of Figure 1. In this particular case, selective interruption of an earth-fault in cable 2 is considered, which means that the protection relays of cable 2 detect and interrupt the earth-fault while no other relay in the MV network may trip. It is important to notice that the transformer is connected wye-delta, which implies that system's neutral coupling is realised by the distributed capacitance of the cables, as is shown in Figure 4. For symmetrically distributed phases, the charging currents provide the neutral voltage to be equal to ground potential. Neutral displacement takes place during earth-faults and, depending on whether the short-circuit is bolted or not, the voltage triangle will shift "downwards" causing the voltage rise of √3 in healthy phases, as depicted in Figure 5.

In most MV networks, the HV/MV transformer is connected in either wye-wye or delta-wye, by which the secondary neutral point is connected to ground through an impedance. This has two major advantages: Firstly, earth-fault currents will be much higher, making relay coordination easier and secondly, insulation coordination can be less critical since healthy phase voltages do not rise during an earth-fault. Although it is quite simple to ground an ungrounded system through a zigzag transformer, many MV networks are still left ungrounded for financial reasons. Furthermore, every single relay must be reconfigured during such a transition, which is quite a challenge since the network must continuously remain protected.

Power system protection and direction determination

Maximum definite-time overcurrent protection (DMT): Widely used inside radial MV networks and coordination is generally realised through discrimination by time. Grading is usually applied with grading times of 0.2 to 0.3 s, rising from load to source.

Inverse definite minimum-time relays (IDMT): Coordination is generally realised through both discrimination by time and discrimination by current, making trip times dependent on short-circuit current. Fault interruption times



(a) Positive-sequence components (b) Negative-sequence components (c) Zero-sequence components

Figure 2: Sequence components during system unbalance

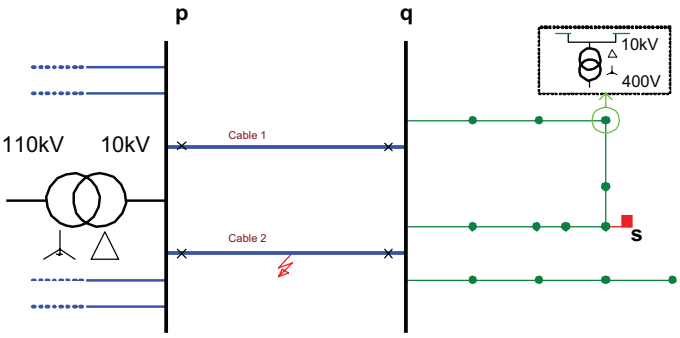


Figure 3: Simplified MV network with two feeder cables between node p and q; an earth -fault is present in cable 2.

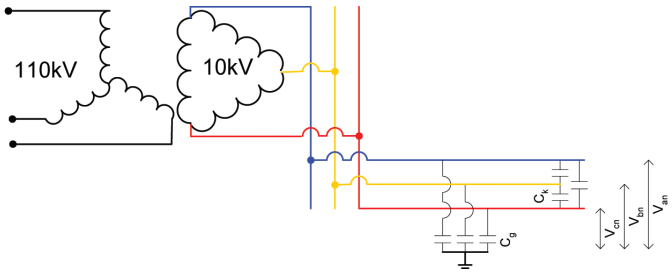


Figure 4: The neutral point of an ungrounded network is determined by the cables' distributed capacitances.

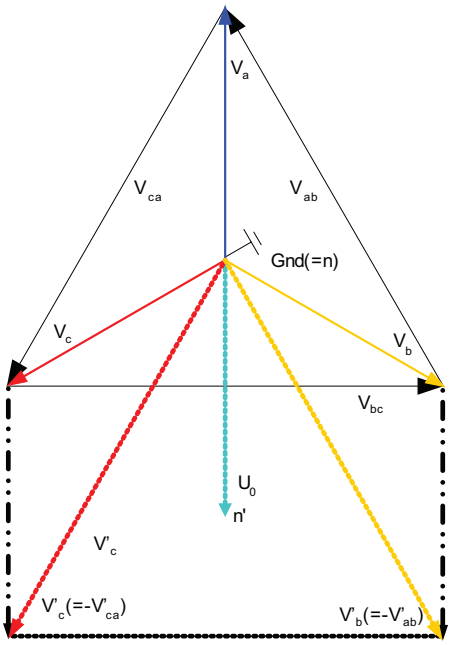


Figure 5: Neutral displacement during an earth-fault in phase a. Post-fault voltages are dotted.

will generally be shorter compared to DMT protection, but network behaviour is less predictable due to the current dependency.

Differential protection (DIFF): Frequently applied in new cable paths and as a part of transformer protection. At both sides of the cable the difference between incoming and outgoing phase-currents is determined by making use of pilot-wires. Switching times are very short and every type of fault inside the cable can be interrupted. Secondary circuits must be fully symmetric however and current transformer saturation can lead to incorrect cable interruption.

Distance protection (D): Extensively used as main protection in HV en MV networks. Operation is based on the measured impedance at the position of the relay in the grid. Comparing this impedance, which is known at every time instant, with the impedance of the cable up to the reach point, short-circuits inside zone 1 (~85% of the cable) can be interrupted quickly. The majority of modern distance relays have several zones, each with its own delay time to maintain proper relay coordination.

The simplified network of Figure 6 is used for further analysis: this is allowed since $C_{grid,0}$ and $C_{dist,1}$ cause the fault current during an earth-fault. In this case, feeder protection is realised traditionally by a combination of DMT relays and directional relays (Dir.DMT). Direction determination is necessary for relays positioned at node q to distinguish between faults inside the feeder cable and faults in distribution cables or parallel feeders. Dir.DMT relays are usually graded at 0.3 s for faults detected forwardly. For the depicted fault, Dir.DMT2 and DMT2 should both trip while DMT1 and Dir.DMT1 may not pick-up. Earth-fault direction is usually determined as follows: after fault ignition, zero-sequence voltages and currents are measured by the directional relay. Zero-sequence fault current ($=\underline{I}_{e,q}=3\underline{I}_0$) measured by Dir.DMT2 typically lags the displaced neutral voltage by 90° as the relay measures currents flowing into the protected feeder cable. Direction is measured according to Figure 7 and determined forward if zero-sequence power is positive:

$$P_0 = U_0 I_{e,7sj62} \cos\left(\varphi_{sc,0} - RCA_0\right) > 0$$

Where U_0 the displaced neutral voltage, $I_{e,7sj62}$ the earth-fault current measured by the relay, φ_{sc} the angle between $\underline{U}_0$ and $\underline{I}_{e,7sj62}$ which equals typically +90° for forward faults and RCA_0 the relay characteristic angle, which can be adjusted according to grid layout and is adjusted to +45° for cable networks.

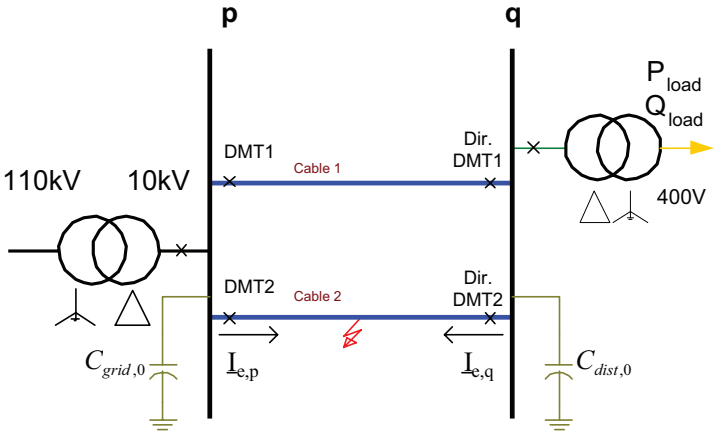


Figure 6: Simplified network used for earth-fault analysis

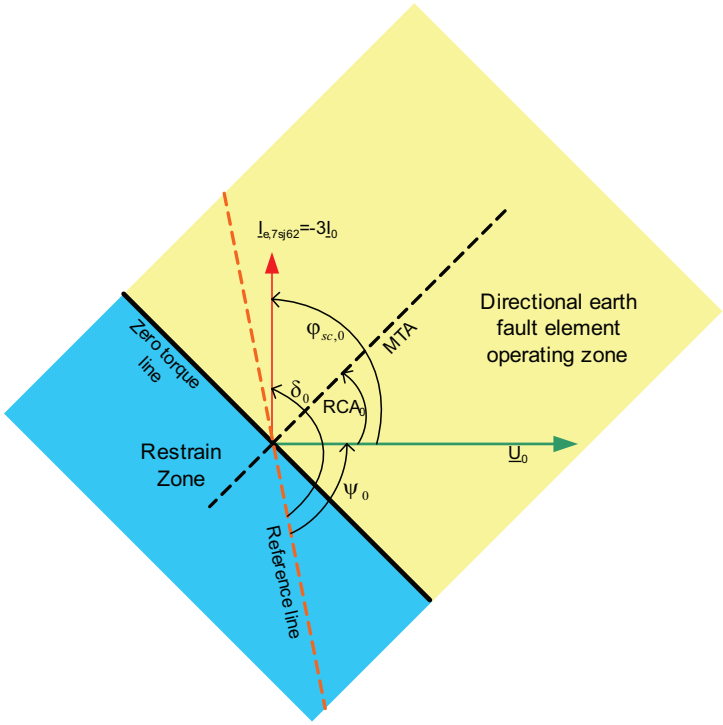


Figure 7: Phasor diagram of a typical directional earth-fault element. Zero-sequence voltage $\underline{U}_0$ is used as a reference phasor for direction determination. RCA_0 of 45° is applied.

Minimum relay settings

As described in the previous section, directional relays may only detect faults in their own cable, in this case a feeder cable. Faults at and beyond node p may therefore not be detected and this leads to a minimum current setting, $I_{e,7sj62}=I_{e,dist}$, which equals the capacitive fault-current produced by $C_{dist,0}$. In order to provide correct relay coordination for two parallel feeder cables, neither DMT1 nor Dir. DMT1 may trip during an earth-fault in cable 2. In case cable 2 was already interrupted at node q due to Dir.DMT2, $I_{e,dist}$ flows through cable 1, node p and cable 2 to the fault location. During this period, which lasts for only a few hundreds of ms, DMT1 may not react and therefore the minimum current setting of both DMT1 and DMT2 is $I_{e,DMT}=I_{e,dist}+I_{e,feeder}$, which is slightly higher than $I_{e,7sj62}$ because of

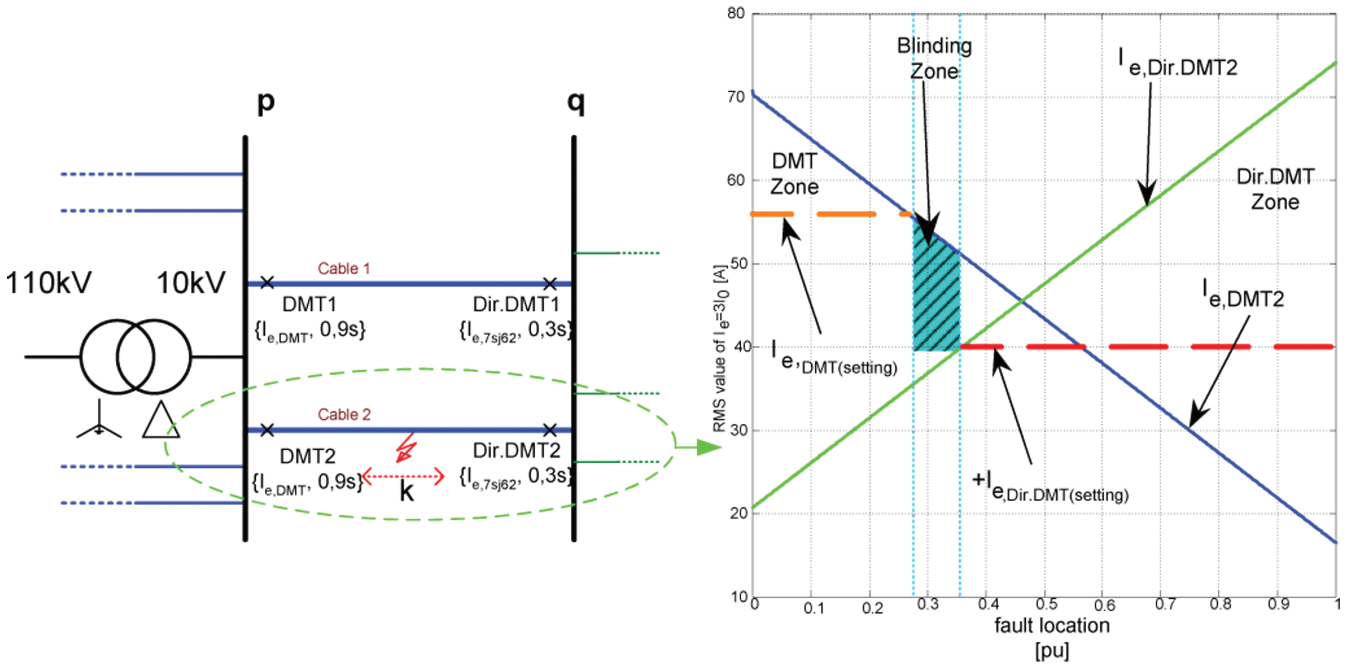


Figure 8: The presence of a blinding zone in the encircled part of the network. For a certain range of the fault location k, the fault currents from both sides are too small for the relays to response. The orange dashed line represents the $I_{e,DMT}$ setting while the red dashed line represents the $+I_{e,Dir.DMT}$ setting. k can be varied from 0 (node p) to 1 (node q).

the distributed capacitances of the feeder cable that are being taken into account. While pickup currents thus depend on network capacitances, delay times can be chosen manually. In this case, Dir. DMT1&2 are configured at 0.3s. and DMT1&2 at 0.9s. The described settings are the very minimum settings; lower pickup values would lead to incorrect circuit interruption. In order to operate the network protection less sensitively, a current setting margin factor α was introduced. α =0, α =25, α =40 and α =50 were examined during the study.

Blinding of protection and simulation results

Radial distribution networks do usually have extended distribution strings. That means that, in some cases, the size of the network beyond node q is large compared to the entire MV network and therefore, $C_{dist,0}$ is large compared to $C_{grid,0}$. Since this affects the minimum current settings of both DMT and Dir.DMT relays, blinding of protection can be experienced: neither Dir.DMT2 nor DMT2 will detect the earth-fault in the feeder cable. Almost

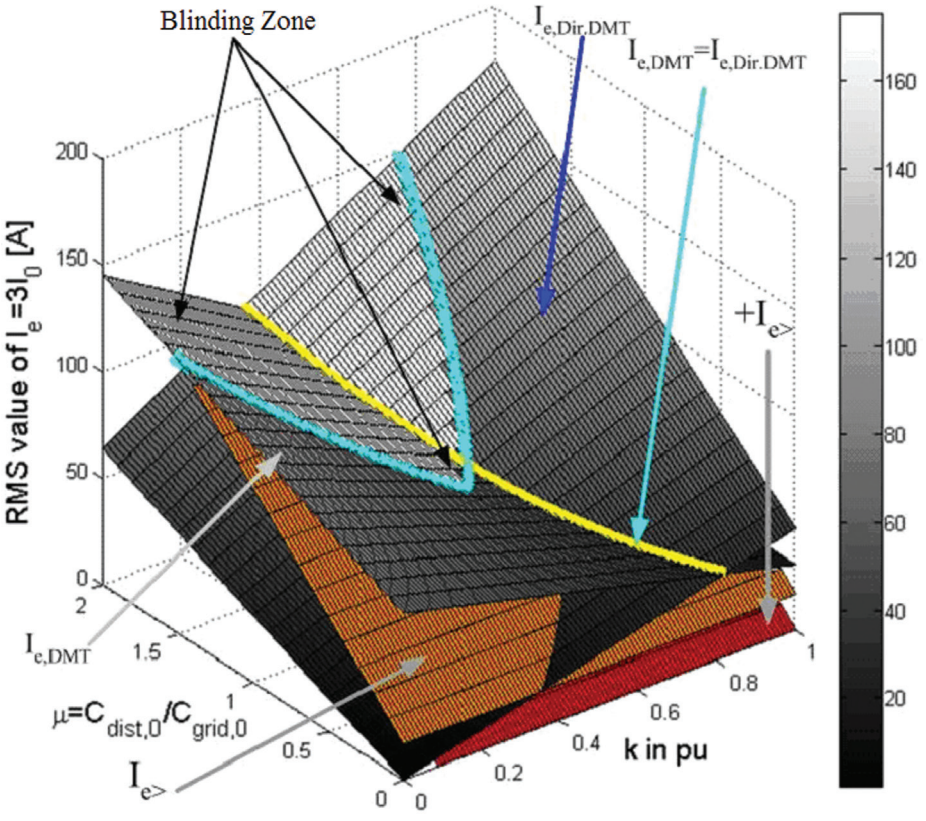


Figure 9: Presence of a blinding zone during a single phase-to-ground fault in cable 2 as the fault location k and the network capacitance factor μ are varied. Earth-fault currents measured at both cable ends are depicted as two planes crossing each other at the indicated line. $I_{e>}$ and $+I_{e>}$ are DMT2 and Dir.DMT2 settings respectively, which vary with μ as well, spanning two parallel planes.

needless to say, blinding of protection is highly dependent on fault location. This is illustrated in Figure 8 in which earth-faults between k=0.28 and k=0.35 per unit cable length will not be interrupted by any relay in the MV network. During the thesis, it was found that correct relay coordination strongly depends on μ, the ratio between $C_{dist,0}$ and $C_{grid,0}$. This factor was varied from μ=0 to μ=2 by changing $C_{dist,0}$ in order to find the first appearance of a blinding zone, leading to μ_{lim}, as can be seen in Figure 9. For this particular case (α =25, 10km feeder cable length), μ_{lim} was equal to 0.8. This calculation was repeated for numerous network sizes by variation of $C_{grid,0}$ and different values of α, as can be seen in Figure 10. It turned out that μ_{lim} is roughly constant between $C_{Grid,0}$=5μF and $C_{Grid,0}$=30μF, which is approximately equal to 100 km of 10kV cable.

RTDS application

During the thesis project, a Siemens 7SJ62 directional relay was connected to the RTDS of the High-Voltage Components and Power Systems group (HCPS). In practice, primary values of voltages and currents (typically 10000V and 400A) are transformed to lower, secondary values (typically 110V and 5A) by measurement transformers. Since the RTDS only produces voltage signals of ±10V, amplifiers were needed for correct relay operation. This was executed with Quad 50E audio amplifiers connected between RTDS and relay, with excellent results. Figure 11 depicts the relatively simple relay test system, in which the described network was implemented on a workstation and the RTDS. The RTDS calculates node voltages and cable currents in real-time while amplifiers generate artificial secondary voltages and currents. A trip contact is fed back to the RTDS to operate a virtual circuit breaker if the relay trips during an earth-fault. Unfortunately, the opposite DMT relay was modelled since too little amplifiers were available to connect both relays to the RTDS.

Outlook

The proposed method will probably be used in ungrounded MV networks of Enexis (former Essent Netwerk). Earth-faults can be interrupted selectively by effectively using zero-sequence components of voltages and currents. Simulation was done with two parallel feeder cables only as this is the worst-case situation for correct relay coordination. Besides the relay coordination study, closed-loop operation of the RTDS was established for the first time since it came into service in 2005.

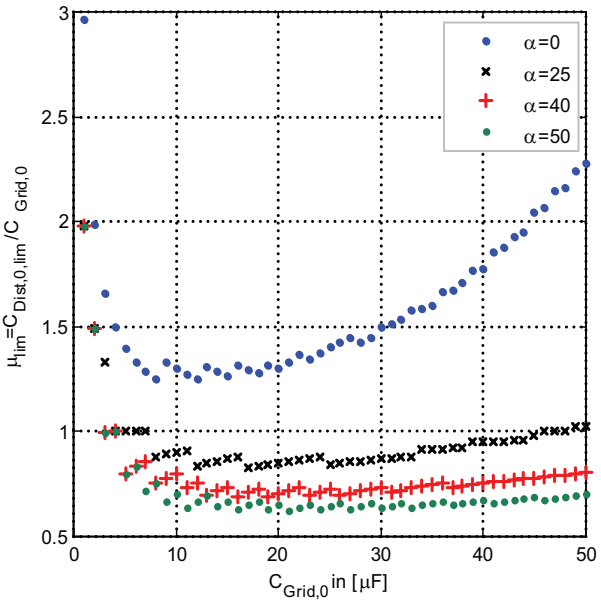


Figure 10: μlim as a function of $C_{Grid,0}$ for a feeder cable length of 10km and μ=0, 25, 40 and 50

The HCPS group offers an interesting course in power system protection, Power System Grounding & Protection (ET4114). Also, feel free to drop by at the EPP or HCPS groups for challenging MSc graduation projects involving power system protection and RTDS.

References

[1] Alstöm: "Network protection & Automation Guide", 2002. Available online at http://www.scribd.com, last accessed February 2009.

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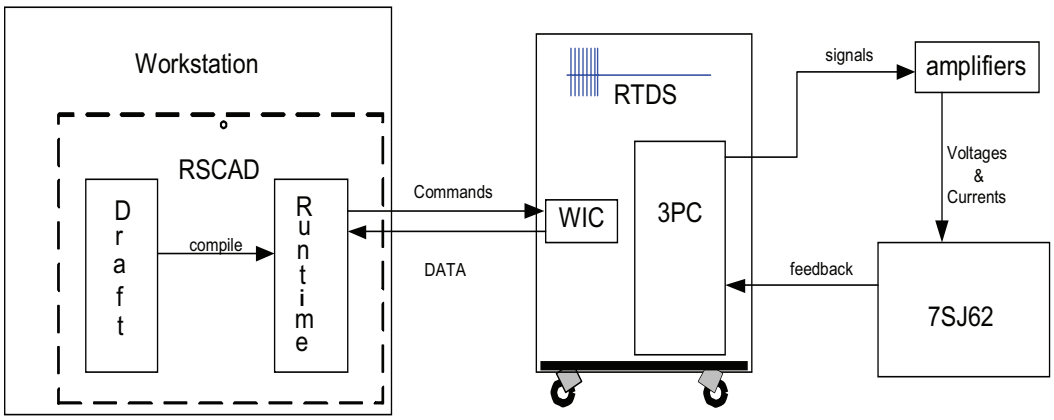


Figure 11: Closed-loop operation of protection equipment and RTDS.

Cooking with...

Prof. Van der Sluis

Egg Nog

Egg Nog is a traditional Dutch delicacy. Mothers, grandmothers and mothers in law love it. Making Egg Nog by your self is not that difficult: a small investment in eggs, sugar and brandewijn, which is a typical Dutch spirit, and half an hour of exercise in the kitchen makes you the proud owner of a liter of excellent home made Egg Nog.

Preparations

Collect a dozen large eggs, take 350 grams of white sugar and a few grams of vanilla sugar. You will need 0.6 liter of brandewijn as well. The brandewijn should contain 35 % alcohol. I always use the brand 'Mispelblom', available in most liquor shops and it sells for approximately 15 Euro's. Further we need: a large bowl, a sieve, two pans that differ in size (the smallest pan must fit into the larger one) and also a small saucer and a wooden spoon.

Method

Let us get started. Break the 12 eggs in the bowl and stir them till the egg-whites and egg-yokes are mixed. Pour the egg-mixture through the sieve into the small pan, this in order to remove the filmy particles of the egg-yokes. Add the sugar and the vanilla sugar and stir until the sugar is dissolved, then pour the brandewijn to it.

Now we reach the difficult part of the job, heating our egg-sugar-brandewijn mixture in a controlled way: we are going to simmer it. The French call this way of heating 'Au Bain Marie. Put the saucer upside down in the large pan, pour some water in it and place the small pan, with our egg-mixture, on top of the saucer. The water level should reach till approximately two centimeters below the rim. Put everything on a gas flame and start stirring immediately. We are now heating our mixture in an indirect way and the trick is to keep on stirring while the egg-whites coagulate. The mixture should not get too hot, otherwise the coagulated egg-white will show as tiny white lumps in our end product. It is not easy to tell the right moment to stop the heating process, also in this case it is the experience that counts. The moment is usually right when the substance thickens and changes its color to light yellowish because of the coagulation of the egg-white. When the decision is made to stop the simmering, switch off the gas, take the pan out of the water and keep on stirring for an additional few minutes. Also stir the Egg Nog every five minutes while it is cooling down. When you put the Egg Nog in clean glass jars you can keep it in the fridge for quite a number of weeks.

Advocaat

Het zelf maken van advocaat is niet echt moeilijk: een kleine investering in eieren, suiker en brandewijn en na een half uurtje klussen aan het fornuis ben je de trotse bezitter van een liter voortreffelijke advocaat. Vriendinnen en aanstaande schoonmoeders zullen er voor vallen!

Voorbereiding

Scharrel 12 grote eieren bij elkaar. Daarnaast zijn nog 350 gram kristalsuiker, een zakje vanille suiker en 0.6 liter brandewijn nodig. De brandewijn moet 35% alcohol bevatten. Zelf gebruik ik altijd het gerenommeerde merk Mispelblom, dat bij de goed gesorteerde spiritualiënhandel voor een kleine vijftien euro over de toonbank gaat. Verder nog nodig: een grote kom, een zeef, twee pannen die in formaat verschillen; de kleinste pan moet in de grote passen, dit ten behoeve van het Au Bain Marie verwarmen van het geheel, en dan nog een schoteltje en een houten lepel.

Bereidingswijze

We gaan aan de slag. Breek de 12 eieren in de kom en roer alles goed door elkaar. Giet het mengsel door de zeef in de kleinste pan om de ongerechtigheden uit het ei, de vliezen van het dooier, de kralen snoeren en kleine stukjes van de schil die bij het breken van de eieren zijn meegekomen, te verwijderen. Roer vervolgens de kristalsuiker en de vanillesuiker door het eimengsel tot de suiker is opgelost en giet dan de brandewijn erbij.

Nu komt het moeilijkste van de klus, het Au Bain Marie verwarmen. Leg in de grootste pan het schoteltje omgekeerd op de bodem, giet er wat water in en zet de kleinste pan op het schoteltje. Het water moet ongeveer een centimeter of twee onder de rand staan. Deze handel gaat op een gaspit, we steken die aan en gaan onmiddellijk met roeren beginnen. Het ei-suiker-brandewijn mengsel wordt op deze wijze indirect verhit. De grote truuk is nu te blijven roeren terwijl de eiwitten langzaam stollen. Het mengsel mag niet te warm worden want dan gaan de eiwitten klonteren, de vakman spreekt van schiften, en de beoogde gladde textuur van ons eindproduct gaat verloren. Het is niet eenvoudig om het juiste moment te bepalen wanneer we moeten stoppen met verhitten, hier spreekt de ervaring een woordje mee. Het goede moment dient zich aan als het mengsel wat dikker begint te worden en de kleur, door de vorming van de eiwitten, lichter geel begint te kleuren. Als het besluit gevallen is om de gaspit uit te draaien, dan de pan uit het water nemen en nog even blijven roeren. Tijdens het afkoelen om de paar minuten roeren en als de advocaat is afgekoeld kan het in goed schoongemaakte glazen potten wekenlang in de koelkast bewaard worden.

Company Interview

An interview with Gleb Vdovin, founder of Flexible Optical BV.

Flexible Optical BV is a company that has gathered some fame from the TV-show Discovery's Project Earth, where they researched a membrane that breaks light in multiple beams. A membrane which is less than 300 nanometers thick. The idea of that project was to prevent the earth from getting too much solar energy. The membranes worked, but the journey to space was not successful.

Authors: Joost van Driel & Johan Splinter

Flexible Optical BV is situated in Röntgenweg Estate, just outside of the TU Delft Campus. Gleb Vdovin leads us trough a small office into a room where we can discuss the company.

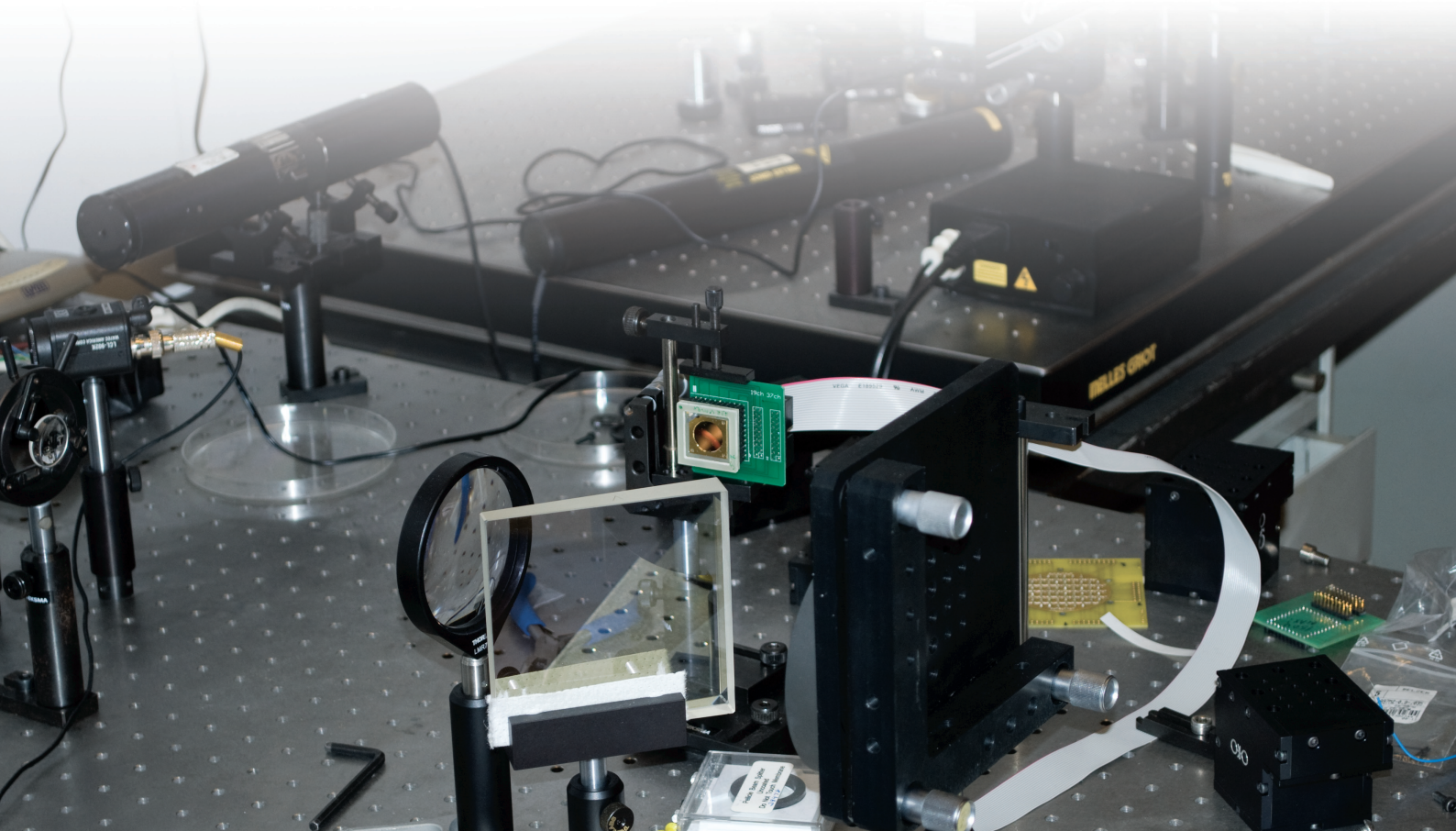
The product

Flexible Optical BV manufactures flexible mirrors. These mirrors have a diameter of roughly 1 to 5 centimeters. The printed circuit board (PCB) they are mounted on measures around 4 by 8 centimeters. Flexible mirrors are deformed by actuators which are placed beneath the mirror. A typical mirror uses 30 to 100 actuators for the deformation. Previously, such an actuator would have cost around €100.000. The technology which was subject of Gleb's PhD research, however is able to manufacture a mirror for around €2.000. Although a mirror using 100 actuators still costs €30.000, it would cost almost a million Euros with the old technology.

Flexible mirrors are used in several applications. Examples are astronomy, laser technology, microscopy and ophthalmology (the branch of medicine which deals with the visual pathways of a human). Furthermore, they can be used for lasers; they can compress laser beams and change the duration. The last action is a tricky one, because the pulse duration can only be femtoseconds. That can be used for synchronization of red and blue lights.

History of the Company

Gleb Vdovin received his masters degree Optics in Russia at the Leningrad Institute of Fine Mechanics and Optics. He



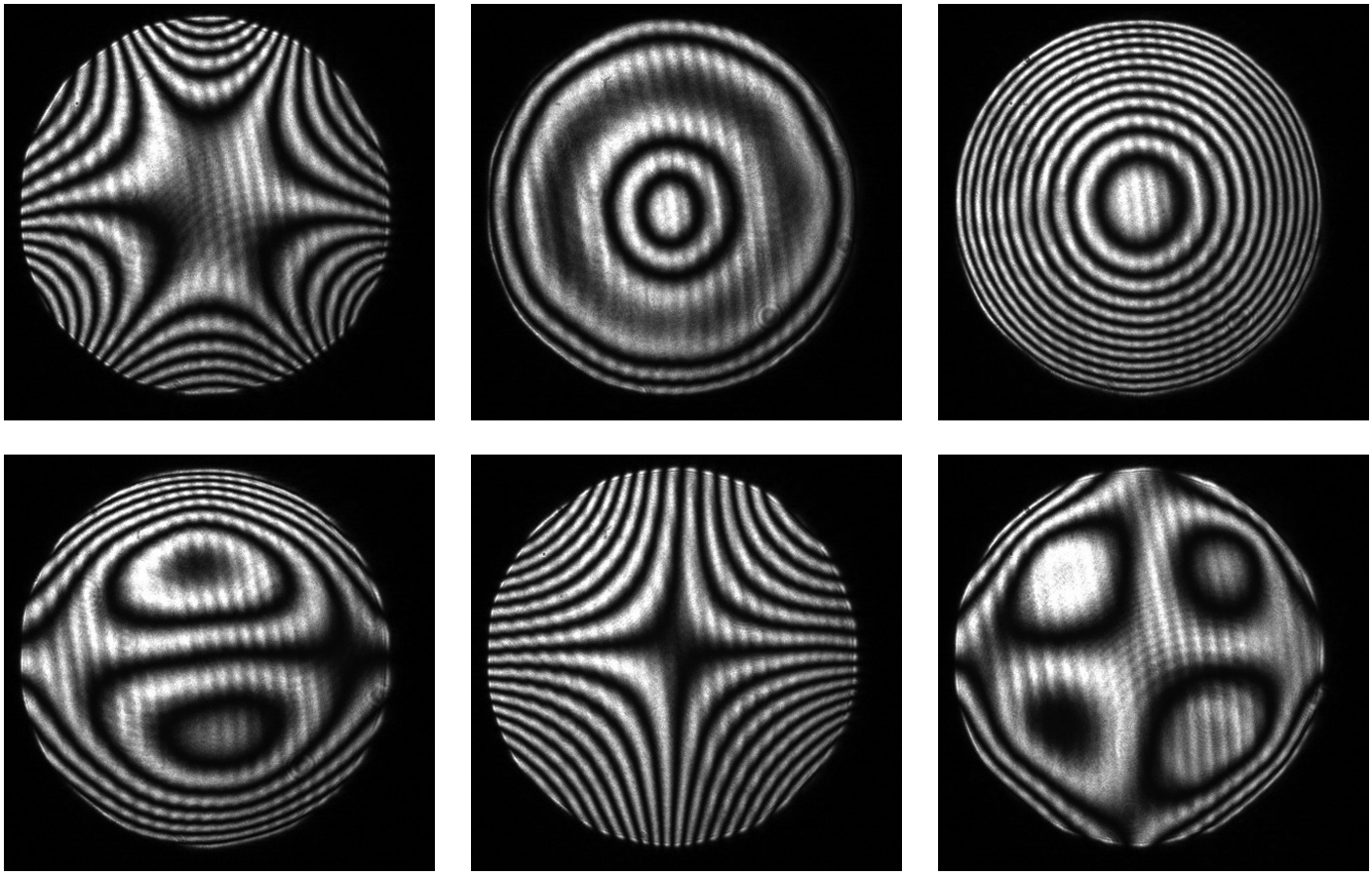


Figure 1: Interference patterns are used to measure the deformation of mirrors. A perfect spherical mirror should have a number of cocentric circles.

tells us Russia is very good at optics, but not as much at Electronics. For six years he worked in the field. Then, in 1991, the Soviet Union collapsed. These were interesting times, possibly comparable to what we will experience in the years to come. A lot of people became unemployed and Gleb Vdovin decided to do his PhD at the TU Delft in the Netherlands. At that time there was no research on deformable mirrors here, so he started investigating Micro Machined Deformable mirrors. At that time, these mirrors were a very hot topic, because they were very expensive but needed in some applications.

After finishing his PhD Gleb Vdovin founded Okotech in 1997. Oko means eye in Russian and many other (Eastern-European) languages, and this word is also similar in many other languages,

Figure on the bottom of the first page: the set-up used to test flexible mirrors

Dutch ("oog") among others. This company would manufacture mirrors using the new technology. The TU Delft wasn't very optimistic about the idea, but the University of Michigan helped with both theory and patents. Gleb's promotion research was a part of MOSiS (Micro Optical Silicon Systems), a European project. After the MOSiS project ended in 2000 there were some leftover materials such as membranes. These materials could be used in the new company. The membranes are not expensive, but very hard to obtain. They were produced at DIMES. The company worked with those materials for about one year. After this year they had to buy these materials.

In 2001 the name changed to Flexible Optical BV. Nowadays the company has five employees, four of them have a PhD degree. They are a mixture of Dutch and Russian people. All of them are scientific personnel. Administrative affairs are handled by Gleb or his wife. The company has a profit-sharing plan, that allows the employees to participate in the company profits.

Flexible Optical BV is different from most High-tech start-ups in that it was profitable from the first year. During these days Gleb rented a room at the University. Because there was no subsidiary from the University, nor an investment from an external company, all initial expenses were covered by Gleb's own money. On the other hand, not much money was needed. In the first years the company had a turnover of fl100.000 (€45.000). The number of customers was very low, around 5 products a year were enough to stay profitable. At this moment th company is looking for a new location, because their housing will be demolished for the new train tunnel in December. The current office at the Röntgenweg is a very nice place with friendly people and

it is cheap. Moving their business won't take too long, since they don't have a lot of supplies and machines to carry. Gleb does not expect it will be hard to find new housing: a lot of office room will become avaiable in the next months due to the economic crisis.

For six years Gleb has given lectures at the TU Delft. He still stands in for his colleagues when they are detained, but has no lecture of his own anymore.

Products and service

In the first years the company sold flexible mirrors as a stand-alone product. The customers needed to implement the systems themselves. Nowadays Flexible Optical BV sells the whole system of mirrors as a product. This includes electronics like High Voltage Amplifiers and PCI-cards. Every system is unique, so for almost every order research is needed. The company also offers consultancy as a service. Clients can explain their problem and Flexible Optical BV will investigate the problem and propose a solution. The company has delivered research projects in the fields of optical instrumentation, optical testing, human vision, laser optics and high resolution imaging.

The technology isn't very complicated. Gleb explains they don't have real technology, they have people with experience. If another company would get all the information needed to produce flexible mirrors, they would fail because they lack experience. The number of systems sold each year is about fifty to sixty. In other words: one product is sold each week. At this moment just a few orders are standing, but experience shows most orders will be done in the coming months, so August will be a very busy month.

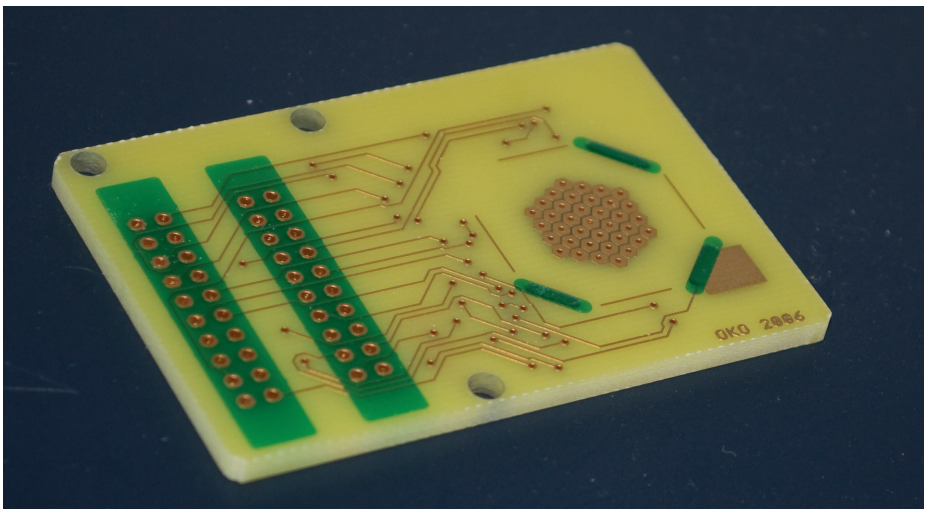


Figure 2: A PCB on which a flexible mirror can be attatched. This PCB supports 37 actuators.

Future of the company

The market for flexible mirrors is not very large. The mirrors are expensive and therefore only used in high-end applications. That's why it is unlikely the company will grow very much in the years to come. It is also a reason for the stable position the company is in. Many people know this company and there are only a few real competitors. Flexible Optical BV has some big contracts of German companies. Unfortunately Gleb is not allowed to tell who these clients are. He states these companies are very big players in their field. As long as the company stays relatively small, the structure of the company won't have to change.

Gleb is not afraid of competitors in the near future. Flexible Optical BV has done years of research. A newcomer would need to do this research and gain experience, which will take them some years. But during these years Flexible Optical BV will also make progression, thus staying ahead of competitors.

Figure 3: A box that can control up to 40 actuators

Patents

Although the company has some patents, it is very hard to protect their technology this way. Every system is different, so the patents are a bit vague. Furthermore, the company does not only sell in the Netherlands. In contrary, the sales in the Netherlands are just 5% of the total. The rest of their products are sold to the United States, Japan, Germany and so on. Worldwide patents are very expensive (around €50.000). But Gleb is not afraid of copies,

Picture to the right: packaging materials

because of their five years of research and knowhow.

Tour

After the interview Gleb show us their facilities. The first room houses the production facility as well as the laboratory. We see setups with a lot of mirrors, lenses and lasers. Gleb shows us a mirror attached to a PCB. These mirrors are connected to a control board, which for example can be a box with a USB connection. All computers used in the laboratory are normal regular Desktop PC's. After he connects the mirror to the computer, a pattern in the mirror forms. The reflection of the mirror can be seen on the wall, but interference patterns are used to see the characteristics of the mirror on the PC screen. The membrane is about 300 nm thick and can deform in 1 ms. That value is limited by the resonance frequency of the membrane. The mirror can be deformed with a maximum amplitude of 3 or 10 microns.

The last chamber is the storage room, which contains among others a 3D milling machine, controlled by a Pentium II. This drill is used to make the packaging for prototypes. The real production is outsourced to companies in Germany, America or China, depending on the needed quality and the price. Sometimes it is outsourced to Dutch companies, but Gleb has reason to believe they also outsource it to China. In one corner of the room a stack of packaging material is visible. Although packaging is not high-tech, it is also important to have experience in this field. The products are delicate, and most Express Mail companies do not handle packages with too much care. The stack we see is enough packaging material for about half a year.

More information

Interested readers can find brochures and papers on the website of Flexible Optical BV, www.okotech.com. On this site you can also find MrFit. MrFit ("Mr" means mirror and "Fit" means to aspecied wavefront)is a program for simulation of membrane and continuous facesheet deformable mirrors.

dhr. dr.ir. G.V. Vdovin can be contacted via gleb@okotech.com

Column

Prof. dr. ir. Fokkema
Rector Magnificus

Wat is de drijfveer achter technologische ontwikkelingen? Is het iemand met een geniaal idee? Is het bepaald door de cultuur? Stimuleert de vrije markteconomie de technologie? Of zijn technologische ontwikkelingen conflictgedreven, zoals de Maxwell-commissie mij als thema meegaf; de commissie kwam mede tot deze conclusie na een recent bezoek aan Israël.

Niet te ontkennen valt dat in tijden van oorlog technische ontwikkelingen in een stroomversnelling lijken te komen. Wanneer in de oudheid de stad Syracuse door de Romeinse troepen wordt belegerd, ontwerpt de Griekse geleerde Archimedes (287-212 v.C.), inwoner van de stad, diverse oorlogsmachines – spiegels om schepen in brand te steken en grote katapulten – om de belegeraars buiten de deur te houden. Het leverde alleen tijdwinst op; uiteindelijk viel Syracuse en werd Archimedes gedood tijdens de plundering van de stad.

Maar er zijn natuurlijk ook meer recente voorbeelden van conflictgedreven technische ontwikkelingen, zoals de tank en het (gebruik van) het vliegtuig in de Eerste Wereldoorlog. Tijdens de Tweede Wereldoorlog is een overeenkomstig patroon te zien, met als het bekendste technische 'wapenfeit' de ontwikkeling van de atoombom, die mede het einde van de oorlog bewerkstelligde, maar ook de potentie in zich heeft de wereld te vernietigen.

Er is dus wel iets te zeggen voor de stelling dat conflicten de ontwikkelingen van de technologie stimuleren. Toch vind ik dit een niet helemaal juiste redenering. Veel technologische ontwikkelingen komen ook zonder conflicten tot stand. Ik ben van mening dat niet het conflict de drijfveer is, maar het gemeenschappelijke doel om iets te bereiken. Natuurlijk is dat in tijden van oorlog de overwinning van jouw land, maar in andere tijden kan het de wens zijn om een probleem op te lossen. Hoeveel er dan met wilskracht is te bereiken, heb ik ondervonden na de brand in de faculteit Bouwkunde. Het gemeenschappelijke doel was om binnen korte tijd het onderwijs en onderzoek weer onderdak te geven en binnen zes maanden is het voormalig hoofdgebouw verbouwd tot BK-city. Een meer wetenschappelijk voorbeeld is het genoomproject, waarin verschillende landen samenwerkten om de structuur van het menselijk DNA in kaart te brengen en dat tot een succesvol einde is gebracht.

Onder druk wordt alles vloeibaar, in dat opzicht ben ik een optimist. Als een groep mensen ergens de noodzaak toe voelt, zijn zij tot grote dingen in staat, zeker op het terrein van de technologie. Het is zelfs beter als technologische ontwikkelingen niet in oorlogsomstandigheden plaatsvinden. In oorlogstijd werken wetenschappers en ingenieurs meestal voor hun eigen vaderland en vaak resulteert dat in technologie die voor andere mensen dood of het verlies van al hun goederen betekent. In vredestijd is het mogelijk te werken voor heel de mensheid en de technologische vondsten aan iedereen ten goede te laten komen.

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